The effects of BNDES loans on the productivity of Brazilian manufacturing firms*

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ABSTRACT

We investigate the effects of BNDES loans on Brazilian firms' productivity and technological upgrading. Our results show that generally granted firms perform better than non-granted firms. Their performance, however, is affected by BNDES loans only when we distinguish between loans for small vs. large project (Automatic BNDES vs. FINEM) and allow some time to pass between the moment loans are awarded and the moment their effects materialize. In particular, we find that the impact of loans on firm productivity appears in the data with a three-year lag and differs between small and large projects. Being negative for the former and positive for the latter, the sign of the impact is consistent with the idea that Automatic BNDES loans are used to implement lower quality projects using old technologies whereas FINEM loans are used to implement higher quality projects using new technologies.

Keywords: heterogeneous firms, productivity, public policy analysis, technology.

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1. Introduction

Credit constraints for long-term projects are considered among the most important market failures in the Brazilian economy as they hamper the entrepreneurial efforts of local firms. That is why the Brazilian government provides long-term loans through the Banco Nacional de Desenvolvimento Economico e Social (henceforth, BNDES), a development bank whose main statutory goal is to improve Brazilian economic competitiveness without neglecting broader social aspects. BNDES invests in several areas including research and development, infrastructures, export support, regional and urban development. More specifically, in the case of manufacturing, BNDES finances long-term projects aimed at the creation of new plants, the enlargement of existing ones, the restructuring and the modernization of production processes, innovation and technological development, export promotion. Overall, the importance of BNDES in the Brazilian economy is quite sizeable: in 2005 its disbursements reached the value of US$ 20.1 billion, representing 12.3% of aggregate investment.[1]

Even though BNDES project analysis involves several dimensions including social and environmental aspects, it is nonetheless interesting to assess their overall impact on the competitiveness Brazilian firms. The aim of the present paper is to contribute to this assessment by investigating the impact of BNDES activities on the productivity of Brazilian manufacturing firms. Though focused, this is of course a central issue from a policy perspective: "Productivity isn't everything, but in the long run it is almost everything. Compared with the problem of slow productivity growth, all our other long-term economic concerns - foreign competition, the industrial base, lagging technology, deteriorating infrastructure and so on - are minor issues" (Paul Krugman,1992).

[1] Source: IPEA and BNDES (www.ipeadata.gov.br and www.bndes.gov.br).

We are not aware of any study targeting the relation between BNDES and the productivity of Brazilian firms. Even though some evaluation of BNDES activities is presented by Bastos (2004), BNDES (2002), Capanema (2006), De Sousa (2003), Moteiro Filha (1994) as well as Torres Filho and Puga (2006), there is no discussion of its impact on firm productivity. Amadeo and Gonzaga (1996), Feijo' and Carvalho (1994), Ferreira and Rossi (2003), Hay (2001), Muendler (2004), Nassif (2005), Salm et al. (1997) as well as Schor (2004) evaluate the productivity of the Brazilian economy after the liberalization process of the 90s but they do not investigate the relation between BNDES and firm productivity. Closer to the spirit of the present paper, De Negri et al (2006) evaluate the impact of the Scientific and Technological Development Fund (FNDCT), administered by the Research and Projects Financing Agency (FINEP), on Brazilian firm productivity and technological upgrading.

The logic of our analysis is the following. We start with the a priori that Brazilian firms may be credit constraint, especially if they are small and in poorer regions. Accordingly, they are in a situation in which they would like to make investments but credit constraints hamper the implementation of projects. BNDES offers loans that could be used to remove those credit constraints. A key question then becomes: *Are BNDES loans indeed instrumental in relaxing the credit constraints faced by Brazilian firms?* A positive answer requires checking that two things are true. First, granted firms must change their performance after receiving a loan. Second, after receiving a loan, granted firms must perform differently than otherwise identical non-granted firms.

Another key question is: *Do BNDES loans lead to an increase or a decrease in firm productivity?* We argue that, even if one were sure that BNDES loans relax the credit constraints, there is a priori no reason to expect a positive impact on firm productivity. We build this argument on a theoretical framework adapted from Bustos (2005) in the wake of the recent literature on the selection effects of trade liberalization with firm heterogeneity (Bernard et al, 2003; Melitz, 2003; Melitz and

Ottaviano, 2005).[2] The theoretical framework describes an imperfectly competitive industry in which firms generate new projects through an R&D process of uncertain outcomes. Accordingly, some projects turn out to be better than others. After their quality is revealed, projects can be brought to the production line by paying a fixed cost of implementation. In so doing, firms may rely on an 'old' technology characterized by lower fixed cost but higher marginal cost. Alternatively, they may adopt a 'new' technology characterized by higher fixed cost but lower marginal cost. The fixed cost differential between new and old technologies represents the pain of technological upgrading while the corresponding marginal cost differential represents its gain. Crucially, fixed costs have to be incurred before production takes place, which requires firms to borrow the financial resources needed. In this respect, credit constraints act on firms' borrowing conditions and thus affect the fixed costs of project implementation, which are larger the more constrained credit is.

When the fixed cost of the new technology is large enough, projects are selected into three categories. Low quality projects are not even able to repay the smaller fixed cost of the old technology, so they are discarded. Intermediate quality projects allow firms to cover the fixed cost of the old technology but not those of the new technology, so they are implemented using the former. Lastly, high quality projects cover also the fixed cost of the new technology, which is therefore used to implement them.

Against this background, the theoretical framework highlights two margins through which firms may react to laxer credit constraints. On the one hand, a reduction in the fixed costs of the old technology induces firms to implement some low quality projects that were previously discarded. This leads to a *decrease* in firm productivity[3]. On the other hand, a reduction in the fixed costs of the new technology promotes its adoption also for some intermediate quality project that was previously implemented using the old one. This leads to an *increase* in firm productivity. Hence,

[2] See Behrens et al (2007), Bernard (2006), Helpman (2006) for updated surveys.
[3] Moral harzard behaviour.

whether laxer credit constraints foster or hamper firm productivity depends on whether they disproportionately affect the fixed costs of old or new technologies.

Our empirical results show that on average granted firms do perform better than non-granted firms. However, their performance is affected by BNDES loans only if one distinguishes between loans for small vs. large project and allows some lag between the time loans are awarded and the time their effects materialize. In particular, we find that the impact of loans on productivity appears after three years and it is different between small and large projects, being negative for the former and positive for the latter. This is consistent with the idea that loans for small projects are used by firms to implement lower quality projects using old technologies whereas loans for large projects are used to implement higher quality projects using new technologies.

The rest of the paper is organized as follows. Section 2 describes the type of loans that are granted by BNDES. Section 3 discusses the dataset. Section 4 presents the methodological framework. Section 5 details the empirical strategy. Section 6 reports the econometric results. Section 7 concludes.

2. Overview of BNDES schemes

BNDES provides a wide range of financial tools to support Brazilian manufacturing firms: FINEM, Automatic BNDES, FINAME, Leasing FINAME, International Competition FINAME (BNDES-Exim) and Subscription of Securities.

FINEM ('Financing and Endeavors') is a direct support scheme for projects with financial needs over R$10 million.[4] Projects with financial needs below this threshold are instead supported indirectly through retailing banks under the Automatic BNDES scheme. Both schemes contemplate

[4] Approximately US$ 4.7 millions.

several categories of expenses covering the creation of new plants, the enlargement of existing ones, the restructuring and the modernization of processes, innovation and technological development.[5] Through the FINAME ('Machines and Equipment') and the Leasing FINAME schemes, BNDES supports the acquisition of new domestically produced machines and equipments either buying them (FINAME) or leasing them (Leasing FINAME). Finally, the aim of BNDES-Exim is to equalize international interest rates for Brazilian firms while the aim of Subscription of Securities is to facilitate changes in firm ownership.

Our focus is on FINEM and Automatic BNDES as they are more focused on supporting the discovery and the implementation of promising projects. Differently, FINAME and Leasing FINAME do not contemplate investments in innovation and technological development. Nonetheless, we will have to account for them in order to isolate the role of FINEM and Automatic BNDES. BNDES-Exim and Subscription of Securities have, instead, rather different objectives.

3. Description of the dataset

Data are drawn from a variety of sources already used by De Negri et al. (2006). The dataset combines information from: the Annual Industrial Research (*Pesquisa Industrial Annual* - PIA) of the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE); the Annual Social Information Report (*Relação Anual de Informações Sociais* – RAIS) of the Ministry of Labor; the Foreign Trade Secretary (*Secretaria de Comércio Exterior* - SECEX) of the Ministry of Industrial Development and Foreign Trade; the Foreign Capital Census and the Central Bank Register of Brazilian Capital Abroad of the Brazilian Central Bank; BNDES itself.[6]

[5] A complete list is available at http://www.bndes.gov.br/english/items_support.asp.
[6] The construction of the dataset has followed procedures that guarantee the confidentiality of information so that individual data cannot be related to any specific firm.

BNDES data are used to identify the granted firms. For that purpose, information is available from 1995 to 2003.[7] In this period 539 firms received FINEM loans and 8505 firms borrowed under the Automatic BNDES scheme. In the latter case, it is not possible to use all firms since some of them are not available from PIA. The reason is that PIA covers all firms with more than 30 employees and some firms granted Automatic BNDES are smaller than that. This reduces the number of firms granted Automatic BNDES in our sample by half.

Our sample is further reduced by three additional issues. First, we want to focus on *manufacturing firms* while BNDES records concern all *manufacturing projects*. In other words, they report manufacturing projects by non-manufacturing firms (e.g., those of large food retailers investing in the development of their own brands) and do not cover non-manufacturing project of manufacturing firms (e.g., in agriculture). Hence, we end up evaluating only the performance of manufacturing firms granted loans to implement project in the manufacturing sector. A second issue is related to mergers. For example, if Firm A received a loan in 1997 and in 2000 merged with Firm B creating a new Firm C, then the initial loan would be registered to firm C. As the past records of Firm C are impossible to reconstruct, we have to drop all information on loans projects granted to firms like A. Finally, there is a time lag of generally two to three years before a firm enters the census part of PIA[8]. Hence, some granted firms with more than 30 employees are not recorded by PIA in the moment they receive BNDES loans.

In the end, we are left with 240 firms granted FINEM loans and more than 2,000 firms granted Automatic BNDES from 1997 to 2001. We also have about 15,000 non-granted firms. The available variables are reported in the Appendix.

[7] Data on 1995 will be used only to exclude firms with more than one treatment.
[8] IBGE receives information of firms' size (number of employees) of a particular year only at the end of the following year. So, any new firm for the census part will provide information only after two or three years it has become elegible to be computed.

4. Methodological framework

Consider the problem faced by a firm that each period generates a new project of random non-observable quality φ, ranging from $(0,+\infty)$, and is credit constraint in its implementation. For concreteness assume that the firm faces a perceived demand for its output with constant price elasticity equal to $\sigma>1$:

$$q = A\,p^{-\sigma} \tag{1}$$

where p is price, q is quantity demanded of the firm's output, and A is aggregate demand, which is unaffected by the firm's behavior.

Production based on a project of quality φ can start only after paying a fixed cost and then incurs a constant marginal cost. There are two types of technologies available, 'old' and 'new', and they differ in terms of both fixed and marginal costs. Specifically, the old technology requires a smaller initial investment but is also less efficient. This implies that its fixed cost is lower but its marginal cost is higher. All this is captured by the following total cost:

$$TC_T = f_T + \frac{c_T}{\varphi} q,\ T = H, F \tag{2}$$

where f_T is fixed cost, c_T is marginal cost and, all the rest given, better project quality (larger φ) maps into lower marginal cost (i.e. higher productivity). T is an index of technology, which equals L and H in the case of old and new technologies respectively. Hence, we have $f_H > f_L$ and $c_H < c_L$.

Profit maximization with constant demand elasticity requires the firm to set its price as a constant markup over marginal cost adjusted for project quality:

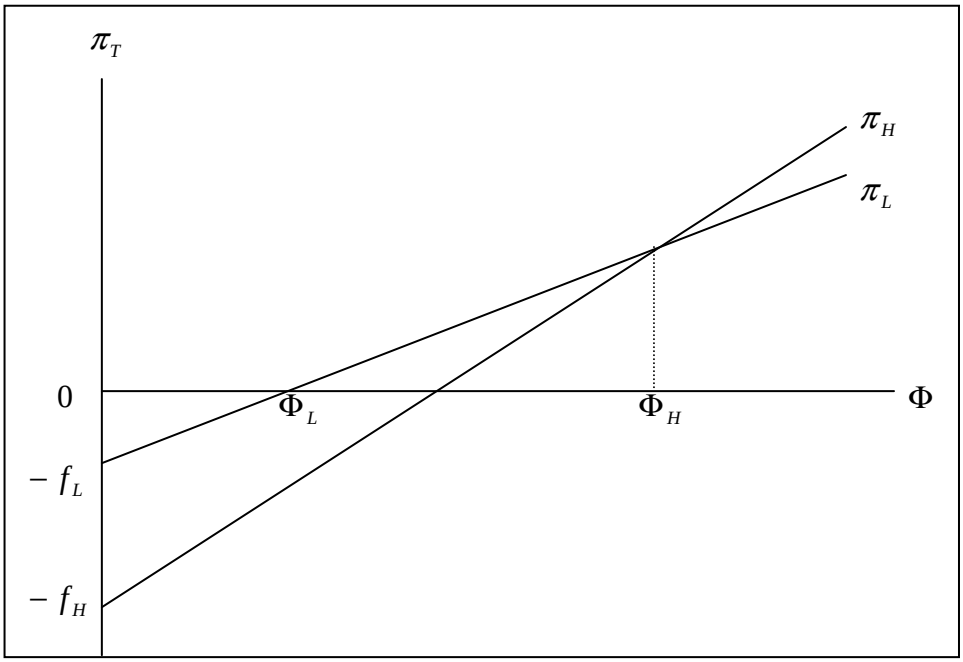
$$p_T(\varphi) = \frac{\sigma}{\sigma - 1}\frac{c_T}{\varphi} \tag{3}$$

which implies the following expressions for the scale of production, revenues and profits:

$$q_T(\varphi) = A\,p_T(\varphi)^{-\sigma}, \quad r_T(\varphi) = A\,p_T(\varphi)^{1-\sigma}, \quad \pi_T(\varphi) = A\,p_T(\varphi)^{1-\sigma}/\sigma - f_T \tag{4}$$

As σ is larger than one, results (3) and (4) show that, for a given technology, a better project leads to lower price, larger scale of production, larger revenues and larger profits. They therefore foster the adoption of the new technology. To see this, consider Figure 1, which depicts the profits associated with the two technologies as functions of the productivity index $\Phi = \varphi^{\sigma-1}$.

Figure 1 – Technology adoption



The assumptions of fixed and marginal costs imply that profits have a lower intercept but a steeper slope for the new technology than for the old one. Figure 1 then shows that the projects the firm may come up with are partitioned in three categories: low quality projects ($0<\Phi<\Phi_L$) do not break even no matter which technology is adopted; intermediate quality projects ($\Phi_L<\Phi<\Phi_H$) generate larger profits when the old technology is adopted; high quality projects ($\Phi>\Phi_H$) yield larger profits when the new technology is adopted instead.[9]

Credit constraints affect the cost of initial investment: the more stringent they are, the larger f_H and f_L. Accordingly, by reducing f_H and f_L, their relaxation shifts both Φ_L and Φ_H to the left with an increase of both the overall share of projects that break even (lower Φ_L) and the overall share of

[9] This holds provided that the fixed cost of the new technology are large enough. The exact condition is $f_H > f_L(c_L/c_H)^{\sigma-1}$.

projects implemented through the new technology (lower Φ_H). Credits constraints may, however, affect the two fixed costs asymmetrically. For instance, if they affected disproportionately the adoption of the new technology, their relaxation would decrease f_H more than f_L, increasing the relative number of projects implemented through the more efficient new technology and thus improving firm productivity. On the contrary, if credit constraints affected disproportionately the adoption of the old technology, their relaxation would decrease f_L more than f_H, increasing the relative number of projects implemented through the less efficient old technology and thus reducing firm productivity.

To summarize, the theoretical framework implies that, if BNDES loans relaxed the credit constraints faced by Brazilian firms, this would map into more projects being adopted. Moreover, if these projects were implemented using new technologies, firms would become more productive after receiving the loans. They could nonetheless become less productive if their new project were implemented using old technologies instead.

5. Empirical strategy

The key question we address is whether BNDES loans are instrumental to relax the financial constraints faced by Brazilian firms. A positive answer to this question requires checking that two things are true. First, granted firms must change their performance after receiving a loan. Second, after receiving a loan, granted firms must perform differently than otherwise identical non-granted firms. A second key question is whether BNDES schemes foster technological upgrading, which is the case if the relative performance of granted firms increases after the loans are awarded.

We use value added per worker (labor productivity) as our measure of firm performance. Table 1 reports the average values of this variable for granted and non-granted firms in the years in which

the former received their loans and in the last year of observation. The 'productivity premium' of granted firms appears between parentheses. This is calculated as the ratio of the average value added per worker of granted firms to that of all manufacturing firms.

The table shows that granted firms are generally more productive than non-granted ones. In the years when loans were awarded, their productivity premium ranges between 1.38 in 1997 and 3.89 in 2000. The last column shows that the premium grows through time from the years loans were awarded, with the only exception of firms granted in 2001.[10] This may suggest some lag in the effect of BNDES loans.

Table 1: Average value added per worker (values at 2003)

Average of Value Added per Employee	1996	1997	1998	1999	2000	2003
Firms granted BNDES' loans in 1997 (Total 1,375 firms)	73,071 (1.38)					63,450 (1.69)
Firms granted BNDES' loans in 1998 (Total 1,127 firms)		92,699 (1.56)				82,316 (2.19)
Firms granted BNDES' loans in 1999 (Total 706 firms)			118,823 (2.27)			84,719 (2.26)
Firms granted BNDES' loans in 2000 (Total 801 firms)				108,462 (1.97)		84,452 (2.25)
Firms granted BNDES' loans in 2001 (Total 808 firms)					100,307 (3.89)	87,469 (2.3)
All firms	52,660 (22,908 firms)	59,251 (21,942 firms)	52,212 (23,216 firms)	54,888 (23,944 firms)	45,723 (24,092 firms)	37,481 (27,976 firms)

Source: IBGE and BNDES

Table 1 seems therefore consistent with the idea that BNDES financial support has helped Brazilian firms to relax their credit constraints. This is, however, very rough evidence that has to may not

[10] For firms granted in 1999, the premium in 2003 is essentially the same as the one before receiving the loan.

survive closer econometric scrutiny. In order to be as accurate as possible, we propose the five following methods, which we present in increasing order of sophistication.

Method 1 – Structural break

We start with checking whether the productivity improvement of granted firms is associated with BNDES loans. The simplest specification that allows us to do this is the following:

$$y_{it} = X_{it}\beta + \delta D_{it} + \varepsilon_{it} \qquad \textbf{(5)}$$

where y_{it} is value added per worker, D_{it} is a dummy variable for all years after the first granted loan, X_{it} is a vector of control variables, ε_{it} is the error term and the rest are parameters to be estimated. In particular, the impact of BNDES loans on firm productivity is measured by the estimated value of δ. The control variables include various firm characteristics: age, wage, number of employees, their skill and education levels, market share, revenues, financial status, exports, intermediate imports, capital imports, and FINAME loans.

There are two potential problems with specification (5) that may lead to biased estimation of the coefficients. First, there may be unobserved characteristics affecting both dependent and independent variables. Second, the linear relation between X_{it} and y_{it} may not be the most appropriate one.

Method 2 – Grant identifier

One way to deal with the first potential bias of Method 1 is to introduce another dummy variable, which takes value 1 if a firm has received a BNDES loan during the period of observation, and 0 otherwise. The specification then becomes:

$$y_{it} = X_{it}\beta + \delta D_{it} + \alpha EVER_{i} + \varepsilon_{it} \qquad \textbf{(6)}$$

where *EVER* is the new dummy variable that captures unobserved time invariant differences between granted and non-granted firms. In other words, if there were some unobserved

characteristics, such as management aspects, influencing the performance of granted firms both before and after receiving a loan, the new dummy would pick them up. However, if there were additional unobserved heterogeneity across firms and such heterogeneity were unrelated to their granted status, specification (6) would still lead to biased estimation.

Method 3 – Fixed effects

One way of dealing with unobserved heterogeneity across firms unrelated to their granted status is to use a fixed effects specification. This can be derived from (5) by writing the error term as:

$$\varepsilon_{it} = \gamma_i + v_{it} \qquad \textbf{(7)}$$

where γ_i is the fixed effect capturing all unobserved firm characteristics that are time-invariant. However, should these vary in time, estimation would still be biased.

Method 4 – Differences

In order to control for time-varying unobserved heterogeneity, such as a sector trend, it is useful to go from a specification in levels to a specification in differences:

$$\Delta y_{it} = \Delta X_{it}\beta + \delta D_{it} + \varepsilon_{it} \qquad \textbf{(8)}$$

which focuses on the relation between BNDES loans and the growth of firm productivity.

Even though these four methods may solve the problem of biased estimators, all still assume a linear relation between control variables and firm performance. Moreover, they may reveal an association between BNDES loans and firm performance but not causality. A way to relax the linearity assumption and to infer causality is through matching estimation.

Method 5 – Propensity score matching

In order to assess the impact of BNDES schemes on firm performance, ideally one would like to compare granted and non-granted firms that, at the time when loans were awarded to the former, were identical in any respect. Propensity score matching (PSM) allows one to pursue such an ideal

comparison by matching each granted firm with a non-granted one exhibiting similar observable characteristics. This artificially generates a 'control group' of non-granted firms to be compared with the 'treated group' of granted firms in order assess the impact of 'treatment' by BNDES schemes. The comparison can then be made in terms of productivity levels or growth rates. As before, the second approach controls for unobserved time-varying characteristics.

There are different ways to implement PSM and we use one-to-one PSM. This approach constructs a counterfactual group by pairing each granted firm with a sufficiently similar non-granted firm and excluding from the analysis all granted firms for which a satisfactory match cannot be found. Matching is based on the following pre-treatment characteristics: productivity, age, number of employees, average salary of employees, market share, total revenues, percentage of highly skilled workers (undergraduate and above), sector, location, educational level of employees (years of schooling), ratio of financial costs over total revenues, ratio of exports over total revenue, ratio of imports of capital goods over investment, ratio of imports of intermediaries over cost of production, multinational status. The evaluation of the treatment effect is performed by differences-in-differences according to the following specification (see Bronzini and De Blasio, 2006):

$$y_{it} = \beta BNDES_i + \sum_t \alpha_t D_t + \sum_t \delta_t (BNDES_i \cdot POST_t) + X_{it}\gamma + \varepsilon_{it} \qquad \textbf{(9)}$$

where y_{it} is again value added per employee, $BNDES_i$ is a dummy variable indicating whether the firm received any loan in the period of observation, D_t is a year dummy, $POST_t$ is a set of dummies for each year after receiving the loan and X_{it} is the vector of control variables. The parameter of interest is δ_t, whose estimated value measures the impact of BNDES schemes on firm productivity over time. Note that the estimation of (9) allows one to assess not only whether BNDES loans affect firm productivity but also when the impact materializes.[11]

[11] PSM is used by De Negri at al (2006) to evaluate the impact of FINEP on firm productivity and R&D investment See also Arnold and Javornik (2005) for a detailed implementation of PSM on foreign investment in Indonesia.

6. Econometric results

Before reporting the results, two additional comments are in order. First, to evaluate the impact of FINEM and Automatic BNDES loans, it is necessary to isolate it from the effect of FINAME. This cannot be achieved by eliminating all firms that received FINAME as most firms in the sample received different types of loans jointly. For instance, during the period of observation, 26 per cent of them received FINEM or Automatic BNDES loans while more than 80 per cent received FINAME support. There are two alternative ways of controlling for this effect. One can construct a dummy variable for firms receiving FINAME loans. Alternatively, one can incorporate the value of FINAME loans into the equation as a control variable. Both ways lead to similar outcomes in Methods 1, 2 and 5, so we report only the results based on the former. As the FINAME dummy cannot be used in Methods 3 and 4, the value of FINAME loans is used instead.

In addition to FINAME, there is a second issue worth discussing. Some firms were granted FINEM or Automatic BNDES loans more than once in the period of observation. Even though the majority was granted only once, repeated treatments may blur the overall picture. To tackle this problem, there are two possible strategies depending on methods. For Methods 1 to 4 ('regression analysis'), we allow the dummy D_{it} to take different values: one after the first treatment, two after the second treatment, three after the third treatment, and so on. Differently, for Method 5 any firm granted FINEM or Automatic BNDES loans more than once is removed from the sample.

Regression analyses

Table 2 presents the estimated values of δ using Methods 1 to 4 without distinguishing between FINEM and Automatic BNDES loans. Values are estimated without controls in the first column, with sector and regional controls in the second, and with the full set of controls in the third.

Table 2: BNDES

All Brazil	With FINAME	with Sector and Region	with all covariates
Method 1	0.47*	0.44*	0.06*
Method 2	0.13*	0.13*	0.05*
Method 3	-0.01	-0.01	-0.01
Method 4	-0.00	-0.00	0.01

* significant at 1% level

Method 1 reveals a positive and significant increase in granted firm productivity after loans is awarded, varying from 47 per cent without controls to 6 per cent with all controls. Method 2 shows that, when we introduce an additional dummy identifying firms that have received loans no matter when, the increase in productivity after the loan is still positive but mitigated. This suggests the presence of unobserved characteristics that foster the performance of granted firms both before and after receiving loans. However, when we control also for time-invariant (Method 3) or time-varying (Method 4) unobserved firm heterogeneity that is unrelated to granted status, the association between loans and granted firm productivity vanishes altogether. Hence, Table 2 implies that on average granted firms do perform better than non-granted firms but their performance is unaffected by BNDES loans per se. Instead, what seem to drive their superior performance are exogenous firm-specific characteristics that predate the loans. On the other hand, there is no evidence that loans have any negative influence on firms performance.

Table 3 distinguishes between firms granted FINEM (large projects) and those granted Automatic BNDES (small and medium size projects).

Table 3: Automatic BNDES and FINEM

	Automatic BNDES			FINEM		
	With FINAME	with Sector and Region	With all covariates	With FINAME	with Sector and Region	with all covariates
Method 1	0.41*	0.40*	0.07*	1.08*	0.97*	0.06*
Method 2	0.13*	0.13*	0.06*	0.09*	0.11*	0.04
Method 3	-0.03***	-0.02	-0.01	0.09*	0.09*	-0.00
Method 4	-0.00	-0.00	0.01	0.01	0.01	0.00

* significant at 1% level; *** significant at 10 level

The pattern is similar to the one in Table 2. There are, however, two main differences. First, when one distinguishes between the two types of loans, Method 1 shows much larger impacts for large projects both without controls and with only sector and regional controls. Second, even after controlling for time-invariant unobserved firm characteristics (Method 3), the impact of loans for large projects remains positive and significant unless all controls are introduced. This does not happen in the case of small projects where one can detect a mild and barely significant negative impact of loans on firm productivity. When also time-varying characteristics are controlled for, all estimates become non-significant whatever the type of loans: BNDES schemes do not affect firm productivity growth.

In Table 4 firms are sorted in terms of location in 'poor' or 'rich' regions.[12]

Table 4: BNDES and Regions

BNDES	Poor Regions			Rich Regions		
	With FINAME	With Sector and Region	With all covariates	With FINAME	with Sector and Region	with all covariates
Method 1	0.62*	0.51*	0.08*	0.43*	0.42*	0.07
Method 2	0.22*	0.19*	0.05	0.11*	0.12*	0.06*
Method 3	-0.04	-0.04	-0.05***	-0.01	-0.00	-0.00
Method 4	-0.01	-0.00	0.00	-0.00	0.00	0.01

* significant at 1% level; *** significant at 10% level

Even though results do not change dramatically, loans seem to have larger impacts in poor regions (Methods 1 and 2). Controlling for time-invariant unobserved firm characteristics (Method 3) makes all estimates non-significant. The only exception is the estimate using Method 3 and the entire set of controls, which reveals a negative correlation between productivity and loans in poor regions.

Finally, Tables 5 and 6 look at regional differences in the case of Automatic BNDES and FINEM loans respectively. Results are essentially the same as in Table 4.

[12] Poor regions are Northeast, Middle-West and North. Rich regions are South and Southeast.

Table 5: Automatic BNDES and Regions

Automatic BNDES	Poor Regions			Rich Regions		
	With FINAME	With Sector and Region	With all covariates	With FINAME	with Sector and Region	with all covariates
Method 1	0.57*	0.45*	0.08**	0.38*	0.38*	0.07*
Method 2	0.25*	0.21*	0.06	0.11*	0.12*	0.06*
Method 3	-0.07***	-0.07	-0.06	-0.02	-0.02	-0.00
Method 4	-0.01	-0.00	0.00	-0.00	0.00	0,01

* significant at 1% level; ** significant at 5% level and *** significant at 10% level

The only notable difference concerns some asymmetry in the impact of different loans in different regions. In particular, FINEM support to large projects appears to be relatively more effective in large regions.

Table 6: FINEM and Regions

FINEM	Poor Regions			Rich Regions		
	With FINAME	With Sector and Region	with all covariates	with FINAME	with Sector and Region	with all covariates
Method 1	1.10*	0.94*	0.09	1.09*	0.98*	0.06
Method 2	0.03	0.12	0.01	0.10***	0.13*	0.06
Method 3	0.06	0.06	-0.06	0.09*	0.10*	0.01
Method 4	-0.01	0.00	0.01	0.01	0.02	0.01

* significant at 1% level; *** significant at 10% level

Propensity score matching

As detailed in Section 5, the aim of PSM is to allow for a comparison between granted firms (‘treated group’) and non-granted firms (‘control group’) that were identical in any respect when the former received loans (‘treatment’). This controls for potential nonlinearities in the relation between control variables and firm productivity and allows one to infer causality from BNDES loans to firm performance.

The implementation of (9) through PSM is not possible for all years. On the one hand, we should allow for some time to pass in order to check the full effect of treatment. Since Automatic BNDES and FINEM are loans that last for at least five years, then it makes sense to check their impact beyond a five-year horizon. This would allow us to see their effects not only during but also after

treatment. Given the time spanned by our dataset from 1996 to 2003, that is clearly not feasible for loans granted from 1998 onwards. On the other hand, to build the control group for firms treated in a certain year, one needs to have at least one previous year of observation to be used for matching. Hence, the impact of BNDES schemes can be scrutinized through PSM only for firms granted Automatic BNDES and FINEM loans in 1997, which therefore define our treated group. Moreover, to avoid concerns about repeated treatment, we also exclude from the treated group all firms that received additional support in any year other than 1997. Lastly, the construction of the control group is based on all firms active in 1996 that were never granted loans during the entire period of observation from 1995 to 2003. In the end we are left with about 200 pairs of treated and control firms on which to perform PSM[13].

As in the previous methods, we have tried different specifications, distinguishing between Automatic BNDES and FINEM as well as poor and rich regions with or without controls. For parsimony Table 7 reports only the results for the specifications in which all controls are introduced, Automatic BNDES and FINEM are considered jointly as well as separately while no distinction is made in terms of regions.

In Table 7 the distinction between large and small projects seems crucial. When the two types of loans are considered together, the impact of BNDES financial support on firm productivity is always non-significant. Differently, when one distinguishes between Automatic BNDES and FINEM loans, their impacts respectively become significantly negative and significantly positive starting from the third year after treatment. This suggests the importance of 'time to build' for investments put on hold until credit constraints were relaxed. Recalling that PSM focuses only on firms granted loans in 1997, Table 7 may explain why the regression analyses, which do not allow

[13] This PSM was done by estimating firms' probability to get a loan from BNDES by using a probit model with the caracteristics mentioned in the appendix (all of them from the year before granted year, in this case 1996). After having this probability, non-granted firms were paired with granted ones by establishing a interval where it could infere if they are alike or not.

for ‘time to build’, hardly spot any impact of BNDES loans after controlling for individual firm characteristics.

Table 7: Propensity Score Matching

All Brazil	BNDES	FINEM	Automatic BNDES
Policy effect in 97	-0.69	0.04	-0.07
Policy effect in 98	-0.73	0.10	-0.03
Policy effect in 99	-0.74	0.13	-0.04
Policy effect in 00	-0.28	0.31***	-0.16**
Policy effect in 01	-0.11	0.45*	-0.17**
Policy effect in 02	-0.09	0.45*	-0.24*
Policy effect in 03	-0.15	0.34**	-0.36*

* significant at 1% level; ** significant at 5% level and *** significant at 10% level

To summarize, BNDES loans seem to be effective only when we distinguish between small vs. large project (Automatic BNDES vs. FINEM) and allow for some lag for their effects to materialize. In particular, these effects appear in the data after three years and their signs differ between small and large projects, being negative for the former and positive for the latter. In the light of the theoretical framework presented in Section 4, these results are consistent with the idea that Automatic BNDES loans are used by firms to implement lower quality projects using old technologies whereas FINEM loans are used by firms to implement higher quality projects using new technologies.

7. Conclusion

We have investigated the effects of BNDES loans on local firms’ productivity and technological upgrading. This bank is the most important financial institution for long-term projects at this country. Our results have shown that granted firms do perform better than non-granted firms. Their performance, however, is affected by BNDES loans only when we distinguish between loans for small vs. large project (Automatic BNDES vs. FINEM) and allow for some interval between the time loans are awarded and the time their effects materialize. In particular, we have found that the

impact of loans on firm productivity appears after three years and differs between small and large projects. Being negative for the former and positive for the latter, we have argued that our results are consistent with the idea that Automatic BNDES loans allow firms to implement lower quality projects using old technologies whereas FINEM loans allow firms to implement higher quality projects using new technologies.

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Appendix – List of variables

Value Added = total value added

Number of employees = total number of employees (end of year)

Age = number of years in operations until 2003

Average salary of employees = total wages over the number of employees

Market share = market share in CNAE 2 sectors in terms of net revenues

Total revenues = total value of net revenues

Percentage of high skilled workers = percentage of workers with at least an undergraduate degree

Sector = sector classification defined by the Brazilian Statistical Institute at the level of CNAE 2

Location = region where the firm was located (North, Northeast, Middle-West, Southeast and South)

Educational level of employees = average number of years spent in schooling by employees

Ratio of financial costs to total revenues = total financial costs over total revenue

Ratio of exports to total revenues = total exports over total revenues

Ratio of imports of capital goods to investment = total capital goods imports over total investment

Ratio of imports of intermediaries to cost of production = total intermediate imports over total cost of production

Multinational status = definition of multinational firm by the Central Bank of Brazil for each firm located in Brazil in 2000