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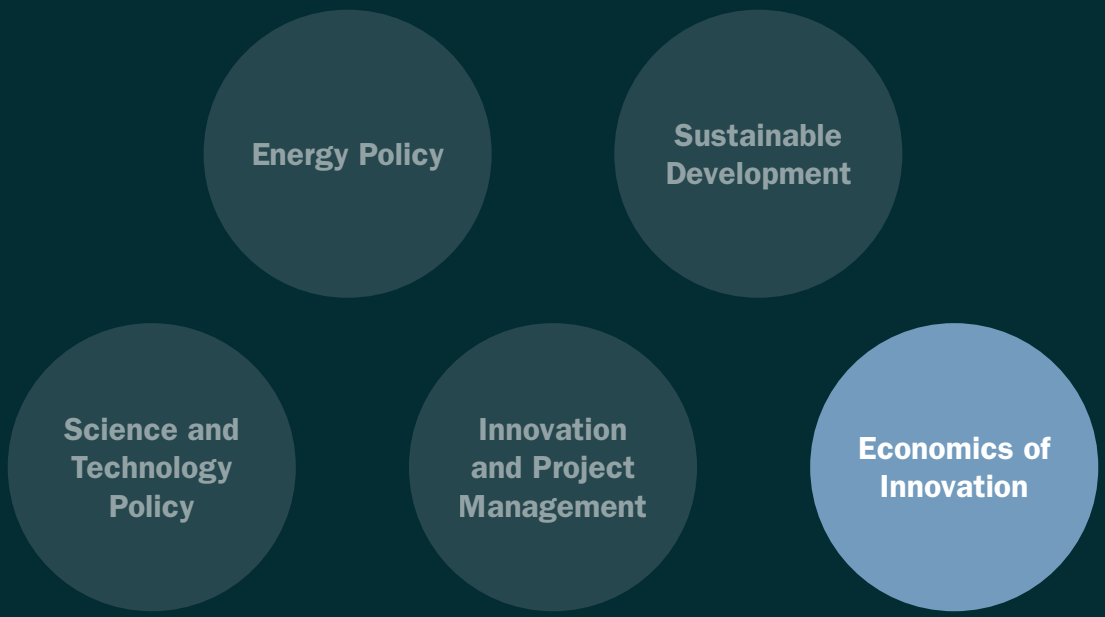
Marco Carreras



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Fostering Innovation Activities with the Support of a Development Bank: Evidence from Brazil

I evaluate the impact of the Banco Nacional de Desenvolvimento Econômico e Social, (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.

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Keywords: *BNDES, development bank, crowding-in/out, R&D intensity*[2]

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1. Introduction

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. In this context, the Brazilian Development Bank, Banco Nacional de Desenvolvimento Econômico e Social (BNDES, *henceforth*), is one of the main actors fostering industrial innovation (Ferraz, Além et al. 2013).

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. Market Failure Theory (MFT) 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 and can be investigated from two different perspectives:

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).

This analysis looks at the crowding-out hypothesis from the second perspective, specifically evaluating 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.

The paper will continue as follows: Section 2 presents the literature review on the degree of complementarity/substitutability of public and private financial resources and on the role of the public

sector; Section 3 introduces the methodology; Section 4 presents the data used for the analysis. Section 5 presents the results and, finally, Section 6 concludes the paper

2. Literature Review

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

In neoclassical economic theory, the role of the State is to fix market failures (Mazzucato 2013). 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. 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 crowing-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. (2015), 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.

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 2013). 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 Minksy (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 run[3] 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 them. 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) and the Small Business Innovation Research (SBIR) among others, in financing and creating a new space in the industrial environment has been highlighted in Mazzucato (2013). 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); 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.

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).

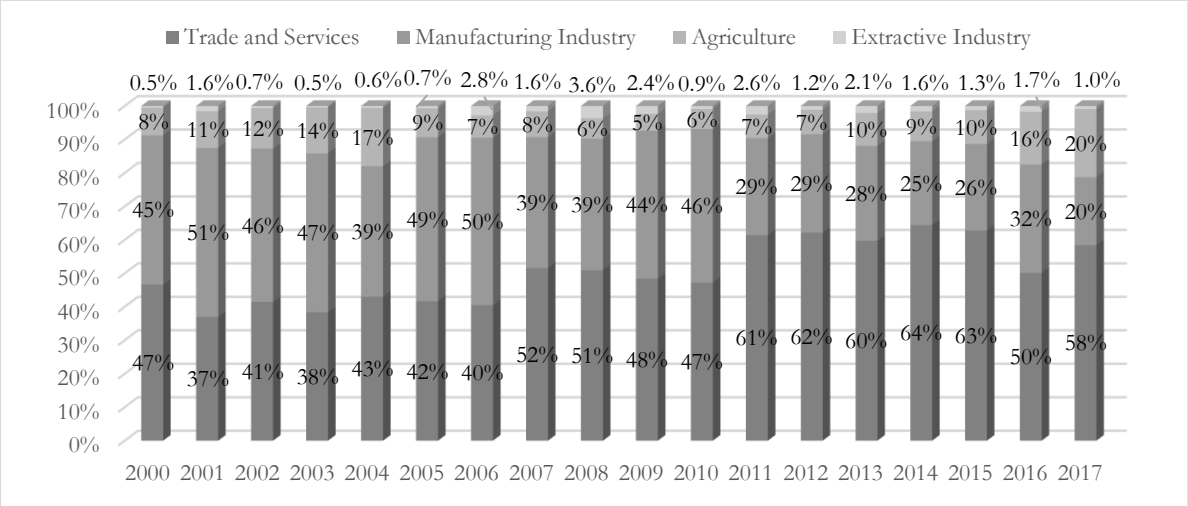
[3] In some economies, there is the further problem of '*financialization*', spending profits on boosting stock prices, rather than on long-run areas like human capital and R&D. For example, an increasing problem in advanced economies, is the use of share buybacks (to boost stock options, hence executive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

2.3 The Brazilian Development Bank and the financial sector in Brazils

BNDES is a 100% state owned development bank created in 1952, controlled by the Brazilian executive and the Ministry of Development, Industry and Foreign trade (MDIC). Together with the *China Development Bank* and the German *KfW*, BNDES is among the three largest mission-oriented development finance institutions. In 2012, each of these banks disbursed loans accounting for more than 10% of their countries' GDP (Ferraz, Além et al. 2013).

BNDES' primary mission aims at economic development through industrial innovation, with the provision of financial resources for the medium-long term for the national industrial sector (Barone and Spratt 2015). Figure 1 below shows BNDES disbursement for the industrial sector by sector aggregate.[4]

Figure 1 - BNDES Annual Disbursement, by aggregate sector 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.

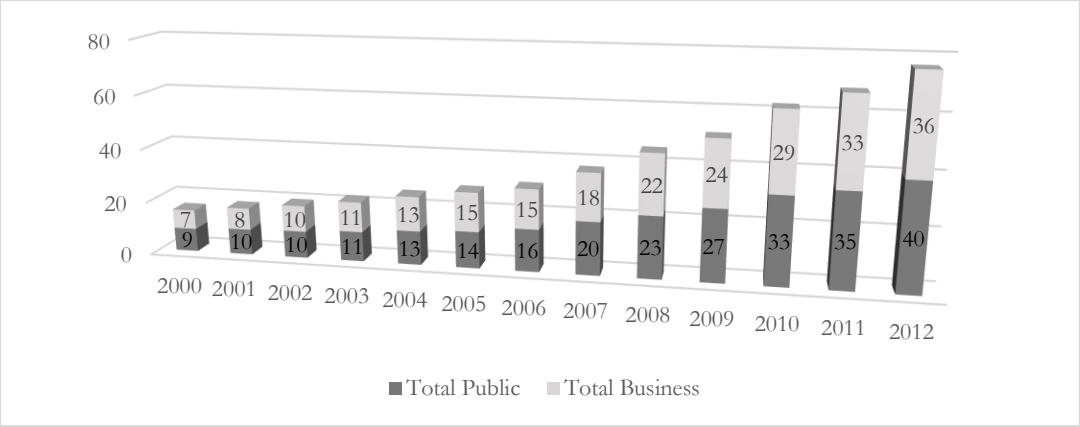
Credit in Brazil, until the middle of the 2000s, has been characterized by scarcity, high volatility, high cost, high concentration and segmentation (Torres and Zeidan 2016). Despite the privatization of financial institution in the 1990s, that contributed to the fast growth and concentration[5] of the 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%

[4] 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

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

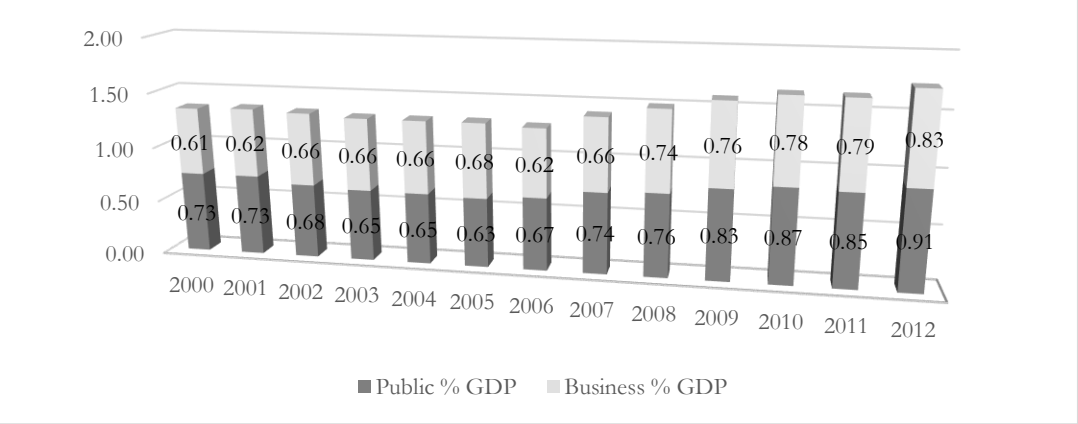
(Lazzarini, Musacchio et al. 2015; Rezende 2015), in also a national context characterized by low R&D intensity of the private industrial sector (de Melo and Rapini 2014) as shown in Figure 2 and 3 below.

Figure 2 - S&T Expenditure (R&D plus correlated activities), by source (Current R$ billion)



Source: MCTI

Figure 3 - S&T Expenditure (R&D plus correlated activities) as % GDP, by source



Source: MCTI

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. 2015). 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.

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 2013). 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.

3.1. The Model

This section describes the model implemented in my analysis. 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. 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:

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

Where $R\&D\ intensity_t = \frac{Own\ Innovation\ Exp_{it}\ (R\$\ Mill)}{Employment_{it}}$ and $BNDES_t$ 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.

3.2. Instrumental Variable Approach

Section 3.2 introduces the instrumental variables used in this analysis to correct for endogeneity, hence to control for the bias in the selection process of those companies receiving BNDES funding. 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)[6]*,* ***its square*** and "***Receiving tax incentives"*** for innovation

[6] 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.

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 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 they are not in forms of money received but money discounted generally from tax payments; tax exemptions do not increase the level liquidity of the company if not at the time of tax collection, when the company will receive a discount on the amount of taxes owed. Further, decisions on how to spend the financial resources obtained later from the tax discount are made solely 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. 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.

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

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

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.

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 analysis 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.

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> 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 available[7], 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.

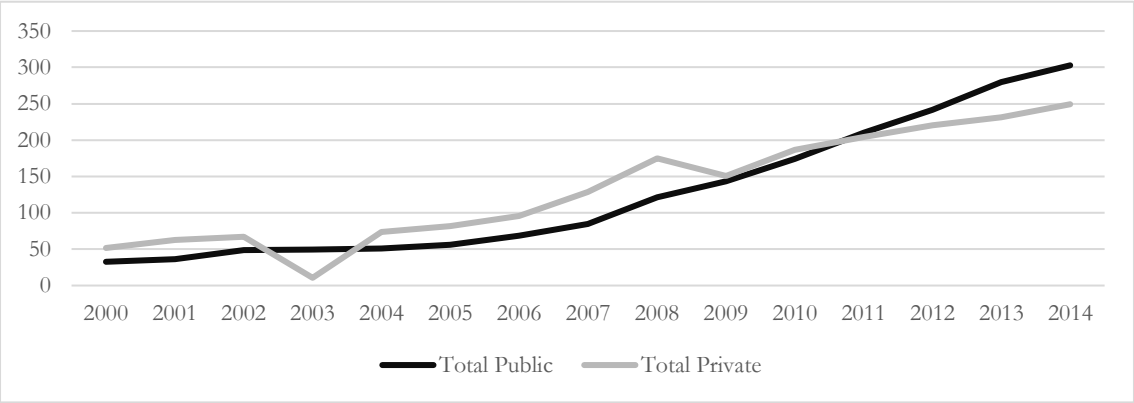
4.1. The Brazilian public financial system in the economic crisis

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 2013; Mazzucato and Penna 2014).

Figure 4 below 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 is Brazil was caused by the Argentinean bailout together with contractionary polices put in place by the newly established Lula administration, with increased interest rates and primary fiscal surplus targets (de Carvalho and de Souza 2011).

[7] Dataset available at: http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Institucional/BNDES_Transparente/Consulta_as_operacoes_do_BNDES/painel_consulta_diretas.html

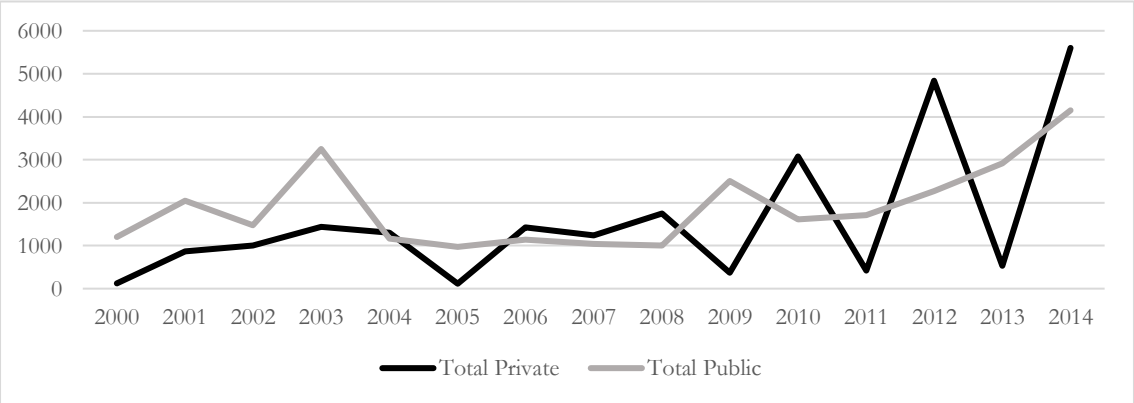
Figure 4 – Total Financial System Loans to Industry (current R$ billion)



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 effects. From Figure 4 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 5.

Figure 5 – 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.

4.2. 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.

5. Results

This section presents the descriptive statistics for the companies present in this analysis. Table 1 reports the main companies' characteristics for the all sample and form companies reporting positive expenditure in innovation activities.

Table 1 - Main companies' characteristics by categories

	All Sample			Companies with positive Innovation Expenditure		
	BNDES			BNDES		
	No	Yes	Total	No	Yes	Total
Number of Employees	2044 *(4230)*	3488 *(6242)*	**2555** ***(5080)***	2336 *(4750)*	4019 *(6943)*	**2960** ***(5722)***
Age	28.2 *(12.9)*	27.9 *(14.8)*	**28.1** ***(13.5)***	28.3 *(13.1)*	28.8 *(14.6)*	**28.5** ***(13.7)***
Export	61.3%	59.3%	**60.6%**	67.1%	64.9%	**66.3%**
Net Sales (R$ Mil)	1059 *(6401)*	1969 *(8485)*	**1381** ***(7217)***	1351 *(7580)*	2361 *(9651)*	**1726** ***(8430)***
Total Expenditure in Innovation (R$ Mil)	21.2 *(107.8)*	52.8 *(186.1)*	**32.4** ***(141.2)***	30.0 *(127.5)*	69.4 *(210.4)*	**44.6** ***(164.2)***
Private financial resources (R$ Mil) for innovation	0.65 *(4.99)*	1.37 *(13.7)*	**0.91** ***(9.2)***	0.92 *(5.9)*	1.80 *(15.7)*	**1.25** ***(10.7)***
Public financial resources (R$ Mil) for innovation	2.25 *(14.1)*	10.9 *(44.5)*	**5.34** ***(29.1)***	3.18 *(16.6)*	14.4 *(50.5)*	**7.35** ***(33.9)***
Own financial resources (R$ Mil) for innovation	18.3 *(99.6)*	40.5 *(170.5)*	**26.1** ***(129.6)***	25.9 *(117.7)*	53.1 *(193.7)*	**36.0** ***(151.1)***
BNDES Disbursement (R$ Mil)	-	57.2 *(205.1)*	**20.2** ***(124.8)***	-	66.0 *(230.1)*	**24.5** ***(143.7)***
R&D intensity (Own Expend R$ Mil\Employees)	0.44 *(2.2)*	1.21 *(6.8)*	**0.71** ***(4.4)***	0.62 *(2.5)*	1.59 *(7.7)*	**0.98** ***(5.1)***
Continuous R&D	46.4%	51.9%	**48.3%**	64.9%	66.8%	**65.6%**
R&D Department	54.7%	59.5%	**56.4%**	74.5%	74.5%	**74.5%**
Tax Incentive	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 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, Musacchio et al. 2015) 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 2 reports the origin of the different financial resources spent by companies (with positive innovation expenditure only).

Table 2 - Average Contribution to companies' total expenditure in innovation

	Funded by BNDES		
	No	Yes	Total
Private Financial resources	4.4%	3.7%	**4.1%**
Public Financial resources	12.0%	22.3%	**15.8%**
Own Financial resources	83.4%	73.9%	**79.8%**

Source: Author's own calculation based on PIA (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. 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 presents the main companies' characteristics by size and category BNDES funded.

Table 3 - Companies with Positive Innovation Expenditure by Size and Category BNDES funded

	Size					
	Small		Medium		Large	
BNDES Funded	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
Number of Employees	64.9	69.1	294	314	3099	4727
Age	20.9	13.3	25.3	21.6	29.7	30.4
Net Sales (R$ Mil)	35.64	24.41	168.2	194.8	1793	2775
Total Expenditure in Innovation (R$ Mil)	2.92	1.88	8.53	18.4	38.3	79.4
Private financial resources (R$ Mil) for innovation	0.06	0.04	0.17	0.21	1.20	2.1
Public financial resources (R$ Mil) for innovation	0.89	0.35	1.47	11.20	3.84	15.3
Own financial resources (R$ Mil) for innovation	1.98	1.49	6.88	7.01	33.15	62.0
Private Innov Expend (% Total Innov Expend)	2.2%	5.0%	4.1%	3.2%	4.6%	3.7%
Public Innov Expend (% Total Innov Expend)	19.3%	15.7%	9.6%	30.1%	12.3%	21.2%
Own Innov Expend (% Total Innov Expend)	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 3, Table 4 presents an overview of the Brazilian geographical differences among macro regions.

Table 4 - Main companies' characteristics by Region

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

Source: Author's own calculation based on PIA (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 5. 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.

5.1. Regression Analysis

This section begins by presenting results from the OLS model in Table 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 6[8]. Table 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 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.

[8] For the second stage results of the model including each single instrument, please refer to Table A2 in the Appendix

Table 5 - Regressions Results OLS

	All Sample						Companies with positive innovation expenditure					
	OLS *(1)*	OLS *(2)*	OLS *(3)*	OLS *(4)*	OLS *(5)*	OLS *(6)*	OLS *(7)*	OLS *(8)*	OLS *(9)*	OLS *(10)*	OLS *(11)*	OLS *(12)*
BNDES	***0.786**** **(0.438)**	***0.752**** **(0.416)**	***0.706**** **(0.403)**	***0.676***** **(0.275)**	***0.697***** **(0.287)**	***0.638***** **(0.271)**	***1.073**** **(0.585)**	***1.024**** **(0.553)**	***0.916*** **(0.538)**	***0.944***** **(0.379)**	***0.924***** **(0.390)**	***0.855***** **(0.373)**
Age (log)	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)
Continuous R&D	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)
Export	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)
R&D Department	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)
Private funds	-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)
Public funds	-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)
Labour Productivity	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)
Constant	-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 6 - Regressions Results Second Stage IV – GMM

	All Sample						Companies with positive innovation expenditure					
	GMM *(13)*	GMM *(14)*	GMM *(15)*	GMM *(16)*[9]	GMM *(17)*[9]	GMM *(18)*[9]	GMM *(19)*	GMM *(20)*	GMM *(21)*	GMM *(22)*	GMM *(23)*	GMM *(24)*
BNDES	***2.116**** **(1.238)**	***2.343**** **(1.352)**	***2.294**** **(1.270)**	***2.032**** **(1.109)**	***2.318**** **(1.249)**	***2.272*** **(1.119)**	***2.270**** **(1.262)**	***2.438**** **(1.385)**	***2.523*** **(1.253)**	***2.202**** **(1.164)**	***3.014*** **(1.535)**	***2.883*** **(1.306)**
Age (log)	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)
Continuous R&D	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)
Export	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)
R&D Department	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)
Private funds	-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)
Public funds	-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)
Labour Productivity	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)
Constant	-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 PIA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

[9] 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 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 paper 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 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.

5.2. First Stage Results and Robustness checks

This section will present the first stage regressions of the model. The following Table 7 presents the results for all estimation strategies presented in Table 6[10]. To consider the instruments valid, the coefficients should be statistically significant in the First-stage. A different scenario would

[10] 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 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 7 - First Stage Results

	All Sample						Companies with positive innovation expenditure					
	GMM (25)	GMM (26)	GMM (27)	GMM (28)[9]	GMM (29)[9]	GMM (30)[9]	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	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 based on PIA (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 8. 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 8 below reports the main tests for the First-stage regressions for both samples of analysis.

Table 8 - First Stage Statistics

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

Source: Author's own calculation based on PIA (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 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 10 are to be referred to the model with the inclusion of all fixed effects, specifically Columns *(30)* and *(36)*.

Table 9 - Results OLS - Residuals from Instrumental Variable regression

	All Sample	**Companies with positive innovation expenditure**
	(37)	**(38)**
$Age\ (log)$	0.012	0.018
	(0.101)	(0.135)
$Continuous\ R\&D$	0.067	0.078
	(0.445)	(0.548)
$Export$	0.001	0.0129
	(0.133)	(0.182)
$R\&D\ Department$	0.029	0.018
	(0.404)	(0.515)
$Private\ funds$	-0.019	-0.017
	(0.186)	(0.199)
$Public\ funds$	-0.067	-0.047
	(0.264)	(0.280)
$Labour\ Productivity$	0.015	0.023
	(0.069)	(0.098)
$Solvency$	-1.291	-1.008
	(1.093)	(1.113)
$Solvency^2$	2.389	1.94
	(2.044)	(2.098)
$Tax\ Incentive$	-0.282	-0.323
	(0.431)	(0.478)
$Constant$	-0.112	-0.1723
	(0.763)	(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 9 are not statistically significant, hence the equations presented in Section 3.1 are correctly specified not reporting any significant correlation between the residuals of the Instrumental Variables model and both control and instrument variables.

6. Conclusions

This paper 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 analysis 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 paper suggests that BNDES loans' allocations have had a significant *additional* impact on companies' investment decisions; findings also highlights that not all financial resources coming from public institutions have the same impact, showing how quality of institutions matters more than ownership itself.

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Appendix

Table A1 - Regressions Results Second Stage IV one instrument– GMM

	All Sample			Companies with positive innovation expenditure		
	Solvency	Solvency²	Tax Incentive	Solvency	Solvency²	Tax Incentive
	(39)	(40)	(41)	(42)	(43)	(44)
BNDES	***3.596****	***2.344****	***-1.706***	***3.745****	***2.830****	***-2.967***
	(1.729)	**(1.136)**	**(5.819)**	**(1.749)**	**(1.337)**	**(8.014)**
Age (log)	0.353**	0.302**	0.138	0.360**	0.339**	0.204
	(0.149)	(0.127)	(0.296)	(0.167)	(0.156)	(0.288)
Continuous R&D	0.151	0.183	0.285	-0.253	-0.205	0.100
	(0.463)	(0.436)	(0.451)	(0.570)	(0.535)	(0.679)
Export	0.015	0.069	0.244	-0.044	0.034	0.527
	(0.165)	(0.131)	(0.261)	(0.231)	(0.194)	(0.696)
R&D Department	1.049***	1.064***	1.112***	1.335**	1.323***	1.249**
	(0.405)	(0.394)	(0.406)	(0.523)	(0.504)	(0.528)
Private funds	-0.237	-0.280	-0.419	-0.258	-0.289	-0.484
	(0.210)	(0.184)	(0.262)	(0.219)	(0.199)	(0.338)
Public funds	-0.911**	-0.675*	0.090	-1.065**	-0.880**	0.290
	(0.430)	(0.402)	(1.147)	(0.465)	(0.447)	(1.640)
Labour Productivity	0.017	0.016	0.013	0.109	0.097	0.019
	(0.082)	(0.071)	(0.068)	(0.115)	(0.105)	(0.175)
Constant				-3.468***	-3.219***	-1.640
				(1.311)	(1.234)	(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 PIA (Annual Industry Survey), PINTEC (Technological Innovation Survey) and BNDES data on disbursement to manufacturing companies

Table A2 - Regressions Results First Stage IV one instrument– GMM

	All Sample			Companies with positive innovation expenditure		
	Solvency	Solvency²	Tax Incentive	Solvency	Solvency²	Tax Incentive
	(45)	(46)	(47)	(48)	(49)	(50)
Solvency	**0.363*** (0.109)**			**0.378*** (0.111)**		
Solvency²		**0.151** (0.065)**			**0.161** (0.070)**	
Tax Incentive			**0.074** (0.033)**			**0.061* (0.034)**
Age (log)	-0.037** (0.019)	-0.038** (0.019)	-0.044** (0.019)	-0.019 (0.022)	-0.020 (0.023)	-0.027 (0.022)
Continuous R&D	0.028 (0.043)	0.027 (0.043)	0.009 (0.044)	0.055 (0.046)	0.054 (0.046)	0.039 (0.047)
Export	0.047 (0.032)	0.046 (0.033)	0.043 (0.033)	0.093** (0.042)	0.091** (0.042)	0.083* (0.042)
R&D Department	0.013 (0.044)	0.011 (0.044)	0.006 (0.044)	-0.008 (0.051)	-0.011 (0.052)	-0.013 (0.052)
Private funds	-0.033 (0.041)	-0.032 (0.041)	-0.032 (0.041)	-0.031 (0.041)	-0.031 (0.041)	-0.032 (0.041)
Public funds	0.169*** (0.028)	0.183*** (0.028)	0.184*** (0.028)	0.183*** (0.029)	0.197*** (0.028)	0.198*** (0.029)
Labour Productivity	0.001 (0.015)	-0.000 (0.015)	-0.003 (0.015)	-0.010 (0.017)	-0.012 (0.017)	-0.016 (0.017)
Constant				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 A3 - First Stage Summary Statistics

	All Sample			Companies with positive innovation expenditure		
	(45)	**(46)**	**(47)**	**(48)**	**(49)**	**(50)**
F-Test	11.05	5.385	4.976	11.58	5.290	3.108
Kleibergen-Paap rk LM	0.006	0.03	0.024	0.007	0.028	0.073
Anderson-Rubin Wald P-value	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

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