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**Essays on innovation and the development bank
in Brazil**

Marco Carreras

Declaration

I hereby declare that this thesis has not been and will not be submitted in whole or in part to another University for the award of any other degree.

Signature:

Marco Carreras

Summary

My PhD thesis studies the role of development banks in financing industrial development and particularly in providing the long-term committed finance needed for innovation. The focus is on the Brazilian development bank, BNDES, and its leading role in supporting the new Brazilian innovation system. I begin by discussing the role of finance in the National System of Innovation framework, the literature on development banks and the motivation of my research. The second chapter looks at the impact of BNDES disbursements on commercial banks' disbursement using balance-sheet data for the period of 2002-2016. Using dynamic panel data techniques, I investigate whether BNDES disbursement for investment in innovation and fixed capital investments crowded-in or crowded-out Brazilian commercial banks' disbursement. The third chapter is a micro-analysis of the impact of BNDES disbursements on the R&D intensity of Brazilian manufacturing companies' sector for the period of 2003-2011. In this chapter, I investigate whether companies that have received funding from BNDES have increased or decreased their commitment in innovation activities. The findings of this analysis provide new evidence regarding the industrial sector activity of the Brazilian development bank, adding on the debate about additionality/substitutability of public financial resources. Finally, the fourth chapter provides qualitative evidence for the Brazilian pharmaceutical sector, presenting the findings of primary collected data on companies' perceived obstacles for investment in innovation and on contribution of BNDES funding in reducing such obstacles. The data have been collected by means of a survey, undertaken for a sample of Brazilian companies in the pharmaceutical and biotech sector.

Acknowledgments

My PhD journey represented an important and unforgettable experience that contributed positively to my personal and professional growth. I am grateful to several people that made this 4-years journey possible.

First, I would like to thank my supervisors, Prof. Mariana Mazzucato and Stephen Spratt. Mariana offered the best academic and personal support, providing indispensable and critical advice. Her approach and rigour in work represent an inspiration for me. Stephen has been an important guide with his insightful feedback that has been of immense help. I would also like to thank Prof. Barry Reilly for his help throughout my PhD. Without his invaluable support, the econometric methodology of this thesis would not have been as developed.

I would like to thank SPRU for the financial support for my PhD thesis and for the opportunity of being part of such dynamic academic department. I am also grateful to the University of Sussex for all teaching opportunities and to Prof. Maria Savona and Tommaso Ciarli, being always present with their support.

I would also like to mention all my dear friends that have been at Sussex and with whom I shared all ups and downs during this beautiful experience: Mattia, Egidio, Gabriele, Eva, Cecilia, Hector, Elsa, Antonia, Rashaad and Filippo.

The most important mention goes to Amrita Saha who always supported me, gave me strength in all moments and, most importantly, during this journey said “yes” to spend the rest of our lives together.

In conclusion, I want to dedicate this thesis to my family: my parents with their support and trust that gave me strength to always believe in what I was doing, my sister who is my moral support and Annie with her warmth.

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1. Introduction and general background

My thesis studies the role of development banks in financing industrial development and particularly in providing the long-term committed finance needed for industrial innovation. In this sense, it puts finance at the centre of the systems of innovation approach. The theoretical starting point of this PhD thesis is the Keynesian assumption according to which liberalized financial markets are not fully developed; hence, development financial banks are public institutions necessary to provide the financial resources for social and developmental national goals, generally not supplied by commercial banks. The focus of the analysis is on the Brazilian development bank (BNDES henceforth) and its leading role in supporting the new Brazilian innovation system, in the context of the recent (since 2004) emphasis on innovation and industrial policy.

The overarching research question of my thesis is about the investigation of the role of BNDES in incentivizing greater commitment in R&D activities. In detail, the analysis will investigate whether the disbursement of BNDES have either crowded-in/out commercial banks' activity, therefore fostering/hampering the development of the domestic financial market, and whether the activity of BNDES have generated greater/lower commitment in R&D activities of companies operating in the Brazilian market. I begin by discussing the motivation and the key literature on the topic in this chapter. My thesis then looks at three different research questions with three different approaches, (i). Macro/meso dimension in the second chapter; (ii). Observing the impact at micro level in the third, using secondary data, and (iii). Using primary data collected by means of survey in the fourth chapter.

The second chapter is based on the evaluation of BNDES disbursement for innovation and fixed capital investments on Brazilian commercial banks' disbursement using balance-sheet data for the period of 2002-2016. The research question in this chapter is: ***“Is BNDES an efficient government tool to transmit policy decisions without hampering the development of the private national financial system?”*** and specifically analysis whether the disbursement of the Brazilian development bank have crowded-in or out financial resources of private commercial banks.

The third chapter is a micro-analysis, for the Brazilian manufacturing sector, on the impact of BNDES resources on companies' own commitment in R&D expenditure. The aim of the chapter is to shed light on the crowding-in/out debate evaluating whether BNDES support is able or not to encourage firms' own commitment to R&D-based projects. The research question of this chapter is: ***“Fostering innovation activities of the national industrial system with the***

support of a development bank: incentivizing greater commitment or displacing financial resources?”

Finally, to complement the quantitative approach, this thesis will also present findings obtained with primary data, collected by means of survey, evaluating the impact of BNDES contribution in reducing the risk associated to investments in innovation for the Brazilian pharmaceutical and biotech industries, two industrial sectors historically highly involved in innovation activities. The fourth chapter, referring to the period 2004-2015, will address the following research question: ***“Risk in Innovation: Theory and Evidence from Pharma and Biotech sectors in Brazil: what role is BNDES playing?”***

The triangulation of evidence proposed in my thesis with a mixed method approach allows the different research questions to complement each other, looking at different aspects part of the same overarching research question.

1.1. The role of finance in the National Systems of Innovation framework

Schumpeter (1939) highlighted the importance of credit creation at the centre of the dynamics of innovation in a capitalist society; in a stationary state of perfectly competitive equilibrium, credit can help entrepreneurs to increase the level of investments in the economy and break the circular flow with the introduction of a new product (Schumpeter 1934). The combination of entrepreneurial spirit and risk-taking capital market would have therefore allowed the industrial sector to introduce innovations in the market (Schumpeter 1934). In this context, Schumpeter explained the essential role of banks as *“nothing but establishments for the manufacture of means of payment”*. Finally, highlighting the central role of banks in promoting technological change, the author recognised bankers as the *“capitalist par excellence”*, those creating *“new purchasing power out of nothing”* (Schumpeter 1934). Yet, he did not predict the degree to which finance has ended up financing itself, a topic that became more important during the later years (Minsky 1981; Wray and Tymoigne 2008; Haldane and Davies 2011; Mazzucato and Wray 2014).

The long-term strategic commitment required to finance technological change draws attention to the kind of finance needed for an innovation-led industrial development. Evidence suggests that the long time necessary for innovation to come about and the high uncertainty involved in such process, whereby more projects are expected to fail than to succeed, means that the profit-maximizing commercial banking sector does not supply the adequate amount of resources, as stated by Mazzucato (2013a; 2013b). Additionally, commercial banks cannot capture all the returns from innovation, which may be disseminated throughout the economy. Government, on the other hand, is concerned with maximising total societal returns, so its ‘risk-return’

considerations are different than the ones of commercial banks. For developing countries, ultimately, where the financial alternatives (Venture Capital, equity, business angels) are not fully developed, the question is where this money should come from (Barone and Spratt 2015), if not from multilateral financial institutions, such as World Bank, that however provide financial resources that are not necessarily in line with national targets and industrial strategies.

In a Schumpeterian approach, economic development is the outcome of endogenous and discontinuous changes in the economy (Schumpeter 1934); in this context, governments often provide both the direction and the patient finance needed to promote these changes, consistently with the economic and social phase of development (de Aghion 1999). The literature on National Systems of Innovation recognises the crucial role of finance and particularly of a long-term source of funding (Freeman 1987; Christensen 1992; Lundvall 1992). However, few authors of innovation studies have investigated the different types of finance that have characterised different systems of innovation (Tylecote 2007). Mazzucato (2013b) argues that this represents a problem since different types of firms require different types of finance, and what finance is actually received (stock market, VC, public grants, etc.) affects the kind of investment and innovation activities that can be carried out. My analysis will therefore examine how the source of finance matters and, more importantly, how a committed source of long-term finance is necessary for the cumulative, path dependent, uncertain processes characterising economic development driven by technological change (Malerba and Orsenigo 1997; Malerba 2005).

My thesis will attempt to shed light on the role of mission-oriented development banks in a National Systems of Innovation, building on the framework proposed by Mazzucato and Penna (2014), focusing on BNDES. The analysis will quantitatively and qualitatively evaluate whether BNDES, characterized by an innovation-based developmental mission, has been able to provide the long-term committed source of credit needed to allow firms to invest in long-term projects aimed at technological change and innovation. In doing so, it will bridge a fundamental gap regarding the ‘quality of finance’ in the systems of innovation literature, as well as bridge this literature to the macroeconomic work that has evaluated the degree to which public finance *crowds-in* or *out* private finance.

1.2. The Literature on Development Banks

Development banks are financial institutions that have changed their structure and mission over the years (de Aghion 1999) and for which there is no consensus on their effectiveness for economic growth (Torres and Zeidan 2016). The conditions for the creation of a development bank differ from country to country, according to the economic, financial and social structure. However, there are few common characteristics applicable cross all countries: *i*) the uncertainty

of a development process caused by long-term investments as infrastructures and *ii*) the difficulty of private actors to evaluate and incorporate the risk, especially when this is very high (Hermann 2010).

From a Keynesian perspective, development banks are necessary because liberalized financial markets are not fully developed, and thus are unable to provide the necessary resources for social and developmental national goals. This gap means financial markets are unable to support those sectors crucial for economic development as infrastructure, funding for innovation and other activities characterized by high social returns.

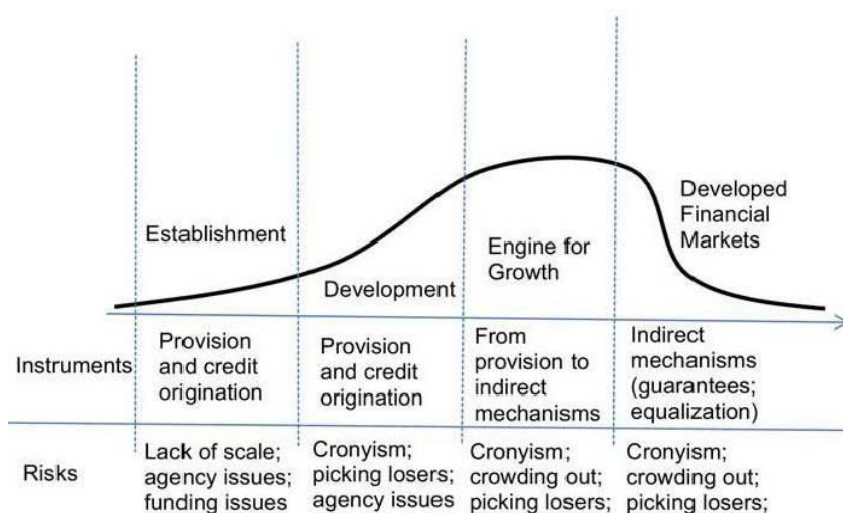
Initially, the creation of development banks in Europe in the 19th century was caused by fast industrialization and by the lack of financial agents providing long-term finance (Diamond 1957; Gerschenkron 1962). In the 20th century, the common characteristic that allowed the creation of development banks has usually been dictated by the consequences of wars, particularly for countries losing the conflicts: after the First World War and in some cases after the Second World War, as in Japan and Germany, development banks have been created with the main mission of reconstructing the countries, moving to a more long-term finance mission after the reconstruction was funded (de Aghion 1999). The German *Kreditanstalt für Wiederaufbau* (KfW), founded in 1948, had the major role of channelling the resources for the reconstruction after WWII; in Japan, two development banks have been created with two different missions: the *Export Bank of Japan* (1950; *Export-Import Bank of Japan* after 1952) with the role of promoting the overseas expansion of domestic firms and the *Japan Development Bank* (1951) with the main mission of providing resources for the development of heavy industries and infrastructure. In Korea, the *Korea Development Bank* (1954), was originally created to financially support the national industries after the Korean War. In countries not having the need of an after-war-reconstruction, the creation of development banks found its motivation in other developmental missions: in Brazil, the *Banco Nacional de Desenvolvimento Econômico e Social* BNDES (1953) was created to provide financial resources for a national industrialisation; in Canada, the *Industrial Development Bank*, aimed to provide funding particularly for small enterprises. Finally, the most recent successful development bank, the *China Development Bank* (CDB), was founded in 1994 with the main mission of supporting economic and industrial development.

The different cross-country evolution of development banks over the years represents the adaptation of these financial institutions to specific national needs, resulting in a diversification of roles and sectors of interest. The German KfW, after financing the reconstruction, moved its interest towards SMEs, environmental protection, energy efficiency and innovation-based industrial development. Similarly to the evolution of the German counterpart, in the 60's the *Japan Development Bank* focused its resources on industrial innovation. In the '70s, the Canadian *Industrial Development Bank* changed its name becoming the *Federal Business Development Bank* and started venture capital operations moving eventually its interests towards industrial innovation in the 90's

under a new name, the *Business Development Bank*. The *Korea Development Bank* changed its role, focusing on new industrial sectors, after the creation of the second development bank in the mid-70s, the *Export-Import Bank of Korea*, having the same mission of the Japanese counterpart.

Torres and Zeldan (2016), identifying the similarities in the heterogeneous development paths undertaken by development banks over the years, proposed a life-cycle hypothesis to justify their existence in countries with inefficient financial markets and good quality institutions. In their life-cycle hypothesis, development banks initially grow together with the development of the State, to eventually scale down once the country's financial markets have developed. Further, as summarized in Figure 1.1, the authors identify instruments and possible risks at each stage of the lifecycle of the development bank.

Figure 1.1 – Torres and Zeldan (2016) lifecycle hypothesis of development banks



Source: Torres and Zeldan (2016)

From this thesis' point of view, what can be argued about Torres and Zeldan's hypothesis is on the role of development banks in the last stage of the lifecycle and, more precisely, at which stage development banks must reduce their participation in the economy. First, it should be fully agreed when financial markets can be defined as developed and, more importantly, that also financial markets widely understood as developed can collapse, as during the 2008 financial crisis. Further, if the level of development of financial markets is measured in terms of financial liberalization, as widely agreed by the mainstream literature, there is a lack of consensus on whether liberalized financial markets automatically lead to economic development. This lack of consensus was evident even before the US housing bubble (Minsky 1992; Knight 2005; Rajan 2006). Second, there is no guarantee that private banks will start financing long-term and high-risk investments once financial markets are developed. It has been historically observed, on contrary, that those investments represent the main target of development banks and are generally discarded by the private financial sector (Minsky 1981; Haldane and Davies 2011).

Nowadays, development banks represents an alternative source of finance, particularly for higher risk investments (Rodrik 2004), with participation in a broader range of institutions, all complementary to each other, creating a dynamic and innovative National Systems of Innovation. The four main roles of development banks (countercyclical, developmental, new venture support and challenge-led), highlighted in Mazzucato and Penna (2014), give a framework through which it is possible to understand the recent role played by these financial institutions. Together with a new narrative of the State, as in Mazzucato and Perez (2014) and Allas (2014), it is possible to understand the relationship between finance, innovation and the different agencies being part of a National Systems of Innovation.

The three largest mission-oriented development banks are the *China Development Bank*, the Brazilian *BNDES* and the German *KfW*. In 2012, each of these banks disbursed loans accounting for more than 10% of their countries' GDP (Ferraz, Além et al. 2013). All three banks have the main mission to provide medium-long term finance for the economic and social development of the country (Barone and Spratt 2015) in areas where private finance feels a too-high-risk-to-intervene (Mazzucato and Penna 2014).

1.2.1. The critiques on Development Banks

Market Failure Theory allows development banks, and public sector more generally, to operate only in those areas particularly affected by market failures. The main critiques moved to these financial institutions, as presented in Mazzucato and Penna (2014), are:

- i)* Financial repression and crowding-out
- ii)* Misallocation of resources due to political biases
- iii)* Incapacity to “*pick winners*”
- iv)* Inefficient governmental structure

The first critique is about the risk of crowding-out generated by the activity of development banks. In the literature, there are two different perspectives from which it is possible to look at the crowding-out hypothesis:

- i)* Crowding out commercial banks' loans (especially in the most profitable sectors) and therefore hampering the development of the domestic financial market because of the lower-than-market interest rate applied to their loans (McKinnon 1973).
- ii)* Crowding out the disbursement of the companies that, following a disequilibrium of the national rate of capital accumulation after the increased public capital, will eventually rely only on development banks' resources, decreasing their own resources (Aschauer 1989).

Other critiques related to financial repression come from the literature on government ownership of financial institutions. La Porta, Lopez-De-Silanes et al. (2002) found that higher government

ownership of banks hampers country's financial development and reduces income and productivity growth. Many authors have criticised these findings, arguing about the weaknesses of the research strategy (Levy Yeyati, Panizza et al. 2007), on how these results hold only for countries with low financial development (Körner and Schnabel 2011), or on how quality of institutions matters more than ownership (Andrianova, Demetriades et al. 2008).

Misallocation of resources due to political bias is generally caused by a non-virtuous crony capitalism in which politicians use bank lending beyond economic purposes, altering the development of both financial markets and industrial development (Carvalho 2014). Additionally, misallocation of resources is also caused by the incapacity of “*picking-winners*”, or by the willingness to “*pick-looser*”, in a rent-seeking vicious cycle (Robinson and Torvik 2005).

Finally, inefficient governmental structures are likely to generate governance issues, particularly when meritocratic selection is overruled by other criteria. Public financial sector is nowadays completely integrated in the regular financial markets and this involves a set of rules and constraints to be followed and understood by professional managers (Torres and Zeidan 2016).

This PhD thesis will primarily engage with the first critique moved to development banks, financial repression and crowding-out. As a limitation of this analysis, findings do not provide evidence to strongly rule out any of the other critiques.

1.3. The Brazilian industrial policy environment

In Brazil, a new wave of government intervention on industrial policy resurged at the end of the 20th century (Pereira, Marcelino et al. 2006). Brazil's focus on innovation started at the beginning of the 21st century, less than 10 years after liberalization policies promoted by international institutions as World Bank and IMF were issued (Wade 2003); these policies, that were supposed to offer a greater penetration of Foreign Direct Investments, did not however offer the expected results and did not provide the big push Brazilian economic and social sectors were waiting for. Since 2004, a new set of industrial and innovation policies started shaping the Brazilian economy, as presented in the following Table 1.1.

Table 1.1 - 2004/2013 Brazilian Policies

<u>Industrial Policies</u>
2004 - 2007: PITCE - Política Industrial, Tecnológica e de Comércio Exterior
2008 - 2011: PDP - Productive Development Policy
2011 - 2014: PBM - Plano Brazil Maior
<u>Innovation Policies</u>
2007 - 2010: PACTI - Action Plan for Science Technology and Innovation
2012 - 2015: ENCTI - National Science, Technology and Innovation Strategy
2013 - 2014: Inova Empresa
<u>Fiscal incentives and subsidy programs</u>
2004: Brazilian Innovation Law
2005: Good Law
2006: Economy subsidy program (administrated by the funding agency FINEP)

Source: Author's own elaboration

Since 2004, Brazilian industrial policies have identified targeted sectors able to lead the economic development of Brazil through a mission based on industrial innovation and social development (for more details, please refer to the [Appendix](#)).

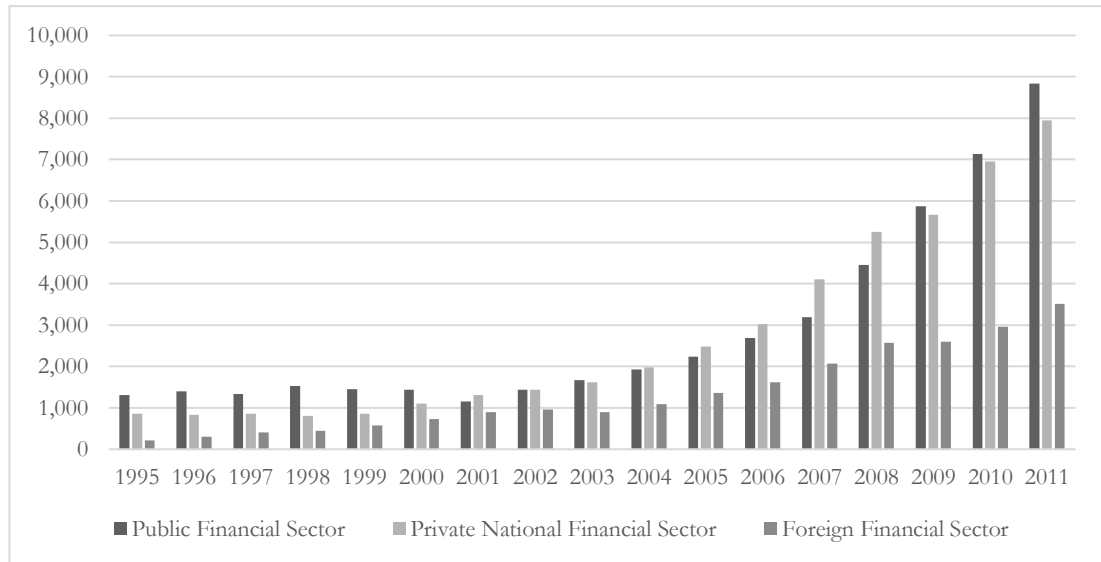
The need of a qualified government intervention with defined missions and targeted goals, aimed at technological development and supported by coherent policies dealing with different State agencies, is the core of the literature on National Systems of Innovation (Nelson 1993; Freeman 1995; de Aghion 1999; Pereira, Marcelino et al. 2006). At the same time, the need to revise these policies over the years to keep them up to date with the economic cycles is dictated by the necessity to account for dynamic and discontinuous changes in the system as the main determinant of economic development (Schumpeter 1934).

1.3.1. A quick overview of the interaction between public-private finance in the Brazilian economy

Since 1980, the Brazilian economy has been affected by different periods of hyperinflation, as consequence of the economic downturn following the energy crisis during the military dictatorship. Hyperinflation crises lasted until the beginning of the '90s, in correspondence with the conclusion of democratic transition of the country; since then, in the last 20 years, monetary and fiscal policies profoundly determined the stabilization of the Brazilian economy (Afonso, Araújo et al. 2016).

As illustrated in the two following figures, the growth of credit operations in Brazil seems to show a complementarity between public and private financial sector that could be evidence of a crowding in more than a crowding out scenario. Although this might be just an ‘optical’ effect (e.g. an effect of common expansion of credit across sources driven by pure economic growth), it is interesting to observe the evolution of different sources of credit across different phases of Brazilian economic growth.

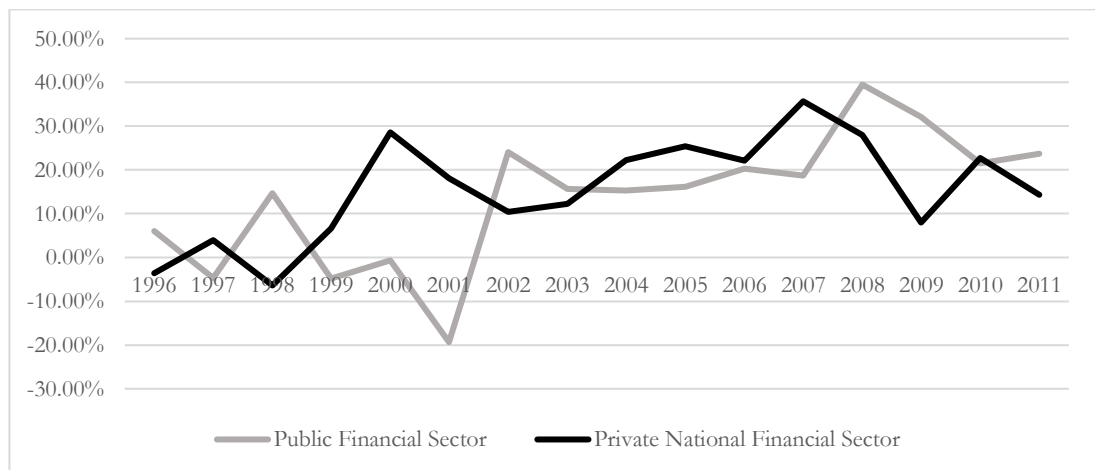
Figure 1.2 - Brazil Volume of Credit Operations, in Nominal R\$ Billion



Source: FEBRABAN

The marginal presence of the foreign financial sector leaves the Brazilian credit market for public and national private financial institutions. The following Figure 1.3 shows the growth rate of the nominal volume of credit operations of public and private financial sectors.

Figure 1.3 - Growth Rate Nominal Volume of Credit Operations



Source: FEBRABAN

The years in which public and private credit growth trajectories evidently diverged are in correspondence of the Argentinean bailout in 2001 and of the more recent subprime mortgage

crisis in 2008. From Figure 1.3 is interesting to notice the different roles of public and private financial sectors in the two crises. In 2003, private financial sector acted with a countercyclical tendency to offset the drop of public credit operations. In the 2008 financial crisis, in line with the new countercyclical role undertaken by the main Brazilian financial institutions, the Brazilian public financial sector counterbalanced the downturn of private credit operations.

1.4. **What is BNDES**

BNDES is a 100% state owned development bank created in 1952 and has been under control of the Brazilian executive and the Ministry of Development, Industry and Foreign trade (MDIC). Since its creation and until 1980s, BNDES supported the industrialization process through government investment and funding. From the 1990s BNDES took part in the liberalization process undertaken by Brazil, changing the country's financial structure and reducing the bank's developmental role in favour of the private actors (Hermann 2010). In 2004, BNDES went back to its primary mission aimed at Brazilian economic development through innovation. The areas in which the Brazilian development bank operates are indicated in Table 1.2 below:

Table 1.2 - BNDES Areas of Operations

Cattle-Raising and agriculture	Infrastructure
Trade, Service and Tourism	Innovation
Culture	Environment
Social and Urban Development	Capital Market
Industry	Exports and international positioning

Source: BNDES

Even though innovation accounts for a small portion of the overall disbursement, the strength of BNDES activity is evidenced by the existence of an agenda that can be implemented with specific tools and a unique target defined by the government (Schapiro 2013). BNDES represents one of the largest development banks, with an amount disbursed in 2014 almost double compared to what disbursed by the World Bank the same year (Torres and Zeidan 2016).

1.4.1. The change in structure of BNDES over the decades until the new mission for innovation

BNDES priorities have changed over years, following the national priorities indicated by each government over decades since its creation.

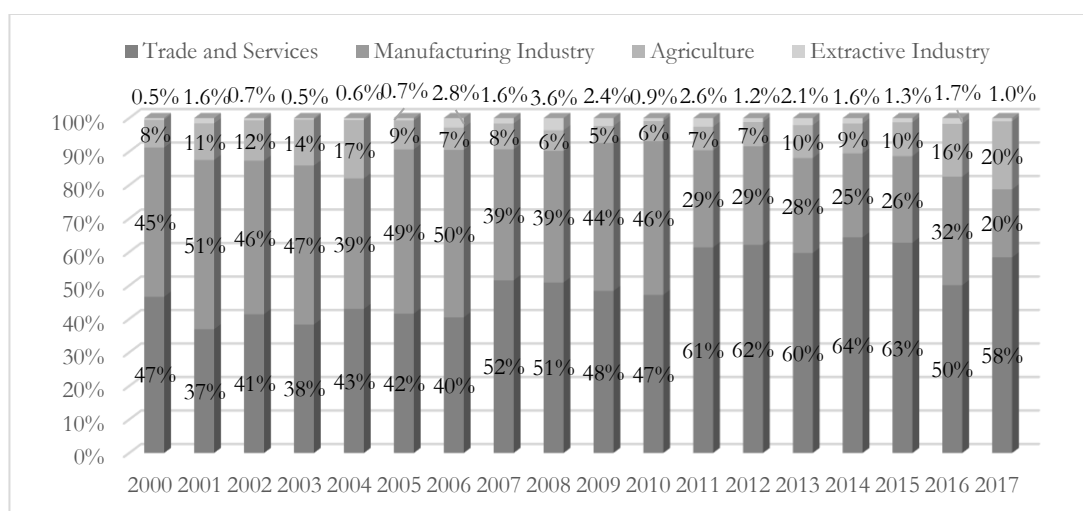
In the '50s, BNDES commitment was primarily focused on infrastructure, with particular attention on transport, energy and on the iron and steel industry. This focus changed in the '60s,

towards heavy industry, SMEs and consumer goods. In the '70s, following the national economic priorities dictated by the government, BNDES played a leading role in supporting the import substitution process started in Brazil and aimed at the replacement of basic inputs and capital goods. Energy, agribusiness and competitive integration became BNDES priorities in the '80s until the '90s when Brazil began its trade liberalization process through the National Privatization Program (PND). This was supported primarily by BNDES together with the two other priorities, private infrastructure and social and urban development.

1.4.2. BNDES' role in the recent Brazilian industrial mission for innovation

BNDES works closely with the Ministry of Development, Industry and Foreign Trade (MDIC) to stimulate the industrial sector and foreign trade (BNDES 2013). Figure 1.4 shows BNDES disbursement for the industrial sector by sector aggregate.¹

Figure 1.4 - BNDES Annual Disbursement by Sector Aggregate 2000-2017



Source: BNDES

Among the industrial sector, trade and services and manufacturing sector have always represented the main receivers of funding from BNDES, leaving a marginal role to the agricultural and extractive industries. As also evident from Figure 1.4, trade and services recently acquired more importance in BNDES' targeting decision, increasing their share in the bank's industrial portfolio. The main instruments implemented by BNDES for the industrial sector are:

¹ It would have been interesting to compare BNDES figures with similar ones for commercial banks; however, to the best of my knowledge, similar data for the commercial banking sector are not available.

Table 1.3 - Financial instruments offered by BNDES

Direct Operations	Exim
Indirect operations	Project finance
Mixed Direct and Indirect	Equity investments
MSME	Grants

Source: BNDES

Direct operations are operations carried out directly by BNDES or by authorized representative. **Indirect operations** are targeted for micro and SMEs; the analysis is carried out by accredited financial institutions in addition to the financing and repayment conditions. Accredited financial institutions assume also the risk of non-repayment. Indirect operations finance projects in different areas: construction, heavy vehicles, machinery and equipment, exports and agriculture. BNDES offers two types of indirect operations:

- **Automatic:** operations that do not need any prior BNDES assessment. The requests are submitted to the accredited financial institutions that, after approving them, ask BNDES for approval and release funds. All isolated purchase of machinery and equipment are funded with this type of operation, regardless of the amount.
- **Non-Automatic:** operations requiring prior consultation by BNDES.

Finally, **mixed direct and indirect** operations combine direct and non-automatic direct characteristics. The investment risk is shared among BNDES and the accredited financial institutions.

Resources of the BNDES are guaranteed by different sources shown in the capital structure of the institution. Since 2010, mainly due to the new countercyclical role assigned to BNDES after the 2008 sub-prime financial crisis (Torres and Zeidan 2016), National Treasury has been the main creditor and the cost of these resources is largely (if not entirely) pegged to the Long-term interest rate (TJLP). The second main contributor is the Workers' Assistance Fund (FAT) that each year transfers automatically 40% of the revenues to BNDES in a quasi-equity funding mechanism and it is remunerated at the Long-term interest rate (TJLP). Other voices are represented by Fundraising Abroad, the PIS/PASEP fund (social contributions fund for workers' insurance), the FI/FGTS fund (the investment arm of the worker's compensation fund), Repurchase Agreement, BNDESPAR Debentures and Other Obligations.

BNDES portfolio comprises Corporate Stakes, Bonds and Securities and Other assets. Cash flow per source of resources shows that return on operations account for almost 80% of the total cash flow; moreover, BNDES system's default rate in 2013 was at a record low, reflecting the strength of its credit and on-lending portfolio. The percentage was only 0.01% in the first 2014 quarter,

lower than the 0.04% registered in the same period in 2013. According to the Brazilian Central Bank, the average default rate for the National Financial System was 3% in March 2014.

1.4.2.1. The role of the accredited financial institutions

The dissemination of accredited financial institutions all over Brazil is crucial to disseminate credit to micro and SME's in all the national territory. Some operations of BNDES are carried out only by these institutions, such as investment projects for a value lower than R\$ 10 million (with some exceptions), separated acquisitions of machinery and equipment of any value and investment projects or acquisition of machinery, equipment and working capital financed by only one form of indirect funding.

1.4.3. Main critiques on BNDES and the need to look at the long-term impact

Concerning the critiques on BNDES role in the Brazilian economy, previous literature has not offered clear predictions about the determinants of allocation of funding and firms' selection; some authors argue BNDES selects firms with good performance to be more likely to be repaid (Lazzarini and Musacchio 2011) or highlight the limitations of the *picking-winner* strategy from a "*market failures*" perspective (Garcia, Oliveira et al. 2011). Forero (2013) discussed about BNDES quick growth and the "*too*" long-lasting intervention in the countercyclical policies. Finally Schwartzman (2011) criticised the recent increase in BNDES direct credit lines, adding to the already high proportion of subsidized direct credits in the Brazilian economy (more than 30% of the total amount of loans) and contributing to limit the role of monetary policy.

Overall, the main accusation moved to BNDES is to crowd-out private banks in providing long-term loans (Wheatley 2013), therefore hampering the development of the local financial markets. The main reason of crowding-out is the rate BNDES charges on its loans (TJLP for direct disbursement, plus accredited financial institutions' fees for indirect operations) is less than the Selic overnight interest rate set by the Central Bank.

Barone and Spratt (2015) summarized the main critiques moved to BNDES as presented in Table 1.4 below: critiques are categorized by thematic areas and look at environmental, social, economic and accountability issues contested to the Brazilian development bank.

Table 1.4 - Summary of critiques moved to BNDES

Environmental issues	Social issues	Adverse impact on the Brazilian economy	Transparency and accountability issues
The BNDES's energy strategy risks further contributing to climate change	Sector-specific regulations are insufficient in practice	Energy efficiency overlooked	No external assessment
Not having signed the Equator Principles	Serious violations of legal, health and safety conditions, culminating in the use of slave labour	Business interests dominate	No detail on the Ombudsperson
No independent evaluation of the environmental impacts of financed projects	Invasion of indigenous land	Displacement of agricultural crops to less productive areas	No public consultation carried out prior project finance approval
		Reinforcing inequality	
		Crowding-out effect	
		Public money for centrally prioritised investments	
		Concessionary finance raises Brazilian interest rates	
		Low profitability of funded projects	

Source: Barone and Spratt (2015)

The quantitative literature on the impact of BNDES on the industrial sector (particularly manufacturing) has seen different scholars trying to establish links with different indicators of labour productivity, which however does not represent the only contribution of public R&D resources to economic performance (David, Hall et al. 2000). Ottaviano and Sousa (2007) tried to establish the impact of BNDES loans on average labour productivity, finding a mixed evidence with a three-year lag depending on whether the loans were for small or large scale projects. Ribeiro

and De Negri (2009), using TFP as productivity measure, found a limited effect of access to BNDES lending for machinery acquisition on the TFP of innovative firms in the manufacturing sector from 1996 to 2006; however, the focus is only on one credit line, FINAME because of its outlay and the main mission targeted at machinery acquisition. Finally, Lazzarini and Musacchio (2011) published a financial analysis on the impact of BNDES loans and equity investments on a sample of Brazilian listed firms between 2002 and 2009. They concluded BNDES loans do not have any consistent impact on performance and investment.

1.5. The Brazilian financial sector

Credit in Brazil, until the middle of the 2000s, has been characterized by scarcity, high volatility, high cost, high concentration and segmentation (Torres and Zeidan 2016). Despite the privatization of financial institution in the 1990s, that contributed to the fast growth and concentration² of the Brazilian credit system from 2004 to 2012, some areas, such as the market for long-term funds, are still characterized by supply constraints. That is why Brazilian public financial institutions remain an important source of capital in the economy; in 2014, state-controlled banks have been responsible for 53% of the outstanding loans in Brazil while the share of outstanding loans of private financial institutions contributed for only 32% (Lazzarini, Musacchio et al. 2011; Rezende 2015). In this scenario, the share of BNDES' outstanding loans represented more than 20% of the total credit to the private sector and the bulk of the long-term credit (Lazzarini, Musacchio et al. 2011).

Although real interest rates declined from 2002 to 2012, from an average of 12% in 2002 to 4% in 2012, the difference between short-term lending rates and commercial banks' funding costs for loans is higher relative to the long-term financing activities (Rezende 2015), shifting portfolio's preferences of Brazilian commercial banks towards high-yield, short-term assets rather than to long-term assets, characterized by low-risk adjusted returns.

1.6. Summary

This chapter has provided a summary on what the role of development banks over the years and on the academic debate about the necessity of such financial institutions. Further, this chapter introduced the Brazilian development bank, BNDES, and its primary role played in the Brazilian economy for the last 20 years, together with the Brazilian political, financial and industrial environment.

² From 1995 to 2012, the share of assets of the 10 largest banks increased from 71% to 89% (Torres and Zeidan 2016)

Summarizing the following chapters of this PhD thesis, the second chapter looks at whether the disbursement of the Brazilian development bank have crowded-in or out financial resources of private commercial banks; the third chapter is a micro-analysis of the impact of BNDES resources for R&D on manufacturing companies' own commitment in R&D expenditure and, finally, the forth chapter evaluates the impact of BNDES contribution in reducing the risk associated to investments in innovation for the Brazilian pharmaceutical and biotech industries. Chapter 5 concludes the thesis by summarizing the findings of all chapters.

2. Is BNDES an efficient government tool to transmit policy decisions without hampering the development of the private national financial system?

I evaluate the impact of BNDES disbursements on Brazilian commercial banks' disbursement using balance-sheet data for the period of 2002-2016. Using dynamic panel data techniques, I find BNDES disbursement for both investment in innovation and fixed capital investments crowded-in commercial banks' disbursement. Further, the results obtained considering the distribution before and after 2008, suggest the beginning of the crowding-in impact together with the countercyclical role adopted by the bank at the beginning of the financial crisis.

2.1. Introduction

The role of public spending in the economy has always represented an academic and political topic of debate. With the well accepted paradigm of the role of the State as coordinator of industrial and economic strategies (Rodrik 2004), one of the main academic questions remains whether public financial resources hamper or foster the development of the national economy and of the national private financial sector.

Since the end of WWII, public financial institutions have represented the main tool for governments to address public disbursement and to transmit policies' decisions to the real economy (Mazzucato and Penna 2014). Their role has changed over time to address the economic and social challenges faced by the countries at each time (de Aghion 1999); still, the persistent critique is about the resource misallocation due to the inefficiencies of the central government, (Robinson and Torvik 2005; Torres and Zeidan 2016) and of non-virtuous crony capitalism (Carvalho 2014). Further, they are often accused of crowding-out either private companies' disbursement (Aschauer 1989) and private banks' disbursement (McKinnon 1973).

The 2008 global financial crisis brought back the discussion about the relationship between private and public financial resources in the economy. The necessity of public financial resources to support the economies hit by the crisis has not been questioned, yet there is still no agreement on which forms of public financial support should be more appropriate. USA enacted the

“*Emergency Economic Stabilization Act*” right at the beginning of the financial crisis in 2008, supporting the US economy with an injection of \$700 billion mainly addressed to the re-purchase of distressed financial assets. The Eurozone announced in 2015 an expansionary monetary policy, the quantitative easing, to buy-back roughly €60 billion (€ 80 billion from 2016) per month of bonds from the central governments of the euro-area. In other countries, such Brazil, China but also Germany, public development banks have represented the government tool to transmit countercyclical policies and to direct financial resources towards investments, both private and public.

This chapter, using balance-sheet data of commercial banks operating in Brazil for the period 2002-2016, looks at the impact of the disbursement of BNDES on their financial disbursement. Further, following the new countercyclical role of the bank since 2009, this analysis will also split the analysis in two periods, to evaluate possible differences in the impact before and after the use of BNDES as a government tool to direct countercyclical financial resources.

The chapter is organized as follows: Section 2 presents the literature review on the relationship between public and private financial resources. Section 3 presents the econometric methodology followed by the presentation of the data used in the analysis in Section 4. Finally, Section 5 presents the results and the following Section 6 concludes the chapter.

2.2. Literature Review

The crucial role of finance in a country’s development process has been highlighted by Schumpeter in “*The Theory of Economic Development*” (1934), and remarked both in the National System of Innovation literature (Freeman 1987; Lundvall 1992; Lundvall 2010) and in the literature on economic development (Wade 1990; Chang 2002; Rodrik 2004). Whether public financial institutions play a positive or negative role in the economy is a long academic and political debate on the relationship between private and public financial institutions that has not yet arrived to a clear consensus (Tylecote 2007; Mazzucato and Penna 2014).

Academic literature has provided different theories and theoretical models to approach the debate on the relationship between government, public and private financial institutions. Shaw (1973) and McKinnon (1973) have been among the first authors to define the concept of financial repression; according to the authors, in both developing and developed countries, government interventions, regulations and public ownership of financial institutions have contributed throughout the years to hamper the development of competitive national financial systems by altering the capital allocation mechanism, therefore causing instability of prices and in the balance of payments. High reserve or liquidity ratios, capital controls, interest ceiling and public control of financial institutions are identified as the main determinants of financial repression.

Looking at the resources to be invested by financial institutions, McKinnon (1973) proposed the *complementarity hypothesis* based on the positive relationship between savings (investments) and real broad money balances, particularly in developing countries where domestic savings are equal to domestic financed investments because of banks' self-financing constraints. Shaw (1973), looking at countries with developed financial systems, proposed the *financial deepening hypothesis*. The development of a national financial system implies that money assets are not the only resource for investments anymore. Cash deposits can now also be used to increase the lending resources of financial intermediaries. Non-money assets can be accumulated and used to relax banks' constraints on cash availability and therefore altering the complementarity among savings and real money balances proposed by McKinnon. The positive relationship proposed by McKinnon will eventually turn into a negative relationship when the country will reach a higher degree of financial development, indicating the substitutability among financial and non-financial assets. Both authors, besides the different interpretation on the role of deposits, had in common the idea that higher interest rate increases deposits which in turn will lead to higher bank lending activity and that, particularly in developing countries, the interest rate has systematically been kept below the equilibrium level by governments, hampering the economic and financial development of the country.

Contrary to financial repression, academic literature has identified financial liberalization, specifically in terms of freely floating interest rate, as one of the most effective government measures to support economic development of the countries through the development of the national financial systems (Shaw 1973). Empirical evidence on the relationship between interest rate and savings is however mixed and in many studies on financial liberalization has been associated with a reduced saving rate (Gmech 2003). Further, recent financial liberalization together with deregulation policies in the global markets have also led to the worst economic crisis the globalized economy ever experienced, raising some questions on the long term sustainability of liberalized financial markets (Rezende 2015). Concerns on whether financial liberalization would have automatically led to economic development have however been raised well before the 2008 economic crisis hit the world economy, particularly about risks of instability and excessive levels of risk embedded in complex financial markets (Minsky 1992; Knight 2005; Rajan 2006).

It is possible to distinguish three phases of the empirical literature on financial repression. The first phase, following the McKinnon-Shaw hypothesis, focused on the impact of financial repression on investment and savings, particularly in developing countries. Academic interest then moved towards other possible impacts of financial repression, namely economic growth and poverty. More recently, and increasingly after the 2008 global financial crisis, empirical literature started looking at the adverse impact of financial liberalization, particularly when combined with deregulated economies.

Looking at the history, the scarcity of financial resources provided by the private sector requires an alternative source of credit (Mazzucato 2013a; Mazzucato 2013b), particularly in developing countries where this scarcity is more exacerbated (Barone and Spratt 2015). Further, for both developed and developing countries, this lack of financial resources is more severe for long-term and high risks investments for which private financial sector has been proven over the years, at best, underbudgeted (Minsky 1981; Haldane and Davies 2011). The patient finance needed to promote social and economic development has generally been offered by the public sector (de Aghion 1999; Mazzucato 2013a) and in recent scenarios of commercial banks' credit crunch the question is on whether the private financial sector can distribute adequate financial resources. Historically, development banks (also called State Investment Banks or more generically public banks) have been the main public actors in providing long-term and committed financial resources (Rodrik 2004; Mazzucato and Penna 2014; Torres and Zeidan 2016).

In both “*developmental*” (Gerschenkron 1962) and “*political*” (Shleifer and Vishny 1994) views of government participation in the economy, public ownership of financial institutions is considered as a means to promote government's goals, more efficient than providing financial resources through subsidies or influencing the direction of commercial banks' resources through regulations. However, in the theoretical neoclassical debate, public ownership of financial institutions is considered a determinant of countries' financial repression. This is mainly due to the lower-than-market interest rate applied to the loans, inefficiency, creation of distortions in the market for capital allocation (La Porta, Lopez-De-Silanes et al. 2002; World Bank 2012) and crowding-out both private financial institutions' (McKinnon 1973) and companies' financial resources (Aschauer 1989).

How monetary policy decisions are transmitted to the real economy is a topic that has not yet been fully explained (Bernanke and Gertler 1995). The role of commercial banks in the monetary policy transmission mechanism has been highlighted in the bank lending channel theory, postulating that a monetary policy shock affects not only the loan demand, as stated in the standard *money view* of monetary policy transmission, but also the loan supply through its impact on banks' reserves and consequently deposits. Also, the impact of a monetary policy shock is heterogeneous and differs according to the size of the bank. Empirical literature has so far tested the existence of a bank lending channel in different countries. Kashyap and Stein (1995; 2000) for US, Ehrmann Gambacorta et al. (2001) for the Euro area, Pruteanu-Podpiera (2007) for Czech Republic and, for Brazil, Takeda, Rocha et al. (2005) and Coelho, De Mello et al. (2010) are among the authors that have provided empirical evidence in support of the credit channel.

To understand the degree to which BNDES can have an impact on the credit market, this analysis will rely on the model widely used in the bank lending channel literature and adapt it to account for BNDES disbursement.

Empirical evidence has so far highlighted how public financial institutions may have a crowding-out impact on the bank lending channel only through increased public borrowing (Hauner 2009). To the best of my knowledge, there is no micro empirical evidence on the impact of BNDES disbursement on commercial banks' disbursement. The only empirical evidence on such topic has been produced by Arnold (2011) that performed a macro analysis finding "weak" crowding-out impact of BNDES disbursement on credit disbursed by private financial institutions.

2.3. Methodology

The econometric model departs from the specification firstly proposed by Bernanke and Blinder (1988) and further developed by Ehrmann, Gambacorta et al. (2001) and, for Brazil, by Takeda, Rocha et al. (2005). This model is adapted to the more recent stream of literature on loan supply reaction to monetary policy shocks using data on banks characteristics, such as size and capitalization, as introduced by Kashyap and Stein (1995). All these authors provided empirical evidence on the bank lending channel of the monetary transmission mechanism and analysed the reaction of commercial bank loans to monetary contractions.

Following the work of Ehrmann, Gambacorta et al. (2001) and Pruteanu-Podpiera (2007), I specify a preliminary model that describes the indicators likely to affect the growth rate of commercial banks' financing activity, outlined in first differences (Δ) due to non-stationarities, excluding banks' characteristics:

$$\Delta \ln L_{it} = \sum_{j=1}^m \alpha_j \Delta \ln L_{i(t-1)} + \sum_{j=1}^m \gamma_j \Delta \ln r_t + \sum_{j=1}^m \theta_j \Delta \ln y_{(t-1)} + \sum_{j=1}^m \varphi_j CPI_{(t-1)} + \varepsilon_{it} \quad (1)$$

Where $t=1, \dots, T$ is a given year and $i=1, \dots, N$ with N being the total number of banks and m is the number of lags. The growth rate of commercial banks' loans (L_{it}) in a given year is related to its lag; a monetary policy indicator r - either interest rate or reserve requirement ratio; two indicators of the economic activity: GDP (y) and the consumer price index (CPI). Differently than the authors previously mentioned, the monetary policy indicator, calculated as a 12-month average, enters in the equation with no lag. This decision is due to the shorter time lag necessary for decision of monetary policy to get to get transmitted to the real economy with the interest rate. The focus of this analysis will then move to equation (2) with the inclusion of bank characteristics³.

$$\Delta \ln L_{it} = \sum_{j=1}^m \alpha_j \Delta \ln L_{i(t-1)} + \sum_{j=1}^m \gamma_j \Delta r_t + \sum_{j=1}^m \theta_j \Delta \ln y_{(t-1)} + \sum_{j=1}^m \varphi_j CPI_{(t-1)} + \lambda_1 \Delta x_{it} + \varepsilon_{it} \quad (2)$$

Where x represents commercial banks characteristic; according to the literature, commercial banks characteristics that are likely to affect the amount of financing activity are related to the

³ This analysis not interested in the heterogeneity of commercial banks' responses, thus this model does not present any interaction of banks' characteristics with the monetary policy indicators.

size, liquidity of the financial institution. As in Takeda and Rocha (2005), Pruteanu-Podpiera (2007) among others, banks' characteristics are normalized with respect to the mean across all banks to avoid any possible trend as follows:

$$Size_{it} = \ln(Total Assets_{it}) - \frac{1}{N_t} \sum_i \ln(Total Assets_{it}) \quad (3)$$

$$Liquidity_{it} = \frac{Liquid Assets_{it}}{Total Assets_{it}} - \frac{1}{N_t} \sum_i \frac{Liquid Assets_{it}}{Total Assets_{it}} \quad (4)$$

Given the primary role played by BNDES in the last 20 years, this paper contributes to the literature by identifying to what extent this active participation of the Brazilian development bank contributed to foster or hinder the development of the commercial banks' system in Brazil. In detail, the focus of the analysis is on whether BNDES disbursement, addressed to foster the development of the Brazilian industrial sector, have stimulated additional financial resources from the private financial sector. This evidence would represent a scenario in which public resources, addressed to specific national goals such financing productive investments, create an additionality in the provision of loans, crowding-in the disbursement of commercial banks. Consequently, I add BNDES activity, measured in terms of annual disbursement, as an additional explanatory variable in Equations (1) and (2), that gives the following equations (5) and (6) :

Without banks' characteristics

$$\Delta \ln L_{it} = \sum_{j=1}^m \alpha_j \Delta \ln L_{i(t-1)} + \sum_{j=1}^m \gamma_j \Delta \ln r_t + \sum_{j=1}^m \zeta_j \Delta \ln BNDES_{(t-1)} + \sum_{j=1}^m \theta_j \Delta \ln y_{(t-1)} + \sum_{j=1}^m \varphi_j CPI_{(t-1)} + \varepsilon_{it} \quad (5)$$

With banks' characteristics

$$\Delta \ln L_{it} = \sum_{j=1}^m \alpha_j \Delta \ln L_{i(t-1)} + \sum_{j=1}^m \gamma_j \Delta \ln r_t + \sum_{j=1}^m \zeta_j \Delta \ln BNDES_{(t-1)} + \sum_{j=1}^m \theta_j \Delta \ln y_{(t-1)} + \sum_{j=1}^m \varphi_j CPI_{(t-1)} + \lambda_1 \Delta x_{it} + \varepsilon_{it} \quad (6)$$

As presented above, BNDES disbursement enters the equation with one lag to account for the time frame necessary for the financial resources to get first disbursed and further have an impact (if any) on commercial banks' disbursement. The signs of the coefficient (ζ) relative to BNDES disbursement will therefore give an indication on the relationship between commercial banks and BNDES activity. In detail, a positive (negative) and statistically significant coefficient would represent a situation a scenario in which public resources have “crowded-in” (“crowded-out”) additional demand for financial resources from the private financial sector. Alternatively, if commercial banks disbursement is not affected by the disbursement of BNDES, the coefficients will do not report any statistically significant impact. Thus, this analysis looks at the specific research question:

“Can a development bank be the government tool to transmit industrial policy decisions to the real economy without hampering the growth of the private financial sector by crowding-out its disbursement?”

The chapter then proceeds by splitting the sample in two periods, before and after the 2008 global financial crisis. The countercyclical role adopted by the development bank at the beginning of the global financial crisis should evidence a different impact of BNDES disbursement due to the new additional role of the bank. If the use of BNDES as an additional government tool to transmit countercyclical policy decisions has been successful, the results should observe a different impact of BNDES disbursement before and after the 2008 crisis. Therefore, this analysis will also try to answer this following research question:

“Can development banks disbursement be used as an additional government instrument to transmit countercyclical policy decisions to the real economy without crowding-out commercial banks’ disbursement?”

The results will shed light on the impact of public financial institutions used as additional government instrument for the development of the private national financial sector. Given the model presented in equation (5) and (6) with lagged BNDES disbursement variable, the second period of the analysis starts in 2010 due to the beginning of the new countercyclical role of BNDES in 2009.

Concluding, banks with no disbursement have been dropped from the sample together with banks above (below) the 98th (2nd) percentile for the distributions of loans that have been considered as outliers. The final sample accounts for 123 commercial banks operating in Brazil during the years of the analysis.

2.4. Data

Information on banks characteristics are obtained from the Estatística Bancária Mensal (Monthly Banking Statistics), which include information on the balance position of commercial banks and multiple banks with commercial portfolio⁴ in Brazil. The dataset includes information such as amount of total financing activity, total and liquid assets, amount of deposits, amount of reserves and other balance sheet’s indicators. For the purpose of this analysis, data on bank loans are only referred to the financing activity of the banks, defined by the Accounting Chart for Institutions of the National Financial System (COSIF)⁵ as:

⁴ The data are publicly available at <http://bit.ly/2pPseyI>

⁵ Available at <http://bit.ly/2wjPdVr>

“... operations carried out with specific destination, linked to the verification of the application of resources. Examples are the financing of industrial parks, machinery and equipment, durable consumer goods, rural and real estate.”

This analysis will therefore not include other types of credit operations carried out by commercial banks, such as loans for working capital, personal loans, advances to depositors and securities discount operations. This strategy is explained by the focus of this analysis for the market for financial resources for long-term investments due the higher impact of fixed capital investments for countries' economic growth.

Data on GDP, reserve requirement ratios and interest rates are obtained from BCB-DEPEC, whereas information on the inflation rate are produced by IBGE⁶ and calculated as the 12-months accumulated monthly variation of the IPCA, the Brazilian consumer price index. Finally, data on BNDES disbursement are publicly available in the BNDES website⁷. A detailed explanation about BNDES data is provided in the following Section 3.1.

2.4.1. Data on BNDES disbursement

The analysis looks specifically at two types of loans issued by BNDES: loans issued by FINAME, one of the three main subsidiaries of BNDES issuing loans for fixed capital acquisitions, and loans issued by the entire BNDES system targeted at investments in innovation, including those issued by FINAME⁸. The FINAME disbursement is selected to compare similar indicators for commercial banks' and BNDES' disbursement, given the nature of BNDES which does not issue personal loans or other financial services usually carried by commercial banks. Investments in innovation are instead selected because characterized by very high embedded risk which causes commercial banks to not supply the necessary amount of financial resources (Mazzucato 2013a; Mazzucato 2013b). At the same time, these investments are the main drivers of industries' long-term economic growth which in turn stimulates additional demand for financial resources.

The BNDES system comprises a variety of different financial products and associated financial instruments, with determined targets of investments or customers. Further, the innovation policies put in place by Brazil including different industrial sectors of the economic scenario, made possible for BNDES to have different and targeted products and instruments to financially support the companies. Table 2.1 shows the number of loans issued by BNDES listed by financial product.

⁶ All the variables are publicly available at <http://bit.ly/2wNwOVm>

⁷ Available at <http://bit.ly/2pPakMN>

⁸ The classification of loans for investment in innovation has been kindly provided by BNDES.

Table 2.1 – Number of loans for innovation by BNDES financial products

BNDES Loans for Innovation			
BNDES AUTOMÁTICO	561	BNDES LIMITE DE CRÉDITO	24
BNDES FINEM	480	FUNDOS	19
BNDES FINAME	120	DEBÊNTURES CONVERSÍVEIS	4
BNDES NÃO REEMBOLSÁVEL	117	OPERAÇÃO FINANCEIRA	3
BNDES FINAME AGRÍCOLA	59	OUTROS	2
RENTA VARIÁVEL	54	BNDES FINAME LEASING	1
Total		1,444	

Table 2.1 reports the number of different BNDES' financial products for innovation disbursed in the period 2002-2016.

As it is possible to notice from Table 2.1, BNDES mainly relies on four financial products to finance investments in innovation. The BNDES AUTOMÁTICO and FINEM, financing indirect and direct operations, represent the two main products used by BNDES, followed by the FINAME product, dedicated to fixed capital acquisitions and by the BNDES non-refundable disbursements. Table 2.2 shows the top 2 financial instruments associated to the main BNDES financial products⁹.

Table 2.2 – Number of loans for innovation by top 2 BNDES financial instruments associated to main financial products

Financial Product	Financial Instrument	
BNDES AUTOMÁTICO	Inovagro	443
	PSI - Inovação	76
BNDES FINEM	Bdes Prosoft	166
	PSI - Inovação	86
BNDES FINAME	PSI - BK - Tecnologia Nacional	90
	PSI - Inovação - BK Eficientes	27
BNDES NÃO REEMBOLSÁVEL	Funtec	109
	Fundo Amazônia	8
BNDES FINAME AGRÍCOLA	Inovagro	59

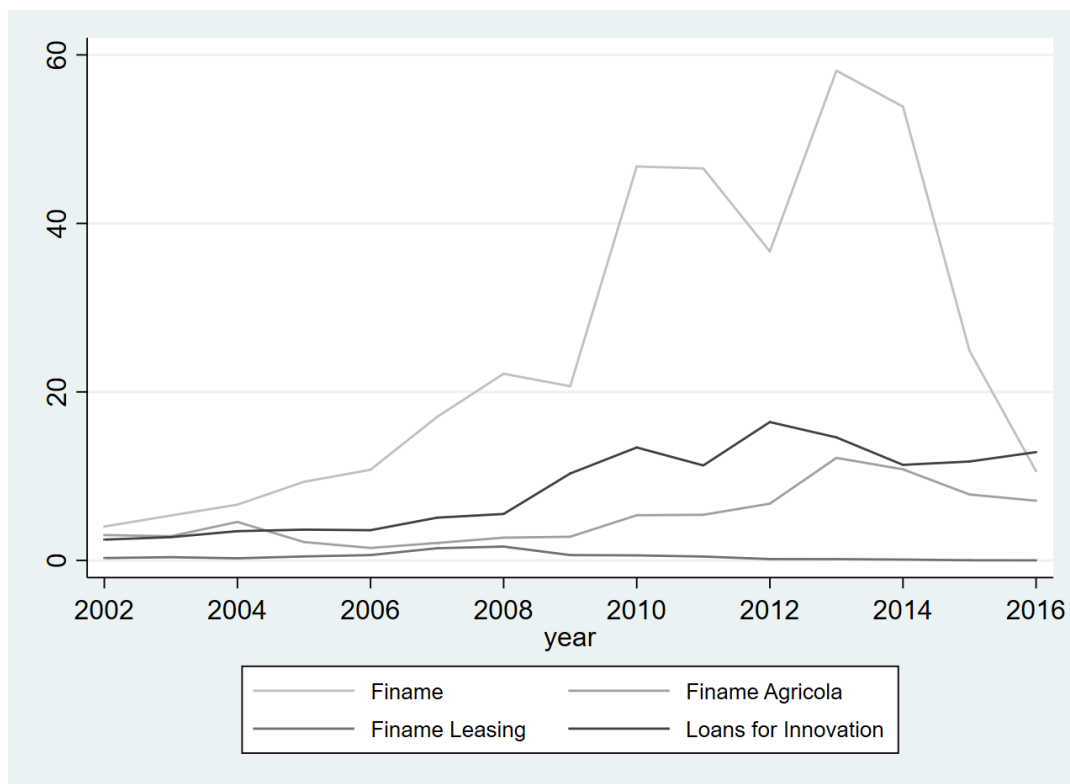
Table 2.2 reports the number of loans of the top 2 instruments associated to the main BNDES product for the year 2002-2016

As reported above, the variety of targeted products and instruments issued by BNDES allows the development bank to differentiate its disbursement throughout most of the Brazilian industrial scenario.

⁹ For the complete list of financial instruments by BNDES product, please refer to Table in the Appendix.

Regarding the disbursement of BNDES FINAME, it is composed by three main products: FINAME, FINAME AGRÍCOLA and FINAME LEASING. Figure 2.1 shows the overall disbursement of the FINAME by product together with the overall disbursement for investments in innovation.

Figure 2.1 –Disbursement in innovation and FINAME by product (r\$ Billion) – 2002-2016

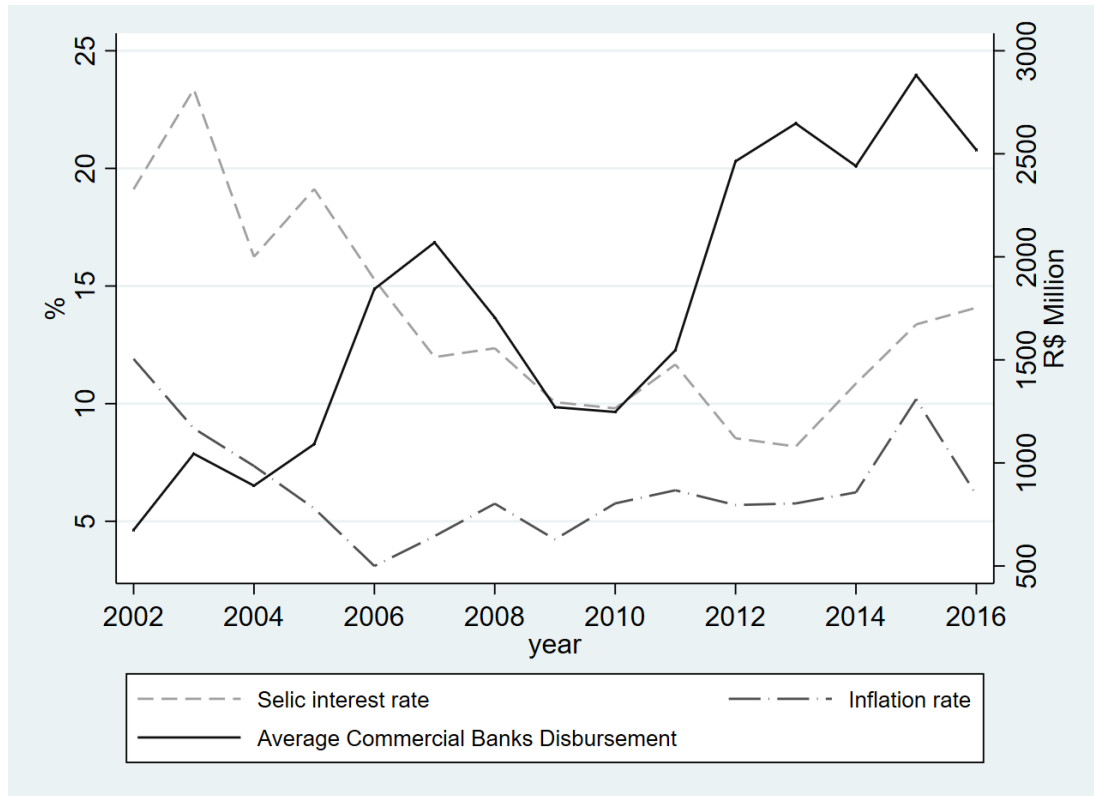


Source: Author's own elaboration

BNDES FINAME has by far the largest development, followed by the disbursement on innovation, which already includes the disbursement of FINAME for investments in innovation. It is therefore possible to notice how the amount of financial resources addressed towards innovation represent a very limited portion of BNDES disbursement. Finally, in the recent years BNDES disbursement consistently decreased due to the political instability and following changes in the economic targets of the new Brazilian administration. However, due to lagged variables used in the model explained in the following Section 4, data on 2016 will not be considered.

2.5. Results

After the financial turbulences during the 90s, characterized by high and volatile interest rate, the Selic interest rate had a constant decline until 2013, briefly interrupted at the beginning of the first Lula's administration in 2002. Figure 2.2 shows the evolution of the Selic interest rate together with the evolution of commercial banks' disbursement over the period 2002-2016.

Figure 2.2 – Selic interest rate and Commercial banks disbursement 2002-2016

Source: Author's own elaboration

As shown by Figure 2.2, commercial banks' disbursement dropped with the global financial crisis to then observe a modest growth between 2009 and 2011, and eventually increased in the following three years. In 2013, Brazilian private financial system experienced a second crisis with a one year drop in terms of disbursed financial resources.

Moving the focus on bank characteristics, Table 2.3 presents the main descriptive statistics for the commercial banks considered in this analysis by size quartile.

Table 2.3 – Main descriptive statistics of Brazilian commercial banks by quartile of size 2002-2016

	Quartile of Size				All Sample	Total
	0%-25%	25%-50%	50%-75%	75%-100%		
<i>Loans (R\$ million)</i>	68	561	1604	5266	1,852	227,796
<i>Total Assets (R\$ million)</i>	2080	12579	47445	530618	145,663	17,916,549
<i>Total Deposits (R\$ million)</i>	4.9	26.5	98.6	188.6	78.9	9,705
Number of banks	33	31	29	30	123	

Table 2.3 presents the main descriptive statistics of the Brazilian private financial sector by quartile of size for the years 2002-2016

Table 2.3 highlights the heterogeneity of commercial banks in the Brazilian private financial sector, with remarkable differences between large and small commercial banks in terms of size

and disbursement. Large commercial banks lend almost one-hundred times more than the smaller private banks and present a higher leverage with respect to both total assets and total deposits.

Focusing on the model, the inclusion of the lagged dependent variable as an explanatory variable requires the estimation of a dynamic panel data. This analysis implements the Generalized Method of Moments (hereinafter “GMM”) designed by Arellano and Bond (1991). This strategy removes individual effects by applying a first difference on the autoregressive model and it further instruments the dependent variable with its own lagged values. As in most of the empirical literature (Takeda, Rocha et al. 2005; Pruteanu-Podpiera 2007), all other variables are considered exogenous. However, in the robustness check section, the analysis will also be performed considering banks’ characteristics as endogenous, where the overall results do not change. GMM methodology is efficient in presence of large N and small T and in absence of serial correlation in ε_{it} , which is indicated by a significant negative first-order correlation. Further, in presence of small number of instruments, the validity of the set of instruments is tested by the Sargan test, or in case of a heteroscedasticity, by the Hansen test. Due to different specifications of the individual weighting matrix, the model estimates both one-step and two-steps estimates. According to Arellano and Bond (1991), the asymptotic standard errors of the two-steps estimator can be misleading even though they should be more efficient being based on the one-step residuals. This analysis will therefore present the one-step estimates as main results, including the two-steps results in the Table A2.11 in the Appendix. Due to the presence of a downward bias caused by weak instruments in the first-differenced estimator, the model has been estimated using a forward orthogonal transformation as suggested by Blundell and Bond (2000). This analysis observes 123 commercial banks for the period 2002-2016. Table 2.4 presents the results for the models in equations (5) and (6). Correlation coefficients are instead presented in Table A2.11 in the Appendix.

Table 2.4 – GMM One-step estimation results – All Sample with Selic interest rate

	(1)	(2)	(3)	(4)	(5)	(6)
<i>BNDES Innovation_{t-1}</i>	0.144* (0.076)	0.145** (0.068)	0.138* (0.074)			
<i>BNDES FINAME_{t-1}</i>				0.571** (0.275)	0.641*** (0.218)	0.548** (0.268)
<i>Loans growth rate_{t-1}</i>	0.806*** (0.081)	0.705*** (0.079)	0.791*** (0.078)	0.796*** (0.083)	0.710*** (0.081)	0.785*** (0.080)
<i>GDP growth rate_{t-1}</i>	-1.603 (1.015)	-1.647* (0.908)	-1.476 (0.986)	-3.295* (1.707)	-3.741*** (1.364)	-3.112* (1.650)
<i>Interest Rate (Selic)_t</i>	0.008 (0.021)	0.014 (0.018)	0.005 (0.021)	-0.006 (0.020)	-0.001 (0.018)	-0.008 (0.020)
<i>Inflation_{t-1}</i>	-0.046 (0.029)	-0.039 (0.025)	-0.045 (0.029)	-0.027 (0.028)	-0.019 (0.025)	-0.027 (0.028)
<i>Size_t</i>		0.592*** (0.054)			0.594*** (0.054)	
<i>Liquidity_t</i>			0.140** (0.064)			0.138** (0.065)
Observations	940	940	940	940	940	940
Number of groups	123	123	123	123	123	123
Sargan p-value	0.0834	0.133	0.0776	0.0588	0.171	0.0608
Hansen p-value	0.271	0.322	0.231	0.238	0.325	0.233
AR1	-5.132	-4.930	-5.119	-5.232	-5.078	-5.230
AR1 p-value	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.515	-0.416	0.423	0.480	-0.371	0.394
AR2 p-value	0.607	0.678	0.672	0.631	0.711	0.694
Number of Instruments	95	96	96	95	96	96

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.4 presents the results of the GMM one-step regressions with exogenous banks' characteristics. Columns (1), (2) and (3) refer to the model with the inclusion of BNDES loans directly aimed at innovation activities. Columns (4), (5) and (6) refer to the model with the inclusion of BNDES loans of the category FINAME.

All model specifications are consistent as indicated by the negative and significant coefficient relative to the first order correlation, AR1, ensuring the absence of serial correlation in ε_{it} and by the non-rejection of the Hansen test that confirms the validity of all set of instruments.

Results in column (1) and (4) are to be referred to the benchmark model in equation (5), the remaining show the results for the model presented in equation (6) with the two different bank characteristics. Regarding the main variables of interest, BNDES disbursement for investment in innovation and for fixed capital acquisition, the overall significance and positive sign indicate the presence of a crowding-in of BNDES disbursement on commercial banks' financial activity. These interesting results provide evidence of a scenario in which the disbursement of public

financial institutions did not harm the development of the private financial sector but, on contrary, it contributed to the growth of available financial resources in the economy.

Among the variables accounting for the demand side, GDP has a negative and significant coefficient in all specifications except two, whereas the inflation rate does not have any significant impact on commercial bank loans. The negative sign of the GDP coefficients can be explained by the increased interest of Brazilian banks for financial assets other than loans for investment following recent development and globalization of financial markets. Finally, the interest rate does not have any impact on the amount of loans disbursed by commercial banks. This quite surprising non-significance of the coefficient might however indicate a situation in which the Brazilian government have been unable to transmit decisions of monetary policy through changes in interest rate. Moving the focus to bank characteristics, as expected bigger and more liquid banks tend to lend more as it is shown by the positive and significant coefficients.

The analysis then moves by splitting the sample into two periods, before and after the 2008 economic crisis, to assess any possible difference in the impact of BNDES disbursement following the countercyclical role adopted by the bank in response to the global financial crisis. Table 2.5 presents the coefficients of both BNDES disbursement variables¹⁰. As explained in Section 4, due to the model specification in difference, the two periods have been divided in two subperiods, 2002-2009 and 2010-2016, to account for the disbursement of BNDES in 2009, considered as the beginning of Brazilian countercyclical policies.

Table 2.5 - GMM One-step estimation results – Two periods: Coefficients of Growth rate of BNDES Loans

<u>BNDES Loans for Innovation</u>			<u>BNDES FINAME</u>		
<u>Results</u>	<u>2002-2009</u>	<u>2010-2016</u>	<u>Results</u>	<u>2002-2009</u>	<u>2010-2016</u>
<i>(1)</i>	-0.005 (0.114)	0.262 (0.264)	<i>(4)</i>	-0.544 (0.774)	0.596* (0.346)
<i>(2)</i>	0.023 (0.098)	0.388** (0.191)	<i>(5)</i>	-0.287 (0.710)	0.720*** (0.275)
<i>(3)</i>	0.001 (0.112)	0.271 (0.260)	<i>(6)</i>	-0.555 (0.769)	0.610* (0.341)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.5 presents the coefficients of the main variables of interest (BNDES loans for innovation and loans from the FINAME product) for two-periods split sample.

As highlighted by Table 2.5, BNDES disbursement for investment in innovation does not have any impact if not in the second period, consistently with the main results in Table 2.4, when the

¹⁰ For the complete set of results with two periods, please refer to Table A3 in the Appendix

model controls for size of the bank. The impact of BNDES disbursement for fixed capital investments instead, while not significant in the period 2002-2008, is showing a positive and significant impact on commercial bank loans in the second period. This indication of crowding-in in the after-crisis is particularly interesting in the light of the countercyclical role adopted by BNDES during the economic crisis (Mazzucato and Penna 2014). According to the above results, the crowding-in impact of BNDES disbursement starts when the bank has been used as one of the tools of the government to transfer countercyclical policy decisions to the real economy. Before this role, BNDES disbursement had no impact on commercial banks' financial disbursement. As important conclusion, these findings do not show any evidence of *crowding-out* of BNDES activity on commercial banks' disbursement, even before the 2008 economic crisis when the disbursement of the Brazilian development bank did not have any impact in the supply of credit of private financial institutions.

2.5.1. *Robustness Checks*

The analysis will now present the coefficients of the lagged dependent variable compared to its coefficients in the OLS and Fixed Effect results. In the OLS regression, the lagged dependent variable is supposed to be upward biased due to the presence positive correlation with ε_{it} . On contrary, the coefficients of the Fixed Effect estimations, particularly in contexts of small N large T are likely to be downward affected by the Nickell bias (Nickell 1981) due to the negative sign on ε_{it-1} . Table 2.6 presents the coefficients of the lagged dependent variable compared to the OLS and Fixed Effects results to ensure the right calibration of the model¹¹.

Table 2.6 – Robustness check – Comparison coefficients Loans Growth Rate (Lagged)

Results	OLS	FE	GMM One-step	Results	OLS	FE	GMM One-step
(1)	0.876*** (0.023)	0.587*** (0.053)	0.806*** (0.081)	(4)	0.877*** (0.022)	0.588*** (0.053)	0.796*** (0.083)
(2)	0.739*** (0.035)	0.525*** (0.052)	0.705*** (0.079)	(5)	0.740*** (0.035)	0.528*** (0.051)	0.710*** (0.081)
(3)	0.875*** (0.023)	0.590*** (0.053)	0.791*** (0.078)	(6)	0.876*** (0.022)	0.591*** (0.053)	0.785*** (0.080)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.6 presents a comparison between the lagged loan growth rate coefficients of the OLS, FE and GMM one-step regressions. A correct specification of the model implies the GMM one-step coefficient to be between the OLS and FE estimated coefficients.

In all model specifications, the coefficients of the lagged dependent variable lie between the OLS and the fixed effect estimates, indicating a correct measurement of the GMM estimator.

¹¹ For the complete OLS results, please refer to Table A4 in the Appendix

In most of the empirical literature and in the model presented in this chapter, banks characteristics are considered exogenous to the model. As additional robustness check, as in Ehrmann Gambacorta et al. (2001), banks characteristics are considered endogenous and instrumented with their lagged values. Table 2.7 shows the GMM One-step results with banks characteristics considered as endogenous determinants of commercial banks' disbursement¹².

Table 2.7 – Robustness check – GMM One-step results with endogenous bank characteristics

	(7)	(8)	(9)	(10)	(11)	(12)
<i>BNDES Innovation_{t-1}</i>	0.144* (0.076)	0.129** (0.064)	0.135* (0.073)			
<i>BNDES FINAME_{t-1}</i>				0.571** (0.275)	0.590*** (0.204)	0.533** (0.266)
<i>Loans growth rate_{t-1}</i>	0.806*** (0.081)	0.537*** (0.071)	0.759*** (0.074)	0.796*** (0.083)	0.554*** (0.071)	0.753*** (0.075)
<i>GDP growth rate_{t-1}</i>	-1.603 (1.015)	-1.092 (0.889)	-1.357 (1.000)	-3.295* (1.707)	-3.109** (1.305)	-2.939* (1.646)
<i>Interest Rate (Selic)_t</i>	0.008 (0.021)	0.021 (0.018)	0.007 (0.021)	-0.006 (0.020)	0.007 (0.018)	-0.006 (0.020)
<i>Inflation_{t-1}</i>	-0.046 (0.029)	-0.034 (0.024)	-0.045 (0.029)	-0.027 (0.028)	-0.016 (0.025)	-0.027 (0.028)
<i>Size_t</i>		0.807*** (0.082)			0.824*** (0.084)	
<i>Liquidity_t</i>			0.092 (0.102)			0.092 (0.104)
Observations	940	940	940	940	940	940
Number of groups	123	123	123	123	123	123
Sargan p-value	0.0834	0.000	0.0223	0.0588	0.000	0.0172
Hansen p-value	0.271	0.652	0.729	0.238	0.677	0.691
AR1	-5.132	-4.126	-5.167	-5.232	-4.225	-5.269
AR1 p-value	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.515	-0.938	0.456	0.480	-0.837	0.427
AR2 p-value	0.607	0.348	0.648	0.631	0.403	0.670
Number of Instruments	95	133	133	95	133	133

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.7 presents the results of the GMM one-step regressions with endogenous banks' characteristics. Columns (7), (8) and (9) refer to the model with the inclusion of BNDES loans directly aimed at innovation activities. Columns (10), (11) and (12) refer to the model with the inclusion of BNDES loans of the category FINAME.

As shown by Table 2.7, the overall results do not change if not for the coefficients of liquidity that become insignificant once instrumented with its own lagged value. Looking at the main variables of interest, results are still consistent with the main model. BNDES disbursement from

¹² For the Two-steps results, please refer to Table A5 in the Appendix

the FINAME subsidiary is persistently positive and statistically significant, while BNDES disbursement for investments in innovation is significant only when the model controls for size.

The original model presented in Section 3 accounts only for past BNDES disbursement, not considering the contemporaneous financial resources disbursed by the public bank. In a scenario of perfect substitutability among the two financial resources, the amount of financial resources disbursed by public banks are resources that would otherwise be provided by the private financial sector. Consequently, an increase (decrease) in public financial resources has a detrimental (incremental) impact on the amount of private banks' disbursement. In this light, as previously highlighted in Section 3.1, the size of BNDES FINAME disbursement might represent a source of crowding-out of contemporaneous commercial banks resources. The following Table 2.8 presents the result of the model accounting for both contemporaneous and lagged disbursement.

Table 2.8 – Robustness check – GMM One-step results - Model accounting for contemporaneous BNDES disbursement

	(13)	(14)	(15)
<i>BNDES FINAME_t</i>	0.027 (0.153)	-0.126 (0.145)	0.019 (0.151)
<i>BNDES FINAME_{t-1}</i>	0.559** (0.277)	0.749*** (0.219)	0.543** (0.271)
<i>Loans growth rate_{t-1}</i>	0.812*** (0.083)	0.723*** (0.080)	0.800*** (0.080)
<i>GDP growth rate_{t-1}</i>	-3.351** (1.664)	-4.025*** (1.308)	-3.179** (1.610)
<i>Interest Rate (Selic)_t</i>	-0.005 (0.023)	-0.009 (0.020)	-0.007 (0.022)
<i>Inflation_{t-1}</i>	-0.027 (0.027)	-0.023 (0.025)	-0.027 (0.028)
<i>Size_t</i>		0.594*** (0.054)	
<i>Liquidity_t</i>			0.139** (0.064)
Observations	940	940	940
Number of groups	123	123	123
Sargan p-value	0.0441	0.124	0.0447
Hansen p-value	0.291	0.358	0.275
AR1	-5.181	-5.085	-5.178
AR1 p-value	0.000	0.000	0.000
AR2	0.486	-0.390	0.397
AR2 p-value	0.627	0.697	0.691
Number of Instruments	96	97	97

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.8 presents the results of the GMM one-step regressions with exogenous banks' characteristics, accounting for contemporaneous and past BNDES FINAME disbursement. Columns (13) refers to the model without banks' characteristics, Columns (14) and (15) refer to the model with the inclusion of, respectively, size and liquidity

The results show no relationship between BNDES disbursement and contemporaneous amount of loans disbursed by commercial banks. These findings also confirm the previous crowding-in indication of past BNDES disbursement on the financial activity of commercial banks.

Finally, as highlighted by Takeda, Rocha et al. (2005), in a context with undeveloped financial markets like the Brazilian economy, other tools such as the required reserve ratio can act as valid monetary policy instruments. The main advantage of using in the analysis reserve requirement rates over short-term interest rate is given by the fact that the coefficient of interest rate might capture the impact on the loan demand effect on the bank loans equation, problem that does not arise when considering reserve requirement rates. The following Table 2.9 proposes the GMM One-step results with reserve requirements on overall deposit, demand, time and saving deposits used as monetary policy instrument instead of the Selic interest rate¹³.

Table 2.9 – Robustness check – GMM Two-steps estimation results - Average requirement ratio as monetary policy indicator

	(16)	(17)	(18)	(19)	(20)	(21)
<i>BNDES Innovation_{t-1}</i>	0.181** (0.078)	0.150** (0.076)	0.172** (0.078)			
<i>BNDES FINAME_{t-1}</i>				0.642** (0.269)	0.671*** (0.218)	0.604** (0.262)
<i>Loans growth rate_{t-1}</i>	0.806*** (0.082)	0.706*** (0.080)	0.791*** (0.079)	0.803*** (0.083)	0.708*** (0.080)	0.791*** (0.080)
<i>GDP growth rate_{t-1}</i>	-2.143** (1.076)	-1.952* (1.026)	-1.941* (1.050)	-3.612** (1.587)	-3.892*** (1.294)	-3.315** (1.531)
<i>Reserve Requirement_t</i>	3.437 (3.838)	1.117 (3.686)	3.060 (3.851)	2.542 (3.471)	1.053 (3.271)	2.164 (3.460)
<i>Inflation_{t-1}</i>	-0.048** (0.022)	-0.029 (0.018)	-0.049** (0.022)	-0.040* (0.022)	-0.022 (0.018)	-0.041* (0.022)
<i>Size_t</i>		0.591*** (0.054)			0.594*** (0.054)	
<i>Liquidity_t</i>			0.138** (0.064)			0.137** (0.065)
Observations	940	940	940	940	940	940
Number of groups	123	123	123	123	123	123
Sargan p-value	0.0892	0.145	0.0819	0.0543	0.174	0.0554
Hansen p-value	0.353	0.271	0.297	0.235	0.305	0.231
AR1	-5.235	-5.018	-5.220	-5.376	-5.151	-5.370
AR1 p-value	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.512	-0.443	0.423	0.463	-0.379	0.382
AR2 p-value	0.608	0.658	0.672	0.643	0.704	0.702
Number of Instruments	95	96	96	95	96	96

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2.9 presents the results of the GMM one-step regressions with exogenous banks' characteristics and reserve requirement as monetary policy instrument instead of the Selic interest rate. Columns (16), (17) and (18) refer to the model with the inclusion of BNDES loans directly aimed at innovation activities. Columns (19), (20) and (21) refer to the model with the inclusion of BNDES loans of the category FINAME

¹³ For the two-steps results, please refer to Table A6

Results shown in Table 2.9 are consistent with all previous results shown in this chapter, with BNDES disbursement for both investment in innovation and fixed capital showing a crowding-in impact on commercial banks' resources.

2.6. Conclusions

The aim of this chapter has been to evaluate whether BNDES disbursement have contributed to the development of the Brazilian private financial sector or hampered it by crowding-out its disbursement. Results show that, while during the period 2002-2008, BNDES had no impact on commercial banks' disbursement, the countercyclical role assumed by BNDES at the beginning of the financial crisis in 2008 had a positive impact on the amount of financial resources disbursed by Brazilian private banks. Such positive evidence on the use of a development bank as an additional instrument for central governments to transmit policy decisions, should encourage additional research on this topic.

These findings shed light on the long debate about additionality/substitutability of private and public financial resources providing evidences of a virtuous interaction, in the short-term, between these two sources in a country with one of the most active development banks. To overcome the impossibility of this study in generalizing the findings for a longer timescale, further analysis may investigate the extent to which such virtuous interaction lasts in the long term.

In terms of policy recommendation, with the recent need of countercyclical policies to offset the economic and social downturns emerged since 2008, this chapter provides evidence on how development banks, or public banks in general, can be the tool of central government to transmit policy decisions to the real economy while directing the financial resources towards national targets defined by economic, industrial and social policies. The possibility of having both these roles, as government financial instrument and as a support for the achievement of national goals, can represent the value added of using development banks' financial resources instead of changes in interest rate when transmitting government decisions to the real economy. In such way, government can channel the additional resources to targets that otherwise would not be possible to reach using the traditional instruments, as the interest rate or the reserve requirement ratio. Finally, if the public financial resources succeed in stimulating additional demand, all scenarios of possible crowding-out of commercial banks' disbursement should disappear due to the increased demand for loans faced by private banks.

This chapter demonstrates that the implicit neoclassical assumption of public resources hampering the development of a national private financial system is not always straightforward. At least for the Brazilian case, the active role of BNDES after the 2008 financial crisis has generated an increase of financial resources from private banks, indicating a crowding-in impact.

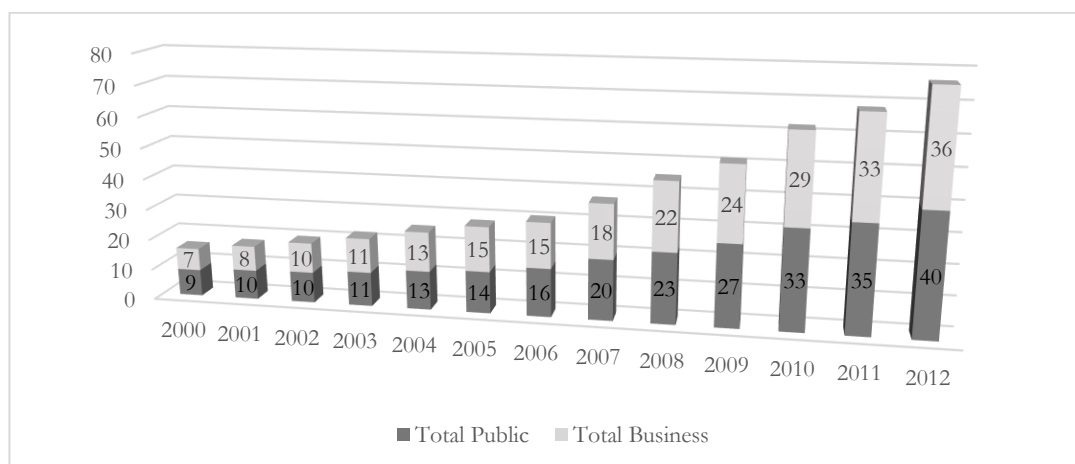
3. Fostering innovation activities of the national industrial system with the support of a development bank: incentivizing greater commitment or displacing financial resources?

I evaluate the impact of BNDES disbursements on companies' R&D intensity of companies operating in the Brazilian manufacturing sector for the period of 2003-2011. Using Instrumental Variable (IV) technique, I find a crowding-in impact of receiving funding from BNDES on business-funded innovation intensity, resulting in an increased commitment in innovation activities for funded Brazilian manufacturing companies. The findings of this analysis provide new evidence regarding the industrial sector activity of the Brazilian development bank, adding on the debate about additionality/substitutability of public financial resources.

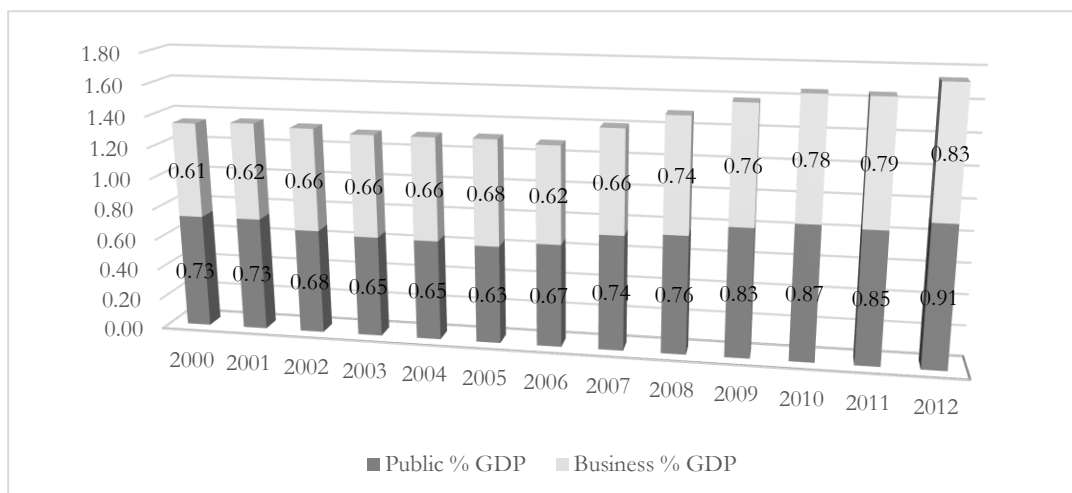
3.1. Introduction

This analysis evaluates the impact of BNDES disbursement on business-funded innovation expenditure for Brazilian manufacturing companies. If crowding-out effect occurs, companies' commitment in innovation activities will decrease after receiving public financial resources. Alternatively, in case of crowding-in effects, companies will increase their innovation activities due to the receipt of public funding. Figures 1 and 2, looking at to recent evolution of R&D expenditure, show that input additionality might have played an interesting role in Brazil.

Figure 3.1 - Evolution of S&T Expenditure (R&D plus correlated activities), by source (Current R\$ billion)



Source: MCTI

Figure 3.2 - S&T Expenditure (R&D plus correlated activities) as % GDP, by source

Source: MCTI

The recent trends of public and private expenditure for R&D seem to show a complementarity, or a crowding-in scenario, between the two different financial sources. In this context, the Brazilian Development Bank, BNDES, is one of the main actors fostering industrial innovation (Ferraz, Além et al. 2013).

3.2. Literature Review

3.2.1. The degree of complementarity or substitutability of public financial resources

The interest of academic literature on the complementarity/substitutability of public resources in the economy has contributed to a long debate that sees different schools of economic thought polarized in different positions.

In neoclassical economic theory, the role of the State is to fix market failures (Mazzucato 2013a). Any public intervention beyond this scope would cause a displacement of resources, raising prices and interest rates, therefore limiting the investments of the private sector (Sundararajan and Thakur 1980). However, this limited role of facilitator precludes the possibility for the State to accomplish the role of “*opportunity creator*” as depicted in Lazonick and Mazzucato (2013), a role that needs to be funded with adequate resources.

Aschauer (1989), found that higher public investments raises the national rate of capital accumulation above the equilibrium level chosen by private-sector agents, crowding-out private investments. The crowding-out occurs because individuals will decrease their savings and investments as a consequence of the disequilibrium in the national rate of capital accumulation, eventually leading to a new equilibrium level. At the same time, public investments with high

social return can raise the marginal productivity of private capital, crowding-in private investments. The crowding-in of companies' own resources ends when private marginal rates of return exceed the social rates of return, a situation in which direct public funding is more likely to cause an "*investment displacement*" (David, Hall et al. 2000).

When public funding takes the form of loans, crowding-out effect may also occur on the side of commercial banks, as discussed in Chapter 2. Particularly for loans in the most profitable sectors, the lower-than-market interest rate applied by public institutions hampers the development of a domestic financial market (McKinnon 1973). On the other side, liquidity constraints and high prudence in intermediating deposits do not allow commercial banks to finance long-term investments with high embedded risk (Rodrik 2004).

The interest on the impact of public R&D funding on companies' innovation engagement has been remarkable in the last decades with, however, most of the studies presenting a potential selection bias that might have affected the conclusions of the authors (David, Hall et al. 2000). More recent studies correct for this selection bias with different econometric methodologies. Aerts and Czarnitzki (2004), Aerts and Schmidt (2008), Almus and Czarnitzki (2003), Czarnitzki, Ebersberger et al. (2007), Duguet (2003), Gonzalez and Pazo (2008), Görg and Strobl (2007) correct for the selection bias with a non-parametric matching approach; Busom (2000), Hussinger (2008), De Negri, Lemos et al. (2006b) implemented a Heckman two-step selection model; Lach (2002) implemented a Difference-in-Difference estimator; finally, Wallsten (2000) used an IV approach to correct for endogeneity in his model.

The predominant question taken in exam by the aforementioned authors is whether public funding (generally subsidies) crowds-out companies' investments. Findings have been so far ambiguous: Busom (2000) finds positive impact of public funding on Spanish manufacturing companies' R&D activities, however she cannot exclude partial crowding-out for 30% for her sample. Czarnitzki and Fier (2002) do not find evidence of full crowding-out for the German Service industries. Lach (2002) reports positive effects for small Israeli manufacturing firms and no effect on large firms. Wallsten (2000) finds full crowding-out effect for the US program SBIR aimed at increasing R&D activities for small and medium companies.

Regarding Brazil, De Negri, Lemos et al. (2006a; 2006b) found positive impact on firm's own R&D disbursement for two government programs, one for technological development support and one for a university-enterprise research program. Lazzarini, Musacchio et al. (2011), using a subsample of companies traded on the stock exchange, find no impact of BNDES loans or equity investments on the performance of the companies and on their level of investment. Their findings on the decrease of financial expenditures have to be mainly attributed to the subsidy applied to the loan. Also, the authors do not find any evidence of BNDES selecting underperforming firms, therefore excluding any "*bailing-out*" role of the bank and, further, authors found that companies

donating political contributions to the winning candidates, in a scenario where both profitable and non-profitable companies donate to political parties, are more likely to receive funding from the Development Bank.

3.2.2. The role of the Public Sector and the need of financial resources

The importance of an industrial policy with an active public sector equipped with the necessary resources has been profoundly highlighted in the literature (Rodrik 2004; Lazonick and Mazzucato 2013; Mazzucato 2013a). Further, an industrial policy targeting innovation activities requires a large and constant flow of financial resources particularly if characterized by high risk, as investments in industrial innovation.

As Minsky (1981) wrote, the model in which banks were supposed to establish a long-term relationship based on trust and commitment with borrowers is no longer existing. The “*loan-officer desk*” model is now replaced by a new one, in which banks simply sell their loans as assets (to then resell them as financial instruments as in the recent home-mortgage securitization in U.S.) through the “*position making desk*” (Wray and Tymoigne 2008). Banks are now more focussed on short-term profits coming from financial markets rather than in long-term relationships based on trust, leaving the market for loans to an impersonal relationship between agents where customers are rated according to credit scores methods (Kregel 2008). Given the short-term focus of the commercial bank system (Haldane and Davies 2011) and given the higher profitability of the financial compared to the non-financial sector (Wray 2011; Kay 2012; Block 2014), governments have to find a more reliable source of finance, that does not only rely on the maximization of profits in the short run¹⁴ and able to supply a constant flow of credit.

The high uncertainty involved in innovation projects makes long-term finance the central tool to obtain resources for investments in innovation, bringing therefore the attention on what kind of financial institution is necessary to provide it. Public funding has always been present in different forms in all countries. In the United States, the leading role of public agencies as the Defence Advanced Research Projects Agency (DARPA), the Small Business Innovation Research (SBIR) and others in financing and creating a new space in the industrial environment has been highlighted in Mazzucato (2013a). Public finance institutions, with different targets and missions, exist in many developed and developing countries: Canada, Chile, South Africa and Finland, are countries in which public financial institutions have performed relatively well (Rudolph 2009);

¹⁴ In some economies, there is the further problem of ‘*financialization*’, spending profits on boosting stock prices, rather than on long-run areas like human capital and R&D. For example, an increasing problem in advanced economies, is the use of share buybacks (to boost stock options, hence executive pay) rather than reinvesting the profits in a long-term innovations (Lazonick and Mazzucato 2013)

Latin America, South Asia and Sub-Saharan Africa are the world regions characterized by a large presence of development banks (Levy-Yeyati, Micco et al. 2004). Finally, Mazzucato and Penna (2014) argue that development banks are indeed playing a greater role in innovation today than before, due to the way in which private financial institutions have become focused on short-term gains and following the increasing role of innovation in national missions.

3.2.2.1. The critiques on an active role of the Public Sector

Most of the critiques on a direct public intervention in the economy come from the *rent-seeking* literature for which politicians pursue in an active role in the economy to maximise their own personal utility (Shleifer and Vishny 1994) or are alternatively captured by interest groups into corruption (Ades and Tella 1997). As a consequence, politicians might bail out failing firms for particular political interests, or simply select firms with higher and closer political connections (Faccio 2006). The neoclassical remedy for these pathologies is the removal of trade barriers and a better institutional framework (Hausmann and Rodrik 2003). In some countries and particularly in Latin America, these orthodox remedies did not however produce the expected outcomes. Countries that largely adopted the policies proposed by the Washington Consensus have experienced a worsening of their economic situation (Lora 2012). Being widely understood that the adoption of these policies does not automatically produce economic development, the role of the State as coordinator of economic and industrial strategies is nowadays recognised by all different economics doctrines (Rodrik 2004).

Another accusation moved to an active participation of the State comes from the monetary policy literature, precisely about the neutrality of money. When the State puts financial resources into the economy either increases the inflationary pressure or, alternatively causes an increase of the interest rate to offset this inflationary pressure (Aschauer 1989).

3.3. Methodology

The effect of public spending on company's R&D investment depends on several factors, such as the elasticity of supply of private capital, the percentage of the investment funded by public resources and the degree of marginality of the loan. The degree of marginality is the most important factor in determining company's own R&D expenditure. Assuming increasing costs of capital and decreasing marginal returns to investment, a marginal loan is more likely to increase company's own R&D expenditure and commitment, while an inframarginal loan is more likely to increase total R&D expenditure while reducing company's R&D commitment. If the firm faces a perfectly elastic supply of private capital, this will cause the company to decrease its R&D expenditure by the amount of the loan, causing a dollar-for-dollar crowding-out of company's own commitment (Wallsten 2000).

My analysis will therefore try to evaluate whether BNDES commitment helped firms to go beyond their previous investment efforts, increasing their level of financial participation in R&D investments. In this study, I present the results for both the entire sample and companies reporting positive innovation expenditure, accounting for 72% of the total sample. Further, due to the focus of the research question on the impact of BNDES intervention in incentivizing a greater commitment in innovation activities, I only consider the impact of receiving financial resources at year t . It is reasonable to assume that receiving external financial resources should immediately relax companies' liquidity constraints, because decisions on the amount of resources to invest are primarily taken considering the current financial situation and the opportunity to extract profit from the investment. Hence, once received credit, companies will in turn decide whether to increase or decrease their financial commitment in innovation activities, incentivized by the industrial policies in place.

The study will provide an understanding on the importance of a public financial institution with a developmental mission in stimulating greater companies' commitment in innovation activities, particularly for developing countries where the private banking system contributes only marginally to high-risk investments as the ones in innovation (Mazzucato 2013a). Further, this study will examine the importance of development banks with defined targets and missions coming from a broader industrial agenda at national level, with the aim of creating an industrial environment with less perceived risk for the companies.

The analysis will first present the results of an OLS model on the impact of BNDES' loans on companies R&D intensity. Further, to correct for the potential selection bias of being selected by BNDES, my study will implement an instrumental variable approach.

3.3.1. The Model

This section describes the model implemented in my analysis. To show the importance of controlling for endogeneity, I firstly run an Ordinary Least Square regression with some measure of firm productivity on the BNDES loan received. I therefore estimate:

$$R\&D\ intensity_{it} = X'\delta_1 + BNDES_{it}\delta_2 + u_{it} \quad (1)$$

Where $R\&D\ intensity_t = \frac{Own\ Innovation\ Exp_{it}\ (R\$ \text{ Mill})}{Employment_{it}}$, $BNDES_t$ is a dummy variable taking value 1 for companies receiving loans from BNDES. By expressing the dependent variable as a ratio of number of employees, I focus primarily on the relative magnitude of financial resources devoted to innovation activities. The variable will therefore act as a proxy to indicate the level of participation of the company in innovation and whether BNDES stimulated a greater commitment. An alternative proxy to measure the level of companies' R&D intensity has often

been the ratio of companies' own expenditure in innovation activities over the turnover (De Negri, Lemos et al. 2006b; De Negri, Lemos et al. 2006a). However, the higher volatility of companies' turnover over the number of employees suggests this latter indicator as more appropriate to use in a proxy measuring the level of R&D intensity.

The assumption of the model is that, for coefficients $\delta_2 \neq 0$, the BNDES loan is disbursed for investments related, directly or indirectly, to industrial innovation. This assumption can be retained plausible due to the main mission of the Brazilian Development Bank targeted at industrial innovation. Hence, it is quite realistic to assume that the majority of loans disbursed by the bank are mainly targeted to projects related somehow to such activities.

The vector X' includes factors that influence companies' own R&D expenditure as receiving financial resources for innovation from other public and private sources, the age (in log), a measure of labour productivity expressed as the ratio of turnover on the number of employees, the export status, whether the company has a R&D department and performs continuous R&D activities.

In presence of endogeneity, OLS estimator will provide bias results, showing high correlation between receiving a loan from BNDES and the error term.

3.3.2. Instrumental Variable Approach

Section 3.3.2 introduces the instrumental variables used in this analysis to correct for endogeneity. The appropriate instruments must be correlated with the endogenous variable and uncorrelated with unobserved factors affecting the dependant variable. In other words, all instruments should affect the probability of receiving a loan from BNDES without having any direct impact on company's own commitment in innovation expenditure.

The instruments selected for my analysis are a measure of the “***Solvency Indicator***” of the company, expressed as the ratio between firm's running innovation expenses funded by borrowing and the firm's turnover (expressed in terms of net sales)¹⁵, ***its square*** and “***Receiving tax incentives***” for innovation activities in the last three years before the survey. The use of the degree of solvency of the company had already been proposed by De Negri, Lemos et al. (2006a; 2006b) that, looking at the impact of two different programs of another Brazilian innovation agency (FINEP), justified their choice of the exclusion restriction for their Heckman selection

¹⁵ The ratio has been calculated expressing the numerator in R\$ '000th and the denominator in R\$ million. The rescaling of the instrumental variable has been necessary due to the (expected) unproportionate size of net sales compared to the other indicator. Nevertheless, the validity and meaningfulness of the indicator is not affected by such transformation, simply requiring carefulness in the interpretation of the coefficients and in the calculation of the maximum (minimum) of the function.

model being solvency one of the criteria of the agency to grant funding. Same argument can be used for the purpose of this analysis and specifically in the case of BNDES, given the nature of loan of the financial instruments disbursed, which rely on the financial stability of the borrower to get repaid. Contemporaneously, having already received financial resources from other institutions can also act as a signal to BNDES by indicating those companies that already have been successfully screened and selected, hence to some extent, that are reliable. If this latter *signalling* effect dominates the former, the coefficient should report a positive sign and the inclusion of its squared term, whether negative and significant, should capture a likely non-linear relationship. Alternatively, whether the *financial stability* argument dominates the *signalling effect*, the degree of solvency indicator will report a negative and significant coefficient with a not-a-priori expected significance for the squared coefficient.

The use of tax incentives as instrument variable instead, and the idea that such instrument is not directly related to the dependent variable, is explained by the ex-post nature of this indirect source of finance; tax incentives are requested once the investment had already been funded by the company and decisions on how to spend the financial resources obtained from the tax incentives are made primarily by the companies that might direct those funds towards investments related or not to innovation. For similar reasons already used for the solvency indicator, being entitled of receiving tax credits might represent a signal suggesting BNDES that the company is already involved in innovation activities and has already successfully received financial resources from public institutions, although indirectly.

3.3.3. The Identification Strategy for the Linear Estimator

To control for endogeneity, I use a Generalized Method of Moments (GMM) estimator instrumenting for the endogenous variable. The choice of GMM over 2-Stage-Least-Square (2SLS) and Limited Maximum Likelihood Information (LIML) estimation method is due to the higher efficiency of this estimator under the standard 2SLS assumptions, *i.e.* strong instruments and exclusion restrictions. The process is modelled as follows: at *Stage 1* the company decides whether to apply to BNDES with a project to fund. At *Stage 2* the company knows whether it received the loan and alters its behaviour.

$$\textbf{Stage 1: } BNDES_{it} = \alpha_{it} + \beta X_{it} + \varphi_1(Solvency_{it}) + \varphi_2(Solvency_{it})^2 + \varphi_3(Tax\ Incentive_{it}) + \varepsilon_{it} \quad (2)$$

$$\textbf{Stage 2: } R\&D\ intensity_{it} = \gamma + \vartheta X_{it} + \xi \widehat{BNDES}_{it} + \omega_{it} \quad (3)$$

The set of covariates X_i includes factors that influence companies' own R&D expenditure as whether the company received any other financial resource for innovation from other public or private institutions, the age of the company (in log), the ratio of the turnover on the number of

employees as a measure of labour productivity, the export status, whether the company has a R&D department and performs continuous R&D activities.

3.4. Data

The main datasets used in my analysis are the Annual Industrial Survey (PIA), the Technological Innovation Survey (PINTEC) both from the *Brazilian Institute of Geography and Statistics (IBGE)*, and BNDES data on industrial disbursement covering the years 2003-2011.

PIA contains yearly data by sector of activity on output and expenditure of Brazilian manufacturing companies, of which I use data for the years 2003-2011. The three main groups of variables contained in the survey can be summarised as follow:

- Information about longitudinal relations across firms
- Balance sheet and income statement information
- Economic information beyond the balance sheet and income statement

Since 1996, the industrial survey changed its sampling method to include small and new firms together with a complete survey of companies with more than 30 workers. The survey contains two strata: a non-random sample of all medium-to-large companies with more than 30 workers and a random sample of small ($5 > \text{workers} < 29$) and medium companies. (Muendler 2003). Regarding sample selection, the *Brazilian Institute of Geography and Statistics IBGE*, uses a firm register based on the from the tax register office *CNPJ*, from the Ministry of Labour *RAIS* and other sources.

The technological Innovation Survey (PINTEC) provides information on technological innovation of the Brazilian manufacturing firms, following the European Community Innovation Survey (CIS). The survey has been conducted for the years 2003, 2005, 2008, 2011. It contains information on firms' innovative effort (expenditure for internal/external R&D, acquisition of R&D, whether R&D activities are occasional or recurrent, presence of R&D department, information about number and qualification of individuals working in R&D, etc.) and funding resources for innovation (public/private/own). Qualitative variables are collected for a period of three years: the survey year and the previous two years; quantitative variables are collected only for the year of the survey (Lustosa 2011). The sample is drawn from the list of enterprises with more than 10 employees registered and active on the Register of Enterprises *Cempre*.

Finally, BNDES data on industrial commitment contains information on the amount disbursed to the company, length of the disbursement, interest rate, date of disbursement, etc. The data are publicly available¹⁶, however BNDES' support has been extremely useful in compiling the dataset.

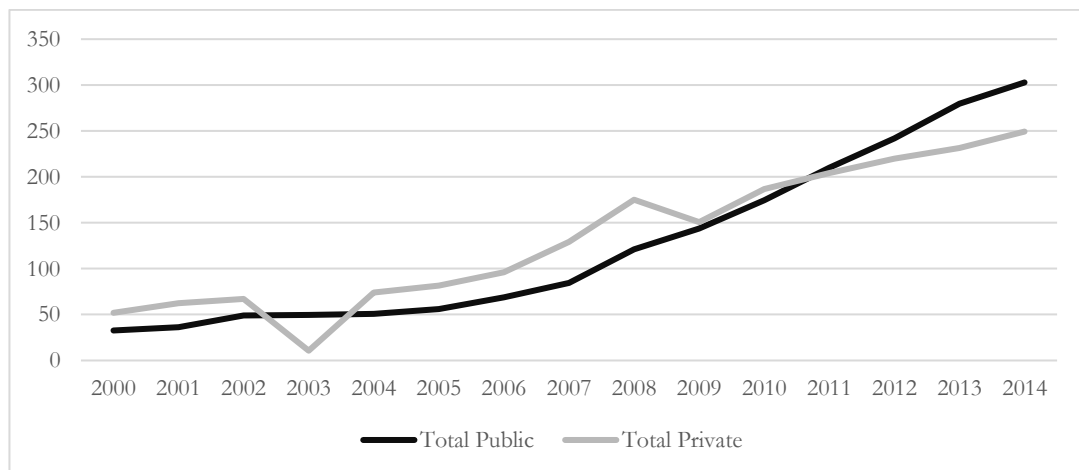
Merging all the datasets, it is possible to have a representative profile of the Brazilian manufacturing sector, knowing whether the firm is innovative, how much is spent on innovation and what are the sources, the output structure and the profitability of the firms.

3.4.1. The Brazilian public financial system in the economic crisis

Particularly in a financial crisis, the flow of financial resources is limited by the volatility of the markets and/or by liquidity constraints of commercial banks (Mazzucato 2013a; Mazzucato and Penna 2014).

Figure 3.3 shows that the Brazilian private financial system experienced two different crises. The first one in 2003 during the short Brazilian recession and the second in 2008 following the more recent financial crisis. These two crises have been however of different nature and length. The 2003 recession in Brazil was caused by the Argentinean bailout together with contractionary policies put in place by the newly established Lula administration, with increased interest rates and primary fiscal surplus targets (de Carvalho and de Souza 2011).

Figure 3.3 – Total Financial System Loans to Industry (current R\$ billion)



Source: Author's own elaboration based on data from BCB

While Brazilian private financial system recovered quickly from the first recession in 2003, the 2008 worldwide financial crisis hit the Brazilian private banks system with more long-lasting

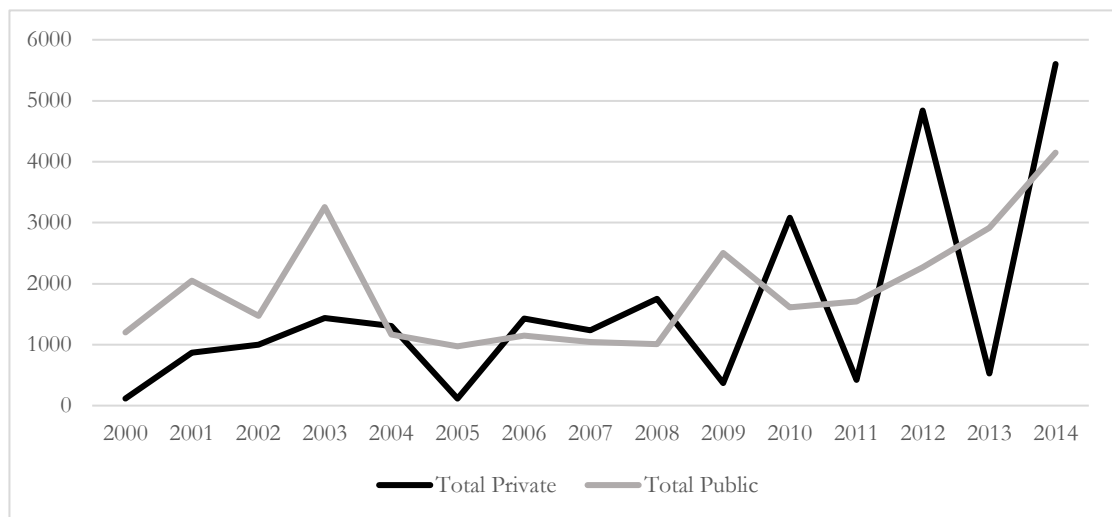
¹⁶ Dataset available at:

http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/BNDES_Transparente/Consulta_as_operacoes_do_BNDES/painel_consulta_diretas.html

effects. From Figure 3.3 it is possible to notice how commercial banks loans to industry recovered their pre-crisis level in one year, repositioning again above the level of public loans in 2004. The impact of the 2008 financial crisis on commercial banks loans to industry has been different. After the initial reduction in 2008, the amount of private banks loans to industry grew less than the amount of public loans and since 2011 the amount of public loans to industry exceeds the amount of private loans.

The 2008 financial crisis also had an impact on loans for industry targeted to the highest class of risk as depicted in Figure 3.4.

Figure 3.4 – Total Financial System Loans to Industry – Class Risk 2 (current R\$ million)



Source: Author's own elaboration based on data from BCB

Excluding the drop in 2005, the amount of loans of commercial banks to industry for high risk investments has been fairly constant. Since 2008, the amount of commercial bank loans for industry targeted at the highest class of risk shows a higher volatility compared to the amount of public loans. It is of particular interest to highlight also the countercyclical behaviour of public loans to industry in 2009, which practically offset the first reduction in the amount of private loans.

3.4.2. Indicator of company's increased commitment in innovative activities

I aim to investigate whether receiving a loan for investment from BNDES has any significant impact on company's level of R&D intensity, defined as companies' own innovation expenditure (in R\$ million) over the number of employees.

3.4.3. Data Limitations

As mentioned above, in the PINTEC, qualitative variables are collected for a period of three years: the survey year and the previous two years; quantitative variables are collected only for the year of the survey (Lustosa 2011).

Regarding BNDES data, I do not have any information about companies that applied for a loan and did not obtain it, nor do I have any information about ranking or classification of the projects made by BNDES in the decision process. Further, data on disbursement are not only for investment in innovation but they refer to all disbursed loans. It is however plausible, due to the main mission of BNDES targeted at industrial innovation, to assume that all disbursement is somehow broadly targeted at innovation activities.

Finally, I do not know from which other public institutions, if any, the company received additional funding for R&D investment for the year it also received BNDES funding.

3.5. Contribution to the literature

The results will contribute to the existing literature by shedding a light on the *crowding-in/crowding-out* debate on companies' level of R&D intensity caused by public financial resource. In addition, the results will add to the limited empirical evidence referred specifically to development banks and their role in providing financial resources to the industrial department. The overarching research question of this chapter is:

“Given the 2004 decision of the Brazilian government to focus on innovation in the industrial sector, what has been the contribution of the main public Brazilian financial institutions so far? Is BNDES relaxing firms’ constraints on R&D expenditure, incentivising a greater commitment or crowding-out companies’ resources?”

The research question will hence examine whether BNDES funding activity have incentivized private companies to increase their level of commitment in R&D activities. If so, this would determine a *crowding-in* scenario of BNDES resources denoting a beneficial impact of the Brazilian development bank in the light of the innovation-based industrial development proposed by the Brazilian industrial policies in the years of interest.

3.6. Results

3.6.1. Descriptive Analysis

This section presents the descriptive statistics for the companies present in this analysis. Table 3.1 reports the main companies' characteristics for the all sample and from companies reporting positive expenditure in innovation activities.

Table 3.1 - Main companies' characteristics by categories

	All Sample			Companies with positive Innovation Expenditure		
	BNDES			BNDES		
	No	Yes	Total	No	Yes	Total
<i>Number of Employees</i>	2044 (4230)	3488 (6242)	2555 (5080)	2336 (4750)	4019 (6943)	2960 (5722)
<i>Age</i>	28.2 (12.9)	27.9 (14.8)	28.1 (13.5)	28.3 (13.1)	28.8 (14.6)	28.5 (13.7)
<i>Export</i>	61.3%	59.3%	60.6%	67.1%	64.9%	66.3%
<i>Net Sales (R\$ Mil)</i>	1059 (6401)	1969 (8485)	1381 (7217)	1351 (7580)	2361 (9651)	1726 (8430)
<i>Total Expenditure in Innovation (R\$ Mil)</i>	21.2 (107.8)	52.8 (186.1)	32.4 (141.2)	30.0 (127.5)	69.4 (210.4)	44.6 (164.2)
<i>Private financial resources (R\$ Mil) for innovation</i>	0.65 (4.99)	1.37 (13.7)	0.91 (9.2)	0.92 (5.9)	1.80 (15.7)	1.25 (10.7)
<i>Public financial resources (R\$ Mil) for innovation</i>	2.25 (14.1)	10.9 (44.5)	5.34 (29.1)	3.18 (16.6)	14.4 (50.5)	7.35 (33.9)
<i>Own financial resources (R\$ Mil) for innovation</i>	18.3 (99.6)	40.5 (170.5)	26.1 (129.6)	25.9 (117.7)	53.1 (193.7)	36.0 (151.1)
<i>BNDES Disbursement (R\$ Mil)</i>	0.00	57.2 (205.1)	20.2 (124.8)	0.00	66.0 (230.1)	24.5 (143.7)
<i>R&D intensity (Own Expend R\$ Mil\Employees)</i>	0.44 (2.2)	1.21 (6.8)	0.71 (4.4)	0.62 (2.5)	1.59 (7.7)	0.98 (5.1)
<i>Continuous R&D</i>	46.4%	51.9%	48.3%	64.9%	66.8%	65.6%
<i>R&D Department</i>	54.7%	59.5%	56.4%	74.5%	74.5%	74.5%
<i>Tax Incentive</i>	20.7%	29.2%	23.7%	28.6%	36.0%	31.3%
N	1128	617	1745	797	470	1267

Source: Author's own calculation based on PIA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies. Standard deviations are reported in brackets

Table 3.1 shows that companies receiving a loan from BNDES have higher number of employees, higher turnover, spend more than double the money in innovation and are receiving more financial resources from both public and private financial institutions with respect to their counterparts. Further, they also report higher level of R&D intensity, are more likely to perform continuous R&D activities, to have a R&D department and to have benefitted from tax incentives in the past three years. This first evidence seems to support the accusation moved to development banks (Lazzarini and Musacchio 2011) and in general to all public sector, of selecting companies with the best performances following a *picking-winner* strategy. Regarding the different contribution to companies' overall expenditure in innovation, Table 3.2 reports the origin of the different financial resources spent by the companies. The results reported in Table 3.2 are for companies with positive innovation expenditure only.

Table 3.2 - Average Contribution to companies' total expenditure in innovation

	<u>Funded by BNDES</u>		<u>Total</u>
	<u>No</u>	<u>Yes</u>	
<i>Private Financial resources</i>	4.4%	3.7%	4.1%
<i>Public Financial resources</i>	12.0%	22.3%	15.8%
<i>Own Financial resources</i>	83.4%	73.9%	79.8%

Source: Author's own calculation based on PLA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

Looking at the ratio of innovation expenditure from different financial sources over the total amount spent by the company in innovation, funds from own financial resources represent by far the highest proportion of the overall expenditure for both companies funded and not funded by BNDES. Financial resources from public financial institutions represent the second source of funding for innovation activities, with companies funded by BNDES reporting almost double the contribution of these funds. Finally, the proportion of funds from private sources does not significantly vary among the funded and not funded companies, representing in both scenarios a very marginal contribution to the overall commitment in innovation. The scarce contribution of private banking sector to companies' investments in innovation raises concerns on whether private banking sector in Brazil represents an adequate source of finance for these peculiar types of investments, usually characterized by high embedded risk. The marginal contribution of private banking sector can have two explanations: either private banking sector is *crowded-out* by the public sector or it is too risk adverse. Even though it would be interesting to also investigate the relationship between commercial banks and public sector, being an interesting aspect of the crowding-in/out literature, this paper does not focus on the causes of this limited role of the private banking sector, but only on the crowding-in/out of companies' own resources. Such topic has already been analysed in the second chapter of my PhD thesis, where I find evidences of a

positive impact of BNDES disbursement on the amount of Brazilian private banks' disbursement for gross fixed capital investments. Further, results show that one of the major determinants of this crowding-in is to be attributed to the countercyclical role played by BNDES since the beginning of the global financial crisis. Looking at the size of the companies, the following Table 3.3 presents the main companies' characteristics by size and category BNDES funded.

Table 3.3 - Companies with Positive Innovation Expenditure by Size and Category BNDES funded

BNDES Funded	Size					
	Small		Medium		Large	
	No	Yes	No	Yes	No	Yes
<i>Number of Employees</i>	64.9	69.1	294	314	3099	4727
<i>Age</i>	20.9	13.3	25.3	21.6	29.7	30.4
<i>Net Sales (R\$ Mil)</i>	35.64	24.41	168.2	194.8	1793	2775
<i>Total Expenditure in Innovation (R\$ Mil)</i>	2.92	1.88	8.53	18.4	38.3	79.4
<i>Private financial resources (R\$ Mil) for innovation</i>	0.06	0.04	0.17	0.21	1.20	2.1
<i>Public financial resources (R\$ Mil) for innovation</i>	0.89	0.35	1.47	11.20	3.84	15.3
<i>Own financial resources (R\$ Mil) for innovation</i>	1.98	1.49	6.88	7.01	33.15	62.0
<i>Private Innov Expend (% Total Innov Expend)</i>	2.2%	5.0%	4.1%	3.2%	4.6%	3.7%
<i>Public Innov Expend (% Total Innov Expend)</i>	19.3%	15.7%	9.6%	30.1%	12.3%	21.2%
<i>Own Innov Expend (% Total Innov Expend)</i>	78.5%	79.3%	85.9%	66.8%	82.8%	75.0%
N	33	8	181	67	583	395

Source: Author's own calculation based on PIA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

While BNDES seems to select more efficient medium and large companies, the opposite happens for the small samples. Small companies funded by BNDES have a lower volume of sales, spend less in innovation (overall and own resources) and receive less funds from public and private sources. This evidence can be explained in two different ways: either due to the inability of BNDES in targeting the best small companies or due to the willingness to provide financial resources to support a *catching-up* of underperforming companies.

Another important source of companies' heterogeneity in Brazil is due to significant regional disparities among different macro areas. To support the inclusion of regional fixed effect in the model as presented in Section 5, Table 3.4 presents an overview of the Brazilian geographical differences among macro regions.

Table 3.4 - Main companies' characteristics by Region

	Macro Regions				
	Mid-West	North	North East	South	South East
<i>Number of Employees</i>	1256	1754	4046	2483	3155
<i>Net Sales</i>	395.5	1140.5	1075.2	741.5	2386
<i>Age</i>	18	20	26	28	30
<i>Average BNDES disbursement (R\$ Mil)</i>	15.97	10.77	21.36	6.37	34.94
<i>Innov Expend from Private Banking (R\$ Mil)</i>	1.34	3.06	0.97	1.65	1.53
<i>Innov Expend from Public Banking (R\$ Mil)</i>	4.17	4.64	12.11	4.05	8.59
<i>Innov Expend from Own Resources (R\$ Mil)</i>	13.70	26.71	13.79	10.31	53.32
<i>Private Innov Expend\Total Innov Expend (%)</i>	7.0%	8.9%	3.6%	10.3%	2.4%
<i>Public Innov Expend\Total Innov Expend (%)</i>	21.7%	13.5%	45.1%	25.3%	13.5%
<i>Own Innov Expend\Total Innov Expend (%)</i>	71.3%	77.6%	51.3%	64.4%	84.0%
<i>Receiving BNDES Loan</i>	6	5	21	59	147
N	27	22	101	379	738

Source: Author's own calculation based on PLA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

Differences in companies' characteristics across macro-areas in Brazil are quite significant as evidenced by Table 3.4. One of the main causes of this disparities goes back to the end of World War II, when the Brazilian government decided to concentrate most of the industrial incentives in Rio de Janeiro and São Paulo, exacerbating the already existing regional disparities (Enders 1980). Nowadays, despite government intervention to reduce regional disparities, industrial disparities still persist. Companies in the Southeast Region report by far a relatively higher volume of sales, higher level of investments in innovation and higher commitment of own resources in innovation activities.

3.6.2. Regression Analysis

This section begins by presenting results from the OLS model in Table 3.5, focusing on the impact of the main variable of interest, BNDES disbursement, on companies' R&D intensity. The analysis will then follow by presenting the results of the second stage of the IV regressions using the GMM estimator in Table 3.6¹⁷. Table 3.5 present the results for the OLS regressions from the model specification with no fixed effects to the inclusion of year, macro-region and sector CNAE 2.0 fixed effects. Due to the endogeneity of the treatment variable, *i.e.* the receipt of a loan from BNDES, which violates the prerequisite of non-randomness of the OLS models, the results presented in Table 3.5 are supposed to be biased. The direction of this bias can be of either direction, depending on the correlation between the treatment variable and the error term.

¹⁷ For the second stage results of the model including each single instrument, please refer to Table A3.10 in the Appendix

Table 3.5 - Regressions Results OLS

	<u>All Sample</u>						<u>Companies with positive innovation expenditure</u>					
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)	OLS (7)	OLS (8)	OLS (9)	OLS (10)	OLS (11)	OLS (12)
<i>BNDES</i>	<i>0.786*</i> (0.438)	<i>0.752*</i> (0.416)	<i>0.706*</i> (0.403)	<i>0.676**</i> (0.275)	<i>0.697**</i> (0.287)	<i>0.638**</i> (0.271)	<i>1.073*</i> (0.585)	<i>1.024*</i> (0.553)	<i>0.916</i> (0.538)	<i>0.944**</i> (0.379)	<i>0.924**</i> (0.390)	<i>0.855**</i> (0.373)
<i>Age (log)</i>	0.318** (0.117)	0.306*** (0.105)	0.290*** (0.088)	0.254** (0.106)	0.241** (0.098)	0.233** (0.105)	0.421*** (0.140)	0.391*** (0.114)	0.393*** (0.097)	0.312** (0.138)	0.328** (0.134)	0.293** (0.138)
<i>Continuous R&D</i>	0.301 (0.490)	0.273 (0.487)	0.316 (0.478)	0.179 (0.460)	0.278 (0.437)	0.226 (0.439)	0.007 (0.561)	-0.006 (0.561)	0.037 (0.572)	-0.132 (0.547)	-0.076 (0.535)	-0.101 (0.536)
<i>Export</i>	0.109 (0.112)	0.188*** (0.065)	0.215** (0.079)	0.136 (0.113)	-0.021 (0.226)	0.143 (0.115)	0.129 (0.186)	0.276** (0.106)	0.289** (0.126)	0.209 (0.154)	-0.036 (0.328)	0.202 (0.156)
<i>R&D Department</i>	1.019** (0.371)	1.061** (0.403)	1.022** (0.373)	1.105*** (0.426)	1.036*** (0.368)	1.084*** (0.388)	1.240** (0.503)	1.273** (0.545)	1.212** (0.517)	1.326** (0.549)	1.263*** (0.471)	1.298*** (0.498)
<i>Private funds</i>	-0.463*** (0.167)	-0.456*** (0.161)	-0.393** (0.147)	-0.403** (0.174)	-0.380** (0.173)	-0.338** (0.165)	-0.500*** (0.167)	-0.487*** (0.157)	-0.416*** (0.146)	-0.434** (0.182)	-0.410** (0.184)	-0.355** (0.173)
<i>Public funds</i>	-0.364 (0.351)	-0.373 (0.358)	-0.305 (0.351)	-0.423 (0.290)	-0.306 (0.275)	-0.353 (0.285)	-0.493 (0.406)	-0.497 (0.414)	-0.411 (0.405)	-0.567* (0.327)	-0.434 (0.304)	-0.481 (0.319)
<i>Labour Productivity</i>	0.103** (0.048)	0.088 (0.056)	0.066 (0.049)	0.028 (0.063)	0.036 (0.059)	0.015 (0.063)	0.199*** (0.062)	0.181** (0.074)	0.134* (0.067)	0.107 (0.093)	0.085 (0.090)	0.070 (0.092)
<i>Constant</i>	-1.275*** (0.411)	-1.427** (0.539)	-1.518** (0.590)	-1.808** (0.732)	-1.238*** (0.471)	-1.961** (0.800)	-1.633*** (0.443)	-1.848*** (0.619)	-2.040*** (0.679)	-2.276** (0.939)	-1.822*** (0.679)	-2.681** (1.078)
Observations	1,742	1,742	1,742	1,742	1,742	1,742	1,265	1,265	1,265	1,265	1,265	1,265
Year Fixed Effects		Yes	Yes	Yes		Yes		Yes	Yes	Yes	Yes	Yes
Region Fixed Effects			Yes		Yes	Yes			Yes		Yes	Yes
Sector Fixed Effects				Yes	Yes	Yes				Yes		Yes
R-squared	0.032	0.032	0.039	0.048	0.050	0.053	0.028	0.029	0.037	0.047	0.051	0.054

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's own calculation based on PIA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

Table 3.6 - Regressions Results Second Stage IV – GMM

	All Sample						Companies with positive innovation expenditure					
	GMM (13)	GMM (14)	GMM (15)	GMM (16) ¹⁸	GMM (17) ¹⁸	GMM (18) ¹⁸	GMM (19)	GMM (20)	GMM (21)	GMM (22)	GMM (23)	GMM (24)
<i>BNDES</i>	<i>2.116*</i> (1.238)	<i>2.343*</i> (1.352)	<i>2.294*</i> (1.270)	<i>2.032*</i> (1.109)	<i>2.318*</i> (1.249)	<i>2.272**</i> (1.119)	<i>2.270*</i> (1.262)	<i>2.438*</i> (1.385)	<i>2.523**</i> (1.253)	<i>2.202*</i> (1.164)	<i>3.014**</i> (1.535)	<i>2.883**</i> (1.306)
<i>Age (log)</i>	0.343*** (0.125)	0.340*** (0.131)	0.309*** (0.117)	0.311** (0.123)	0.306*** (0.114)	0.310** (0.122)	0.405*** (0.131)	0.390*** (0.123)	0.375*** (0.110)	0.367** (0.144)	0.377*** (0.133)	0.378*** (0.143)
<i>Continuous R&D</i>	0.740** (0.372)	0.719* (0.378)	0.647* (0.364)	0.632* (0.341)	0.562 (0.356)	0.518 (0.356)	0.537 (0.418)	0.492 (0.425)	0.336 (0.417)	0.327 (0.410)	0.036 (0.479)	0.043 (0.467)
<i>Export</i>	0.075 (0.118)	0.084 (0.071)	0.111 (0.082)	0.056 (0.128)	0.001 (0.213)	0.081 (0.127)	0.030 (0.183)	0.081 (0.139)	0.069 (0.144)	0.058 (0.185)	-0.004 (0.297)	0.030 (0.184)
<i>R&D Department</i>	0.610** (0.258)	0.563** (0.277)	0.648** (0.259)	0.620** (0.313)	0.734** (0.312)	0.767** (0.325)	0.779** (0.391)	0.720* (0.418)	0.882** (0.393)	0.820** (0.407)	1.102*** (0.426)	1.104** (0.441)
<i>Private funds</i>	-0.277 (0.182)	-0.264 (0.178)	-0.229 (0.166)	-0.266 (0.185)	-0.260 (0.184)	-0.240 (0.177)	-0.324* (0.191)	-0.318* (0.190)	-0.271 (0.175)	-0.306 (0.201)	-0.296 (0.196)	-0.265 (0.189)
<i>Public funds</i>	-0.761* (0.420)	-0.749* (0.431)	-0.671 (0.441)	-0.857** (0.376)	-0.797** (0.392)	-0.811** (0.381)	-0.859* (0.442)	-0.798* (0.463)	-0.699 (0.459)	-0.968** (0.402)	-0.970** (0.437)	-0.976** (0.421)
<i>Labour Productivity</i>	0.057 (0.059)	0.082 (0.077)	0.062 (0.065)	0.024 (0.069)	0.022 (0.061)	0.017 (0.065)	0.184** (0.073)	0.225** (0.088)	0.187** (0.080)	0.122 (0.097)	0.113 (0.092)	0.116 (0.095)
<i>Constant</i>	-1.719** (0.690)	-1.592** (0.639)	-1.709*** (0.650)				-1.913*** (0.637)	-1.773*** (0.617)	-2.144*** (0.613)	-2.395** (0.980)	-2.998*** (1.152)	-3.270*** (1.218)
Observations	1,742	1,742	1,742	1,742	1,742	1,742	1,265	1,265	1,265	1,265	1,265	1,265
Year Fixed Effects		Yes	Yes	Yes		Yes		Yes	Yes	Yes		Yes
Region Fixed Effects			Yes		Yes	Yes			Yes		Yes	Yes
Sector Fixed Effects				Yes	Yes	Yes				Yes	Yes	Yes
R-squared	0.010	0.002	0.006	0.025	0.018	0.022	0.015	0.010	0.011	0.031	0.014	0.021

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

*Source: Author's own calculation based on PLA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies*¹⁸ The inclusion of sector fixed effects for the all sample requires the partialling-out of one CNAE2.0 sector (CNAE2.0=58), hence the drop of the constant in columns (16), (17) and (18).

Table 3.6 reports the results of the Second-Stage regressions for both samples, starting from the base model with no fixed effects up to the inclusion of annual, macro-regional and sectoral fixed effects. The main variable of interest associated to the BNDES disbursement reports positive and statistically significant coefficients across all different model specifications for both samples. These results indicate an increase of companies' R&D intensity following the receipt of a loan from BNDES, hence denoting a *crowding-in* impact of BNDES loans on companies' own financial resources for innovation. This *additionality* of BNDES resources on companies' R&D intensity represents the main finding of this chapter and the consistency of the signs and magnitude of the coefficients throughout all model specifications indicates a correct model identification strategy. The source of this increased companies' commitment in R&D activities is likely to be generated by the increased marginal productivity of private capital as a consequence of the intervention of BNDES in projects with possibly high returns, which encourage private companies' in spending additional resources for R&D activities.

Among the control variables, age (in log) and R&D department have positive and statistically significant coefficients in all specifications. On contrary, receiving financial resources for innovation activities from other public institutions has a *crowding-out* impact on companies' level of R&D intensity. This interesting result, highlighting the different impact of receiving funds from BNDES and other public institutions, indicates that even financial resources coming from the same source (public institutions in general) can generate heterogeneous outcomes. One possible explanation can be due to the nature of loans of the financial instruments disbursed by BNDES that, compared to other indirect forms of funding disbursed by public institutions as subsidies, induce entrepreneurs to dedicate more financial resources to innovation activities. Another interesting finding is the non-significant impact of receiving financial resources from private financial institutions. The limited financial contribution of these private institutions, also presented earlier in Table 3.2, can be one of the explanations of this non-perceived impact of private financial resources on companies' level of R&D commitment. Finally, performing continuous R&D, exporting and increases in labour productivity do not have any statistically significant impact on companies' R&D intensity.

3.6.3. First Stage Results and Robustness checks

This section will present the first stage regressions of the model. The following Table 3.7 presents the results for all estimation strategies presented in Table 3.6¹⁹. To consider the instruments valid, the coefficients should be statistically significant in the First-stage. A different scenario would

¹⁹ For the first stage results of the model including each single instrument, please refer to Table A2 in the Appendix

shed doubts on the validity of the model, because it would denote an absence of impact of the instruments on the probability of receiving funding from BNDES, hence not correcting for the endogeneity in the model. Following Table 3.7, this Section presents the First-stage summary statistics by reporting the results for the under-identification test (Kleibergen-Paap rk LM), overidentification test (Hansen-J), weak instrument test (Anderson-Rubin Wald) and orthogonality tests (Hansen-J and C-statistic) for all the instrumental variables.

Table 3.7 - First Stage Results

	<u>All Sample</u>						<u>Companies with positive innovation expenditure</u>					
	GMM (25)	GMM (26)	GMM (27)	GMM (28) ¹⁸	GMM (29) ¹⁸	GMM (30) ¹⁸	GMM (31)	GMM (32)	GMM (33)	GMM (34)	GMM (35)	GMM (36)
Solvency	0.699** (0.307)	0.783** (0.325)	0.757** (0.337)	0.790*** (0.284)	0.704** (0.274)	0.765*** (0.284)	0.692** (0.304)	0.789** (0.327)	0.722** (0.329)	0.823*** (0.283)	0.696*** (0.269)	0.762*** (0.279)
Solvency²	-0.227 (0.156)	-0.267 (0.165)	-0.258 (0.178)	-0.277* (0.143)	-0.245* (0.140)	-0.266* (0.144)	-0.210 (0.155)	-0.254 (0.166)	-0.225 (0.174)	-0.283** (0.143)	-0.236* (0.139)	-0.255* (0.143)
Tax Incentive	0.083** (0.040)	0.056* (0.034)	0.057* (0.033)	0.075** (0.033)	0.106*** (0.033)	0.078** (0.033)	0.067 (0.044)	0.037 (0.038)	0.037 (0.039)	0.061* (0.035)	0.094*** (0.034)	0.065* (0.035)
Age (log)	-0.024 (0.017)	-0.036** (0.018)	-0.037** (0.019)	-0.040** (0.019)	-0.036* (0.019)	-0.041** (0.019)	0.002 (0.019)	-0.016 (0.022)	-0.016 (0.021)	-0.024 (0.022)	-0.011 (0.023)	-0.023 (0.022)
Continuous R&D	0.009 (0.054)	0.014 (0.051)	0.020 (0.051)	0.005 (0.043)	0.001 (0.044)	0.011 (0.043)	0.037 (0.063)	0.040 (0.061)	0.052 (0.058)	0.026 (0.046)	0.037 (0.048)	0.041 (0.046)
Export	-0.014 (0.024)	0.045* (0.027)	0.050* (0.027)	0.040 (0.032)	0.006 (0.025)	0.045 (0.032)	-0.003 (0.030)	0.084** (0.038)	0.086** (0.038)	0.086** (0.042)	0.019 (0.030)	0.089** (0.042)
R&D Department	-0.018 (0.063)	-0.011 (0.060)	-0.014 (0.060)	0.010 (0.044)	0.011 (0.045)	0.009 (0.044)	-0.046 (0.083)	-0.028 (0.080)	-0.035 (0.080)	-0.003 (0.052)	-0.016 (0.052)	-0.006 (0.051)
Private funds	-0.042 (0.051)	-0.035 (0.046)	-0.031 (0.045)	-0.038 (0.041)	-0.046 (0.042)	-0.034 (0.041)	-0.042 (0.049)	-0.033 (0.045)	-0.026 (0.043)	-0.040 (0.041)	-0.045 (0.042)	-0.032 (0.041)
Public funds	0.161*** (0.046)	0.152*** (0.046)	0.158*** (0.046)	0.143*** (0.030)	0.163*** (0.030)	0.150*** (0.030)	0.168*** (0.051)	0.161*** (0.051)	0.173*** (0.052)	0.154*** (0.031)	0.176*** (0.031)	0.167*** (0.030)
Labour Productivity	0.009 (0.017)	0.002 (0.016)	0.000 (0.017)	0.000 (0.015)	0.004 (0.015)	-0.001 (0.015)	0.005 (0.016)	-0.003 (0.015)	-0.010 (0.014)	-0.007 (0.017)	-0.009 (0.017)	-0.012 (0.017)
Constant	0.370*** (0.072)	0.204*** (0.061)	0.260** (0.104)				0.284*** (0.103)	0.100 (0.090)	0.169 (0.146)	0.213** (0.095)	0.506*** (0.123)	0.265** (0.129)
Observations	1,742	1,742	1,742	1,742	1,742	1,742	1,265	1,265	1,265	1,265	1,265	1,265
Year Fixed Effects		Yes		Yes		Yes		Yes		Yes		Yes
Region Fixed Effects			Yes		Yes				Yes		Yes	Yes
Sector Fixed Effects				Yes	Yes	Yes				Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's own calculation based on PLA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

The characteristics affecting BNDES' decision on whether to provide financial resources to the companies are indicated by the significant coefficients of the results presented in Table 3.7. All significant coefficients, including the instrumental variables, have expected signs. The significance and positive coefficient of the solvency indicator indicates that a higher proportion of financial resources for innovation borrowed from private or other public sources acts as a signal to BNDES, reasonably indicating companies that have been already successfully screened by other financial institutions. At the same time, the significant and negative coefficient of the squared variable evidences a non-linear relationship, indicating that the *signalling* effect dominates up to a certain limit where the *financial stability* argument becomes of primary importance. Looking at the last instrument used in this analysis, having received tax incentives reports a positive and significant coefficient, due to the *signalling* effect previously explained.

Moving the focus on the other significant variables, the negative and significant coefficient of the variable age indicates a preference of BNDES towards younger companies whether having received financial resources from other public institutions positively affects the probability of receiving funding from BNDES. Being an exporter seems to have a significant effect on the probability of receiving a loan, but only for companies with positive innovation expenditure, reporting however no significant impact for the all sample. Finally, the non-significant coefficients of the labour productivity indicator, used as a proxy of company's performance, indicate an absence of *picking-winner* strategy by BNDES. Table 3.8 below reports the main tests for the First-stage regressions for both samples of analysis.

Table 3.8 - First Stage Statistics

	<u>All Sample</u>						<u>Companies with positive innovation expenditure</u>					
	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)
<i>F-Test</i>	27.57	22.37	30.3	15.51	14.03	12.46	27.67	24.74	21.43	16.05	11.37	10.55
<i>Anderson-Rubin Wald</i>	0.103	0.079	0.079	0.09	0.152	0.08	0.103	0.079	0.079	0.09	0.152	0.08
<i>Kleibergen-Paap rk LM</i>	0.083	0.104	0.099	0.004	0.001	0.004	0.082	0.108	0.097	0.007	0.001	0.01
<i>Hansen-J Overid</i>	0.115	0.134	0.177	0.26	0.383	0.355	0.137	0.165	0.24	0.308	0.558	0.499
<i>Hansen-J Solvency</i>	0.399	0.425	0.344	0.507	0.557	0.481	0.459	0.478	0.375	0.504	0.509	0.454
<i>C-Stat Solvency</i>	0.057	0.069	0.109	0.133	0.209	0.209	0.064	0.078	0.151	0.167	0.392	0.362
<i>Hansen-J Solvency²</i>	0.154	0.245	0.221	0.368	0.387	0.374	0.254	0.375	0.308	0.409	0.411	0.395
<i>C Statistic Solvency²</i>	0.123	0.106	0.161	0.17	0.279	0.257	0.102	0.093	0.178	0.195	0.483	0.414
<i>Hansen J Statistic Tax Incentive</i>	0.098	0.109	0.141	0.111	0.178	0.177	0.108	0.122	0.193	0.142	0.349	0.328
<i>C Statistic Tax Incentive</i>	0.206	0.242	0.254	0.688	0.747	0.62	0.238	0.27	0.281	0.651	0.591	0.51
<i>Year Fixed Effects</i>		Yes	Yes	Yes		Yes		Yes	Yes	Yes		Yes
<i>Region Fixed Effects</i>			Yes		Yes	Yes		Yes			Yes	Yes
<i>Sector Fixed Effects</i>				Yes	Yes	Yes			Yes	Yes		Yes

Source: Author's own calculation based on PLA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

All First-stage regressions report a *F-stat* greater than 10, indicating a good fit of the model specification. The Anderson-Rubin Wald test rejects the null hypothesis of weak instruments, confirming that the coefficients of the instruments in the structural equation are not jointly equal to zero. The Kleibergen-Paap rk LM test rejects the null hypothesis of under-identification, confirming that the excluded instruments are correlated with the endogenous regressor (*i.e.* receiving a loan from BNDES). The Hansen J-statistic does not reject the null hypothesis of valid instruments, hence uncorrelated with the error term and correctly excluded from the estimated equation. Finally, all instruments respect the orthogonality conditions as reported by the non-rejection of the null hypothesis associated to both Hansen-J and C-stats.

As final robustness check, Table 3.9 presents the OLS results of the residuals of the Instrumental variables model regressed on the set of control and instrument variables. The results reported in Table 3.9 are to be referred to the model with the inclusion of all fixed effects, specifically Columns (30) and (36).

Table 3.9 - Results OLS - Residuals from Instrumental Variable regression

	All Sample (37)	Companies with positive innovation expenditure (38)
<i>Age (log)</i>	0.012 (0.101)	0.018 (0.135)
<i>Continuous R&D</i>	0.067 (0.445)	0.078 (0.548)
<i>Export</i>	0.001 (0.133)	0.0129 (0.182)
<i>R&D Department</i>	0.029 (0.404)	0.018 (0.515)
<i>Private funds</i>	-0.019 (0.186)	-0.017 (0.199)
<i>Public funds</i>	-0.067 (0.264)	-0.047 (0.280)
<i>Labour Productivity</i>	0.015 (0.069)	0.023 (0.098)
<i>Solvency</i>	-1.291 (1.093)	-1.008 (1.113)
<i>Solvency</i> ²	2.389 (2.044)	1.94 (2.098)
<i>Tax Incentive</i>	-0.282 (0.431)	-0.323 (0.478)
<i>Constant</i>	-0.112 (0.763)	-0.1723 (1.045)
Observations	1,742	1,265
R-squared	0.0009	0.0009
Year Fixed Effects	Yes	Yes
Region Fixed Effects	Yes	Yes
Sector Fixed Effects	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's own calculation based on PIA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

If the model is correctly specified, all variables should be uncorrelated with the error term. All variables of interest presented in Table 3.9 are not statistically significant, hence the equations presented in Section 3.3 are correctly specified not reporting any significant correlation between the residuals of the Instrumental Variables model and both control and instrument variables.

3.7. Conclusions

This chapter contributes to the empirical literature on the role of development banks in fostering industrial innovation and, specifically, in incentivizing greater private companies' financial commitment. By using industrial and innovation surveys' data on Brazilian manufacturing companies for the period 2003-2011, this analysis investigated the impact of receiving a loan from BNDES on the level of R&D intensity of the recipients. These important results build on the extensive literature on public expenditure and on the more limited literature on development banks. The main findings of this chapter highlight a scenario in which companies have increased their level of R&D intensity after receiving funding from BNDES. Further, the results highlight a heterogeneous impact of financial resources received depending on the source of this credit. Public resources coming from public institutions other than BNDES have reported a *crowding-out* impact on companies' R&D intensity, while funding coming from private institutions have shown no significant impact. Through the First-stage regression of the Instrumental Variable strategy it is also possible to investigate the determinants affecting BNDES' decisions on whether issue a loan. Results report that BNDES disbursement decisions are primarily influenced by factors *signalling* companies for which other public funding for innovation has already been granted, either directly or indirectly, and also influenced by additional attention on the *financial stability* of the beneficiary companies. Further, the non-perceived impact of private financial institutions represents another remarkable finding of this analysis. The limited contribution of commercial banks' resources on companies R&D activities, also reported by the non-significant impact of the indicator in the treatment equation together with the non-significant impact in the Selection equation, denote the marginality of private financial institutions in the Brazilian industrial innovation context, highlighting the inadequacy of Brazilian commercial banks in fostering companies' innovation activities. This chapter suggests that BNDES loans' allocations have had a significant *additional* impact on companies' investment decisions.

In conclusion, the role and impact of the Brazilian development bank has to also be understood in light of the industrial policy framework in place over the considered time frame. The necessity of defined targets and missions of both policies and public financial institutions represents a crucial combination to direct financial resources to pre-determined goals.

4. Risk in Innovation: Theory and Evidence from Pharma and Biotech sectors in Brazil

“In the pharmaceutical industry, the problems of great uncertainty about the outcome of R&D, the length of the R&D process (12 ± 14 years), and asymmetric information combine to make the difference between internal and external funds especially important.” (Grabowski and Vernon 2001).

4.1. Introduction

The fourth chapter provides qualitative evidence for the Brazilian pharmaceutical sector, adding value to the quantitative results of the previous two chapters. The data have been collected by means of a survey, undertaken for a sample of Brazilian companies in the pharmaceutical and biotech sector. The results add a different perspective to the findings of the second and third chapter that quantitatively evaluates the impact of BNDES funding on the private financial sector and on companies' own resources.

Particularly regarding radical or breakthrough innovations, the high embedded risk combined with high failure rate represent the most important constraints for companies to perform these type of activities in the pharmaceutical sector (Robbins and O'Gorman 2015). As a consequence of these constraints, available external financial resources are limited and come at high price. Further, the long timespan necessary for pharmaceutical innovation to produce results requires long-term availability of financial resources that, particularly during economic crisis, is not always available. In this context, BNDES played a crucial role in providing countercyclical financial resources in Brazil, with sector-specific programs aimed at innovation activities. Understanding sector-specific obstacles to innovation activities, particularly during economic downturns, is crucial to design policies and financial instruments able to foster the development of the national industry.

The nature of the pharmaceutical industry as a system of networks among different actors and institutions at national and global levels (McKelvey and Orsenigo 2001) points the attention to the need of a coordinated action among different players in the economy. The discrepancy between *social* and *private* returns of basic research provides the theoretical ground for an active role of the public sector (Nelson 1959). Further, the long-term necessary for basic research to produce practical implications and the low appropriability of their returns make public financial resources a key tool to deal with the underinvestment of private companies in such area

(Cockburn and Henderson 2000; Mazzucato 2013a), particularly in countries like Brazil, where alternative private financial institutions, like private venture capital, are absent.

The focus of the survey is to understand obstacles faced by Brazilian pharmaceutical companies while innovating and what role BNDES played in support of those activities. Innovation will be examined as product innovation, distinguishing between radical and incremental types of innovation, and process innovation. The constraints, building on the list proposed by Kaplan (2004) and WBES (2009), are categorized into internal or external depending on whether they directly depend on companies' specific characteristics or on the economic and industrial environment where firms operate.

The survey is divided into 4 parts, looking specifically at companies' main characteristics, perceived obstacles to innovation activities, importance of different financial resources and specific projects recently funded by BNDES. The remainder of this chapter is structured as follows. Section 2 outlines the characteristics of innovation on the pharmaceutical sector. Section 3 presents the survey methodology, followed by the study framework in section 4. Section 5 outlines the findings based on the survey data. Section 6 provides a summary of policy implications and concludes the paper.

4.2. Characteristics of Innovation in the Pharmaceutical Sector

Technological innovation in the pharmaceutical sector historically occurred in long waves of activity (Achilladelis and Antonakis 2001)²⁰, with the most recent one driven by the discovery and application of biotechnology in the production of new drugs. Successful outcomes of innovation activities in the pharmaceutical industry can lead to introduction of new products or changes in the process by which companies manufacture their products. However, innovation activities in the pharmaceutical sector are characterised by high failure rates (Robbins and O'Gorman 2015) and low level of returns in R&D investments²¹ which, in turn, contribute to make finance limited and expensive. Other obstacles to innovation activities can be either related to companies' internal

²⁰ The First generation (1820-1880) started following the Lavoisier "Chemical revolution" at the end of the 18th century. The Second generation (1880-1930) has been driven by the new challenges dictated from the Industrial revolution and sequent urbanization. Later on, the Third generation (1930-1960) produced innovations in organic and natural products chemistry for the synthesis of various elements (vitamins, antibiotics, etc.). As a result of the new scientific basis of the pharmaceutical industry, the Fourth generation (1960-1980) experienced a shift from chemistry and pharmacology to life sciences as scientific bases. Finally, the Fifth generation (since 1980) is still surfing the new wave given by the discovery and application of biotechnology in the production of new drugs.

²¹ It is estimated that out of 5000 projects only 1 completes the development process (Kaplan 2004), and among the successful projects only 3 out of 10 actually returns the R&D investment (Grabowski, Vernon et al. 2002).

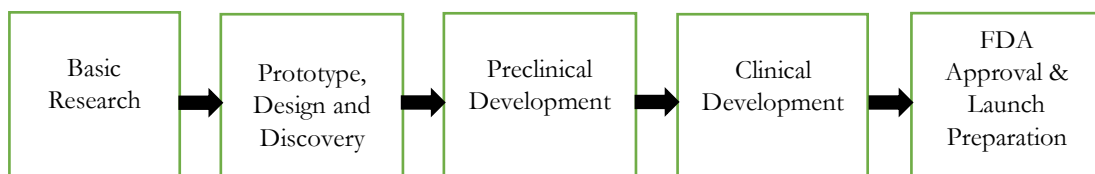
factors, such lack of physical and human capital or shareholders reluctance towards risky investments, or depend on the economic and institutional environment where firms operate. Brazil represents an interesting case study particularly due to the institutional environment, characterised by strong government's interest towards industrial innovation activities, in a highly bureaucratic and poorly financially developed State. The next Section will first present the different categories of pharmaceutical innovation, then the focus will move towards the classification of obstacles and main characteristics of the Brazilian pharmaceutical sector.

4.2.1. Innovation Types

- Product Innovation

The ever increasing cost of drug development (DiMasi, Hansen et al. 2003) requires more resources for the creation of new products having possibly high returns, as the business view of the companies would imply. Drug development is a time and resource consuming process, composed of different sub-activities before the commercialization of the product. The USA Food and Drugs Administration (FDA) defined the drug development process as composed of different stages leading to the commercialization of the product (Achilladelis and Antonakis 2001):

Figure 4.1 – Drug Development Process



Based on the degree of novelty of the product innovations in the pharmaceutical sector, the new drug can present:

- (i). “*New Molecular Entities*” (NMEs) never approved before in the market, hence radical innovations, or
- (ii). Altered but pre-existing molecules, therefore incremental innovations, presenting new features (dosage form, route of administration, etc.), so-called “*Incrementally Modified Drugs*” (IMDs).

Each company in the market has different strategies to create its portfolio and assess its long-term risk, diversifying the activity among the two types of innovation. IMDs, with their low

development cost, high return on investment and high pricing potential, are the ones indicated for increasing firms' profits.

- **Process Innovation**

Process innovation are divided into five categories, looking specifically at investment in human or physical capital and general within company environment. In detail, investments in physical capital include "*Acquisition of machinery/plant expansion*", "*Acquisition of external R&D (software excluded)*" and "*Acquisition of software*", whereas human capital investments are expressed in terms of "*Hiring workforce for R&D activities*". Finally, perceptions about performed innovation activities are captured by the category "*R&D activities performed within the company*".

4.2.2. Risks & Obstacles to Innovation in the pharmaceutical sector

The high risk embedded in innovation activities of the pharmaceutical industry is due to the interrelation of different social and economic characteristics. Demographic uncertainty, lack of consensus on long term industrial and social policies and on future needs of the public sector, together with poor institutional framework, are among the major contributors to this embedded risk that, combined with low returns on R&D activities, increase the cost of the limited financial resources. The innovative power of the investment is negatively related to the degree of failure of the investment, such that companies prefer lower risk types of innovation activities, such development of "*me too*" drugs, showing companies' risk aversion towards investment that would lead to radically innovative outcomes but likely to increase companies' market share.

Kaplan (2004) discusses a list of obstacles directly related to product innovation activities, that either have origin from institutional factors, such as "*Regulatory authority rituals*", "*Uncertainty about the timing and level of reimbursement decisions leading to uncertainty among stakeholders*", and "*Potential increases in the cost of doing business due to intellectual property concerns*", or may be related to companies' characteristics, such as "*General business uncertainties in drug development*", "*Differences in perception of risk among different stakeholders*" and "*Inadequate understanding of basic science*". The WBES identifies categories related to the general business environment which, however, presents some overlaps. Barriers in WBES can as well be classified depending on whether they are directly related to access to finance or land, licensing and permits, corruption, tax, regulation and jurisdictional barriers, access to electricity and transport, poor institutions and lack of human capital or competition.

4.2.3. The Brazilian Pharma and Biotech industries

The Brazilian pharmaceutical industry is a sectoral system of innovation that involves a wide variety of public and private institutions (McKelvey and Orsenigo 2001). However, weak private industrial infrastructures, particularly regarding the innovation chain (Urias and Furtado 2009), lack of human capital (Lugones and Suárez 2007) and access to finance (Goedhuys and Veugelers 2012) represent the main fragilities of the national system. Recently, the Brazilian pharmaceutical sector is experiencing an increasing number of domestic firms (Urias and Furtado 2009) and innovative domestic firms (Caliari and Ruiz 2010), in an industrial scenario that sees the predominance of foreign pharmaceutical companies. Other two major difficulties affecting the development of a Brazilian bio-tech System of innovation have been represented by the lack of a strong venture capital sector able to fund particularly start-up and medium-size biotech companies and by a poor and undefined legislation regarding the development of biotechnological products (Marques and Neto 2007):

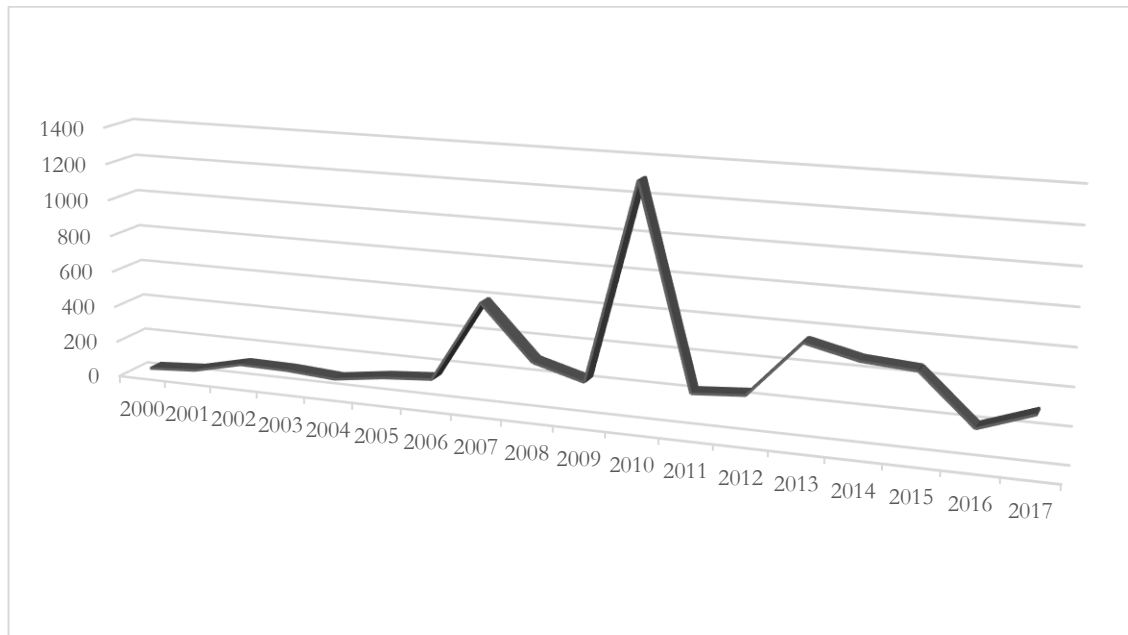
Brazilian pharmaceutical market is among the largest and represents an important case study given the development in the last decades. In the '90s, several factors have changed the structure of the industrial sector. Among all, patents for pharmaceutical products became fully operating in 1996, import restriction were significantly lowered and generic drugs have been introduced in 1999.

The introduction of generic drugs increased the participation of domestic industries and their competitiveness, changing the structure of the entire industrial sector. In 2009, almost 75% of sales in the Brazilian generic markets were made by domestic companies (Urias and Furtado 2009). Generics are perfect substitutes of trademark medicines previously created with research activity and do not usually require research expenditure being only a copy of an already existent product, therefore their lower price. However, an industrial system solely dedicated to the generic drugs market hardly survive or grow given the low R&D intensity linked to the production of these products.

Brazilian pharmaceutical and biotech industries have been among the major sectors of intervention since the first industrial policy of the Lula's administration in 2004 (PITCE). It has been further confirmed as key industrial sectors for development in the second industrial policy (PDP). Between the two industrial policies, the importance of the pharmaceutical and biotech industries has been highlighted by the creation of the PROFARMA program in 2004. Finally, both sectors remained among the key strategic sectors in the Plano Brasil Maior (2011).

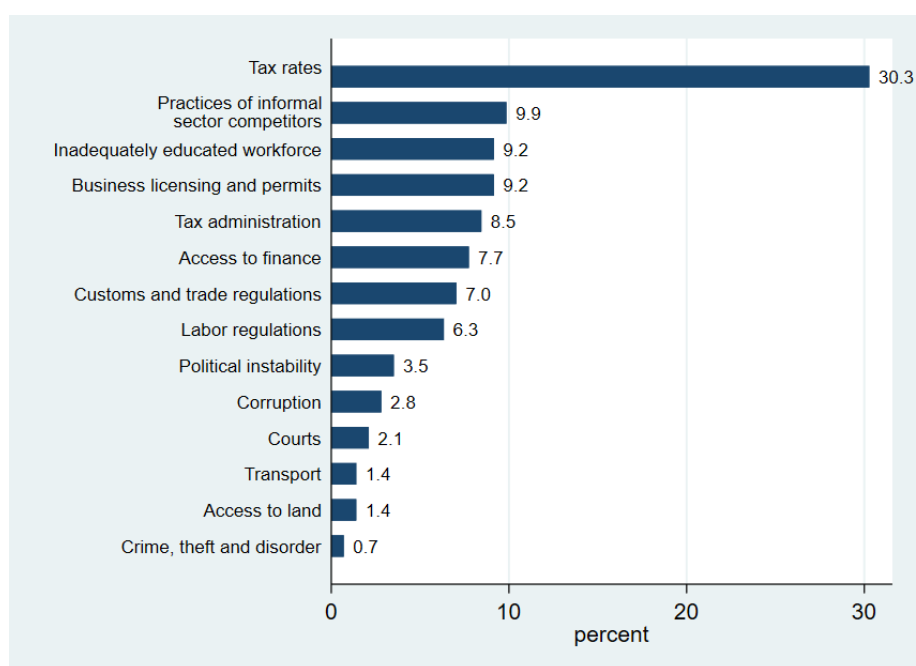
Since the first industrial policy in 2004, vertical strategies were adopted by the Brazilian government for industrial development, with policies focused on specific industrial sectors in which BNDES interpreted a primary role in the provision of financial resources to the companies, as shown in Figure 4.2 below.

Figure 4.2 - BNDES Disbursement for Pharmaceutical sector 2000-2017 (Current R\$ Million)



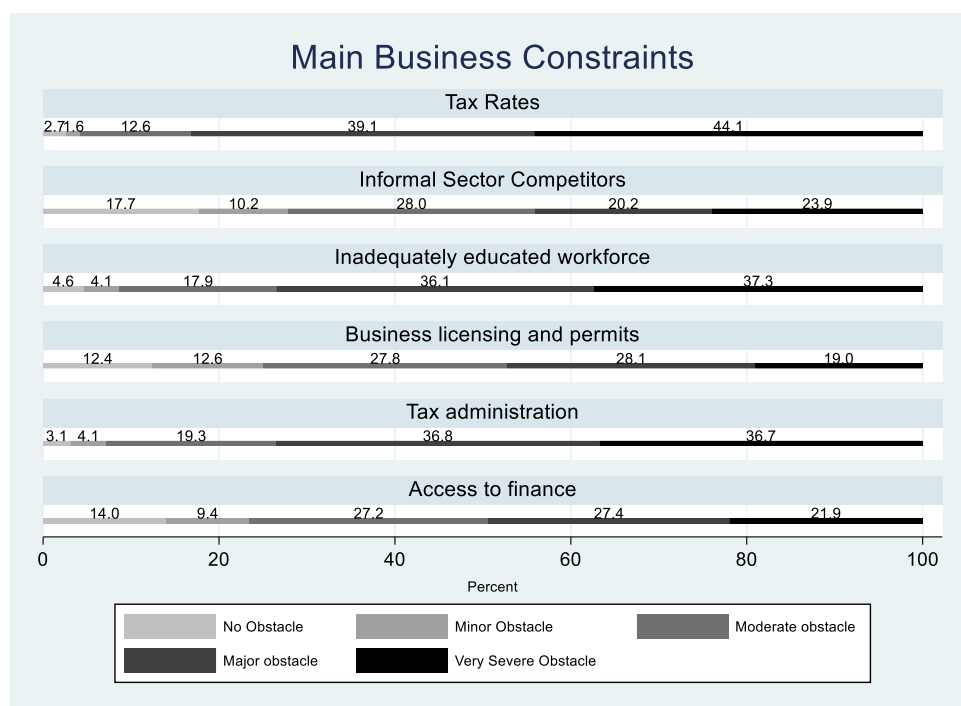
Source: BNDES

Prior to this, horizontal policies shaped the whole industrial sector in the earlier decades. In the nineties, liberalization policies, price liberalization and exchange rate fluctuations brought an increase in imports with a stable export rate, in the acquisition of Brazilian companies by foreign companies and an increase in prices and stagnation of domestic production. The increased foreign competition however did not bring the expected price reduction and increase in consumption (Caliari and Ruiz 2010). The attracted foreign and domestic investments have so far produced research that barely moved forward to the market. The process of changing a system that until 1996 predominantly copied foreign products for resale is a slow and a path dependant process. The high risk involved given the peculiar characteristics of the pharmaceutical industry, increases the risk and obstacles in the industrial structural change. Perceptions about main business environment constraints for chemical and pharmaceutical companies (ISIC 24) are presented in the following Figure 4.2 and are extracted from the World Bank Enterprise Survey (WBES), conducted in 2009. These perceptions refer to the general business environment and not directly related to innovation activities, as addressed in this chapter. Further, perceptions refer to a period before the 2008 financial crisis, which might have altered the national economic and industrial scenario.

Figure 4.3 - Main Business Environment Constraints in Brazil

Source: WBES 2009

As presented in Figure 4.3, in the top 10 business constraints for Brazilian chemical and pharmaceutical companies, only three out of the top 10 main obstacles are not directly attributable to public institutions. It is also quite evident how the majority of the companies identifies tax rates as the main constraint for their business. Looking at companies' degree of perceived obstacles, the following Figure 4.4 presents companies' responses based on a 5-points Likert scale from "No obstacle" to "Severe Obstacle".

Figure 4.4 – Perceived degree of obstacle for chemical and pharmaceutical companies

Source: WBES 2009

While the identification of tax rates as principal obstacle for the business environment was already previously highlighted in Figure 4.2, it is interesting to notice how more than 70% of the companies considers low skilled human capital a severe or high severe obstacle for the business.

4.3. Survey Methodology

In light of the current industrial scenario in Brazil, and in particular regarding the pharmaceutical and biotech sector, I aim undertake a survey to examine companies' perceived obstacles on innovation and whether BNDES financial support help pharmaceutical companies in innovation activities. The value added of collecting primary data is to provide more recent findings on companies' perceptions about obstacles to innovation activities combined with an in-depth investigation of the funded projects. To the best of my knowledge, there is limited evidence on the relation between obstacles to innovation between BNDES funded and non-funded companies.

4.3.1. Survey Design and Sampling Reference

The questionnaire for the survey was carefully designed to incorporate views from preliminary interviews and a pilot survey. A systematic sampling procedure was chosen to draw a random sample of firms from two strata, a list of BNDES funded companies and a list of non-funded companies from ORBIS.

With the assistance of carefully monitored and trained local survey teams (cost around £1800), details regarding the survey were sent out via personalised emails to potential respondents. The target respondents were managers who were fully aware of investment decisions and investment risk analysis.

4.3.2. Stratified Sampling & Randomization

I used stratified sampling using two strata; first the list of BNDES' funded companies and second the list based on companies in ORBIS. First, I began with the BNDES list, being representative of the population of firms who are funded by BNDES, for a total number of 65 companies. Second, the list of companies in ORBIS was used to build another list. The second list was constructed by dropping any overlapping firms with the BNDES list, leading to a final number of 115 companies. The final list consisted of a total of 180 firms. Therefore, each stratum was mutually exclusive. Using the two lists, I was able to draw a representative sample of firms such that the broad target population comprised companies that were funded by BNDES and those that received no BNDES funding.

I use a disproportionate sampling procedure, such that I set the final sample size (distributed across the two different strata), taking into account two important aspects of costs and precision.

4.3.3. Final Sample & Limitations

In total, the survey rendered 77 responses, representing a final response rate of 43 per cent. Some responses were incomplete and could not be used. On the whole, in spite of the potential limitations of the data, information from the survey helps revealing important insights on both companies' perceived barriers to innovation together with detail information on BNDES funded projects.

4.4. Framework

This Section introduces the three sections of the questionnaire by first presenting the categories of obstacles to innovation activities as in Part 1 of the survey. The focus then moves to Part 2 of the questionnaire, looking at the degree of importance of different sources of financial resources, to then conclude the survey with the last Part 3 on BNDES specific funded projects.

4.4.1. Obstacles to Innovation

The survey begins with a focus on main business characteristics and entrepreneurs' perceived risk associated to investments in innovation, providing evidence on the recent pharmaceutical industry

environment in Brazil. After the identification of the degree of importance of different sources financial supply, the survey proceeds with companies that have received at least one loan by BNDES since 2004, investigating the main characteristics of the funded projects.

For all the categories of pharmaceutical innovation, the interviewed identifies associated perceived obstacles based on the presented categories, building on the list of obstacles provided by Kaplan (2004) and WBES (2009), with the inclusion of additional questions for the purpose of this analysis. The additional questions define additional proxies for obstacles to innovation, both for general business environment and regarding the specific project funded by BNDES. Further, while categories in Kaplan are directly related only to product innovations, categories of obstacles in the WBES are selected with reference to the general business environment rather than to innovation activities. Nine categories of obstacles have been identified and are then presented in the following Table 4.1.

Table 4.1 - Categories of obstacles for investment in innovation

Lack of qualified human resources, lack of previous investment in R&D	Shareholder pressure	High risk of failure involving investment in innovation
Bureaucratic obstacles	Uncertainty about the timing of reimbursement of public funding	Inability to capture returns due to inappropriate IPR protection
Lack of tax incentives	Uncertainty about the timing of reimbursement of private funding	Limited access to commercial bank finance (availability, interest rates, fees, and collateral requirements)

Source: Author's own elaboration

Table 4.1 reports the risk categories relative to investment in innovation for the pharmaceutical industry built on the list proposed by Kaplan (2004) and WBES (2009), with study-specific additional categories.

All questions related to the self-identification of the risk will be measured with a Likert Scale as follows:

1. No Obstacle, 2. Minor Obstacle, 3. Moderate Obstacle, 4. Major Obstacle, 5. Very Severe Obstacle.

Based on the origin of such obstacles, I categorize the obstacles into two types as outlined below.

- **Internal** obstacles are defined as any type of constraint to innovation activities generated within the company: “*Lack of Human Resources or previous investments in R&D*”, “*Shareholder pressure*” and “*High risk of failure involving investment in innovation*”

- **External** obstacles on contrary, do not depend on companies’ internal constraints but depend either from the State level administration, such as “*Bureaucratic obstacles*”, “*Lack of tax incentives*” and “*Inability to capture returns due to inappropriate IPR protection*”, or are related to the available financial resources, such as “*Uncertainty about the timing of reimbursement of public funding*”, “*Uncertainty about the timing of reimbursement of private funding*” and “*Limited access to commercial banks finance*”.

4.4.2. Sources of Financial Resources

The second part of the questionnaire looks at the identification of the importance of different sources of financial resources, asking also some specific question regarding access to BNDES credit. In detail, the first part of Section 2 asks the respondents to identify the degree of importance of *Public Institutions, Private Commercial Banks, Other Private Institutions and Companies’ own resources* on a Likert Scale as the following:

1. High Importance, 2. Major Importance, 3. Minor Importance, 4. No Importance

The identification of the degree of importance of different financial sources is crucial to understand how different players have taken part into companies’ innovation processes. Following the identification of the degree of importance, the respondents reported the number of projects, if any, that have not been funded by BNDES, whether the company undertook the investment after the rejection by BNDES and, in case of project undertaken, the degree of importance of the different financial sources for that specific project.

4.4.3. BNDES Projects

The analysis will provide an understanding of the obstacles to innovation activities for the Brazilian pharmaceutical industry, 10 years after the beginning of the world financial crisis and following the intervention of BNDES as countercyclical tool in the economy. Two questions look at the extent to which access to finance and failure risk represented an obstacle for the specific projects funded by BNDES and are presented below.

- *To what extent was access to finance a problem for the investment you requested the loan for?*
- *To what extent do you evaluate the failure risk for the project you obtained the fund for?*

These specific questions aim at providing an understanding of what type of projects are selected by the Brazilian development bank, whether it selects projects that are not considered particularly risky or whether provides financial resources for projects that were not particularly suffering of lack of funding.

Finally, Section 3 of the questionnaire looks at the specific projects funded by BNDES, identifying the magnitude of the received financial support, the degree of complementarity with different financial resources, possible alternatives to BNDES financial resources and reasons behind the preference over the Brazilian development bank.

Section 3 ends by asking what the company would have done if BNDES would have not funded the project, whether it would have been done in any case, or whether another investment in innovation or not in innovation would have been undertaken. Such questions, together with the reasons behind the preference of BNDES over other alternatives, are aimed at providing evidence on whether BNDES intervention can be accused of crowding-out either commercial banks' activity or companies' own resources.

4.5. Findings

4.5.1. Company Profiles

This Section begins by presenting companies' main characteristics for the sample (77 companies) in the following Table 4.2. These characteristics are defined in terms of age, measured as the difference between the year of the survey (2018) and the year in which the company was established, number of total workers, by quartile, and number of workers in the R&D department, number of companies that export, with ratio of export over annual sales and ratio of R&D expenditure over annual sales.

Table 4.2 – Companies' main characteristics

	<u>N</u>	<u>Mean</u>
Age	66	23.55
Number of Workers	74	311.6
1 st quartile	19	10.6
2 nd quartile	18	44.7
3 rd quartile	18	128.8
4 th quartile	18	1089.2
Number of Workers in R&D Department	65	22.2
Export	36	
Export/Annual Sales	21	16.8%
R&D Expenditure/Annual Sales	41	7.49%

Source: Author's own elaboration based on primary data

Table 4.2 reports main companies' characteristics of the respondents.

As reported in Table 4.2 above, on average companies in the dataset are slightly older than 20 years, have 311 workers, of which less than 10% in the R&D department. Further, roughly 50% of the companies export a quantity of goods equal to 16.8% of annual sales. Finally, companies in the sample spend in R&D activities an amount equal to 7.5% of annual sales.

One of the accusations often moved to BNDES is related to the “*picking-winner*” strategy adopted by the bank to increase the likelihood to be repaid (Lazzarini, Musacchio et al. 2011). On the other side, public financial resources are often accused of incapacity in “*picking winners*” or, willingness to “*pick-looser*”, due to political bias (Robinson and Torvik 2005). To investigate whether BNDES strategy can be accused of either of the two critiques often moved by the literature, the following Table 4.3 looks at differences in companies' characteristics among BNDES funded and non-funded companies.

Table 4.3 – Companies main characteristics, by category BNDES funded

	<u>Not Funded</u>		<u>Funded</u>		<u>Δ</u>	<u>P-value</u>
	<u>N</u>	<u>Mean</u>	<u>N</u>	<u>Mean</u>		
Age	33	18.6	33	28.5	-9.8	0.015
R&D Expenditure/Annual Sales	13	7.6	28	7.4	0.2	0.961
Export/Annual Sales	5	23.6	16	14.7	9.0	0.628
Number of workers	36	211.5	38	406.4	-194.9	0.228
Number of workers in R&D department	31	9.0	34	34.2	-25.1	0.094

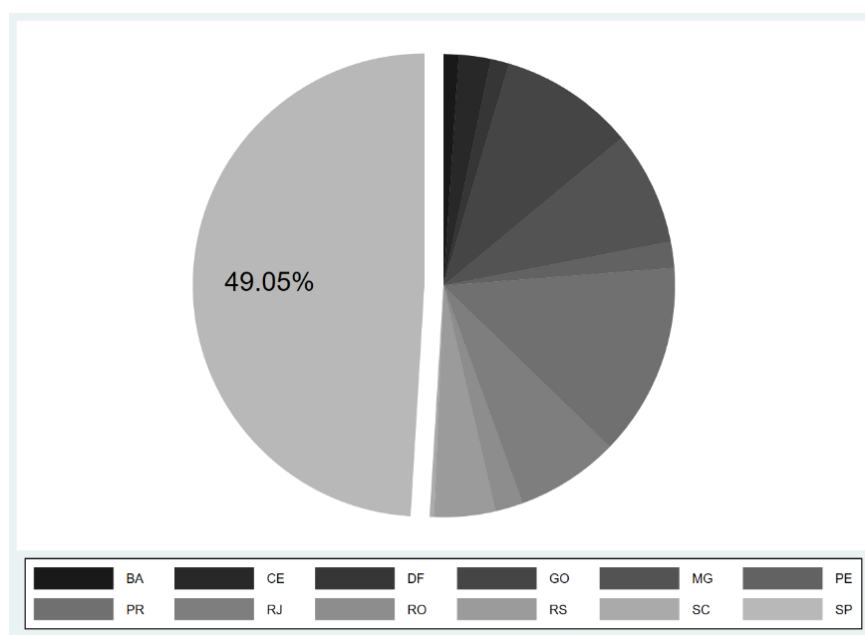
Source: Author's own elaboration based on primary data

Table 4.3 reports the t-test results on companies' main characteristics among BNDES funded and non-funded companies.

Results from Table 4.3 report that the main difference among BNDES funded and non-funded companies lies on the age, with funded companies being older than their counterpart. The other difference among companies, although only statistically significant at 10%, is about the number of workers in the R&D department, with funded companies reporting more than three times the number of employees devoted to innovation activities without, however, showing differences in R&D intensity. Although the limited sample for the analysis, it therefore seems that neither of the two critiques exposed above (*picking-winner* or *picking-looser* strategy) can be attributable to BNDES.

Information on geographical location of the companies, derived from Question “IV” where companies are asked to report the location of the plants, are summarized in Figure 4.5 below.²²

Figure 4.5 - Location of companies' plants



Source: Author's own elaboration based on primary data

Figure 4.5 reports the share of plants geographical location by State.

Half of the plants of the companies of interest are located, expectedly, in the State of São Paulo, the economic capital of Brazil. States of Paraná and Rio de Janeiro represent the second and third most recurrent plants' locations, whereas the other companies are distributed across other Brazilian States. Regarding companies' ownership, the following Table 4.4 reports the different categories as presented in question “V” of the questionnaire.

²² 5 companies have plants in more than 1 location.

Table 4.4 – Share of companies by ownership

	%
<i>Purely Domestic</i>	74%
<i>Foreign 0-20%</i>	2.6%
<i>Foreign 21-40%</i>	1.3%
<i>Foreign 41-60%</i>	2.6%
<i>Foreign 61%+</i>	18.2%
<i>Purely Foreign</i>	1.3%

Source: Author's own elaboration based on primary data

Table 4.4 reports the share of companies by category of ownership.

The majority of pharmaceutical companies in the sample is purely domestic, while the second highest incidence is registered by companies having more than 60% owned by foreign companies. Overall, companies with foreign participation account for 26% of the sample. Regarding the type of innovation activities performed by the companies, the following Table 4.5 reports the share by type of activity.

Table 4.5 – Share of companies by innovation activities performed

	%
<u>PRODUCT INNOVATION</u>	
<i>Development of a new molecular entity (NME)</i>	28.6%
<i>Development of an incrementally modified drug (IMD)</i>	26.0%
<u>PROCESS INNOVATION</u>	
<i>Acquisition of machinery / plant expansion</i>	77.9%
<i>Acquisition of external R&D (software excluded)</i>	36.4%
<i>Acquisition of software</i>	39.0%
<i>R&D activities performed within the company</i>	54.5%
<i>Hiring workforce for R&D activities</i>	40.3%
<i>Other product / process innovation</i>	10.4%

Source: Author's own elaboration based on primary data

Table 4.5 reports the share of companies by category of innovation activities performed.

While only slightly more than a quarter of the companies perform product innovation activities, process innovation activities represent a more frequent type of performed innovation. Among process innovation activities, acquisition of tangible capital and R&D activities performed within the company are performed by, respectively, 78% and 54.5% companies of the sample, whereas acquisition of external R&D or software represents less performed types of innovation activities,

showing a difficulty for Brazilian pharmaceutical companies in acquiring knowledge from outside the company.

4.5.2. The recent risk environment in the Brazilian pharmaceutical sector

The analysis proceeds with the identification of two macro categories of obstacles to innovation activities, internal and external, based on the origin of such obstacles. Internal obstacles are defined as any type of constraint to innovation activities generated within the company and, referring to the categories presented in Table 4.2, are “*Lack of Human Resources or previous investments in R&D*”, “*Shareholder pressure*” and “*High risk of failure involving investments in innovation*”. External obstacles on contrary, do not depend on companies’ internal constraints but depend either from the State level administration, such as “*Bureaucratic obstacles*”, “*Lack of tax incentives*” and “*Inability to capture returns due to inappropriate IPR protection*”, or are related to the available financial resources, such as “*Uncertainty about the timing of reimbursement of public funding*”, “*Uncertainty about the timing of reimbursement of private funding*” and “*Limited access to commercial banks finance*”.

4.5.2.1. Internal Obstacles

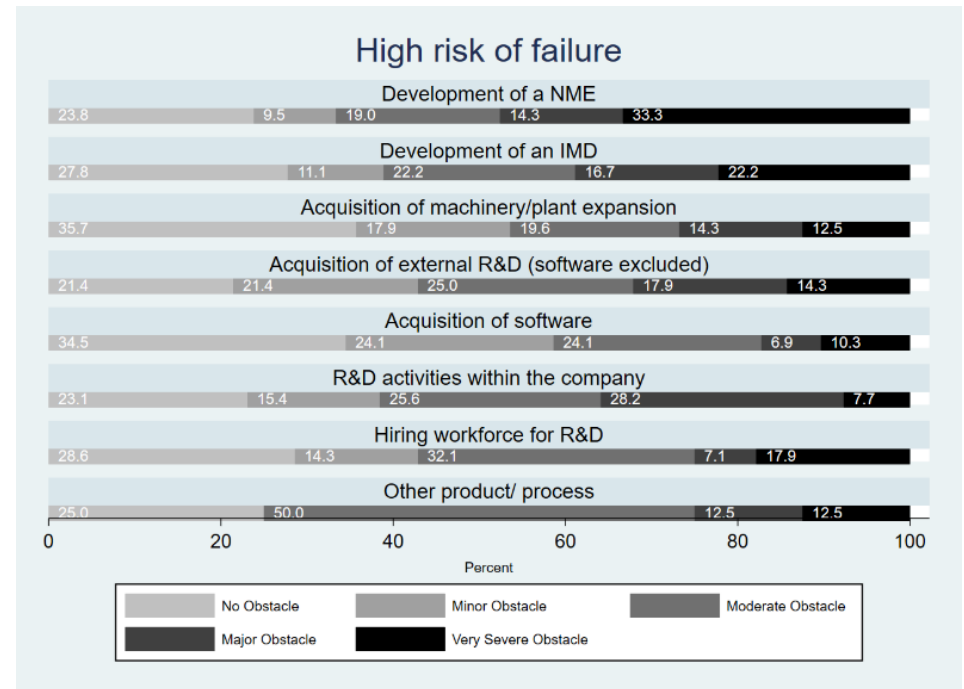
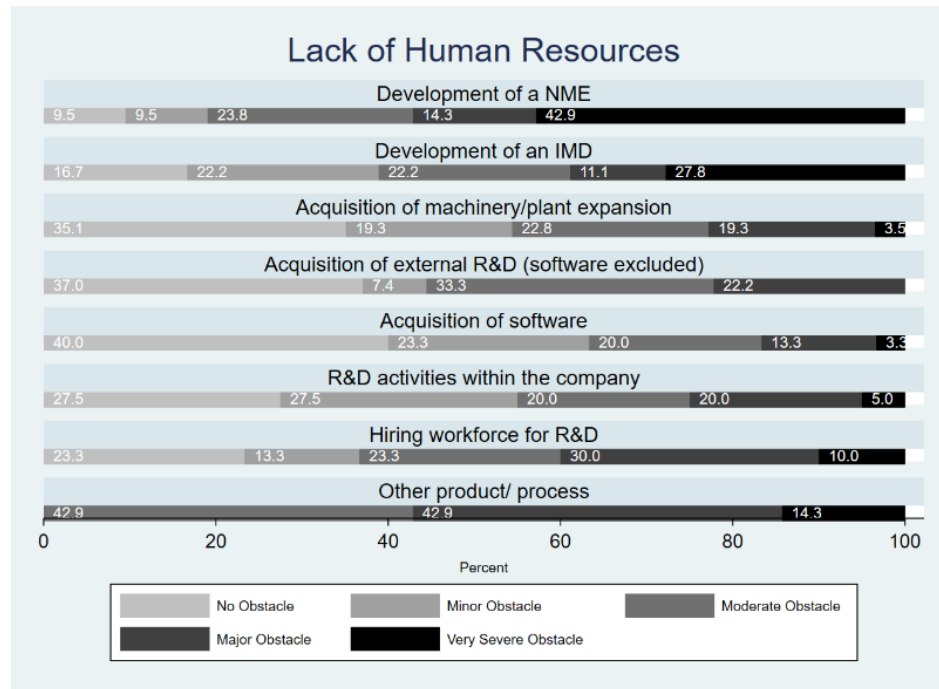
Internal obstacles are defined as constraints to innovation activities arising due to company specific factors, such as lack of human or physical capital, shareholder pressure or high risk of failure embedded in performed innovation activities.

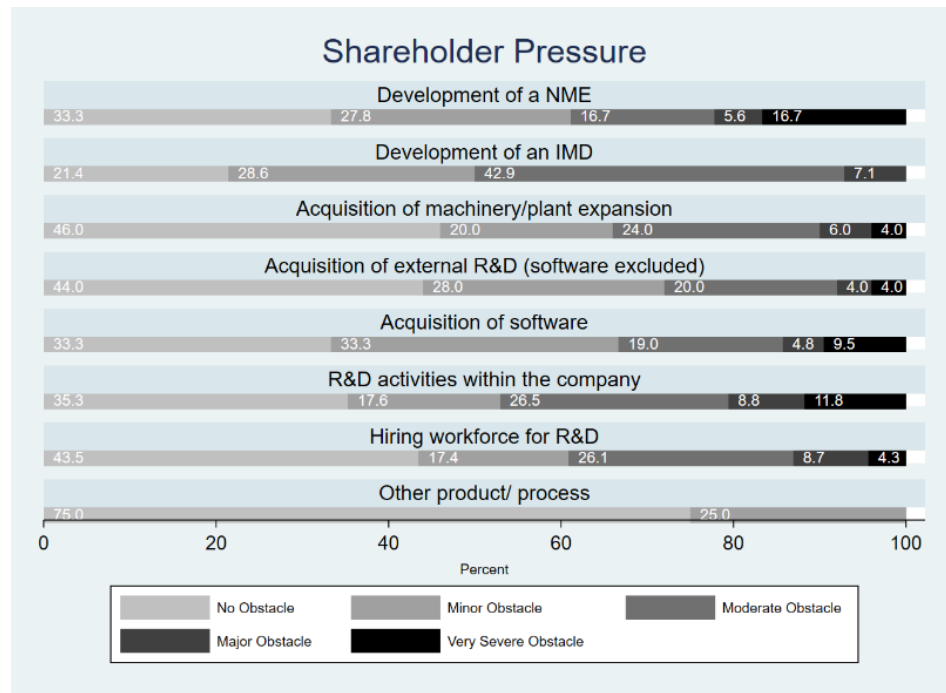
Figure 4.6 – Internal Obstacles to Innovation

Figure 6 reports the perceived severity of internal obstacles to innovation on a Likert scale:

"1. No Obstacle, 2. Minor Obstacle, 3. Moderate Obstacle, 4. Major Obstacle, 5. Very Severe Obstacle".

Obstacles are classified as "Lack of qualified human resources, lack of previous investment in R&D", "Shareholder Pressure" and "High risk of failure involving investments in innovation".





Source: Author's own elaboration based on primary data

Among companies' internal obstacles to innovation, shareholder pressure is identified as the least severe constraint to companies' innovation activities. A possible explanation for such finding can be related to the interest of the shareholders towards innovation activities, in the light of targeted policies and lines of credit. Regarding the categories "*Lack of human resources or previous companies' R&D investment*" and "*High risk of failure involving investments in innovation*", the two types of product innovation represent the type of innovation with the highest incidence of severe or very severe obstacles.

4.5.2.2. External Obstacles

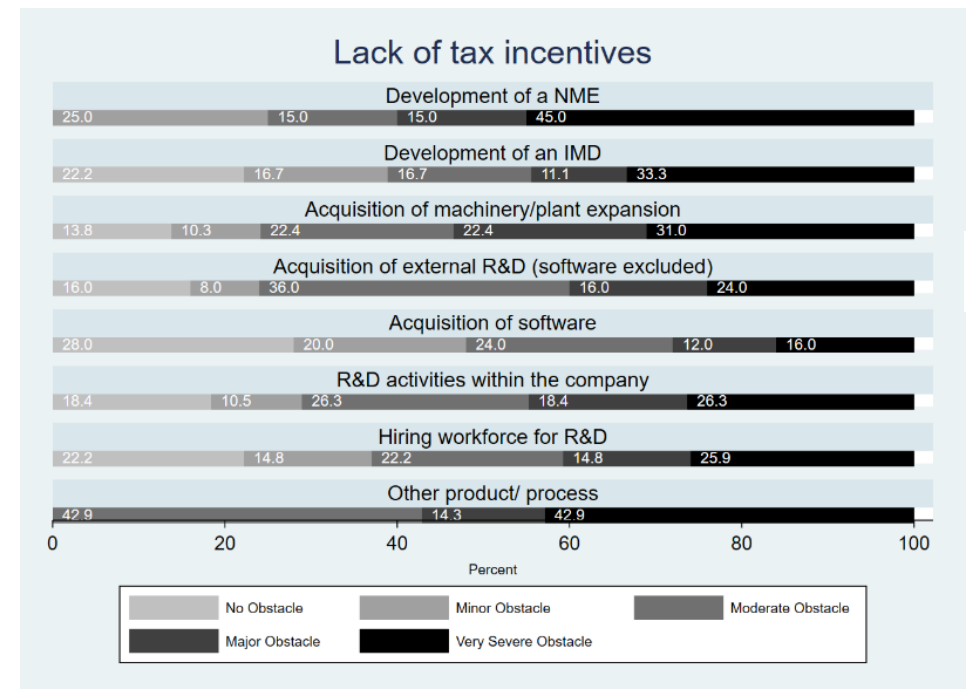
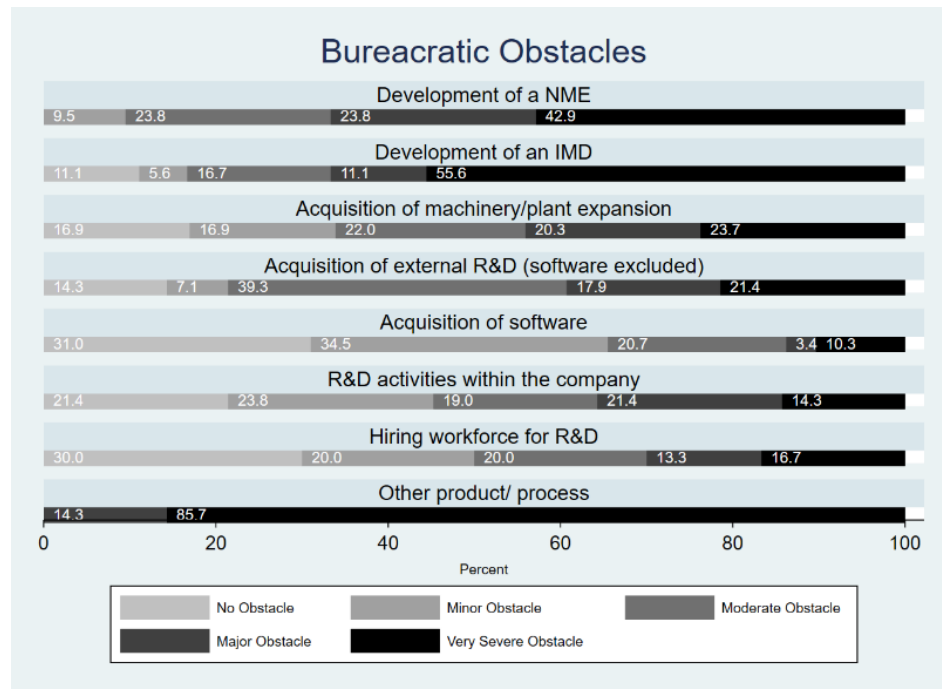
External obstacles are defined as constraints to innovation activities that do not directly depend on companies' internal factors but are related to the economic, financial and industrial environment where the companies operate. These obstacles are either related to public institutions, such as high levels of bureaucratization of the State, lack of tax incentives and poor IPR protection, or arise due to an underdeveloped national financial system, both public and private, which brings companies to either not receive adequate financial resources or to be uncertain about the timing of repayment. The following Figure 4.7 presents the perceived severity of external obstacles to innovation that can be directly related to public institutions.

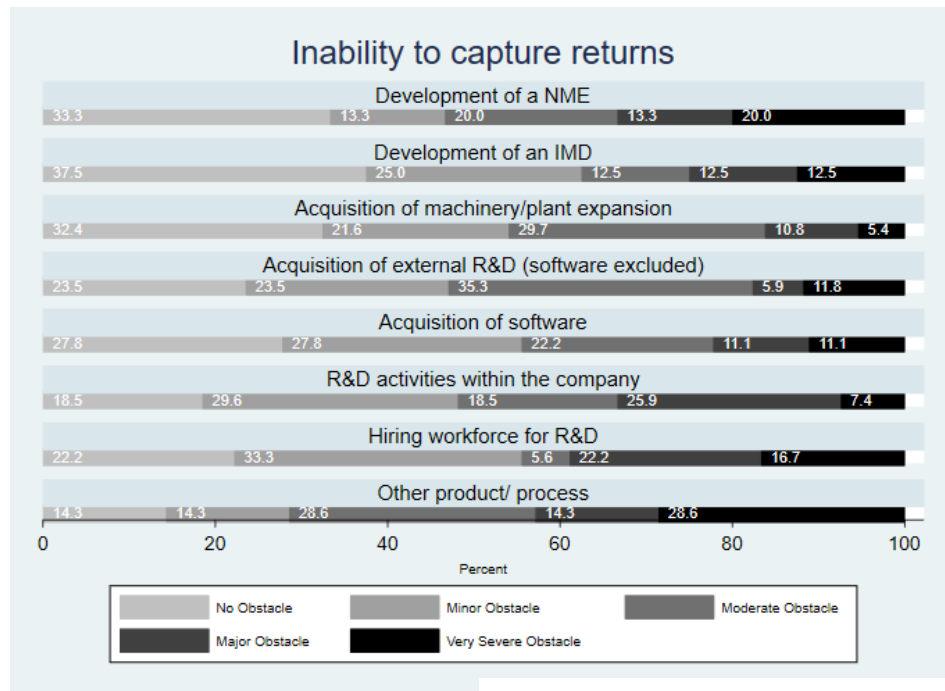
Figure 4.7 External obstacles to innovation related to public institutions

Figure 7 report the perceived severity of external obstacles to innovation related to public institutions on a Likert scale:

"1. No Obstacle, 2. Minor Obstacle, 3. Moderate Obstacle, 4. Major Obstacle, 5. Very Severe Obstacle".

Obstacles are classified as: "Bureaucratic Obstacles", "Lack of tax incentives" and "Inability to capture returns due to inappropriate IPR protection".





Source: Author's own elaboration based on primary data

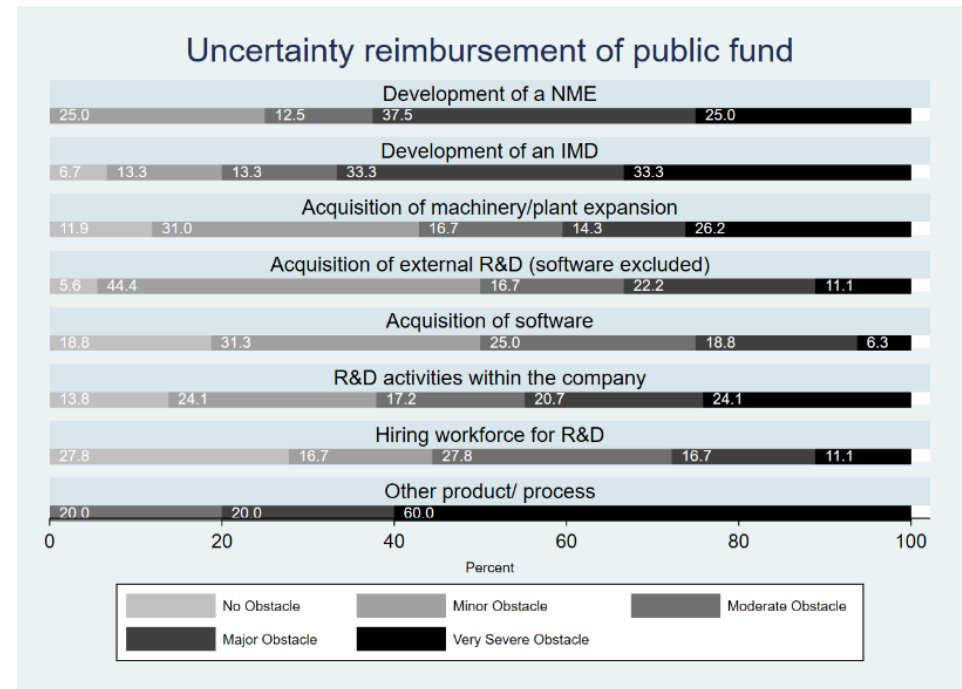
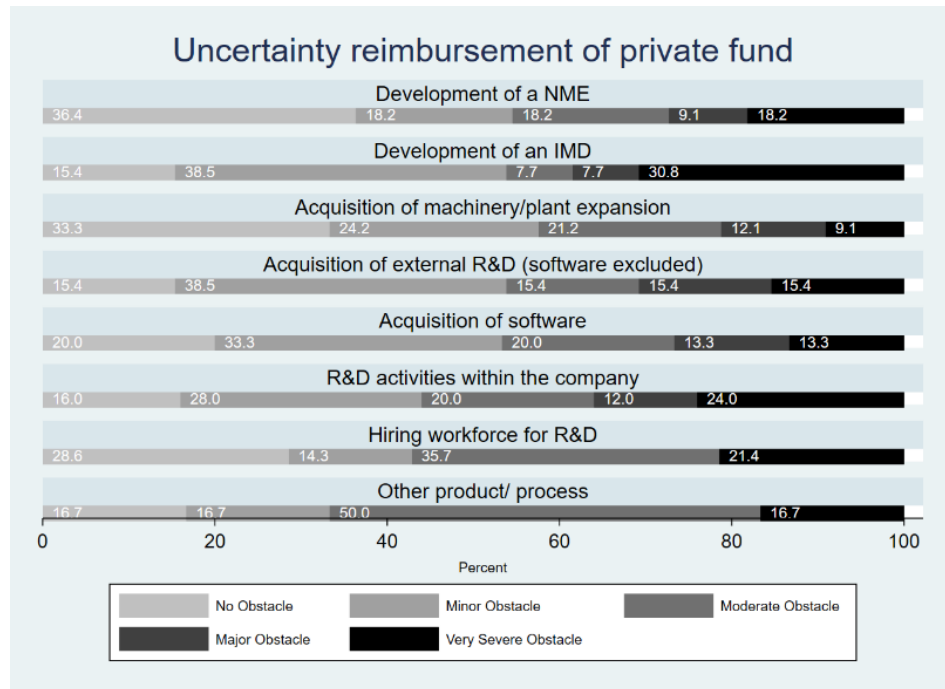
“*Bureaucratic Obstacles*” and “*Lack of tax incentives*” represent the most severe external obstacles that can be directly attributable to public institutions. In detail, “*Bureaucratic Obstacles*” are more related to product innovation practices, whereas “*Lack of tax incentives*” represents a crucial constraint also with referment to the acquisition of machinery or plant expansion. The following Figure 4.8 refers to the categories of external obstacles directly referable to national financial institutions.

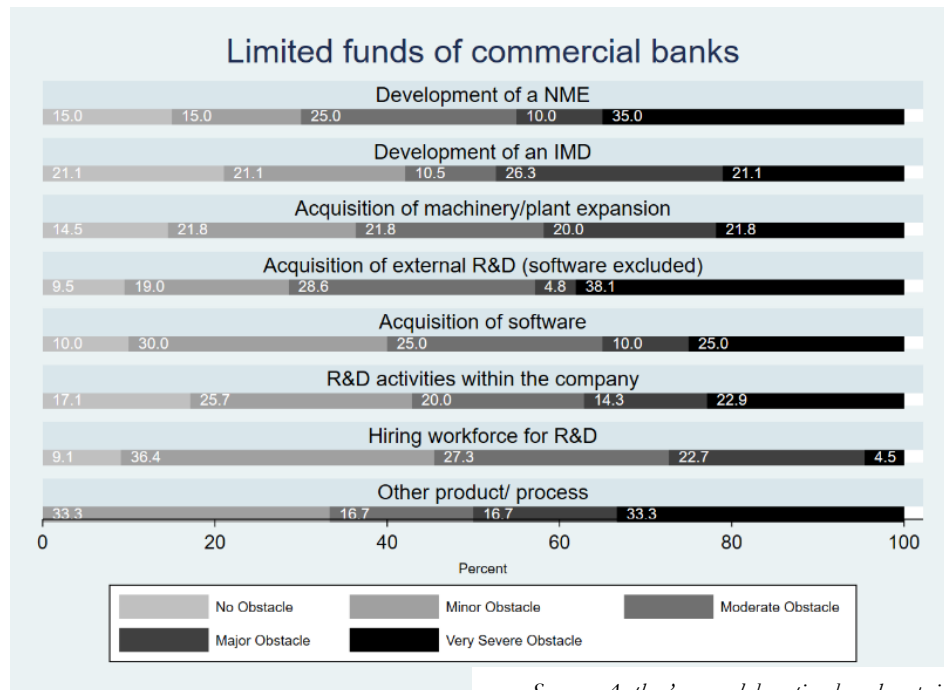
Figure 4.8 – External obstacles to innovation related to financial institutions

Figure 8 report the perceived severity of external obstacles to innovation related to financial institutions on a Likert scale:

"1. No Obstacle, 2. Minor Obstacle, 3. Moderate Obstacle, 4. Major Obstacle, 5. Very Severe Obstacle".

Obstacles are classified as: "Uncertainty about reimbursement of private fund", "Uncertainty about reimbursement of public fund" and "Limited funds of commercial banks".



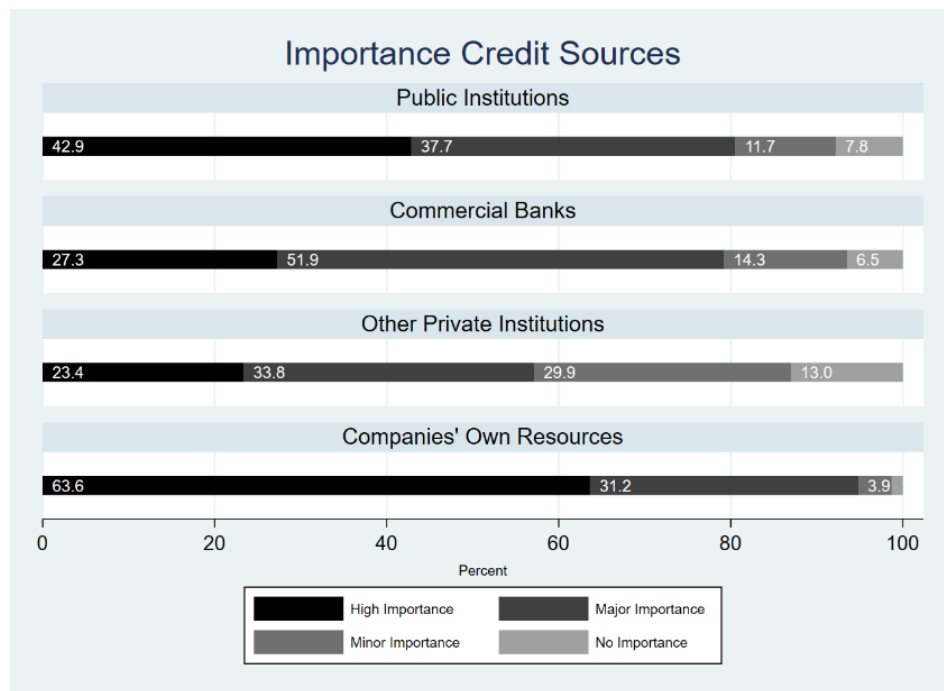


Source: Author's own elaboration based on primary data

The high incidence of severe and high severe replies relative to the “*Uncertainty about timing of repayment of public funds*” indicates the low perceived reliability of Brazilian pharmaceutical companies on public credit lines. It is also interesting to notice the difference between the reliability on public and credit funds, where commercial banks are reported to be more accurate about the timing of repayment of their credit lines with, however, limited reported availability of financial resources.

4.5.3. The degree of importance of different financial sources

In countries where underdeveloped national financial institutions do not provide adequate credit, one of the major companies' constraints is represented by the availability of external credit, which leads companies to mostly rely on their own financial resources. Section 2 of the questionnaire points the attention to companies' perceived degree of importance of different types of financial resources, by institutional source. The answers are reported in the Figure 4.9 below.

Figure 4.9 – Degree of importance of financial resources, by source

Source: Author's own elaboration based on primary data

Figure 4.9 reports the degree of importance of financial resources by source, on a Likert scale: "1. High Importance, 2. Major Importance 3. Minor Importance 4. No Importance".

As reported in the above Figure 4.9, Brazilian pharmaceutical companies mostly rely on internal financial resources to fund their innovation activities. Public financial resources represent the second most important type of credit whereas private financial resources, both from commercial banks or other private actors represent the least important type of credit, consistently with what expected due to the underbudgeting of the Brazilian private financial system.

4.5.4. BNDES Specific Funded Projects

Looking at the specific funded projects, this section presents the main characteristics of projects approved by BNDES. In detail, Table 4.6 below reports the share of companies receiving funding for at least one project in the last 5 years and their average number of approved projects, the average BNDES contribution and degree of complementarity of BNDES financial resources with other institutions' financial resources. Finally, it presents the share of companies with at least one project rejected by BNDES in the last 5 years and the average number of projects rejected and undertaken after the rejection.

Table 4.6 – BNDES approved projects²³

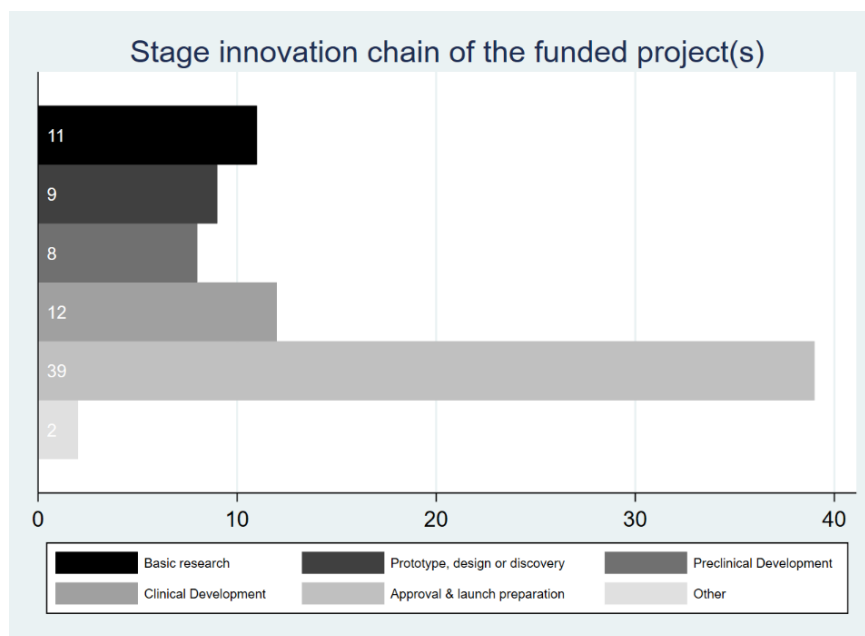
	N	Mean/%
Received Funding by BNDES	77	49.35%
Number of BNDES approved projects	38	1.84
Average BNDES contribution	31	57%
Received Other Financial Support	38	23.8%
Other Financial Support from Commercial Banks/ Other Private Institution	5	40%
Other Financial Support from Other Public Banks	3	36.7%
Other Financial Support from Public Direct	2	32.5%
Other Financial Support from Public - Indirect Subsidy/Tax Credits	2	35%
At least one project rejected by BNDES	70	11.4%
Number of BNDES rejected projects	8	3.25
Number of projects undertaken after BNDES rejection	5	2.60

Source: Author's own elaboration based on primary data

Table 4.6 reports the main descriptive statistics of the companies participating into the survey.

Roughly 50% of the companies present in the sample received funding for, on average, almost two projects in the last 5 years. Almost a quarter of the companies receiving funding from BNDES also received additional financial support from other sources, reporting a complementarity scenario between BNDES funds and financial resources from commercial banks and public institutions. Regarding the stage of the innovation chain of BNDES funded projects, Figure 4.10 below reports six stages including all life cycle of a pharmaceutical innovation activity, from the “Basic Research” stage, to the “Prototype, design and recovery”, “Pre-clinical development”, “Clinical Development” and “Approval & launch preparation” phase.

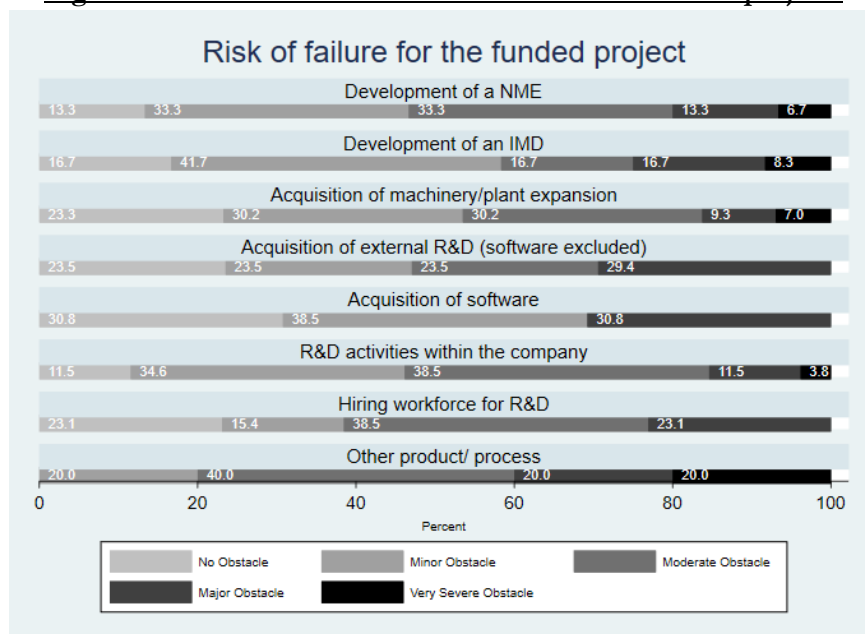
²³ The questions are about the last 5 BNDES funded projects.

Figure 4.10 – Stage of the innovation chain of the funded project(s)

Source: Author's own elaboration based on primary data

Figure 4.10 reports the number of projects funded by BNDES, by stage in the innovation chain.

Most of BNDES funded projects have been in the “*Approval & launch preparation*” stage, showing a preference of BNDES towards the commercialization phase of the investment. Findings also can be interpreted as a preference of BNDES towards projects that have already been successfully through the innovation chain and now are at the final stage, hence carrying a lower risk of failure. To investigate the risk profile of BNDES funded projects, the questionnaire asks respondents to identify the perceived degree of risk of the innovation activities that received financial support, as presented in Figure 4.11 below.

Figure 4.11 – Perceived risk of failure of BNDES funded projects

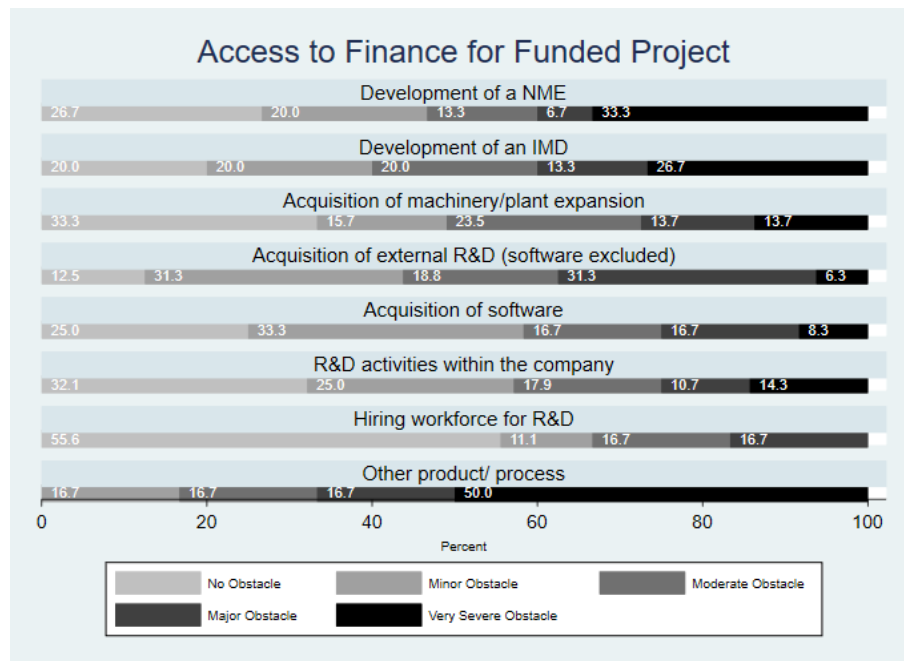
Source: Author's own elaboration based on primary data

Figure 4.11 reports companies' perceived risk of failure of BNDES funded projects.

The majority of BNDES funded projects are perceived by pharmaceutical companies as investments with low embedded risk. Particularly regarding product innovation activities, it is quite striking to notice the difference between the degree of perceived risks of general innovation activities reported in Figures 7 and 8 and the one associated to the funded projects reported in the above Figure 4.11. This difference indicates that BNDES tends to select low-risk types of projects, which are generally the type of investments that do not often lead to radical innovations. It is however important to highlight that incremental innovations, although not carrying any breakthrough outcome, can be important due to the high social returns, particularly in developing countries. The case of the “*me too*” drugs represents an example of the importance of outcomes combining very low innovative power together with high social returns. In light of the responses presented in Figure 4.11, the role of BNDES in pharmaceutical innovation seems to have been more focused towards social returns rather than towards the funding of investments with potentially breakthrough-innovative outcomes. Such findings are in line with the developmental role of BNDES and industrial policies for the pharmaceutical sector put in place since 2004.

In developing countries where financial resources are limited and expensive like in Brazil, it is likely that even low-risk investments face financial constraints. For this reason, the survey investigates the degree to which access to alternative sources of finance was a problem for the funded investments, for which results are reported in the following Figure 4.12.

Figure 4.12 – Access to alternative source of finance for the BNDES funded project(s)



Source: Author's own elaboration based on primary data

Figure 4.12 reports companies' the extent to which access to alternative sources of finance was a problem for the BNDES funded project(s)

Even though projects funded by BNDES seem to not be characterized by particularly high risk of failure, the scarcity of available financial resources still represented a major or very severe obstacle, particularly regarding the investments in innovative products. It therefore seems that a major financial constraint for Brazilian pharmaceutical companies is to be attributed to the lack of resources even for low-risk types of investment that are, in turn, funded by the development bank. One of the causes of the high perceived degree of obstacle attributable to access to finance is represented by the high Brazilian interest rate that makes financial resources highly expensive. A way to verify this hypothesis is to see whether companies had alternative sources of finance at the time investment but they still preferred BNDES as money lender and the reason beyond this choice. The next Table 4.7 reports the responses on the presence of alternative sources of finance followed by Figure 4.13 reporting the reasons behind the choice of BNDES regardless the presence of possible alternatives.

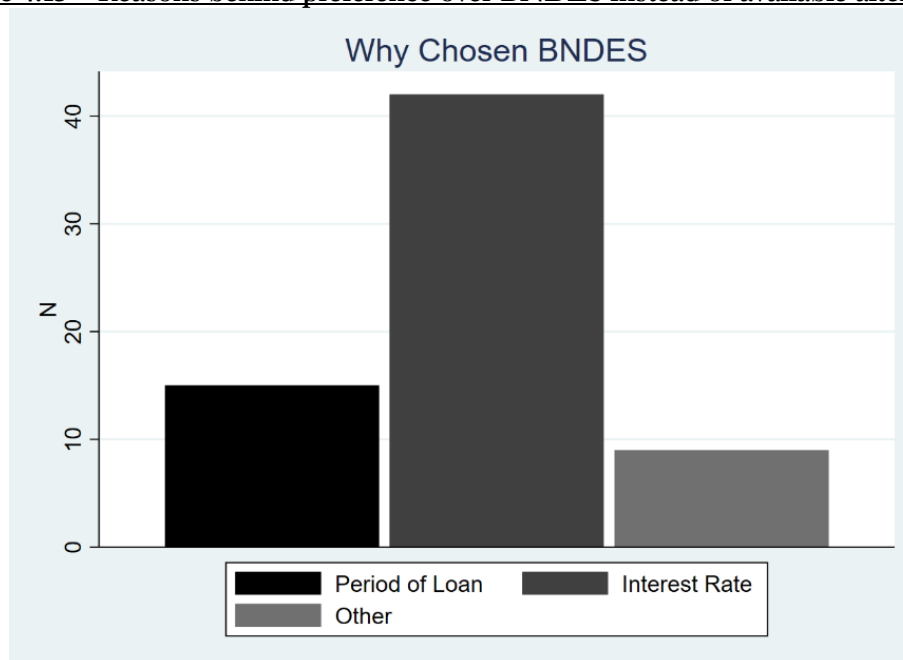
Table 4.7 – Alternative to BNDES funding

Alternative to BNDES funding	
No	29.2%
Yes	70.8%

Source: Author's own elaboration based on primary data

Table 4.7 reports the responses on the presence of alternative sources of finance to BNDES for the funded project(s).

More than two-third of the companies reported the presence of an alternative source of finance for the BNDES funded projects, suggesting that the lack of available resources may be related to causes other than purely shortage of funds and more related to other factors such as length or high cost of the loans. Figure 4.13 below reports companies' responses on the reasons behind the preference over BNDES finance even in presence of alternative sources of financial resources.

Figure 4.13 – Reasons behind preference over BNDES instead of available alternatives

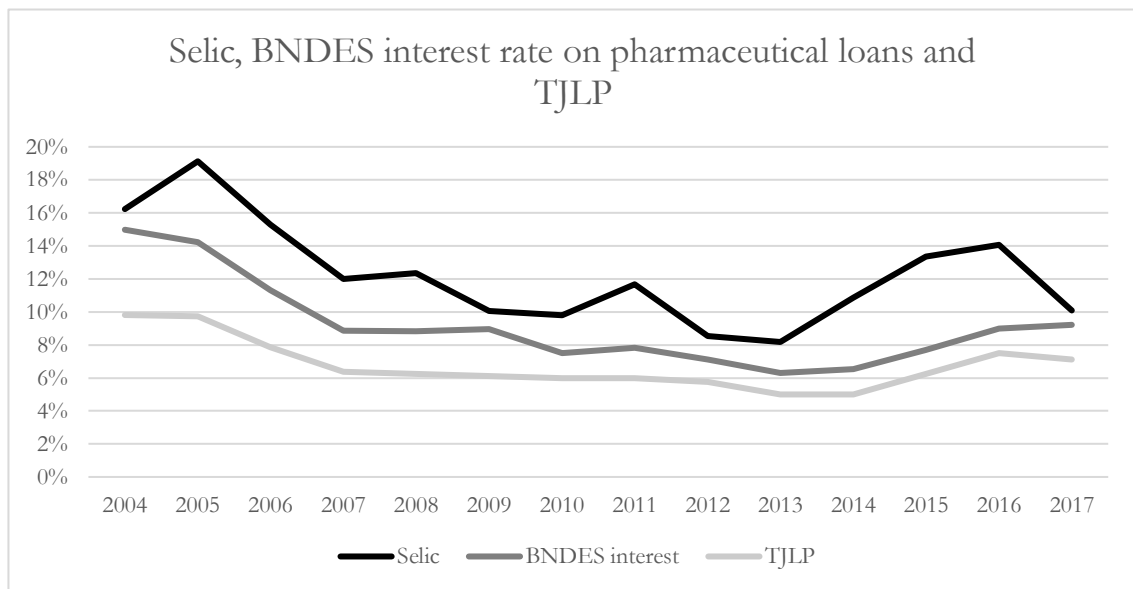
Source: Author's own elaboration based on primary data

Figure 4.13 reports the reasons behind preference over BNDES even in presence of alternative sources of financial resources.

The main reason behind companies' preference over BNDES seems to be related to the lower interest rate applied by the development bank, followed by the length of the loans. Among other reasons, bureaucratic simplicity represents, interestingly, a value added of BNDES' support. This scenario can be interpreted in two ways: it might indicate a crowding-out scenario in which the preference over BNDES only depends on the lower-than-market interest rate applied to its loans or it may also indicate that interest rates applied by commercial banks are too high to leave companies indifferent in the selection of the sources of funds. The likelihood of a possible crowding-out scenario of BNDES over commercial banks' resources is positively related to the size of the difference between the TJLP, the long-term interest rate at which BNDES loans are pegged²⁴ (to which BNDES applies a spread²⁵), and the overnight interest rate, Selic, set by the Central Bank and at which commercial banks will in turn have to apply their own spread. The following Figure 4.14 reports the development of the Selic, TJLP and average BNDES interest rate for the loans issued to pharmaceutical companies and pegged to the TJLP.

²⁴ Not all BNDES loans are pegged to the TJLP. The percentage of BNDES loans to pharmaceutical companies pegged to TJLP is equal to 47%. The remaining loans are pegged to the TFB, the BNDES fixed rate (25% of the loans), Extended Consumer Price Index, IPCA (18% of the companies), fixed interest rate plus variation of the US dollar (12%), Selic (6%), TJ462 equal to TJLP+1% or are issued without any interest rate (24%).

²⁵ The spread in BNDES loans can also be represented by the spread of the commercial financial institutions in case of BNDES indirect loans (to know more about BNDES financial instruments, please refer to the Introduction of the thesis)

Figure 4.14 – Brazilian interest rates 2004-2017

Source: Author's own elaboration based on BCB and primary data

Figure 4.14 reports the development of Selic, average interest rate applied to BNDES loans for pharmaceutical companies and TJLP over the period 2004-2017.

Over the period 2004-2013, it is possible to observe a convergence between TJLP and Selic interest rate, with a steep decrease of the overnight interest rate that almost halved. After 2013, the Selic interest rate observed a rapid increase at faster rate than the long-term interest rate, TJLP. Looking at the spread between the average BNDES interest rate applied to loans for pharmaceutical companies and the overnight interest rate, it is not possible to exclude the presence of a crowding-out scenario of BNDES resources over commercial banks' activity. The interest rate applied by BNDES is consistently 2-3 percentage points lower than the rate at which commercial banks fund themselves and to which they will have, in turn, to apply their own spread. This situation has the outcome of pushing private financial resources out of market due to the higher cost, probably the most typical neoclassical example of financial repression. At the same time, the presence of high interest rates, starting from the long-term TJLP rate, should raise some questions about companies' feasibility to invest in projects with high cost, high embedded risk of failure and low level of returns in R&D investments. If companies' decisions on whether proceeding with an investment are driven by a cost-benefit analysis, an investment will be made only if the costs, including the cost of funding, are not greater than the level of economic returns.

A way to establish whether public financial resources can be accused of crowding-out is to establish whether the same investment would have been anyway done, even without public financial resources. The following Figure 4.15 reports companies' responses on the hypothetical counterfactual in which BNDES would have not provided funds for the investment.

Figure 4.15 – If BNDES would have not funded this investment, would you have invested in the same project?



Source: Author's own elaboration based on primary data

Figure 4.15 reports companies' responses on whether the same investment would have been done even without BNDES financial support.

Responses presented in Figure 4.15 highlight a scenario in which public financial resources have not created that additional public spending is expected to generate. In detail, BNDES financial resources seem to have funded investments that would have happened anyway, possibly at higher financial costs that would, however, not discouraged companies to still invest in such projects. The role of public financial institutions in supporting those investments that are usually discarded by the private financial sector (Minsky 1981; Haldane and Davies 2011) and in creating outcomes that would have not happened without their support (Mazzucato and Penna 2014), does not seem to be appropriate to describe BNDES activity in the pharmaceutical sector in the last 5 years.

4.6. Conclusions

This chapter presents evidence for innovation activities in the Brazilian pharmaceutical sector and the role of the Brazilian development bank, BNDES. Results present companies' perceived risk environment for innovation activities, the degree of importance of different sources of financial resources and eventually focus on the specific projects funded by BNDES.

Innovation activities in the pharmaceutical sector are characterized by high risk of failure and low returns in R&D investments, making financial resources scarce and expensive. In developing countries like Brazil, the absence of adequate financial resources is even more exacerbated due to

the presence of high interest rates and in these contexts, one of the roles of development banks is to provide access to credit for companies that would not otherwise have it. In such way, public financial resources should contribute in reducing obstacles for activities that would have not otherwise happened. At the same time, the presence of development banks can represent an obstacle to the development of the private financial system, due to misallocation of resources arising from crony capitalism or selection of the best candidates that could have obtained funds from commercial banks, hence crowding-out private financial institutions' activity.

4.6.1. Obstacles to innovation activities for pharmaceutical companies

The first set of results, looking at obstacles to innovation activities, presents companies' perception about obstacles classified as internal and external, depending on the origin of such constraints to innovation activities. Among obstacles directly attributable to company's internal factors, lack of qualified human capital represents the main obstacle for product innovation activities while high risk of failure represents an important obstacle to process innovation activities. Among external obstacles, high level of bureaucratisation and lack of tax incentives represent, equally, the major constraint.

4.6.2. The importance of different sources of financial resources

The second set of results of this chapter reports the degree of importance of different sources of financial resources, showing companies' preference towards own financial resources, followed by public financial resources and, lastly, resources coming from the private financial sector. The preference of pharmaceutical companies towards own financial resources is a signal of low the weakness of Brazilian financial institutions in supplying the necessary financial resources.

4.6.3. The BNDES funded projects

Finally, the chapter presents findings on the specific projects funded by BNDES showing that, while BNDES seems to have not adopted any *picking-winner* or *picking-looser* strategy in selecting which companies to fund, it seems however that its activity might have not generated additionality, in terms of promoting activities that otherwise would have never happened. This is shown by the high incidence of respondents declaring that the same project would have anyway happened without BNDES' support. The preference for BNDES resources due to the lower interest rate indicates, on contrary, that the activity of the Brazilian development bank might have crowded-out both commercial banks disbursement and companies' own commitment. At the same time, this preference for lower interest rates has to be contextualized in the Brazilian economy, where high interest rates make financial resources very expensive, which might persuade private companies from requesting a loan from the private financial sector.

4.6.4. Policy recommendations and concluding remarks

In terms of policy recommendations, the presented scenario in which public financial resources are supporting investments that would have anyway happened, should represent a major concern for Brazilian policy makers. If the scope of public financial institutions is to push activities of national industry beyond the actual frontier through provision of adequate financial resources, public credit suppliers should ascertain the indispensability of their financial resources for the activity to take place. On contrary, the risk is that companies will end up preferring public financial institutions only because of the lower interest rate applied to their loans, whereas they should be addressed towards challenging investments usually disregarded by the private financial sector due to the high embedded risk of failure.

5. Conclusions

This thesis presented an analysis on the role of the Brazilian development bank, BNDES, with its recent role as primary public lender of financial resources for innovation activities, and generally, for industrial development, since 2004²⁶. Being the second-largest development financial institution in the world, BNDES is an interesting case study on the use of a large amount of public financial resources targeted towards goals identified by “*mission-oriented*” industrial policies. The overarching research question of the PhD thesis has been about the investigation of the role of BNDES in incentivizing greater commitment in R&D resources for both companies and commercial banks. More in detail, this thesis engaged with mainly the first accusation moved to development banks, as presented in Mazzucato and Penna (2014):

- i)* Financial repression and crowding-out
- ii)* Misallocation of resources due to political biases
- iii)* Incapacity to “*pick winners*”
- iv)* Inefficient governmental structure

The first chapter presented an introduction about the role of development banks and discussed related literature. The following second and third chapters quantitatively evaluated the activity of BNDES over the past years. These two chapters have investigated whether BNDES activity have crowded-out either commercial banks’ activity or companies’ financial commitment in innovation activities. Finally, the fourth chapter proposed qualitative evidence, using primary data, on BNDES activity in the pharmaceutical sector, together with companies’ perception on constraints affecting innovation activities.

5.1. Summary of Findings: Is BNDES activity crowding-in or crowding-out financial resources from the private sector?

Findings of this PhD thesis show that, although quantitative evidence does not indicate any financial repression and crowding-out of BNDES activity, qualitative findings on the pharmaceutical sector reveal that companies mainly prefer financial resources from BNDES due

²⁶ And ended in 2017

to the lower than market interest rate applied to its loans and, further, that investments funded by BNDES would have anyway been undertaken by the company.

Results of the second chapter show that, while during the period 2002-2008 BNDES had no impact on commercial banks' disbursement, the countercyclical role assumed by BNDES at the beginning of the financial crisis in 2008 had a positive impact on the amount of financial resources disbursed by Brazilian private banks. Evidence from the third chapter highlights a scenario in which companies have increased their level of R&D intensity after receiving funding from BNDES. Further, while there is no quantitative evidence on crowding-out of BNDES activity on both commercial banks' disbursement and companies' financial commitment, the qualitative evidence suggests that companies in the Brazilian pharmaceutical sector have preferred BNDES, in presence of alternative sources of funding, mainly due to the lower interest rate applied by the development bank. Pharmaceutical companies also declared that the funded investment would have anyway happened in absence of financial resources from BNDES. The combination of the findings emerging from the qualitative evidence seems to present an exception on the activity of the Brazilian development bank, possibly given by the peculiarity of innovation activities of pharmaceutical companies in developing countries, where high interest rates are combined with high risk associated to those investments.

5.1.1. The impact of BNDES resources on commercial banks' disbursement

Findings of the second chapter provide empirical evidence to the debate about additionality/substitutability of private and public financial resources. Results presented in the chapter show that, for the period 2002-2016, BNDES activity had an additional impact on financial resources disbursed to companies by commercial banks. More importantly, results show an increase in additionality, simultaneously, with the adoption of a countercyclical role by BNDES, at the beginning of the 2008 financial crisis. This evidence presents the Brazilian development bank as an efficient government tool that has been able to transmit countercyclical policy decisions without hampering, and on contrary fostering, the development of national commercial banks.

5.1.2. The impact on companies' R&D intensity

The third chapter quantitatively evaluates the impact of receiving funding from BNDES on companies' commitment in innovation activities. Results, over the period, 2003-2011, show a positive impact of receiving a loan from BNDES on the level of R&D intensity of the recipients. Further, the analysis reports heterogeneous impacts of different financial resources received,

depending on the source of the credit, also within different public financial resources, where the coefficients associated to BNDES and other public financial resources report opposite signs.

5.1.3. *The role of BNDES for the Brazilian pharmaceutical sector*

The fourth chapter provides qualitative evidence on the role of BNDES in funding innovation activities for the pharmaceutical sectors. The results, produced with the use of primary data collected by means of survey, report companies' perceived risk environment for innovation activities, the degree of importance of different sources of financial resources and eventually focus on the specific projects funded by BNDES. Findings report lack of qualified human capital, high embedded risk of failure, high level of bureaucratization and low tax incentives as the major obstacles to innovation activities in the Brazilian pharmaceutical sector. Further, results highlight that companies mostly rely on their own financial resources, indicating scarce access to credit for innovation activities. Finally, while BNDES shows to have not adopted any *picking-winner* or *picking-loser* strategy in selecting companies to fund, it emerges that the main reason why companies preferred funding from BNDES, instead of available alternatives, is due to the lower-than-market interest rate applied to its loans. Further, findings reveal that the projects funded by BNDES would have likely happened even without BNDES financial resources. The combination of these findings for the Brazilian pharmaceutical sector should encourage further research to better understand the financial necessities of companies operating in a peculiar sector as pharmaceutical and biotech.

5.2. Limitations and Future Research

Different limitations emerged, particularly regarding the third and fourth chapter, due to the necessity to work with confidential data for the former and collecting primary data for the latter.

Regarding the third chapter, it would be interesting to test the robustness of the results by including the 2014 wave of both industrial and innovation surveys that became available once the fieldwork was terminated.

Regarding the survey conducted for the fourth chapter, budget and time constraints represented the main limitations. It would be also interesting to follow-up with the interviews in the next years to construct a panel dataset, to be able to reveal changes over time, and extend this analysis to other countries.

5.3. Concluding Remarks and Policy Implications

The purpose of this thesis has been to contribute to the debate on the role of development banks in providing financial resources for industrial development. The topic belongs to a bigger strand of literature on the impact of public financial resources and on how governments should address them to the real economy. While the activity of the Brazilian Development Bank did not displace commercial banks' disbursement to the industry, nor companies' financial resources, it however emerges, from the qualitative evidence, that pharmaceutical companies preferred BNDES resources mainly due to the lower-than-market interest rate applied to its loans. Further, it also emerged that funded projects in the pharmaceutical sector would have anyway happened without the financial support from the development bank. Such scenario, other than attracting critiques about the displacement of financial resources in the economy and consequent obstacles to the development of national private institutions, should concern policymakers about the non-incisiveness of BNDES in going beyond the actual frontier of investment. In other words, a *"mission-oriented"* type of public finance should address its resources towards investments, possibly with high social returns, that otherwise would have not happened due to lack of credit as a consequence of the high embedded risk. On contrary, public resources, while still providing financial resources to the national industry, will fail in pushing the frontier of investment beyond its national threshold, funding investments that would have anyway taken place hence not providing that additionality this type of finance is required to generate.

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Appendix

A1.1 The Brazilian industrial policy context

In March 2004, Brazilian administration, working closely with BNDES, introduced an **Industrial, Technological, and Foreign Trade Policy (PITCE)**, under which government export promotion programmes were integrated into industrial development programmes, targeting sectors with high innovation capacity and with a view to increasing competitiveness. The priority sectors chosen in the PITCE framework were pharmaceuticals, semiconductors, computer programs and capital goods (Hermann 2010). According to the Ministry of Development, Industry and Foreign trade (MDIC), PITCE's final goal is to induce economic growth through increased competitiveness, technological update and increase in productivity (Federal 2003); the agents involved in this new industrial policy are both public and private, all complementary to the achievement of economic growth, which will be the result of industrial and social development. Industrial policy is therefore part of the bigger economic development plan started by Brazilian government and comes together with other development policies issued during the same years. According to the Ministry of Development, Industry and Foreign trade (MDIC), PITCE is structured following three complementary axes:

- ***Horizontal action lines:*** focusing on innovation and technological development, international insertion, industrial modernization, production capacity and scale.
- ***Strategic options:*** targeting the priority sectors chosen in the PITCE, *semiconductors, software, capital goods and pharmaceutical.*
- ***Activities with future perspectives:*** focusing on the future strategic industrial sectors for Brazilian economic development, *biotechnology, nanotechnology, biomass and renewable energies.*

However MDIC guidelines highlight that without horizontal policies, sectoral industrial policies are inefficient because of their transiency and their specific targets (Pereira, Marcelino et al. 2006); therefore MDIC guidelines stress the importance of permanent horizontal policies as priorities in order to develop a healthy industrial sector. These horizontal measures, for all the industrial sectors, are focused on investment on education and infrastructure, to increase flexibility in the labour market, to develop the capital market by reducing the interest rate and to provide a fiscal reform.

In December 2004, Brazil passed the **Innovation Law**, which allowed researchers in Public Research Organizations (PROs) and federal universities to leave their post for up to three years, maintaining pension benefits and career evolution rights, to create a technology-based start-up

and promotes the establishment of technology transfer offices (TTOs) in PROs and federal universities among other provisions, which came into effect in December 2005. A major change brought about by the Innovation Law and its subsequent regulatory measures was in the realm of innovation financing. The law established a new legal framework to allow the provision of innovation subsidies directly to firms. Previously the government had to finance corporate R&D and innovation projects either through grants to individual researchers collaborating in corporate projects or university and public research organizations in cooperative projects with firms (Balbachevsky and Botelho 2011).

In the wake of the Innovation Law, the government launched the **Good Law**. This Law created a set of favourable fiscal incentives and tax regime depreciation schemes for R&D investments. It permits automatic use of fiscal benefits for companies that invest in R&D, and are within requirements, without any need for a formal request, accelerating and expanding the scope of incentives for investments in innovative activities. It comprises deductions from income tax and social contributions on net profits.

In November 2007, the Government launched the 2007-2010 **Action Plan for Science Technology and Innovation (PACTI)**. This Plan expresses the new configuration of the National Policy of Science, Technology and Innovation and reflects the expectation that the Ministry of Science and Technology (MCT) act in a more intense and crucial way to the economic and social development of the country. According to the plan joint initiatives will be strengthened between the MCT and other ministries, states of the federation, municipalities and the business sector, still counting with the participation of other relevant government agencies and public owned enterprises, such as the BNDES and Petrobrás.

Following the new active interventionist approach, Brazilian government kept on stimulating the industrial sector, issuing in 2008 a new industrial policy entirely in line with the previous one's focus on competitiveness and innovation of the Brazilian industrial sector, the **Productive Development Policy (PDP)**. PDP aims at increasing public investments and encourage private investments in R&D through different kinds of incentives and actions. The priority goal is to provide sustainability to the current growth cycle with different actions: expanding supply capacity, preserving balance of payment's strength, improving innovation capacity and strengthening SMEs.

In 2011 a new industrial policy, the **Brazil Plano Maior**, aimed at increasing industrial competitiveness through innovation ("*Innovate to compete. Compete to grow*") for the period 2011/2014. The focus is on innovation and technological development to sustainably create and reinforce strategic competencies in the economy, increase productivity and technology density, increase domestic and international market share of Brazilian companies. The sectoral programs are focused on strengthening the production chains, allowing the creation on new technological

and business competencies, to develop the energy supply chain, promoting export diversification and R&D of foreign companies and to consolidate competencies in the natural knowledge economy. The systemic programs are the cross-sectional priorities involving the whole Brazilian industrial scenario. The focus is on foreign trade, incentives for investments and innovation, professional education and qualification, sustainable production, competitiveness of SMEs, regional industrial development and consumer welfare.

The **National Science, Technology and Innovation Strategy (ENCTI)**, launched in 2012, one year after the previous innovation policy, PACTI, was expired. The strategic sectors indicated in the ENCTI are the following:

Table A5.1 - Strategic industrial sectors in the National Science, Technology and Innovation Strategy (ENCTI)

Common to the Brasil Plano Maior	Only part of ENCTI
ICT	Nuclear
Pharmaceuticals and Health industry Complex	Innovation Border:
Oil and gas	Biotechnology
Defence Industrial Complex	Nanotechnology
Aerospace	
Promotion of green economy (renewable energy, climate change, biodiversity, oceans and coastal zones)	
ST&I for social development (diffusion and improvement in science education, productive inclusion and social technology, and technologies for sustainable cities)	

Finally, in 2013 the new industrial policy, **Inova Empresa** aims at increasing the level of private R&D, engage companies in riskier technological projects and decentralize the plan implementation to reduce bureaucracy and to be more accessible for micro and small enterprises. The agents actively participating in the program are FINEP, the Ministry of Science and Technology (MCTI) and BDNS. Brazilian red tape has always been one of the major constraints in the Brazilian economy and to overcome this problem the new policy aims at centralising the disbursement of resources for corporate technological innovation by reducing the bureaucracy.

A1.2 Brazilian Industrial Policies and targeted industrial sectors

2004 - 2007: PITCE – Política Industrial, Tecnológica e de Comércio Exterior

According to the Ministry of Development, Industry and Foreign trade (MDIC), PITCE is structured following three complementary axes:

- **Horizontal action lines:** focusing on innovation and technological development, international insertion, industrial modernization, production capacity and scale.
- **Strategic options:** targeting the priority sectors chosen in the PITCE, **semiconductors, software, capital goods and pharmaceutical.**
- **Activities with future perspectives:** focusing on the future strategic industrial sectors for Brazilian economic development, biotechnology, nanotechnology, biomass and renewable energies.

2008 - 2011: PDP - Productive Development Policy

Aiming to increase public investments and encourage private investments in R&D through different kinds of incentives, the PDP is designed as a 3-level policy where:

- **Level 1: Systemic actions** are focused on factors generating positive externalities for the entire productive sector. Interfacing with other national policies, they aim at lowering tax burden on investments, providing more funds for capital investment at lower interest rate, more funds for innovation, reduce Brazilian red tape and improving foreign trade regulation.
- **Level 2: Structuring programs for productive systems** are guided by strategic objectives taking in consideration the diversity of the Brazilian industrial sector. The areas of interest are:
 - **Programs for strategic industries: 6 programs:** healthcare, ICTs, Nuclear energy, defense, nanotechnology and biotechnology.
 - **Programs to consolidate and expand leadership: 7 programs:** aeronautic, oil, gas and petrochemical, bio-ethanol, mining, steel, cellulose and meat industry. Coordinated by BNDES
 - **Programs to strengthen competitiveness: 12 programs.** Coordinated by MDIC
- **Level 3: Strategic highlights: 5 programs,** where public policies intervene in strategic areas for the long term productive development. Coordinated by the Agency for industrial development (ABDI).

2011 – 2014: PBM - Plano Brazil Maior

To increase industrial competitiveness through innovation (*“Innovate to compete. Compete to grow”*) for the period 2011/2014.

The main actions promoted in the Brasil Maior Plan are regarding:

- **Incentives for investment and innovation:** through tax relief, direct and indirect funds and a legal framework for innovation
- **Foreign trade:** introduction of tax reliefs, trade remedies, financing and guarantees for exports and trade promotion
- **Industry and domestic market defence:** introduction of tax exemption on payroll, special automotive regime, government procurement and harmonization of funding policies.

The priority goals are:

- **Increase ratio fixed investment/GDP** from 18.4% in 2010 to 22.4% in 2014
- **Increase ratio corporate spending on R&D/GDP** from 0.59 in 2010 to 0.90% in 2014 (based on the National Strategy for Science and Technology)
- **Increase human resource qualification** as percentage of industry workers with at least secondary education, from 53.7% in 2010 to 65% in 2014
- **Increase value added in manufacturing** as VALUE ADDED/TURNOVER ratio (VIT/GVP) from 44.3% in 2009 to 45.3% in 2014
- **Increase percentage of knowledge intensive manufacturing** as value added of high-tech manufacturing/total manufacturing value added from 30.1% registered in 2009 to 31.5% for 2014
- **Strengthen SMEs enterprises**, increasing the number of innovative SMEs by 50% from 37100 in 2008 to 58000 in 2014
- **Promote clean production** reducing energy consumption per unit of industrial GDP (energy consumption in ton of oil equivalent – toe per unit of industrial GDP) from 150.7 ton/R\$ million in 2010 to 137 ton/R\$ million in 2014 (at 2010 constant prices)
- **Diversify exports by increasing the country’s share in the global market** from 1.36% in 2010 to 1.6% in 2014
- **Develop the national energy market** by increasing the ratio of value added/gross turnover of energy-goods manufacturing from 64% in 2009 to 66% in 2014
- **Increase access to goods and services for improving quality of life**, by increasing the number of urban households with broad band access (National Broad Band Plan), from R\$ 13.8 million registered in 2008 to R\$ 40 million in 2014

A1.3 Innovation Policies

2007 - 2010: PACTI - Action Plan for Science Technology and Innovation

Four priority axes characterize the PACTI:

- **Expansion and Consolidation of the ST&I System:** through the institutional consolidation of national ST&I system, human resources capacity building in ST&I and support to S&T research infrastructure. The priority goals were expanding state and municipal partnerships, increasing international cooperation and increase the number of PhD awards per year, focusing on strategic sectors as engineering.
- **Promotion of technology innovation in business:** through financial support to innovation, technology in support of innovation by enterprises and incentives to start-ups and consolidation of technology-intensive companies. The priority goal was to increase R,D&I expenditure from 0.51% to 0.65% of GDP by 2010, increasing the number of instruments in support of technological innovation.
- **R&D in strategic areas:** the strategic areas highlighted in the PACTI are:
 - Biotechnology and nanotechnology
 - ICT
 - Inputs for health sector
 - Biofuels, electric energy, hydrogen and renewable energies
 - Oil, gas and coal
 - Agribusiness
 - Biodiversity and natural resources
 - Development of the Amazon and semi-arid region
 - Meteorology and climate change
 - Space Program
 - Nuclear Program
 - National defence and public security
- **S&T for social development**

2012 – 2015: ENCTI - National Science, Technology and Innovation Strategy

The main goals are:

- **Increase GERD** by increasing the ratio GERD/GDP from 1.16 in 2010 to 1.8 in 2014 (same goal of Brasil Maior Plan)

- **Increase BERD** by increasing the ratio BERD/GDP from 0.56 in 2010 to 0.9 in 2014
- **Increase the innovation rate** by increasing the share of industrial firms involved in innovation from 38.6% in 2010 to 48.6% 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 of the government innovation support measure** from 22.3% in 2010 to 30% in 2014

The strategic sectors indicated in the ENCTI are the following:

- **Common to the Brasil Plano Maior:**
 - ICT
 - Pharmaceuticals and Health industry Complex
 - Oil and gas
 - Defence Industrial Complex
 - Aerospace
 - Promotion of green economy (renewable energy, climate change, biodiversity, oceans and coastal zones)
 - ST&I for social development (diffusion and improvement in science education, productive inclusion and social technology, and technologies for sustainable cities).
- **Only part of ENCTI:**
 - Nuclear
 - Innovation Border (biotechnology and nanotechnology)

2013 - 2014: Inova Empresa

Brazilian red tape has always been one of the major constraints in the Brazilian economy. To overcome this problem, Brazilian government in 2013 launched a new policy aimed at centralising the disbursement of resources for corporate technological innovation by reducing the bureaucracy. The Inova Empresa Plan's macro goals aim at increasing the level of private R&D, engage companies in riskier technological projects and decentralize the plan implementation to reduce bureaucracy and to be more accessible for micro and small enterprises. The agents actively participating in the program are FINEP, the Ministry of Science and Technology (MCTI) and BDNES.

The targeted sectors are:

- Information and Technology
- Social and environmental sustainability
- Aerospace and defense
- Health
- Oil and gas
- Energy
- Agriculture

A1.4 Fiscal incentives and subsidy programs

- **2004: Brazilian Innovation Law** → facilitates private/public research partnerships and the transfer of innovation from public research institutions to the private sector
- **2005: Good Law** → Fiscal incentives to invest in R&D

Table A5.2 – Number of BNDES loans by financial product and associated financial instrument

Product	Instrument	Product	Instrument
BNDES AUTOMÁTICO	Inovagro	443	Psi - Inovação
	Psi - Inovação	76	Bndes Inovação
	Capacidade Produtiva Na Indústria, Agric..	11	Capacidade Produtiva - Demais Industr..
	Outros	10	Capacidade Produtiva - Comércio, Turis..
	Psi - Capital Inovador	8	Linha De Apoio Ao Comércio E Serviços 3
	Micro, Pequenas E Médias Empresas	6	Linha De Apoio Ao Comércio E Serviços 4
	Indústria, Agropecuária E Infraestrut..	3	Linha De Apoio À Indústria 2
	Bndes Mpmc Inovadora	2	Linha De Apoio À Indústria 3
	Bndes Profarma	1	
	Psi - Bk - Demais Itens	1	
BNDES FINEM	Bndes Prosoft	166	BNDES LIMITE DE CRÉDITO
	Psi - Inovação	86	
	Bndes Inovação	21	
	Bndes Profarma	21	
	Inovação Produção	19	
	Psi - Inovação Tecnológica	19	
	Capacidade Produtiva - Demais Industr..	16	
	Psi - Proengenharia	16	
	Outros	14	
	Bndes Prodesign	13	
BNDES FINAME	Others	(+ 26)	FUNDOS
	Psi - Bk - Tecnologia Nacional	90	
	Psi - Inovação - Bk Eficientes	27	
	Outros	3	
	Funtec	109	
	Fundo Amazônia	8	
	Inovagro	59	
	Issued by Bndespar		
BNDES NÃO REEMBOLSÁVEL			DEBÊNTURES CONVERSÍVEIS
BNDES FINAME AGRÍCOLA			OPERACÃO FINANCEIRA
REDA VARIÁVEL			OUTROS
REDA VARIÁVEL			BNDES FINAME LEASING
Total		1,444	

Table A5.3 – Correlation coefficients

	<i>Loans growth rate_t</i>	<i>GDP growth rate_{t-1}</i>	<i>Inflation_{t-1}</i>	<i>Interest Rate (Selic)_t</i>	<i>BNDES Innovation_{t-1}</i>	<i>BNDES FINAME_{t-1}</i>	<i>Liquidity_t</i>	<i>Size_t</i>
<i>Loans growth rate_t</i>	1							
<i>GDP growth rate_{t-1}</i>	0.1459*	1						
<i>Inflation_{t-1}</i>	-0.0692	-0.3527*	1					
<i>Interest Rate (Selic)_t</i>	-0.1270*	-0.8004*	0.5151*	1				
<i>BNDES Innovation_{t-1}</i>	0.1358*	0.7847*	-0.3315*	-0.7474*	1			
<i>BNDES FINAME_{t-1}</i>	0.1443*	0.8073*	-0.3700*	-0.7773*	0.7376*	1		
<i>Liquidity_t</i>	0.0465	-0.0615	0.0243	0.0536	-0.0597	-0.0605	1	
<i>Size_t</i>	0.6306*	0.0664	-0.0451	-0.0568	0.0564	0.063	0.0131	1

* p<0.05

Table A2.11 presents correlation coefficients for the variables used in the model. All coefficients are below (the absolute value) 0.811, which is the limit indicated by Kennedy (1985)

Table A5.4 – GMM Two-steps estimation results – All Sample with Selic interest rate

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Loans growth rate</i> _{<i>t</i>-1}	0.822*** (0.087)	0.704*** (0.082)	0.804*** (0.085)	0.807*** (0.087)	0.728*** (0.084)	0.797*** (0.082)
<i>GDP growth rate</i> _{<i>t</i>-1}	-1.663 (1.048)	-1.586* (0.898)	-1.585 (1.010)	-3.139* (1.624)	-4.124*** (1.433)	-3.147** (1.533)
<i>Interest Rate (Selic)</i> _{<i>t</i>}	0.011 (0.020)	0.017 (0.017)	0.008 (0.021)	-0.003 (0.021)	-0.005 (0.019)	-0.007 (0.021)
<i>Inflation</i> _{<i>t</i>-1}	-0.043 (0.028)	-0.039* (0.023)	-0.043 (0.029)	-0.025 (0.026)	-0.013 (0.024)	-0.023 (0.027)
<i>BNDES Loans Innovation</i> _{<i>t</i>}	0.157** (0.075)	0.145** (0.066)	0.153** (0.072)			
<i>BNDES FINAME</i> _{<i>t</i>-1}				0.561** (0.247)	0.680*** (0.227)	0.561** (0.238)
<i>Size</i> _{<i>t</i>}		0.598*** (0.055)			0.599*** (0.054)	
<i>Liquidity</i> _{<i>t</i>}			0.158** (0.070)			0.133* (0.070)
Observations	940	940	940	940	940	940
Number of groups	123	123	123	123	123	123
Sargan p-value	0.0834	0.133	0.0776	0.0588	0.171	0.0608
Hansen p-value	0.271	0.322	0.231	0.238	0.325	0.233
AR1	-4.123	-3.894	-4.093	-4.221	-3.968	-4.204
AR1 p-value	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.513	-0.425	0.413	0.470	-0.380	0.389
AR2 p-value	0.608	0.671	0.680	0.638	0.704	0.697
Number of Instruments	95	96	96	95	96	96

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A5.5 – Gmm One-Step results two periods – All Sample with Selic interest rate

	2002-2008	2009-2016	2002-2008	2009-2016	2002-2008	2009-2016	2002-2008	2009-2016	2002-2008	2009-2016	2002-2008	2009-2016
	(1)	(1)	(2)	(2)	(3)	(3)	(4)	(4)	(5)	(5)	(6)	(6)
<i>Loans growth rate</i> _{<i>t</i>-1}	0.887*** (0.091)	0.769*** (0.142)	0.795*** (0.099)	0.701*** (0.115)	0.869*** (0.086)	0.788*** (0.135)	0.878*** (0.091)	0.838*** (0.152)	0.790*** (0.099)	0.764*** (0.125)	0.860*** (0.086)	0.868*** (0.145)
<i>GDP growth rate</i> _{<i>t</i>-1}	-0.950 (1.303)	-1.749 (4.376)	-1.341 (1.092)	-4.145 (3.205)	-0.926 (1.290)	-2.239 (4.410)	1.798 (4.069)	-1.467 (2.500)	0.352 (3.706)	-2.665 (2.038)	1.935 (4.040)	-1.920 (2.578)
<i>Interest Rate (Selic)</i> _{<i>t</i>}	-0.025 (0.027)	0.039 (0.066)	-0.025 (0.024)	0.088 (0.054)	-0.026 (0.027)	0.041 (0.065)	-0.028 (0.026)	-0.024 (0.040)	-0.028 (0.023)	0.001 (0.038)	-0.030 (0.026)	-0.025 (0.039)
<i>Inflation</i> _{<i>t</i>-1}	-0.005 (0.036)	-0.073 (0.053)	0.003 (0.033)	-0.052 (0.039)	-0.006 (0.036)	-0.067 (0.052)	0.006 (0.036)	-0.054 (0.053)	0.012 (0.034)	-0.040 (0.045)	0.006 (0.037)	-0.048 (0.054)
<i>BNDES Innovation</i> _{<i>t</i>-1}	-0.005 (0.114)	0.262 (0.264)	0.023 (0.098)	0.388** (0.191)	0.001 (0.112)	0.271 (0.260)						
<i>BNDES FINAME</i> _{<i>t</i>-1}							-0.544 (0.774)	0.596* (0.346)	-0.287 (0.710)	0.720*** (0.275)	-0.555 (0.769)	0.610* (0.341)
<i>Size</i> _{<i>t</i>}			0.495*** (0.073)	0.775*** (0.131)					0.495*** (0.073)	0.770*** (0.124)		
<i>Liquidity</i> _{<i>t</i>}					0.099 (0.061)	0.348** (0.172)					0.099 (0.061)	0.360** (0.169)
Observations	562	378	562	378	562	378	562	378	562	378	562	378
Number of groups	108	86	108	86	108	86	108	86	108	86	108	86
Sargan p-value	0.0643	0.0450	0.0183	0.359	0.0647	0.0477	0.0948	0.381	0.0164	0.942	0.0918	0.447
Hansen p-value	0.116	0.148	0.148	0.183	0.120	0.141	0.157	0.319	0.109	0.335	0.158	0.290
AR1	-4.887	-4.139	-4.440	-4.172	-4.904	-4.201	-4.982	-4.060	-4.494	-4.101	-5	-4.155
AR1 p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.327	0.583	-0.402	-0.407	0.277	0.387	0.152	0.493	-0.615	-0.595	0.0838	0.258
AR2 p-value	0.744	0.560	0.688	0.684	0.782	0.699	0.879	0.622	0.538	0.552	0.933	0.796
Number of Instruments	22	34	23	35	23	35	22	34	23	35	23	35

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A5.6 – OLS and Fixed Effects estimation results – All Sample with Selic interest rate

	OLS (1)	FE (1)	OLS (2)	FE (2)	OLS (3)	FE (3)	OLS (4)	FE (4)	OLS (5)	FE (5)	OLS (6)	FE (6)
<i>Loans growth rate</i> _{t-1}	0.876*** (0.023)	0.587*** (0.053)	0.739*** (0.035)	0.525*** (0.052)	0.875*** (0.023)	0.590*** (0.053)	0.877*** (0.022)	0.588*** (0.053)	0.740*** (0.035)	0.528*** (0.051)	0.876*** (0.022)	0.591*** (0.053)
<i>GDP growth rate</i> _{t-1}	-0.962 (0.801)	-0.650 (0.995)	-0.745 (0.755)	-0.896 (0.875)	-0.938 (0.795)	-0.607 (0.982)	-2.616* (1.467)	-1.926 (1.676)	-2.201* (1.312)	-2.604* (1.356)	-2.601* (1.446)	-1.846 (1.631)
<i>Interest Rate (Selic)</i> _t	0.013 (0.022)	0.014 (0.020)	0.019 (0.019)	0.020 (0.018)	0.012 (0.022)	0.011 (0.020)	-0.000 (0.021)	0.003 (0.020)	0.006 (0.019)	0.007 (0.018)	-0.001 (0.021)	0.001 (0.020)
<i>Inflation</i> _{t-1}	-0.049* (0.029)	-0.041 (0.028)	-0.046* (0.026)	-0.035 (0.024)	-0.048* (0.029)	-0.040 (0.029)	-0.031 (0.028)	-0.027 (0.027)	-0.029 (0.026)	-0.018 (0.025)	-0.030 (0.028)	-0.027 (0.028)
<i>BNDES Loans Innovati</i>	0.139* (0.073)	0.115 (0.070)	0.138** (0.066)	0.123* (0.062)	0.139* (0.073)	0.112 (0.069)						
<i>BNDES FINAME</i> _{t-1}							0.551** (0.265)	0.437 (0.270)	0.512** (0.236)	0.532** (0.215)	0.553** (0.262)	0.425 (0.263)
<i>Size</i> _t			0.274*** (0.032)	0.630*** (0.059)					0.274*** (0.032)	0.632*** (0.059)		
<i>Liquidity</i> _t					0.080*** (0.029)	0.127* (0.071)					0.080*** (0.029)	0.126* (0.072)
Observations	1,063	1,063	1,063	1,063	1,063	1,063	1,063	1,063	1,063	1,063	1,063	1,063
R-squared	0.724	0.328	0.761	0.487	0.726	0.333	0.724	0.329	0.761	0.489	0.726	0.334
Number of groups		123		123		123		123		123		123

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A5.7 – Robustness check – GMM Two-steps results with endogenous bank characteristics

	(7)	(8)	(9)	(10)	(11)	(12)
<i>Loans growth rate</i> _{<i>t</i>-1}	0.822*** (0.087)	0.536*** (0.071)	0.762*** (0.074)	0.807*** (0.087)	0.554*** (0.071)	0.753*** (0.075)
<i>GDP growth rate</i> _{<i>t</i>-1}	-1.663 (1.048)	-1.093 (0.890)	-1.375 (1.004)	-3.139* (1.624)	-3.122** (1.303)	-2.937* (1.648)
<i>Interest Rate (Selic)</i> _{<i>t</i>}	0.011 (0.020)	0.021 (0.018)	0.007 (0.021)	-0.003 (0.021)	0.007 (0.018)	-0.006 (0.020)
<i>Inflation</i> _{<i>t</i>-1}	-0.043 (0.028)	-0.034 (0.025)	-0.045 (0.029)	-0.025 (0.026)	-0.015 (0.025)	-0.027 (0.028)
<i>BNDES Innovation</i> _{<i>t</i>-1}	0.157** (0.075)	0.131** (0.064)	0.135* (0.074)			
<i>BNDES FINAME</i> _{<i>t</i>-1}				0.561** (0.247)	0.592*** (0.203)	0.534** (0.266)
<i>Size</i> _{<i>t</i>}		0.805*** (0.083)			0.824*** (0.084)	
<i>Liquidity</i> _{<i>t</i>}			0.091 (0.102)			0.093 (0.103)
Observations	940	940	940	940	940	940
Number of groups	123	123	123	123	123	123
Sargan p-value	0.0834	0.000	0.0223	0.0588	0.000	0.0172
Hansen p-value	0.271	0.652	0.729	0.238	0.677	0.691
AR1	-4.123	-3.522	-4.107	-4.221	-3.617	-4.118
AR1 p-value	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.513	-0.932	0.451	0.470	-0.838	0.422
AR2 p-value	0.608	0.352	0.652	0.638	0.402	0.673
Number of Instruments	95	133	133	95	133	133

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A5.8 – GMM Two-steps estimation results – All Sample with reserve requirement rate

	(16)	(17)	(18)	(19)	(20)	(21)
<i>Loans growth rate</i> _{<i>t</i>-1}	0.819*** (0.088)	0.713*** (0.079)	0.800*** (0.086)	0.812*** (0.093)	0.720*** (0.086)	0.797*** (0.087)
<i>GDP growth rate</i> _{<i>t</i>-1}	-2.526** (1.117)	-2.008** (0.996)	-2.361** (1.092)	-3.574** (1.490)	4.014*** (1.250)	-3.345** (1.417)
<i>Reserve Requirement Rate</i> _{<i>t</i>-1}	4.740 (3.711)	1.389 (3.626)	4.110 (3.968)	2.486 (3.477)	0.708 (3.337)	1.946 (3.466)
<i>Inflation</i> _{<i>t</i>-1}	-0.044** (0.021)	-0.026 (0.018)	-0.045** (0.022)	-0.035* (0.020)	-0.019 (0.018)	-0.036* (0.020)
<i>BNDES Loans Innovation</i> _{<i>t</i>-1}	0.213*** (0.080)	0.155** (0.077)	0.205** (0.081)			
<i>BNDES FINAME</i> _{<i>t</i>-1}				0.634*** (0.244)	0.679*** (0.218)	0.604** (0.236)
<i>Size</i> _{<i>t</i>}		0.596*** (0.057)			0.601*** (0.052)	
<i>Liquidity</i> _{<i>t</i>}			0.142** (0.069)			0.124* (0.073)
Observations	940	940	940	940	940	940
Number of groups	123	123	123	123	123	123
Sargan p-value	0.0892	0.145	0.0819	0.0543	0.174	0.0554
Hansen p-value	0.353	0.271	0.297	0.235	0.305	0.231
AR1	-4.098	-3.915	-4.059	-4.160	-3.934	-4.137
AR1 p-value	0.000	0.000	0.000	0.000	0.000	0.000
AR2	0.514	-0.455	0.427	0.456	-0.391	0.384
AR2 p-value	0.607	0.649	0.669	0.649	0.696	0.701
Number of Instruments	95	96	96	95	96	96

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A5.9 - Regressions Results Second Stage IV one instrument– GMM

	All Sample			Companies with positive innovation expenditure		
	Solvency (39)	Solvency ² (40)	Tax Incentive (41)	Solvency (42)	Solvency ² (43)	Tax Incentive (44)
<i>Age (log)</i>	0.353** (0.149)	0.302** (0.127)	0.138 (0.296)	0.360** (0.167)	0.339** (0.156)	0.204 (0.288)
<i>Continuous R&D</i>	0.151 (0.463)	0.183 (0.436)	0.285 (0.451)	-0.253 (0.570)	-0.205 (0.535)	0.100 (0.679)
<i>Export</i>	0.015 (0.165)	0.069 (0.131)	0.244 (0.261)	-0.044 (0.231)	0.034 (0.194)	0.527 (0.696)
<i>R&D Department</i>	1.049*** (0.405)	1.064*** (0.394)	1.112*** (0.406)	1.335** (0.523)	1.323*** (0.504)	1.249** (0.528)
<i>Private funds</i>	-0.237 (0.210)	-0.280 (0.184)	-0.419 (0.262)	-0.258 (0.219)	-0.289 (0.199)	-0.484 (0.338)
<i>Public funds</i>	-0.911** (0.430)	-0.675* (0.402)	0.090 (1.147)	-1.065** (0.465)	-0.880** (0.447)	0.290 (1.640)
<i>Labour Productivity</i>	0.017 (0.082)	0.016 (0.071)	0.013 (0.068)	0.109 (0.115)	0.097 (0.105)	0.019 (0.175)
<i>BNDES</i>	<i>3.596**</i> (1.729)	<i>2.344**</i> (1.136)	<i>-1.706</i> (5.819)	<i>3.745**</i> (1.749)	<i>2.830**</i> (1.337)	<i>-2.967</i> (8.014)
<i>Constant</i>				-3.468*** (1.311)	-3.219*** (1.234)	-1.640 (2.576)
Observations	1,742	1,742	1,742	1,265	1,265	1,265
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	-0.040	0.022	-0.005	-0.010	0.024	-0.059

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's own calculation based on PLA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

Table A5.10 - Regressions Results First Stage IV one instrument– GMM

	All Sample			Companies with positive innovation expenditure		
	Solvency (45)	Solvency ² (46)	Tax Incentive (47)	Solvency (48)	Solvency ² (49)	Tax Incentive (50)
<i>Solvency</i>	0.363*** (0.109)			0.378*** (0.111)		
<i>Solvency²</i>		0.151** (0.065)			0.161** (0.070)	
<i>Tax Incentive</i>			0.074** (0.033)			0.061* (0.034)
<i>Age (log)</i>	-0.037** (0.019)	-0.038** (0.019)	-0.044** (0.019)	-0.019 (0.022)	-0.020 (0.023)	-0.027 (0.022)
<i>Continuous R&D</i>	0.028 (0.043)	0.027 (0.043)	0.009 (0.044)	0.055 (0.046)	0.054 (0.046)	0.039 (0.047)
<i>Export</i>	0.047 (0.032)	0.046 (0.033)	0.043 (0.033)	0.093** (0.042)	0.091** (0.042)	0.083* (0.042)
<i>R&D Department</i>	0.013 (0.044)	0.011 (0.044)	0.006 (0.044)	-0.008 (0.051)	-0.011 (0.052)	-0.013 (0.052)
<i>Private funds</i>	-0.033 (0.041)	-0.032 (0.041)	-0.032 (0.041)	-0.031 (0.041)	-0.031 (0.041)	-0.032 (0.041)
<i>Public funds</i>	0.169*** (0.028)	0.183*** (0.028)	0.184*** (0.028)	0.183*** (0.029)	0.197*** (0.028)	0.198*** (0.029)
<i>Labour Productivity</i>	0.001 (0.015)	-0.000 (0.015)	-0.003 (0.015)	-0.010 (0.017)	-0.012 (0.017)	-0.016 (0.017)
<i>Constant</i>				0.213* (0.129)	0.224* (0.130)	0.305** (0.126)
Observations	1,742	1,742	1,742	1,265	1,265	1,265
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's own calculation

Source: Author's own calculation based on PIA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

Table A5.11 - First Stage Summary Statistics

	All Sample			Companies with positive innovation expenditure		
	(45)	(46)	(47)	(48)	(49)	(50)
<i>F-Test</i>	11.05	5.385	4.976	11.58	5.290	3.108
<i>Kleibergen-Paap rk LM</i>	0.006	0.03	0.024	0.007	0.028	0.073
<i>Anderson-Rubin Wald P-value</i>	0.0167	0.0332	0.768	0.00890	0.00966	0.705

Source: Author's own calculation

Source: Author's own calculation based on PIA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

A4.1 Consent Form

University of Sussex

CONSENT FORM FOR PROJECT PARTICIPANTS

PROJECT TITLE: SURVEY ON INNOVATION OBSTACLES AND FINANCIAL RESOURCES IN THE BRAZILIAN PHARMACEUTICAL AND BIOTECHNOLOGY SECTORS

Project Approval

Reference:

ER/MC408/1

I agree to take part in the above University of Sussex research project being conducted by Marco Carreras. I have had the project explained to me and I have read and understood the Information Sheet, which I may keep for records. I understand that agreeing to take part means that I am willing to be interviewed by the researcher.

I understand that any information I provide is confidential and that no information that I disclose will lead to the identification of any individual in the reports on the project, either by the researcher or by any other party. The information will be used for quantitative and qualitative research only. No data that can identify individual responses will be shared with other parties.

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalized or disadvantaged in any way. I consent to the processing of my personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential and handled in accordance with the Data Protection Act 1998.

Please tick here if you want a copy of the study for your records:

Name: _____

Signature _____

Date: _____

A4.2 Participant Information Sheet

SURVEY ON INNOVATION OBSTACLES AND FINANCIAL RESOURCES IN THE BRAZILIAN PHARMACEUTICAL AND BIOTECHNOLOGY SECTORS

**Marco Carreras, University of
Sussex, United Kingdom**

The purpose of this document is to provide a brief background of the survey questions to the interviewees.

The long-term strategic commitment required to finance technological change focuses attention on the type of finance that is required for innovation-based industrial development. The high uncertainty involved in innovation leads to more projects failing than succeeding and means that the profit-seeking commercial banking sector does not supply the appropriate amount of investment resources. Moreover, in developing countries where the financial alternatives (VC, equity, business angels) are not fully developed, a key question is where this investment should come from.

Pharmaceuticals and biotechnology have been among the major sectors for intervention since the first Brazilian industrial policy in 2004 (PITCE). These have been further confirmed as among the key industrial sectors for development in the second industrial policy (PDP). Between the two industrial policies, the importance of the two sectors has been highlighted by the creation of the PROFARMA program by BNDES in 2004. Finally, both sectors remained among the key strategic sectors in the Plano Brasil Maior (2011).

The Brazilian pharmaceutical and biotech industries represent sectoral systems of innovation involving a wide variety of public and private institutions. However, observers have noted that one of the main fragilities in Brazil is the weak private industrial infrastructure, particularly regarding the innovation chain. The industrial setting has recently experienced an increasing number of domestic firms and innovative domestic firms, in a scenario dominated by foreign pharmaceutical companies. In this context, BNDES has sought to provide funding for investment in innovation. In doing so, it seeks to reduce the financial obstacles that may prevent companies from investing in areas characterized by high risks and unpredictability of results.

This survey aims to collect information about the role of pharmaceutical and biotechnology companies' perceived obstacles in innovation investment, and information about the role that BNDES plays in reducing the risk associated with innovation activities.

Please note that the information collected here is intended to provide a better evidence base concerning private and public roles in pharmaceutical finance. The information collected in this survey will be kept strictly confidential and no information that I disclose will lead to the identification of any individual in the reports on the project, either by the researcher or by any other party.

A4.3 Questionnaire

- i. *Company Name:* _____
- ii. *Address:* _____
- iii. *Size:*
- a. Number of workers: _____
 - b. Workers in R&D department: _____
- iv. *In which States are your plants located?*
- _____
- v. *In what year was your company established (yyy)?* _____
- vi. *What is the ownership of your company?*
- a. *Domestic* ☐
 - b. *Foreign* ☐ 0% – 20% ☐ 20% – 40% ☐ 40% – 60% ☐ 60% or more
- vii. *In which stage(s) of the innovation chain is the project you obtained/requested the loan for?*
1. Basic research ☐
 2. Prototype, design or discovery ☐
 3. Preclinical development ☐
 4. Clinical development ☐
 5. Approval & launch preparation ☐
- viii. *What is your expenditure on R&D as a percentage of annual sales?* _____ %
- ix. *Do you export?*
- Yes ☐ No ☐
- a. *If Yes, What is the value of your export as percentage of annual sales?* _____ %

Risk in innovation investment in the Brazilian Pharmaceutical Sector

Please report the degree of importance of each of the following obstacles **for the period 2004–2015** on the table on the next page.

▪ **Classification of perceived investments risk in innovation for pharmaceutical sector:**

1. Lack of qualified human resources, lack of previous investment in R&D
2. Bureaucratic obstacles
3. Lack of tax incentives
4. Shareholder pressure
5. Uncertainty about the timing of reimbursement of *public* funding
6. Uncertainty about the timing of reimbursement of *private* funding
7. High risk of failure involving investment in innovation
8. Inability to capture returns due to inappropriate IPR protection
9. Limited access to commercial bank finance (availability, interest rates, fees, and collateral requirements)

▪ **For the specific project funded by BNDES:**

10. To what extent was access to finance a problem for the investment you requested the loan for?
11. How high do you evaluate the risk of failure for the project you obtained the funding for?

The self-identification of the obstacles will be reported with a Likert scale with values in the range from 0 to 5, representing the degree of importance of the each element.

	<u>Product Innovation</u>		<u>Process Innovation</u>					
Values: 1: No obstacle 2: Minor obstacle 3: Moderate obstacle 4: Major obstacle 5: Very severe obstacle	Development of a new molecular entity (NME)	Development of an incrementally modified drug (IMD)	Acquisition of machinery / plant expansion	Acquisition of external R&D (software excluded)	Acquisition of software	R&D activities performed within the company	Hiring workforce for R&D activities	Other (please specify):
Lack of qualified human resources, lack of previous investment in R&D	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Bureaucratic obstacles	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Lack of tax incentives	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Shareholder pressure	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Uncertainty about the timing of reimbursement of <i>public</i> funding	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5

	<u>Product Innovation</u>		<u>Process Innovation</u>					
Values: 1: No obstacle 2: Minor obstacle 3: Moderate obstacle 4: Major obstacle 5: Very severe obstacle	Development of a new molecular entity (NME)	Development of an incrementally modified drug (IMD)	Acquisition of machinery / plant expansion	Acquisition of external R&D (software excluded)	Acquisition of software	R&D activities performed within the company	Hiring workforce for R&D activities	Other (please specify):
Uncertainty about the timing of reimbursement of <i>private</i> funding	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
High risk of failure involving investment in innovation	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Inability to capture returns due to inappropriate IPR protection	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Limited access to commercial bank finance (availability, interest rates, fees, and collateral requirements)	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
Other (please specify): _____	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5

Specific to the Project(s) funded by BNDES (Please write ONLY in the box related to the type of investment of the project(s) you asked the loan for)								
	<u>Product Innovation</u>		<u>Process Innovation</u>					
Values: 1: No obstacle 2: Minor obstacle 3: Moderate obstacle 4: Major obstacle 5: Very severe obstacle	Development of a new molecular entity (NME)	Development of an incrementally modified drug (IMD)	Acquisition of machinery / plant expansion	Acquisition of external R&D (software excluded)	Acquisition of software	R&D activities performed within the company	Hiring workforce for R&D activities	Other (please specify): _____
To what extent was access to finance a problem for the investment you requested the loan for?	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5
How high do you evaluate the risk of failure for the project you obtained the funds for?	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5

Importance of financial resources

- Regarding investments in R&D, please indicate the importance of each of the following sources of credit on a scale:

1 = HIGH IMPORTANCE, 2 = MAJOR IMPORTANCE, 3 = MINOR IMPORTANCE, 4 = NO IMPORTANCE

- | | | | | | |
|------|---------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| i. | Public Institutions | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 |
| ii. | Private commercial banks | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 |
| iii. | Other private institution | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 |
| iv. | Company's own resources | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 |

- Did you apply to any BNDES program with another project that has not been accepted?

Yes ☐

No ☐

Don't know/refuse to answer ☐

If No, GO TO SECTION 3

- a. If Yes, how many projects have not been accepted? _____

- b. If Yes, did you undertake the project(s) you were requesting funds for anyway?

Yes ☐

No ☐

Don't know/refuse to answer ☐

If No, GO TO SECTION 3

- c. If Yes, how many projects have you undertaken after BNDES rejection?

- d. If Yes, what kind of financial resources have you used to undertake the project, after BNDES did not commit any disbursement? Please indicate the degree of importance of each of the following sources of credit on a scale:

1 = HIGH IMPORTANCE, 2 = MAJOR IMPORTANCE, 3 = MINOR IMPORTANCE, 4 = NO IMPORTANCE

- | | | | | | |
|------|---------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| i. | Public institutions | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 |
| ii. | Private commercial banks | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 |
| iii. | Other private institution | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 |
| iv. | Company's own resources | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 |

For the specific project(s) funded by BNDES

NOTE: The following questions refer to the specific investment project being funded by BNDES. In case your company has been approved more than one project, please **fill as many copies of Section 3 as there are funded projects.**

1. Number of funded projects
 - How many investment projects in innovation has BNDES approved for a loan?

2. Magnitude of BNDES support for the project
 - How much did BNDES contribute to the overall expenditure of the project (as a percentage)?: %

3. Complementarity of BNDES Support
 - Did you receive any other financial support for this project from external sources?

Yes ☐
No ☐

If No, go to Question 4

- a. If Yes, from which type of institution did you obtain financial support?
 - i. Private commercial bank (as a percentage): _____ %
 - ii. Other private institution (as a percentage): _____ %
 - iii. Public institutions:
 - Direct funding (as a percentage): _____ %
 - Indirect funding:
 - a. Tax credit ☐
 - b. Subsidy ☐

4. Degree of additionality/ complementarity of BNDES support
 - Did you have an alternative to BNDES as a supplier of finance for the project?

Yes ☐
No ☐
Don't know/refuse to answer ☐

 - a. If Yes, why did you prefer BNDES? (e.g., maturity, interest rate, other support)
 - i. Period of loan ☐
 - ii. Interest rate ☐
 - iii. Other (please specify): _____

 - If BNDES had not funded the project:
 - Would you have had undertaken this investment anyway?

Yes ☐
No ☐
Don't know/refuse to answer ☐

 - Would you have undertaken any other investment in pharmaceutical innovation?

Yes ☐No ☐Don't know/refuse to answer ☐

- *Would you have undertaken any other non-innovation-related investment?*

Yes ☐No ☐Don't know/refuse to answer ☐

SURVEY FINISHED

Thank you for your
cooperation