Does BNDES Innovation Credit Boost Firms' Efforts and Results? Evidence from Brazilian Panel Data*

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Abstract

We evaluate the effects of BNDES direct support for R&D on firms' innovation efforts and results. Using data from *Pesquisa de Inovação* (Pintec, IBGE) for the period of 2003-2014, a firm-level dataset that surveys innovation activities among Brazilian industrial and services sectorial firms, and BNDES data on credit for supporting firms' innovation activities over the period 2004-2014, we construct a panel dataset and estimate the impact of the BNDES direct support over this whole period. We adopt a Fixed Effects approach to deal with the endogeneity problem associated to the selection of firms who receive the credit and then estimate the impact of the BNDES support on R&D expenditures and New Product Sales. We also use a complementary approach based on the Differences-in-Differences estimator to address the BNDES effects based on a before-and-after evaluation design. Our findings show evidence of positive and significant impact of BNDES credit on firms' R&D expenditures for both estimators, although the effects on New-Product Sales were not significant. Based on the FE estimates, we obtained an increase in current firms' R&D expenditures varying between 30% and 60% percent, depending on the specification used. We also found evidence of a negative effect on future R&D expenditures, what might be associated to an anticipating behavior of the treated firms' R&D expenditures decision.

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Introduction

The purpose of this paper is to evaluate the impact of BNDES innovation credit on firms' innovation efforts and results. There is a theoretical consensus that public support is needed to promote firms' innovation activities, especially research and development (R&D), which can result in the development of new products and processes for society. This process can ultimately lead to new market sales and create new employment opportunities within individual firms.

Direct support for innovation based on credit or grants are then generally offered in many countries to companies based on the idea that, without these incentives, firms' investment in innovation would be suboptimal from the social point of view. That fact is due to market imperfections, such as uncertainty and lack of appropriability. The first makes credit market imperfect and the difficulty to finance innovative activities leads then to underinvestment. The latter is related to the semi-public good characteristics of knowledge.

As appropriability of knowledge is incomplete, externalities arise, which could lead to underinvestment in innovation activities (Nelson,1959 and Arrow, 1962). In addition, in an innovative environment it is important to consider interaction between agents and innovative networks comes up (Teece, 1986). Hence, some kind of public incentive and coordination is justified to spur private agents to interact and devote resources to innovation (Mazzucato, 2011).

In Brazil, innovation public policy started in the 1970s at the same time the industrial catching-up process was taking place in domestic market, previously occupied by foreign firms (Furtado, 1964). Nowadays, in order to support innovation, Brazilian government provides a variety of programs and tax incentives to support R&D activities and induce innovation networks. Governmental resources for innovative activities increased from BR$ 15,8 billion, in 2000, to BR$ 85, 6 billion, in 2013 (MCTI, Brazilian Science and Technological Ministry). BNDES has had an important role in this process, by offering innovation credit with better financial conditions to companies.

This paper focuses on evaluating the impact of BNDES innovation credit on innovation efforts and results. Therefore, the main question to be answered is: does BNDES support for innovation increase the level of innovation effort and result of supported firms?

To answer that question, this paper uses a panel data econometric approach as applied by other authors (David Hall and Toole, 2000). Despite the difficulty in capturing a causal relationship among the variables (innovation efforts and results and credit), the empirical evidence in general finds a positive effect in terms of correlation (e.g., Hall 1993; Berger, 1993; Irwin and Klenow, 1996; David, Hall and Toole, 2000; Bloom, Griffith und Van Reenen, 2002; McKenzie and Sershun, 2010).

Most of the empirical literature on direct support for innovation focuses on studies that econometrically look at input additionality. These studies are typically based on firm-level panel data and usually estimate R&D demand equations using a dummy variable for the innovation support (see Hall and van Reenen 2000). Although the focus on input additionality is fully justified as a main criterion for evaluating direct support effectiveness, a smaller number of evaluations have also addressed the effects of R&D incentives on innovation outputs. Cappelen et al. (2008), for instance, investigated

output additionality in terms of introducing new products and processes and found significant effects for innovations with rather low degree of novelty.

Brazilian empirical literature on innovation policy impact estimates the effects of different government programs[3], most of them focused on tax incentives. For example, Avellar (2009) measures governmental programs impacts on R&D expenditures, using Pintec and propensity score matching techniques. Her main results point to significant impacts on R&D expenditures. Araujo et al. (2012) measure the impact of grants on R&D employment. They showed R&D expenditures of the treated group grew at a higher rate than those of the control group.

We noted that, despite there is an expressive number of papers that evaluate different innovation programs, including Brazilian most important ones, none of them focus specifically on evaluating BNDES innovation credit on input and output additionality. This paper contributes to the Brazilian literature as it is the first one to evaluate BNDES direct credit support, taking into account its significant role in National Innovation System.

BNDES innovation credit

Innovation support is a strategic priority for BNDES, due mainly to its potential in increasing companies' productivity and competitiveness and in creating wealth, that's why BNDES finances investment projects associated with firm's innovative activities.

BNDES innovation support has begun in the 1960s with the establishment of the Technological Fund (Funtec), created to finance the technological development in Brazil. After a long period without creating additional financing instruments dedicated to innovation, the issue came back to the fore in the late 1990s through the creation of sectorial programs and equity funds to support technology-based companies.

For example, in 1997 BNDES created a specific program, called Prosoft, to develop software and information technology services national industry. In 2004, Profarma was created to support pharmaceutical industry, an intensive research and development sector. After that, BNDES launched Proengenharia program to support local engineering in sectors such as automotive, capital goods, defense oil & gas, chemical and petrochemical and shipbuilding.

On the 2000s, BNDES launched horizontal credit lines to support R&D and project innovation in all companies, regardless of its size or sector of its activity: *Linhas de Inovação*. The lines were created in addition to the existing sectorial support structure (Prosoft, Proengenharia and Profarma).

Those programs offered better financial conditions to encourage companies to invest in innovation projects. Their interest rates are lower than the ones charged in other BNDES lines and sometimes fixed. BNDES innovation credit finances equipment acquisition; training of employees; acquisition and licensing of intellectual property rights; registration of patents, trademarks, designs and plant varieties; research and development activities; among others.

To look closer to BNDES innovation credit, Table 1 presents BNDES data on financing contracts to support firms' innovation activities during the period 2004-2014. BNDES had 598 financing contracts with companies in the whole period and this number increased over time, going from 10 contracts in 2004 to 106 contracts ten years later.

[3] To a more detailed review, Rocha, 2015.

BNDES sectorial programs, Profarma, Proengenharia and Prosoft, concentrated almost 57% of the contracts in the period. Table 1 also shows that the horizontal lines for supporting firms' innovation, like the innovation lines, are the second group in number of contracts.

The analysis of the evolution of contracting for the horizontal lines over time shows that innovation line are gradually substituted for Innovation/PSI from 2012 on, because of the more attractive financial conditions of PSI Innovation Program. The 'Others' category includes several BNDES lines that were irrelevant in terms of contracts or those that were extincted.

On the other hand, Table 2 shows the total value of the loans given by BNDES for firms to support innovation activities in the 2004-2014 period. It can be seen that BNDES gave more than BR$ 16 billion in credit for firms during the whole period. The total amount of loans grew over time, mainly after 2009, coinciding with the period of BNDES expansion in the Brazilian credit market.

In terms of the amount of credit relative magnitude, Proengenharia was the more relevant BNDES Program, with almost BR$ 5 billion in contracts in the whole period. The total amount of loans for BNDES horizontal lines were roughly BR$ 3.6 billion in the period, being the second most relevant category of financing. The amount of credit for Profarma (approximately BR$ 3 billion) is more than twice the value of Prosoft, what might be associated with the lower size of Prosoft firm's compared to the average size of Profarma firms.

Table 1: Descriptive Statistics of BNDES data – number of contracts by BNDES Innovation Programs and year during 2004-2014

Program	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Profarma	1	15	16	17	18	17	12	14	13	15	13	**151**
Inovação/PSI									24	65	39	**128**
Prosoft	7	4	8	7	14	14	12	13	11	7	23	**120**
Linhas Inovação			1	15	10	9	14	23	7			**79**
Proengenharia					2	6	6	5	13	20	13	**65**
Others	2	2	4	1		3	7	10	2	6	18	**55**
Total	**10**	**21**	**29**	**40**	**44**	**49**	**51**	**65**	**70**	**113**	**106**	**598**

Source: BNDES. Elaborated by the authors.

Table 2 Descriptive Statistics of BNDES data – total of loans (in BR$ thousands) by BNDES Innovation Programs and year during 2004-2014

Program	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Proengenharia					118,723	286,194	700,309	584,952	824,054	1,860,348	579,422	**4,954,002**
Inovação/PSI									676,757	2,220,786	715,372	**3,612,915**
Profarma	16,873	102,004	230,802	526,629	114,775	234,476	45,236	343,809	217,060	742,973	475,863	**3,050,501**
Others	38,000	13,557	10,265	5,025		21,779	1,088,252	354,324	29,494	27,185	327,969	**1,915,851**
Prosoft	14,885	56,562	24,629	22,877	235,044	70,499	56,721	90,936	148,918	625,478	209,441	**1,555,991**
Linhas Inovação			6,788	180,175	44,473	204,416	217,787	366,332	366,188			**1,386,159**
Total	**69,758**	**172,123**	**272,484**	**734,706**	**513,015**	**817,364**	**2,108,305**	**1,740,353**	**2,262,471**	**5,476,770**	**2,308,067**	**16,475,419**

Source: BNDES. Elaborated by the authors.

By looking at firm-level data on the access of BNDES Innovation lines and Programs, we note that the number of firms supported grows over time, from just 8 companies in 2004, to 71 in 2014, as it is shown in **Table 3**. This table also presents loan value distribution statistics for firms during the 2004-2014 period. The mean value of the distribution of loans for firms increased over the period, going from roughly BR$ 8.7 million to BR$ 32.5 at the interval end.

However, given the loans value distribution is right-skewed, we observe the median is far below the mean for each year. For instance, the loans median were BR$ 2,464 in 2008, while the mean were BR$ 15,089. The median loan for supporting firms' innovation varied between BR$ 4.5 million (in 2004) and BR$ 14.8 million (in 2013). After 2009, the last quartile of the loans distribution started to remain above BR$ 20 million per firm.

Table 3: Distribution of Loans per Firm and Share of large companies

Year	BNDES Loans per firm (BR$ Thousand)						Large Firms Share
	N	Mean	S.D.	P25	P50	P75	
2004	8	8,720	9,953	2,370	4,473	12,437	25.0%
2005	15	11,475	13,958	3,000	5,811	13,050	40.0%
2006	22	12,386	18,808	2,550	4,750	9,900	59.1%
2007	30	24,490	58,809	2,350	5,717	15,828	53.3%
2008	34	15,089	37,497	1,400	2,464	7,799	32.4%
2009	42	19,461	35,604	2,433	4,700	23,960	47.6%
2010	37	56,981	190,755	2,794	6,156	20,982	48.6%
2011	36	48,343	139,893	3,668	6,205	23,750	58.3%
2012	48	47,135	90,508	3,485	12,326	36,174	70.8%
2013	69	79,373	193,309	5,300	14,787	71,000	73.9%
2014	71	32,508	56,448	3,000	11,471	33,188	62.0%

Source: BNDES. Elaborated by the authors.

Additionally, **Table 3** shows the share of large firms in the total number of companies supported by BNDES Innovation Programs (accordingly to BNDES threshold)[4] increased over time. In 2004, just 25% of firms were classified as large, while, in 2013, almost three quarters of the firms were on that category.

Empirical Strategy

We estimated the effects of the direct BNDES support to firms' innovation activities based on two variables: R&D expenditures and new products sales. We estimated the current and future BNDES effects and also looked at the effects on the variation of those variables.

We employed a microeconometric approach to try to separate how much of the difference in innovation efforts and results between supported firms and not supported can be, in fact, attributed to BNDES funding. The main problem associated to this goal is to deal with the selection bias that can occur because firms that are more likely to carry out innovative activities are more inclined to meet BNDES' credit requirements.

We adopt a Fixed Effect approach to try to reduce the endogeneity problem derived from the sample selection bias. In a fixed-effects model, firms variation over time serve as their own

[4] The threshold varied over the period of the analysis. In 2010, BNDES changed firm size classification: Big firms were the ones that had annual or annualized Gross Operating Income higher than or equal to BR$ 90 million. For detailed information, see: http://www.bndes.gov.br/SiteBNDES/bndes/bndes_en/Institucional/Press/Noticias/2010/20100623_porte_empresa.html.

controls. The idea is that whatever effects the omitted variables have on the firms at one time, they will also have the same effect at a later time, hence we can eliminate this fixed components with those models.

In order to estimate BNDES effects on the current level of the outcome variables of interest, we estimated the following equation:

$$Y_{it} = \alpha_i + \beta_1 B_{it} + \cdots + \gamma X_{it} + \varepsilon_{it} \quad (1)$$

Where Y is a variable for effort or result of firm *i* in year *t*; B is an indicator variable that assumes 1 if firm *i* in year *t* had BNDES innovation credit and 0 otherwise, and X are control variables.

In order to estimate the effects on the future level of the variables of interest, we use another specification:

$$Y_{it} = \alpha_i + \beta_1 B_{it} + \beta_2 B_{i(t-1)} + \cdots + \gamma X_{it} + \varepsilon_{it} \quad (2)$$

Where Y is a variable for effort or result of firm *i* in year *t*; and $B_{i(t-1)}$ captures the effect of BNDES credit on the future level of the outcome variables. This variable allows us to verify if there is some anticipation effect.

We estimated these equations using a Fixed Effect approach, so we control for unobserved heterogeneity that is time invariant.

Finally, we used a complementary approach to estimate the effects of BNDES support on the trends of firms' outcomes, based on the Differences-in-Differences (DID) estimator:

$$Y_{it} = \beta_1 BNDES_{it} + \beta_2 After_t + \beta_3 BNDES_{it} * After_t + X_{it}\gamma + \varepsilon_{it} \quad (3)$$

Differences-in-Differences methodology compares one group before and after the treatment (i.e., innovation effort before and after BNDES credit). The identification assumption is that, in the absence of the treatment, both groups would have displayed parallel trends.

Data

The Brazilian Innovation Survey (PINTEC) from IBGE (Brazilian Geographic and Statistics Institute) aims to explore and measure the innovative activities developed in industrial and service companies, as well as to monitor their evolution over time. The observations contained in this database include companies registered in the National Registry of Legal Entities (CNPJ), maintained by the Ministry of Finance. The companies covered by the research are restricted to the sectors of extractive industry, manufacturing industry, electricity and gas, music editing and recording, data processing and internet hosting, telecommunications, information technology services, architecture, engineering, testing and technical analysis and research and development (R&D) services.

Pintec is a triennial sample survey that is, in each reference year, Pintec's time frame refers to a period of three years: the survey year and previous two. By 2014, five editions were already been published for reference years of 2000, 2003, 2005, 2008, 2011. Pintec is consistent with the conceptual and methodological guidelines of Oslo Manual of Organization for Economic Cooperation and Development (OECD, 1997) and because of that Pintec is comparable to any other innovation database.

Pintec is composed of two topics - innovative efforts and results. The survey is designed to produce statistically significant samples of companies in the 10 to 29, 30 to 99, 100 to 249 and 250 to 499 employees' strata and attempts to cover all companies with 500 or more employees. In addition, Pintec attempts to cover all companies that have received any governmental support for innovative efforts, companies that have declared to carry out formal R&D efforts and that have applied for patents.

For the other hand, BNDES Data includes information about firms' innovation financing contracts over the period 2004-2014. We found that BNDES had 598 financing contracts with companies in the whole period. BNDES data considers only credit contracts, thus our data filters out grants and equity BNDES lines.

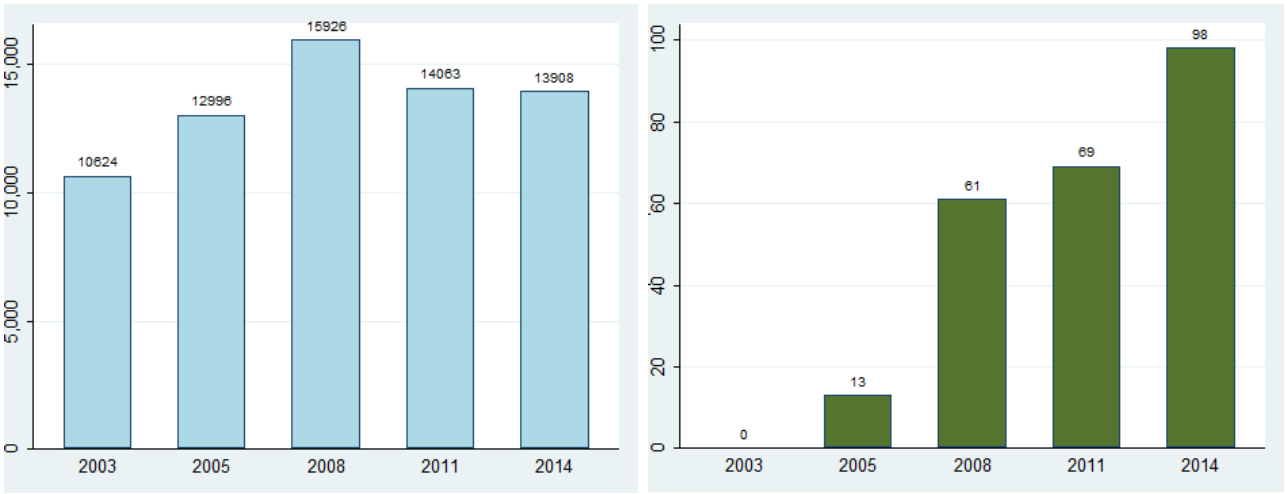
Data preparation consisted of building a panel of firms for the 2003-2005 period. We use data from Pintecs Surveys 2003, 2005, 2008, 2011 and 2014. In order to maximize the number of BNDES firms found on each year of Pintec, it was necessary to adapt the contract year of supported firms in a way that converges to the specific Pintec year. As Pintec is triennial, we related to each Pintec year, three BNDES contract years. For example, we linked 2014 Pintec data to 2014, 2013 and 2012 BNDES contract information.

The variables explained by the econometric estimations include both indicators of innovative efforts and results, respectively, R&D expenditures and New Product Sales. Our control variables includes a series of firm size indicators such as number of employees, net revenue, production costs, raw material consumption and wages. Also included was a labor productivity indicator, calculated as the ratio of gross production value to total staff employed in the firm. Finally, there is a dummy for firms in the industrial sector and another for firms that have received other forms of public support for innovative activities.

Chart 1 indicates, respectively, the total number of firms in the sample and those treated by BNDES support in each year of the analysis. The total sample includes 67,517 observations, with a mean of 13,500 per year. The firms supported by BNDES account for 241 observations of firms found in Pintecs over the whole period. The bank's support is on a growing trajectory from zero in 2003 to 98 in 2014, the last year of the analysis.

Chart 1: Number of Firms

(a) Total sample (b) Supported by BNDES

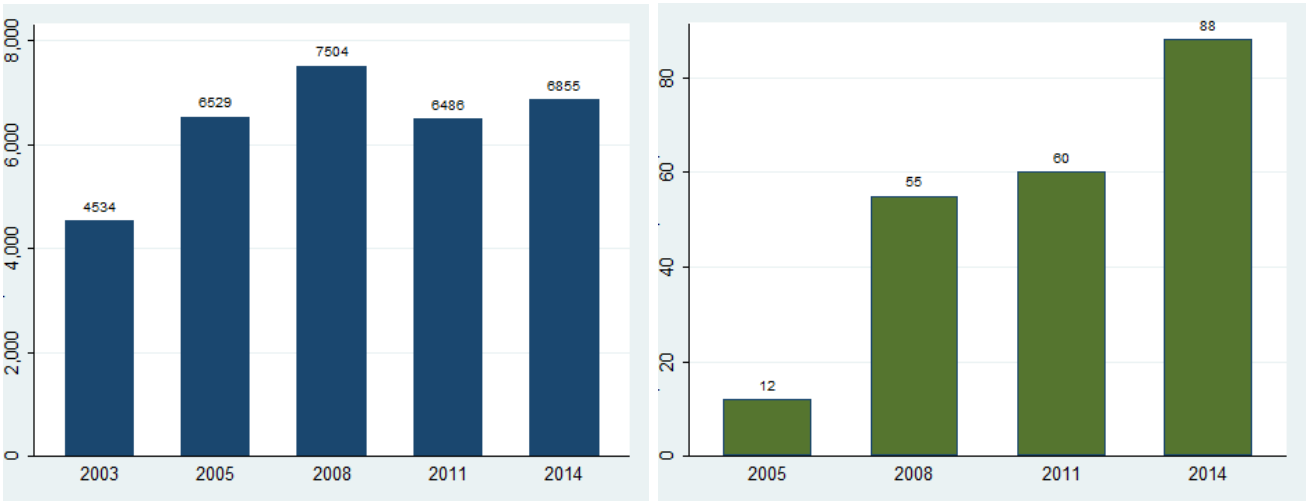


Source: Pintec, IBGE.

Chart 2 indicates the total number of firms that promoted some type of innovation in each year of the analysis, respectively in the total sample and among those treated by BNDES support. The total sample includes 31,908 observations, with an average of 6.4 thousand per year. On the other hand, the firms supported by BNDES account for 215 observations (89.2% of the total number of firms supported).

Chart 2: Number of Innovative Firms

(a) Total sample (b) Supported by BNDES



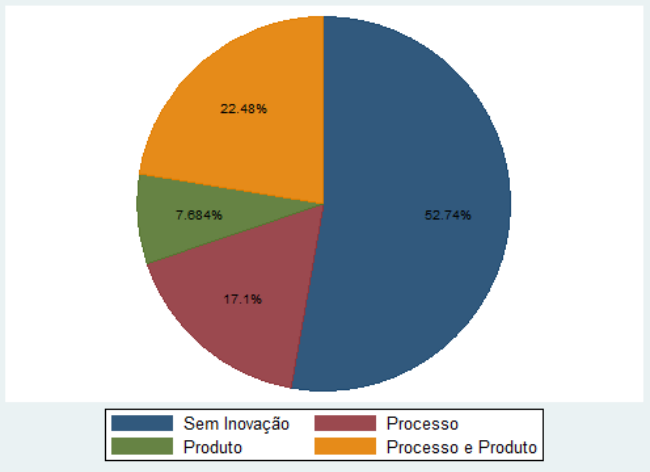
Source: Pintec, IBGE.

Chart 3 classifies the firms included in each year of analysis according to the results of their innovative efforts. As indicated earlier, BNDES-supported companies tend to be more

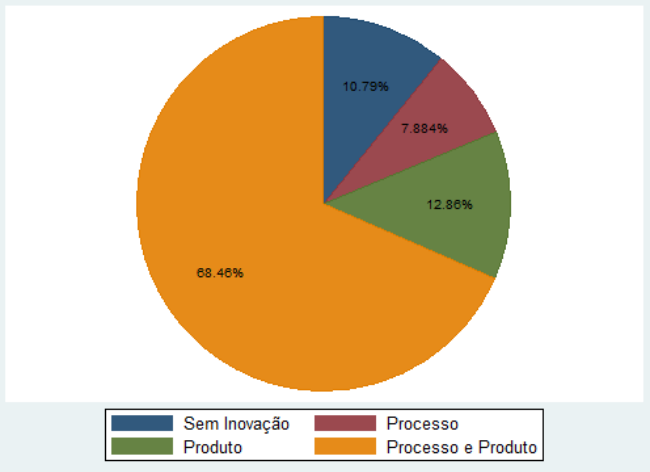
innovative than average. Whereas, in the total sample, 52.74% of the firms are non-innovative, among those treated this percentage is only 10.79%. Most of the firms supported are innovative in both product and process (68.46%).

Chart 3: Firms by Innovation Category (%)

(a) Total sample



(b) Supported by BNDES



Source: Pintec, IBGE.

Figure 1 presents the means of the variables used in the present study. It should be noted that there are large differences between those supported by BNDES and the total sample. In general, companies treated by BNDES support tend to invest more in R&D and are larger than the others in terms of sales revenue, number of employees, operating costs, raw material consumption, wage mass and productivity. This phenomenon certainly stems from a selection bias, since the procedures for framing the firms' innovative projects in BNDES disbursement policies tend to favor larger firms. However, the use of estimation techniques for panel data with fixed effects accurately seeks to control this bias, since it ponders each observation by the firm's average over time. This technique helps to better explore the contribution of bank support to the innovative efforts of the firms observed.

Figure 1: Summary statistics

Group	Variable	N	Mean	sd
Total	Any innovation (dummy)	67,517	0.473	0.499
	Product innovation (dummy)	67,517	0.302	0.459
	Process innovation (dummy)	67,517	0.396	0.489
	Product and process innovation (dummy)	67,517	0.225	0.417
	Expenses in R&D	67,517	1,228	29,956
	Employees in R&D	67,517	3.231	48.97
	Revenue innovation	67,295	21,251	381,215
	R&D is important to the firm (dummy)	67,517	0.194	0.396
	BNDES support	67,517	0.00357	0.0596
	Total employees	67,387	328.6	1,321
	Net revenue	67,295	119,603	1,676,000
	Operational costs	65,500	60,587	501,732
	Consumption of raw material	65,489	47,661	375,165
	Wages	65,500	10,204	93,184
	Industrial firm (dummy)	67,517	0.907	0.291
	Other public support (dummy)	67,517	0.159	0.366
	Labor productivity	64,591	197.8	1,133
Supported by BNDES	Any innovation (dummy)	241	0.892	0.311
	Product innovation (dummy)	241	0.813	0.390
	Process innovation (dummy)	241	0.763	0.426
	Product and process innovation (dummy)	241	0.685	0.466
	Expenses in R&D	241	43,109	164,267
	Employees in R&D	241	113.7	353.6
	Revenue innovation	240	590,176	2,123,000
	R&D is important to the firm (dummy)	241	0.763	0.426
	Total employees	241	2,633	5,233
	Net revenue	240	1,809,000	4,806,000
	Operational costs	238	984,870	2,666,000
	Consumption of raw material	238	877,724	2,468,000
	Wages	238	156,753	361,912
	Industrial firm (dummy)	241	0.722	0.449
	Other public support (dummy)	241	0.772	0.421
	Labor productivity	237	531.3	1,501

Source: Pintec, IBGE

Figure 2 shows the evolution of the mean of the same variables over time. There is a general trend of growth in continuous variables, especially from 2011 on. This trend is more pronounced in firms supported by BNDES. On the other hand, the percentage of firms that promoted some innovation was little altered in this period, remaining below 50% for the total sample and about 90% for firms treated by the bank's support.

Figure 2: Summary statistics

Group	Variable	2003	2005	2008	2011	2014
Total	Any innovation (dummy)	0.427	0.502	0.471	0.461	0.493
	Product innovation (dummy)	0.267	0.316	0.319	0.278	0.318
	Process innovation (dummy)	0.346	0.402	0.387	0.400	0.434
	Product and process innovation (dummy)	0.186	0.215	0.235	0.217	0.259
	Expenses in R&D	494.9	792.4	1,058	1,429	2,188
	Employees in R&D	1.986	3.442	2.783	3.600	4.125
	Revenue innovation	15,931	13,880	14,073	22,592	38,949
	R&D is important to the firm (dummy)	0.192	0.218	0.136	0.207	0.228
	BNDES support	0	0.00100	0.00383	0.00491	0.00705
	Total employees	290.6	295.0	312.7	356.1	378.9
	Net revenue	70,976	86,928	104,619	141,273	182,076
	Operational costs	38,443	45,608	55,427	66,362	95,532
	Consumption of raw material	33,324	37,136	43,515	50,878	72,791
	Wages	5,415	6,470	8,277	12,001	18,710
	Industrial firm (dummy)	0.998	0.942	0.876	0.903	0.844
	Other public support (dummy)	0.108	0.140	0.129	0.189	0.219
	Labor productivity	133.1	162.1	202.3	208.8	272.0
	Bndes	0	0.00100	0.00383	0.00491	0.00705
Supported by BNDES	Any innovation (dummy)		0.923	0.902	0.870	0.898
	Product innovation (dummy)		0.923	0.738	0.812	0.847
	Process innovation (dummy)		0.769	0.705	0.768	0.796
	Product and process innovation (dummy)		0.769	0.541	0.710	0.745
	Expenses in R&D		30,375	11,196	48,725	60,707
	Employees in R&D		89.62	38.13	138.2	146.8
	Revenue innovation		101,476	104,264	754,284	836,956
	R&D is important to the firm (dummy)		0.923	0.525	0.797	0.867
	Total employees		956.4	2,140	3,060	2,862
	Net revenue		507,344	1,018,000	2,276,000	2,137,000
	Operational costs		274,009	398,230	1,268,000	1,244,000
	Consumption of raw material		134,190	250,929	1,180,000	1,154,000
	Wages		40,083	70,125	192,037	201,238
	Industrial firm (dummy)		0.846	0.689	0.696	0.745
	Other public support (dummy)		0.692	0.590	0.841	0.847
	Labor productivity		331.8	240.3	791.9	558.1

Source: Pintec, IBGE

Results

Table 4: shows the estimates of the effects of BNDES credit on firm R&D expenditures. We present results for the R&D expenditures in levels and in logs and compare estimates for Pooled OLS and Fixed Effects estimators. We also compare results for base case estimates (without sample restrictions) and for a sample where we apply a 1% trimming on the tails of the distribution of the interest dependent variable, restricting the presence of outliers. For the FE estimator, we also show results comparing estimates for an unbalanced panel sample and a balanced one.

We progressively show the current effects of BNDES credit on R&D expenditures based on these combinations (columns 1 to 10 of Table 4:), and our preferred specification (column 11) estimates also the future effect on our dependent variables (coefficient on the BNDES lagged variable on the table). We see that the estimated effects of BNDES on firm R&D expenditures are positive and significant at the 1% percent level for most of the specifications.

The results for R&D expenditures (in BR$ thousand) show a decrease in the magnitude of the effect when we compare the POLS estimates with the FE ones. The same pattern emerges when we look to the dependent variable in logs, with a little increase in the size of the effect for the balanced panel estimates. The specification in column 11 reveals a considerable increase in the magnitude of the BNDES current effect (roughly 60% superior relatively to the control group).

However, we see a reversal in the signal of the effect on firms' future R&D expenditures (column 11). This result jointly with the positive current effect can be, for one side, interpreted as associated to an anticipating behavior of supported firms. In that view, the positive current effect might be (at least in part) due to anticipating future R&D expenditures, and not only with R&D expenditures addition. For the other side, we can view this negative effect as associated with a more concentrated pattern of firms R&D investment cycles in comparison with the non-treated firms, that could be otherwise smoothing their investment cycles. Also, it is important to note that the magnitudes are different for the current and future BNDES estimates, evidencing just a partial reduction in the future R&D expenditures for the firm.

Table 5 shows the estimated effects of BNDES on Sales associated to new products developed by the company. The pattern of the estimates presented is the same of Table 4:. We note that the current BNDES effects are positive and significant only for the POLS estimates both for the dependent variable in levels and in logs. On the other side, the FE estimates have a positive sign but not statistically significant effect, and are lower in size than the POLS estimates. This means that BNDES credit for innovation appears to have no current impact on new product sales over the period analyzed. The coefficient associated to BNDES lagged dummy was negative but not significant.

The analysis of the DID estimates of BNDES effects on firm innovation tend to show a positive and (in some specifications) significant effect over the period 2005-2014. Table 3 shows the significant positive effects are concentrated in BNDES 2014-2011 and 2011-2008 DID estimates. Also the estimates tend to be more significant for R&D expenditures rather than for New Product Sales.

The estimates presented in Table 3 indicate BNDES tend to have a positive effect also on the variation over time of the innovation indicators analyzed here, additionally to the positive effect showed for the variables in level. After all, BNDES estimates presented for the FE and the DID estimator pointed to the conclusion that BNDES support to firm innovation tend to have significant effects mainly for the R&D expenditures.

Table 4: Estimated effects of BNDES on R&D expenditures

	Dependent variable: R&D expenditures (in BR$ thousand)					Dependent variable: R&D expenditures (in logs)					
	POLS		FE			POLS		FE			
	Base case	1% trimming	Base case	1% trimming	1% trimming and Balanced	Base case	1% trimming	Base case	1% trimming	1% trimming and Balanced	1% trimming and Balanced
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
BNDES	45,238***	13,722***	9,790	8,980***	10,035***	1.369***	1.219***	0.176	0.318***	0.403***	0.590**
	(5,524)	(774.1)	(11,794)	(2,486)	(2,912)	(0.124)	(0.125)	(0.108)	(0.111)	(0.123)	(0.232)
BNDES (lagged)											-0.325**
											(0.158)
Log net revenues	4,108	623.2	6,326	371.2	547.3	0.130*	0.147**	0.250	0.266	0.411*	0.225
	(3,185)	(422.8)	(6,171)	(1,366)	(2,305)	(0.0718)	(0.0682)	(0.191)	(0.187)	(0.242)	(0.324)
Log employees	2,506	-238.3	-1,420	1,366	1,459	-0.166**	-0.156**	0.0112	-0.0320	-0.141	0.279
	(3,562)	(472.4)	(6,600)	(1,488)	(2,596)	(0.0803)	(0.0762)	(0.198)	(0.196)	(0.265)	(0.344)
Log wages	4,558***	2,017***	909.0	-140.0	-136.9	0.740***	0.694***	0.156*	0.157*	0.219*	-0.107
	(1,594)	(211.4)	(1,430)	(538.7)	(955.9)	(0.0359)	(0.0341)	(0.0818)	(0.0816)	(0.122)	(0.147)
Log production costs	-3,624*	-628.8**	1,109	981.9**	1,350	-0.0846**	-0.118***	0.0833	0.0729	0.0633	0.0834
	(1,864)	(248.9)	(2,563)	(461.3)	(973.3)	(0.0420)	(0.0402)	(0.0729)	(0.0716)	(0.106)	(0.124)
Log raw material costs	-881.7	152.3	-1,691	-318.3*	-409.3	-0.00716	0.00596	-0.0337	-0.0273	-0.0596*	-0.0712**
	(974.4)	(129.3)	(1,431)	(167.1)	(322.0)	(0.0220)	(0.0209)	(0.0335)	(0.0338)	(0.0305)	(0.0326)
Log Labor productivity	4,248	570.3	-3,936	-670.1	-361.4	0.173**	0.160**	-0.0618	-0.0881	-0.0707	0.174
	(3,383)	(449.4)	(6,328)	(1,431)	(2,508)	(0.0762)	(0.0725)	(0.184)	(0.180)	(0.229)	(0.303)
Government support	3,591**	1,803***	-518.0	1,065***	1,180**	0.602***	0.566***	0.315***	0.290***	0.291***	0.285***
	(1,491)	(196.2)	(1,301)	(337.3)	(509.8)	(0.0336)	(0.0317)	(0.0574)	(0.0507)	(0.0654)	(0.0852)
Constant	-67,190***	-17,158***	-39,781***	-6,255	-8,917	-0.430***	0.00321	4.415***	4.086***	5.021***	2.326
	(6,746)	(897.1)	(15,240)	(5,277)	(8,292)	(0.152)	(0.145)	(0.730)	(1.002)	(1.068)	(1.572)
Sector*Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,506	8,322	8,506	8,322	3,179	8,506	8,322	8,506	8,322	3,179	2,298
R-squared	0.057	0.229	0.011	0.081	0.093	0.492	0.474	0.144	0.153	0.174	0.077
Number of firms			5,593	5,493	1,416			5,593	5,493	1,416	1,234

Notes: Robust Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Estimated effects of BNDES on New Product Sales

	Dependent variable: New produtc Sales (BR$ thousand)					Dependent variable: New produtc Sales (in logs)					
	POLS		FE			POLS		FE			
	Base case	1% trimming	Base case	1% trimming	1% trimming and Balanced	Base case	1% trimming	Base case	1% trimming	1% trimming and Balanced	1% trimming and Balanced
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
BNDES	639,637***	69,911***	167,276	54,009	45,593	0.420***	0.280***	0.130	0.220	0.243	0.340
	(40,540)	(8,914)	(227,613)	(33,611)	(41,031)	(0.102)	(0.107)	(0.143)	(0.170)	(0.193)	(0.390)
BNDES (lagged)											-0.167
											(0.202)
Log net revenues	102,091***	27,782***	52,758	34,205***	37,517	0.848***	0.793***	1.064***	1.046***	1.026***	0.796***
	(19,989)	(4,122)	(61,333)	(12,614)	(24,901)	(0.0502)	(0.0496)	(0.135)	(0.136)	(0.209)	(0.246)
Log employees	-3,549	3,102	72,854	12,425	25,075	0.0703	0.0707	-0.0513	-0.0816	0.172	0.633**
	(22,007)	(4,536)	(63,660)	(13,464)	(24,136)	(0.0553)	(0.0546)	(0.149)	(0.150)	(0.239)	(0.297)
Log wages	-11,407	1,172	-55,127	-18,247***	-29,269**	-0.0109	0.00218	-0.140*	-0.120*	-0.280**	-0.389**
	(8,936)	(1,857)	(34,203)	(6,963)	(12,912)	(0.0224)	(0.0224)	(0.0724)	(0.0716)	(0.115)	(0.158)
Log production costs	-7,471	-2,104	37,369**	3,672	9,672	-0.0258	-0.0214	-0.0101	-0.0195	-0.0333	-0.122
	(9,634)	(1,998)	(18,939)	(5,657)	(9,580)	(0.0242)	(0.0240)	(0.0622)	(0.0621)	(0.104)	(0.111)
Log raw material costs	-3,237	-1,365	-15,023	619.3	2,166	-0.00704	-0.00223	0.0471	0.0531*	0.0515	0.0430
	(5,327)	(1,101)	(16,448)	(3,491)	(3,904)	(0.0134)	(0.0133)	(0.0293)	(0.0294)	(0.0447)	(0.0434)
Log Labor productivity	-38,007*	-5,707	-40,308	-4,854	-1,716	0.0896*	0.0854	-0.0964	-0.118	-0.0541	0.262
	(21,111)	(4,352)	(63,685)	(12,178)	(21,212)	(0.0530)	(0.0524)	(0.133)	(0.134)	(0.204)	(0.235)
Government support	38,336***	12,204***	18,920	978.3	-3,794	0.146***	0.146***	0.0822**	0.0771*	0.0374	-0.0230
	(8,819)	(1,820)	(19,129)	(4,122)	(6,574)	(0.0222)	(0.0219)	(0.0409)	(0.0409)	(0.0566)	(0.0770)
Constant	-545,642***	-185,602***	-531,975***	-246,510***	-381,411***	-0.549***	-0.154	-0.973	-0.678	-0.698	-0.591
	(39,240)	(8,191)	(185,774)	(69,999)	(101,834)	(0.0986)	(0.0986)	(0.612)	(0.625)	(0.919)	(1.222)
Sector*Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,213	14,945	15,213	14,945	4,120	15,213	14,945	15,213	14,945	4,120	2,952
R-squared	0.102	0.219	0.024	0.052	0.064	0.710	0.681	0.212	0.196	0.184	0.112
Number of firms			10,627	10,493	1,806			10,627	10,493	1,806	1,595

Notes: Robust Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Conditional DID estimates of BNDES effects on firm innovation

	R&D expenditures (in BR$ thousand)		R&D expenditures (in logs)		New Product Sales (in BR$S thousand)		New Product Sales (in logs)	
	Base case	1% trimming	Base case	1% trimming	Base case	1% trimming	Base case	1% trimming
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
BNDES (2008-2005)	6,517	6,931***	0.315	0.341	101,329	48.24	-0.0692	-0.0921
	(14,908)	(1,862)	(0.424)	(0.405)	(110,485)	(21,726)	(0.345)	(0.346)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,013	2,958	3,013	2,958	4,629	4,537	4,629	4,537
R-squared	0.060	0.229	0.435	0.424	0.103	0.247	0.673	0.637
BNDES (2011-2008)	2,636	5,100**	0.0343	0.0306	295,799**	53,448**	-0.0395	0.0513
	(17,896)	(2,590)	(0.350)	(0.357)	(121,351)	(27,211)	(0.285)	(0.315)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,841	2,790	2,841	2,790	4,586	4,505	4,586	4,505
R-squared	0.086	0.261	0.473	0.456	0.161	0.270	0.652	0.611
BNDES (2014-2011)	36,042**	7,198***	-0.0701	-0.0456	247,553	21,659	0.490*	0.451
	(18,237)	(2,499)	(0.286)	(0.292)	(162,304)	(41,383)	(0.260)	(0.282)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,852	2,799	2,852	2,799	3,850	3,787	3,850	3,787
R-squared	0.079	0.280	0.461	0.435	0.170	0.267	0.604	0.558

Notes: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Controls are Log net revenues, Log employees, Log wages, Log production costs, Log raw material costs and Log labor productivity.

Conclusion

This paper aimed to evaluate the impact of BNDES innovation credit on firms' innovation outcomes. Using data from Pintec for the period of 2003-2014 and BNDES data on credit for supporting firms' innovation activities over the period 2004-2014, we construct a panel dataset and estimate the current and future effects.

We adopted a Fixed Effects approach to deal with the endogeneity problem associated to the selection of firms who receive the credit and then estimated the impact of BNDES support on R&D expenditures and New Product Sales. We also used a complementary approach based on the Differences-in-Differences estimator to address the BNDES effects based on a before-and-after evaluation design.

Our findings showed evidence of positive and significant impact of BNDES credit on firms' R&D expenditures for both estimators, although the effects on New-Product Sales were not significant. Based on the FE estimates, we obtained an increase in current firms' R&D expenditures varying between 30% and 60% percent, depending on the specification used. We also found evidence of a negative effect on future R&D expenditures, what might be associated to an anticipating behavior of the treated firms' R&D expenditures decision. Although this conclusion requires further analysis.

Future agenda will focus on decompose the analysis by company size and economic sectors. We also intend to employ alternative approaches for estimating the BNDES impact on innovation such as dynamic panel and quasi-experimental empirical strategies. Besides we will look at other innovative dimensions than the ones presented in this work.

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