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Abstract

The Investment Maintenance Program (PSI) was structured by the Brazilian Government in 2009, with the explicit aim of stopping the aggregate investment plummet, observed in the first semester of that year. With an expressive budget, this program has recently received much attention in the Brazilian economic debate, with several authors questioning its capacity to boost investments, since the gross fixed capital formation (GFCF) has not recovered its pre-crisis level. Using information available at the firm level, this paper aims to contribute to the debate by evaluating the impact of PSI on the investment level of firms – focusing on the industrial sector. The identification strategy adopted for this purpose was based on two complementary matching estimators: the Propensity Score Matching (PSM) and the Conditional Differences-in--Differences Matching (DIDM). The data used came from the Annual Industrial Survey (PIA) of the Brazilian Institute of Geography and Statistics (IBGE) on economic activities of industrial firms for the 2007-2010 period and from the BNDES records on industrial firms receiving PSI financing in the 2009-2010 period. The empirical results showed a positive impact of PSI on the firms' investment level, even though its magnitude declined between 2009 and 2010. The cost-effectiveness analysis also showed a decreasing pattern over this period.

Keywords: BNDES; PSI; Investment; Propensity score; Matching; Industrial firms; Impact analysis.

Contents

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1. Introduction

The Brazilian aggregate investment level measured by the gross fixed capital formation (GFCF) fell by approximately 20% in nominal terms between the third quarter of 2008 and the first quarter of 2009, as one of the observed consequences of the international financial crisis on the real side of the Brazilian economy. Thus, even after a timid recovery in the second quarter of 2009, the GFCF still remained at a much lower level than the one reported prior to the crisis.

In that context, the Brazilian Government adopted several countercyclical policies, which included the creation of the Investment Maintenance Program (PSI), in July 2009, with the explicit aim of stopping the investment plummet. Under the Brazilian Development Bank (BNDES) mandate, the program consisted fundamentally of a temporarily reduction in the interest rates of existing BNDES long-term lines of credit for fixed capital goods.

Conceptually, PSI was designed to affect the aggregate investment level of the Brazilian economy. On the one hand, the program worked as a positive shock on the economy total credit supply, considering its R$ 40 billion initial budget (approximately US$ 20 billion at that date). It was expected to mitigate potential negative effects on investment associated with bank loan supply shocks as a reflection of the financial crisis.

Several authors have shown evidence of the effects of bank supply shocks on the real side of the economy. Dell'Ariccia, Detragiache e Rajan (2004), for example, discuss the role of banking crisis on real activity and find that more financially dependent industrial sectors perform worse as a result of banking crisis. Amiti and Weinstein (2013) also find significant effects of supply-side financial shocks on firms' investment using data at the firm level, even in no crisis periods. They also show that these shocks are important to explain investment fluctuations at the more aggregate level.

On the other hand, PSI should also positively affect firms' demand for investment, as the program reduced the marginal cost of capital (viewed as present value of capital goods) through more attractive financial conditions. Jaramillo and Schiantarelli (2002), for Ecuador, and Bronzini and De Blasio (2006), for Italy, have evaluated the impact of targeted credit programs on firms' investment. However, those policies did not have countercyclical purposes like PSI.

This paper aims to evaluate the effects of PSI on investments of Brazilian industrial companies for the 2009-2010 period. Due to the classic problem of selection bias, discussed in Heckman, Ichimura and Todd (1997; 1998), it is not a simple task to identify to what extent the PSI stimulus has effectively been converted into investment. To deal with this problem, widely used matching estimators, such as Propensity Score Matching and Conditional Difference-in-Difference Matching, were applied to obtain the impact estimates. The data used for this purpose were:

(i) the IBGE Annual Industrial Survey (PIA) from 2007 to 2010; and (ii) information on financing within the scope of PSI (Phase 1) from 2009 to 2010.

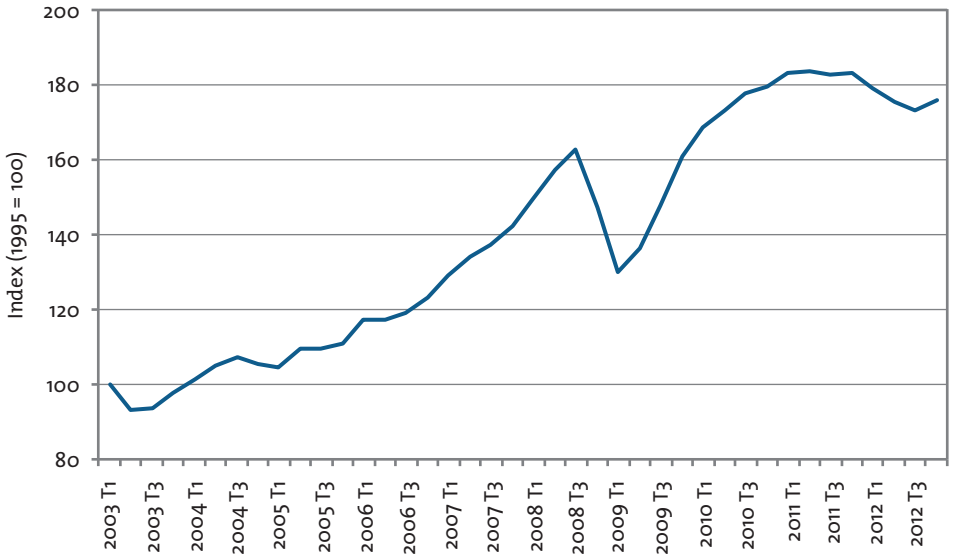
The results obtained show a positive and significant impact of PSI on the level firms' investment. That is, in the absence of the program, the Brazilian industrial segment would have invested less. However, we observed a reduction of the estimated effect in 2010, when compared with 2009. This robust result was achieved through several specifications, based on a progressive control of the selection bias.

The paper is structured in seven sections, including this introduction. The program section contextualizes and describes PSI financial conditions and its disbursement performance in the 2009-2010 period. The Empirical strategy section presents the econometric approach used to estimate the impact of the program. In the Data section, the sources of data and information used are presented, as well as some descriptive statistics of the Brazilian industrial sector. The PSI impact estimates are presented in the Results section, and we conduct a cost-effectiveness analysis in its self-named section. The last section discusses the main findings and implications of the evidence found.

2. The program

Between 3Q08 and 1Q09, the GFCF fell approximately 20% in nominal terms,[1] after the international financial crisis reached the Brazilian economy. In late June 2009, after a timid recovery, investment remained at a much lower level than that recorded immediately prior to the crisis.

Chart 1. Evolution of quarterly GFCF in Brazil



Source: Elaborated by the authors from Ipeadata (www.ipeadata.com.br).

[1] Source: IpeaData (www.ipeadata.com.br).

It was in this scenario that the PSI was launched, in July 2009. With an initial allocation budget of R$ 40.1 billion, the program consisted fundamentally of a temporally change to the then-existing financial conditions for BNDES Finame, which is one of several long-term lines of targeted credit held by BNDES.

Under the lines of BNDES Finame, the Brazilian Development Bank provides specific funds for private commercial banks that wish to finance the acquisition of capital goods manufactured in Brazil. While BNDES provides funding, commercial banks are responsible for evaluating their client's credit risk and for assuring that the acquisition complies with the legal and regulatory requirements of BNDES Finame.

PSI employed favorable financing conditions with explicit aim of reversing the investment decline that had occurred. Table 1 summarizes the financing conditions for operations covered by PSI between July 2009 and June 2010, a period in which the first phase of the program remained in effect. For comparison, the traditional conditions for financing machinery and equipment of BNDES Finame established final interest rate (all-in) comprising the long-term interest rate (TJLP) – then at 6.25% p.a., a spread for BNDES of 0.9% p.a., an intermediation tax of 0.5% p.a.[2] and a risk spread negotiated directly between the client (buyer) and the commercial bank responsible for the operation.

Table 1. Financing conditions of PSI – per company size and capital good group

	Buses and trucks (MSME)	Buses and trucks (large)	Other capital goods (MSME)	Other capital goods (large)
All-in interest rates (% p.a.)	7.0	7.0	4.5	4.5
Total term of loan (months)	up to 96	up to 96	up to 120	up to 120
Participation (in %)	up to 100	up to 80	up to 100	up to 80

Source: Elaborated by the authors.

Note: MSME – micro, small and medium-sized companies.

Therefore, this new set of conditions meant a substantial reduction in the interest rate of BNDES Finame. Chart 2 compares the distribution of the final average interest rates for operations in the PSI (Phase 1) and BNDES Finame, while Chart 3 makes the same comparison of the distribution of the total term of the loan. It is possible to note that the final interest rate median dropped from approximately 10% p.a., in traditional BNDES Finame loans, to 4.5% p.a. under PSI. It is also possible to note that the distribution of loan terms became denser at longer terms after PSI, when periods above 100 months became more customary.

[2] The intermediation tax is not applied upon small and medium-sized firms.

So, from a theoretical point of view, PSI can be understood as a reduction in the final price of capital goods (price of the good plus the cost of financing), which should work as an incentive for Brazilian companies to allocate more resources for investment. Therefore, the incentive mechanisms of the program were operating at a microeconomic level, regardless of their motivation stemming from the macroeconomic context of the Brazilian economy.

Chart 2. Distribution of operations according to interest rates (all-in)

Chart 2A. Before PSI

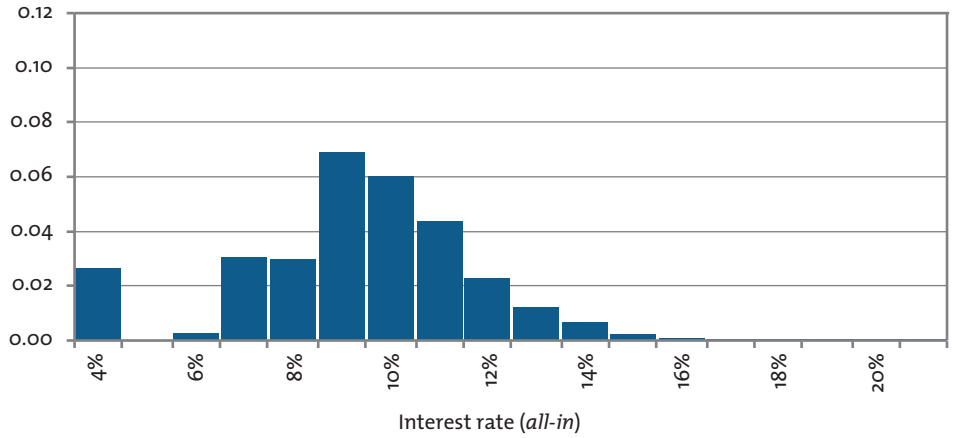
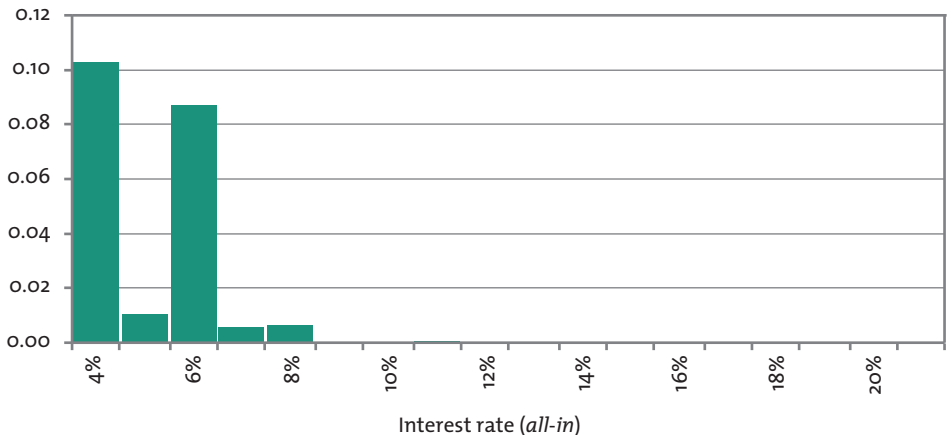


Chart 2B. After PSI



Source: Elaborated by the authors.

Note: For BNDES Finame, the period between January 2007 and June 2009 was taken into consideration, immediately prior to the launch of PSI.

Chart 3. Distribution of operations per term of loan

Chart 3A. Before PSI

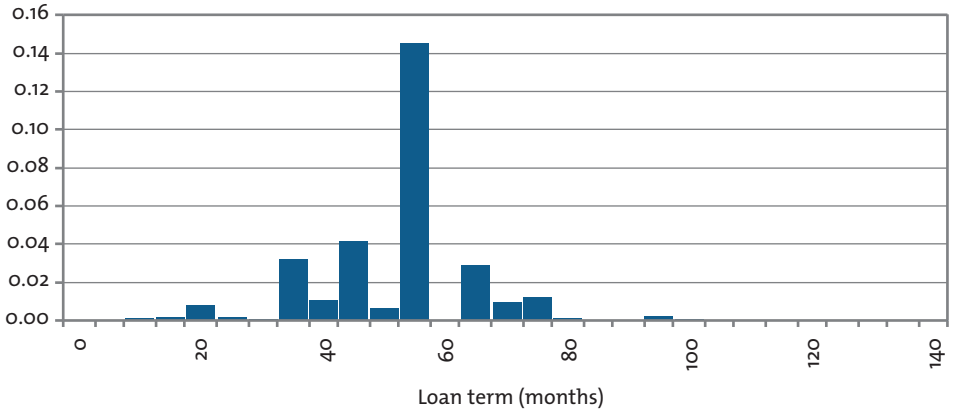
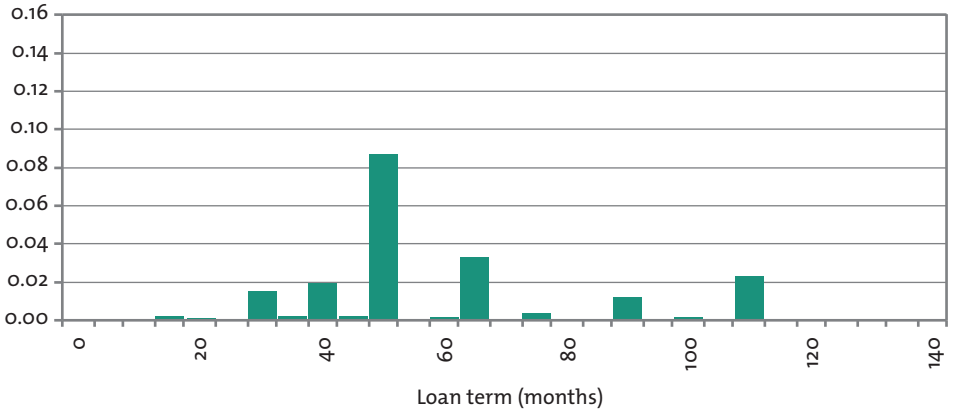


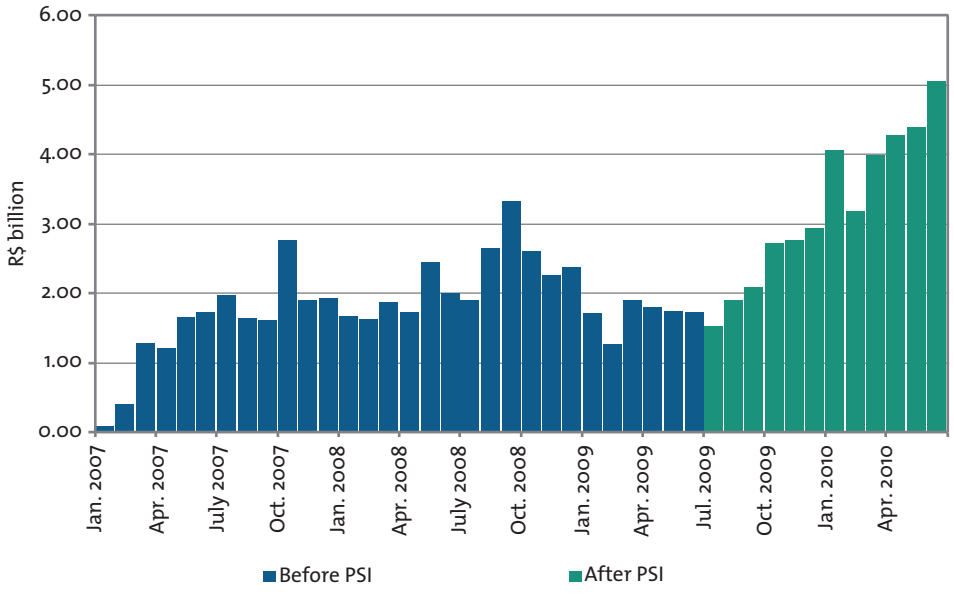
Chart 3B. After PSI



Source: Elaborated by the authors.

Note: For BNDES Finame, the period between January 2007 and June 2009 was taken into consideration, immediately prior to the launch of PSI.

Chart 4. BNDES monthly disbursements for capital goods financing



Source: Elaborated by the authors.

Chart 4 suggests that the Brazilian companies considered that the most advantageous financial conditions of the program were attractive, given the increase of the demand for BNDES disbursements. However, the question this paper tries to face is: to what extent was this additional demand for funds from BNDES effectively associated with a change in investment decisions of Brazilian companies?

The behavior noted in the aggregate investment level (Chart 1) does not support an appropriate answer to this question. After all, there are several factors affecting the behavior of the Brazilian GFCF, such as the exchange rate, business expectations and changes to regulation etc. It is not reasonable to evaluate the results of PSI based solely on the behavior of macroeconomic series – which consolidate not only the impact of PSI, but also a set of other economic variables.

The effect of PSI should be assessed at the microeconomic level. This implies the adoption of an empirical strategy that enables the identification of whether there is a causality relationship between PSI incentives and the reaction of companies' investments, which would represent a breakthrough in discussions on the impact of the program.

3. Empirical strategy

While discussing methods for public policy evaluations, Heckman, Ichimura and Todd (1998, p. 264) concluded that the main difficulty arises fundamentally from a lack of information, originating from the impossibility of observing a single agent in two different circumstances – treated and untreated. In the words of the authors:

> Each person can be in one of two possible states, 0 and 1, with associated outcomes (Y_0, Y_1), corresponding to receiving no treatment or treatment respectively. (...) Let $D = 1$ if a person is treated; $D = 0$ otherwise. The gain from treatment is $\Delta = Y_1 - Y_0$. We do not know Δ for anyone because we observe only $Y = DY_1 + (1 - D)Y_0$, i.e., either Y_0 or Y_1.

That is, it is not possible to compare the evolution of a company receiving PSI support with the progress that the firm itself would have had with no access to the program. Any technique that aims to estimate the impact of PSI on investment decision needs to extract this information by comparing a group that had access to the program with another group of companies, containing only firms with no access. Besides, the access to PSI is the result of a process in which two important events take place: (i) based on their innate characteristics, firms choose to seek or not financing within the program; (ii) commercial banks,[3] in their turn, select

[3] PSI operates by means of indirect operations, in which commercial banks are responsible for the credit risk analysis.

companies to which they grant credit, based on an analysis of credit risk and in compliance with the legal and regulatory requirements of the program.

These two selection processes tend to produce a sample in which the differences between the groups of companies are correlated, at the same time, with the expected policy outcome and the probability of access to the policy instrument. Thus, there is a clear problem of bias in selection.

To deal with this problem, this study used a traditional method at the evaluation literature: the Propensity Score Matching (PSM) originally proposed by Rosenbaum and Rubin (1983; 1984). This method basically increases the degree of comparability between the treated and untreated groups, ensuring that they comprise similar firms with regard to this propensity score, i.e., the probability of taking part in a program that is conditional to the important features for access (productivity, size, profitability etc.). The basic assumption in this method is that if companies are "equal" in terms of this probability, then the difference noted in investment can be considered a result of the program.[4]

Formally, consider a set of characteristics *X,* and one variable *d* that defines the status of participation of a particular firm in PSI, assuming a value of *1* for participants and *0* for other firms. It is then possible to estimate the propensity score $P(X_{it-1}) = P(d_{it} = 1|X_{it-1})$, which represents the probability that a given firm *i* will take part in PSI at *t*, given its characteristics in *t-1*, before accessing the program.

By initially assuming that this probability depends solely on the characteristics of companies that are observable, the first stage of the PSM method is to obtain $\hat{\rho}(X_{it-1})$ an estimator of $P(d_{it} = 1|X_{it-1})$, which can be obtained by estimating a parametric model such as a *logit* or *probit* (more details in BLUNDELL; DIAS, 2009).

Having obtained $\hat{\rho}(X_{it-1})$ for the sample of companies used,[5] the second step is to estimate the Average Treatment Effects on the Treated (ATT). This estimator is formally defined in (1) below:

$$\alpha^{PSM} = \sum_{i \in I} \left\{ y_{it} - \sum_{j \in J} \widetilde{w}_{ij} y_{jt} \right\} w_i \qquad (1)$$

[4] The use of PSM was motivated by the work of Rosenbaum and Rubin (1983; 1984), which demonstrated the validity of the balancing property in the propensity score. The validity of this property implies that if the propensity score is known, it is possible to use it as a substitute for the set of variables that condition participation when matching.

[5] Implementing the method requires the specification of the estimated model of the propensity score to satisfy the balancing property of the sample. This verification is based on a *t-test* of average differences between groups receiving support and those not receiving support, for each of the co-varieties in the model, the sampling strata defined based on the distribution of $\hat{\rho}(X_{it}-1)$. For details, see Becker and Ichino (2002).

$\hat{\alpha}^{PSM}$ is the measure of impact of PSI on current investments of treated companies y_{it}. Moreover, I and J represent the treated and control groups, respectively, $\tilde{w}_{ij}$ is the weight placed on the observation of comparison j for the company i (calculated using the estimated propensity score), and w_i is the reconsideration that recovers the outcome variable for the treated sample.[6]

Following Blundell and Dias (2009), two identification hypotheses are essential to ensure the consistency of the estimates in this method: first, it is assumed that there is independence, conditional to the propensity score, between the results of the untreated firms y^0 and the status of treatment. This hypothesis can be formally defined as (2):

$$y_i t^0 \perp d_{it} | P(X_{it-1}) \tag{2}$$

Moreover, it is necessary to satisfy the common support assumption, formally defined in (3) below. It is intuitive to note that if a particular group X_{it-1} is associated with $\hat{\rho}(X_{it-1}) = 1$, then there will be only treated companies with these characteristics, and therefore you cannot obtain a group of firms that is comparable and has not used PSI resources.

$$y_{it}^0 \perp d_{it} | P(X_{it-1}) \tag{3}$$

The main limitation to this estimation method, however, is that it deals solely with the selection bias related to observable variables. For this reason, this paper employed a second identification strategy, initially proposed by Heckman, Ichimura and Todd (1997), which combines the method of Difference-in-Differences (DID), widely used in the evaluation literature, with the PSM (referred to as the Conditional Difference-in-Differences Matching – DIDM hereinafter). The DIDM method can be understood as a variation of PSM, which may be applied when there is longitudinal data available for treated and control groups.

Intuitively, this estimator compares the evolution of the results of treated companies with untreated firms throughout the observation period (before and after treatment) and attributes any difference in evolution to the impact of the treatment. This identification strategy is quite interesting to evaluate PSI, since literature has shown it is capable of dealing with selection bias, caused by unobservable variables (provided they are time invariant).

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[6] The literature uses different methods to calculate these weights based on individual estimated probabilities of participation in the program. Notable techniques include "Nearest Neighbour", Kernel and Stratification.

Formally, the identification hypothesis assumed here is that, conditional to the observable factors X, development of the unobservable part y^0 between the periods before and after the treatment is independent of the treatment status:

$$(u_{it} - u_{it-1}) \perp d_{it}|X_i \tag{4}$$

Additionally, it is necessary to impose the common support hypothesis, as in the case of the PSM estimator. The version of the common support hypothesis for DIDM, however, requires all treated firms to have a counterpart in the untreated population observed before and after treatment. Formally:

$$P[d_{it} = 1|X_i, t] < 1 \tag{5}$$

Based on those assumptions, the ATT parameter for accessing PSI estimated by DIDM, in the region of common support of X in the sample, is formally defined as:

$$\hat{\alpha}^{DIDM} = \sum_{i \in T} \{[y_{it} - y_{it-1}] - \sum_{j \in C} \tilde{w}_{ij} [y_{jt} - y_{jt-1}]\} w_i \tag{6}$$

in which notation is similar to that used previously. It is expected that this method will be better able to control a possible selection bias associated with program participation when compared to PSM, as Heckman, Ichimura and Todd (1997) have demonstrated.

4. Data

In order to apply the methods described in the previous section, it was necessary to construct a database that, on the one hand, listed the companies that have accessed the program. On the other hand, it should also consolidate a set of economic characteristics for a large group of firms, a requirement for determining comparable controls.

A list of companies who used the program was obtained through a consolidated database from BNDES operational records, consolidating information for all releases associated with the acquisition of machinery and equipment carried out under PSI Phase 1. Companies receiving PSI support totaled 18,624 in 2009 and 36,761 in 2010. Although PSI finances firms from various sectors of the economy, this evaluation focused on the industrial sector. Considering only this segment, the number of firms financed by PSI reached 4,271 in 2009 and 10,317 in 2010, as shown in Table 2.

Table 2. Number of firms financed by PSI Phase 1 – per size (BNDES) and sector (Cnae 2.0)

Size	2009				2010			
	Agriculture	Services	Industry	Total	Agriculture	Services	Industry	Total
Large	57	790	567	1,414	127	1,369	1,199	2,695
Medium-sized-large	-	-	-	-	16	174	139	329
Medium-sized	63	2,070	854	2,987	123	3,424	1,934	5,481
Small	103	5,005	1,509	6,617	237	8,037	3,224	11,498
Micro	103	6,162	1,341	7,606	303	12,634	3,821	16,758
Total	**326**	**14,027**	**4,271**	**18,624**	**806**	**25,696**	**10,317**	**36,761**

Source: Elaborated by the authors.

Table 3 shows the total PSI disbursement to financed companies per group size and sector. The main information to note in this table is the total amount disbursed in loans to the industrial sector, which reached approximately R$ 1.7 billion in 2009 and R$ 8.6 billion in 2010, totaling just over R$ 10 billion in disbursements during the first phase of the program.

Table 3. Total disbursements to firms financed by PSI Phase 1 (in R$ million) – per size (BNDES) and sector (Cnae 2.0)

Size	2009				2010			
	Agriculture	Services	Industry	Total	Agriculture	Services	Industry	Total
Large	101	1,691	741	2,533	436	6,736	4,746	11,918
Medium-sized-large	-	-	-	-	25	287	176	488
Medium-sized	54	1,728	367	2,150	178	5,104	1,810	7,092
Small	22	1,093	214	1,329	85	2,548	731	3,365
Micro	37	1,660	384	2,081	142	3,812	1,162	5,116
Total	**214**	**6,172**	**1,707**	**8,092**	**866**	**19,051**	**8,626**	**27,979**

Source: Elaborated by the authors.

To obtain reliable economic characteristics on program users, this study chose to use the IBGE Annual Survey of Industry – Enterprise (PIA-Enterprise), which is the most important source of micro data from the Brazilian Industrial Sector. In this study, we took into consideration data from this survey for the years 2007-2010[7] and worked solely with firms surveyed in Right Stratum,[8] because there is more detailed economic and financial information, required to implement the identification strategy adopted.

[7] At the time of this work, the last PIA-Enterprise survey available was for the year 2010.

[8] All industrial enterprises with 30 or more employees in the year prior to the survey reference year.

After merging BNDES and PIA databases, we constructed a dummy (called PSI) that took a value of 1 when observation had received any amount of PSI resources, and zero otherwise.[9] Then, exploratory analysis and information validation were conducted, in order to identify outliers and observations with insufficient or inconsistent information. An important decision taken while consolidating the database was to exclude all observations with declared investment equal to zero.

This choice represents an undeniable bias towards increasing the average investment in the control group and, therefore, a bias towards underestimating the effect of the program – which stands against the tested hypothesis. Moreover, as PSI is an investment financing program, one could argue that companies that have chosen not to invest would be, by definition, ineligible for the program, not serving as a comparison group. Again, that choice increases homogeneity between control and treatment groups.

Finally, companies that had very low or very high investment rates were considered outliers.[10] The intention was to exclude companies that reported a volume of investment incompatible with their declared revenue, in order to reduce informational errors that might distort results.

Clearly, the methodological choices above reduced the number of observations available. Still, the final base was a robust selection of information, comprising more than 15,000 industrial companies in each reference year. Of this total, approximately 1,500 companies received resources from PSI in 2009; in 2010, that number rose to approximately 3,700 companies.

Table 4 aims to show the characteristics of groups of firms financed in comparison with the group of nonfinanced companies for each year in which the impact of PSI was estimated. The goal is to compare these groups in terms of the variables used in the estimated models before participating in the program to identify the degree of pre-existing heterogeneity among them. Despite the fact that constructing the database favored homogeneity, the group of financed companies still shows characteristics that are substantially different from the other group – emphasizing the difficulties involved in this exercise. In such cases, the use of ordinary least squares (OLS) estimators tend to produce inconsistent estimates of the average impact of the program.

9 Each observation considers a company in a given year.

10 Observations with investment rate at the first or last percentile of the distribution of this variable.

Table 4. Characteristics of the sample in 2010

Variable	No PSI financing			PSI financing		
	N	Average	Standard-deviation	N	Average	Standard-deviation
In(Investment)	14,645	11.963	2.302	3,777	13.621	2.091
In(Work productivity)	14,645	10.791	1.268	3,777	11.067	1.021
In(Net operational revenue)	14,645	15.847	1.719	3,777	16.802	1.716
Rate of financial exposure	14,645	(0.014)	0.066	3,777	(0.013)	0.049
Investment rate	14,645	0.181	0.422	3,777	0.251	0.408
Rate of earnings	14,645	0.058	0.223	3,777	0.096	0.152
Variation of investment	12,451	1.826	4.746	3,474	1.652	4.489
Variation of productivity	12,451	0.072	0.929	3,474	0.074	0.780
Variation of revenue	12,451	(0.023)	0.386	3,474	0.045	0.323

Source: Elaborated by the authors from PIA-Enterprise (IBGE) and internal data.

Note: Variable of industrial firms in t-1.

5. Results

Table 5 shows the impact estimates of PSI on the current investment level of the industrial companies and compares the results for each method used for the 2009-2010 period. Besides PSM and DIDM estimates,[11] it also shows basic OLS estimates to discuss the selection bias problem. The first point to note is that all results presented in Table 5 indicate that PSI had a positive and statistically significant impact on the industrial companies' investment level. This is certainly the main conclusion produced by this work.[12]

Table 5. Impact estimates of PSI

	2009			2010		
	OLS	PSM	DIDM	OLS	PSM	DIDM
ATT	0.96***	0.89***	0.34***	0.95***	0.85***	0.24***
Test statistics	22.44	11.23	3.99	33.85	16.82	4.36

Source: Elaborated by the authors from PIA-Enterprise (IBGE) and internal data.

Notes: Dependent variable is the natural logarithm of the current level of the company.

*** Statistically significant at 1%. PSM estimates based on "Nearest Neighbor". T-Statistic (OLS and PSM) and Z-Statistic (DIDM). Bootstrapped standard errors for PSM and DIDM estimates.

[11] Propensity score of the company estimated by Logit. The appendices to this study presents more detailed estimated-selection equations and the respective set of conditional variables used in this first estimation step for each year. It is worth noting that all specifications satisfied the balancing properties, which is evidence that the selection model is well specified. For details on implementing the PSM, see Becker and Ichino (2002) and Leuven and Sianesi (2003); for DIDM, see Villa (2011).

[12] It is important to point out that several specifications were tested, with changes in the explained variable, in the definition of the sample and in the matching method. Altogether, some 28 estimations were carried out, and in 26 of those the result was a positive and statistically significant impact. Table 6 in the Appendix B offers the results of all tested specifications.

As expected, the OLS estimate appears to have a positive bias, with a tendency to overestimate the impact of the program. It is possible to see that the coefficients estimated using this method – respectively 0.96 and 0.95 for 2009 and 2010 – are substantially higher than those estimated using DIDM – 0.34 and 0.24. The coefficients estimated using PSM, in their turn, were closer to those made by OLS. This may indicate that most of the existing selection bias derives from unobservable variables.[13]

It should be noticed that the average impact of PSI was higher in 2009 than in 2010. This was found in all proposed estimates, but was particularly strong in the DIDM specification – precisely the better method to control the problem of selection bias. In this model, the coefficient falls from 0.34 to 0.24 from one year to the next. In order to investigate the magnitude of the PSI impact on the companies' investment level, we calculate the average investment in the sample for companies that used the program – which reached approximately R$ 1.2 million in the two reference years. Using the DIDM coefficients to estimate the counterfactual investment level for each year in the analysis, we see that, in 2009, the impact of the program reached approximately R$ 352,000 per supported firm. This number represents an increase of 40% compared to what would have occurred in the absence of PSI. Regarding 2010, this number fell to R$ 272,000 – representing an increase of 28%.[14]

The decrease in the average impact of PSI was accompanied by a rise in the average disbursements of the program for the period, which reached R$ 465,000 in 2010 – against R$ 298,000 a year earlier. These two combined movements generated a strong fall in our measure of the additionality of the program, that is, the impact per disbursement ratio. Thus, on average, every R$ 1 of PSI disbursement generated an impact of R$ 1.18 on the company's investment in 2009. In the next year, the same R$ 1 disbursed was associated with only R$ 0.58 of investments that would not have occurred without that financing.

Therefore, in 2009, PSI was able to affect the investment decision to the extent it induced the inclusion of other capital sources. However, it is possible to observe some degree of substitution in 2010, with the disbursements of PSI taking the

[13] In the case of the OLS estimation, the same relation of variables used in the final selection equations for the PSM and the DIDM was used as covariates. In this case, the coefficient associated with the dummy PSI was used to model the effect of access to PSI in the investment decision of companies. Again, further details of this specification can be found in the Appendix B.

[14] Assuming that industrial companies financed by PSI outside our sample are similar to those that have been used – a strong assumption – it is possible to obtain the total investment added by PSI on the Brazilian industrial sector. Using the average impact calculated in reais (R$), we reached approximately R$ 2 billion in 2009, when 4,271 companies used about R$ 1.7 billion in releases from the program. In 2010, that number would amount to approximately R$ 5 billion, associated with 10,317 companies financed with approximately R$ 8.6 billion in disbursements.

place of other capital sources. Thus, this dynamic means that the additionality of PSI decreased during the analyzed period. Two possible causes for this behavior are considered.

The first possible explanation relies on the credit constraint problem, which was particularly severe in 2009 when the financial crisis was acute. Therefore, it was natural that the program was more important to release investment decisions of Brazilian industrial firms in that year. The macroeconomic context was very different in 2010, when the Brazilian economy seemed to be operating under normal conditions.

The second explanation is based on the intertemporal aspect of the investment decision. In this case, companies would simply take advantage of the more attractive PSI financing conditions to make investments in the current period that, otherwise, would have occurred in the future. Concisely, at least part of the PSI positive effect might be associated with anticipation rather than investment creation. If PSI does not affect the companies' long-term investment, then the anticipating behavior has a limit.

6. Cost-effectiveness analysis

This section presents a cost-effectiveness analysis of the PSI program.[15] Its goal is to calculate the social returns and costs of the program, based on the idea of opportunity cost. The cost-effectiveness indicator constructed here is the ratio of the economic cost of the program for the National Treasury and the social benefits in terms of investment created. The analysis focused only on the direct cost and benefits of the program, thus it is not a general equilibrium cost-benefit analysis of the whole impact of the program.[16]

We use our previous estimates of the impact of the PSI program on firms' investment as our measure of the effectiveness (direct economic benefit) of the policy. To calculate the direct economic cost involved in each loan, we firstly need to explicit the structure of the flows for each loan from the point of view of BNDES and the National Treasury (considering also the spread charged by the

[15] This paper contributes originally to the literature that evaluates the impact of subsidized earmarked credit to support firms' investment in a context of countercyclical program, as it is the first one to proceed to a cost-effectiveness analysis of such a policy. While, for the one side, some authors have estimated the cost of credit programs – Andrade and Lucas (2010), Feijó (2014) and CBO (2015) – or its effectiveness, for the other side, Machado, Parreiras and Peçanha (2011), Bronzini and De Blasio (2006), De Negri *et al.* (2011) and Da Mata and Resende (2015), none have done both.

[16] The cost-effectiveness indicator allows the policy maker to order its preferences about available instruments for ones purpose of public policy; it says nothing about being socially worth to have implemented the program.

commercial banks involved in the credit operation). For each period, each loan is subject to the following flows:

$$\begin{aligned} Flow^{BNDES} &= i^{PSI} + i^{Equalization} - i^{TJLP} \\ &\quad - spread^{bank} - \theta^{costs} - \pi \\ Flow^{Treasury} &= i^{TJLP} + \pi - i^{Equalization} - i^{Treasury} \end{aligned} \tag{7}$$

From the BNDES point of view, the loan is associated with an entry flow defined by the final fixed interest rate (i^{PSI}) of the loans for the beneficiary plus the Treasury equalization rate ($i^{Equalization}$).[17] The exit flow for the Bank is associated with the sum of the payment of TJLP (i^{TJLP}), the commercial bank risk spread ($spread^{bank}$), the operational cost (θ^{costs}), and the pay back of the loans profits for the Treasury funding (π).

From the Treasury standpoint, the loan is associated with receiving (TJLP rate), plus dividends associated with BNDES profits, as the Central Government is the only shareholder of BNDES. The explicit subsidy in the loan is associated with the Treasury payment for BNDES of the equalization rate. The implicit subsidy in the loan is the Treasury cost of debt issuing (issuing a Treasury bond) ($i^{Treasury}$). Consolidating these flows for the government as a whole, the direct return of the loan is:

$$Return^{G} = i^{PSI} - i^{Treasury} - spread^{banks} - \theta^{costs} \tag{8}$$

Based on this equation, we identify the following sources of influence on the fiscal result of the government: the Treasury funding for the program, the final fixed interest rate, the operational costs and commercial banks spreads. As the fixed rate for PSI loans is below the Treasury cost of funding and the other associated costs involved in the BNDES indirect lending process, there is a potential fiscal direct cost (FDC) for the Central Government associated with each PSI loans:

$$FDC^{G} = i^{Treasury} + spread^{bank} + \theta^{costs} - i^{PSI} \tag{9}$$

Ideally, the FDC would be calculated for each loan based on its specific financial conditions. Equation (10) defines the fiscal cost, FC_j, associated with a PSI loan j, where r_j indicates the repayment period, g_j indicates the grace period, LV_j is equal to the loan value, and $i^{discount}$ is the intertemporal discount rate.

[17] The equalization rate is defined by: $i^{PSI} - i^{TJLP} - spread^{bndes} - spread^{commercialbank} + i^{Equalization} = 0$.

$$FDCj = \sum_{t=1}^{r_j+g_j} \frac{[1-Max(\frac{t-g_j}{r_j},0)]LV_j(i_{j,t}^{Treasury}+spread_j^{bank})...}{\prod_{s=1}^{t}(1+i_{j,s}^{discount})} \sum_{t=1}^{r_j+g_j} \frac{...\prod_{s=1}^{t}(1+i_{j,s}^{discount})+\theta^{cost}-i_j^{PSI}}{\prod_{s=1}^{t}(1+i_{j,s}^{discount})} \quad (10)$$

This equation can be interpreted as follows: for each disbursement associated with a PSI loan, the government should issue a bond for raising funds for the PSI loan. As the loan is not repaid, the government receives its remuneration as stated above, so in each period it can pay at least part of its costs – cost of funding plus spread and operational costs. Each of these flows must be converted in terms of its present values, so that they are comparable.

One can argue that we should take into consideration a specific BNDES default risk in the calculation of the PSI direct fiscal cost.[18] We consider that, in the specific case of the PSI indirect loans, as the commercial banks assume the loan default risk and this risk is already incorporated in the calculations in the form of the spread of those banks, there is not a specific BNDES default risk to be accounted for. Consequently, we do not need to adjust our presented approach to incorporate the BNDES default risk.

We adopt an economic approach to estimate the costs involved for each specific PSI loan. As a result, we use an accrual method and a market value method to evaluate the loans.[19]

Based on those choices, the whole economic cost is due at the time of the loan release. For its calculation, it is necessary to consider the structure of future releases flows and also the term structure of the market interest rates (Special Clearance and Escrow System – Selic) in the instant of a specific PSI loan release. Thus, the economic cost of the loan would be defined as the present value of the net economic cost for the government (BICKLEY, 2012).[20]

We aggregate PSI loans and its financial conditions on a monthly basis.[21] The BNDES operational cost was fixed at 0.2% for the whole period (roughly 10% of

[18] See, for example Bickley (2012); Andrade and Lucas (2010); Lucas (2012; 2014).

[19] The Treasury, for example, uses a cash basis method to estimate the PSI equalization costs, but this approach creates some difficulties for the calculations, such as the need for correcting the costs each period and the necessity of establishing a method for forecasting the financial market conditions in the future (SPE, 2013).

[20] In the Appendix B, we report the results for an accounting approach of the costs of the program, closer to the one adopted for the Treasury.

[21] Thus, FC_j turns out to be $FCm = \sum_{j \in \Omega_m} FC_j$, where Ωm is the volume of loans released in a specific month m. We thus calculate all the respective financial conditions associated with this monthly aggregated flow.

the BNDES general spread). The Treasury cost of funding was defined by the term structure of the Selic rate (Selic-Pré), observed on the first working day of the month *m*, for a repayment period equal to the average repayment period of the loans of the aggregated monthly flow. For each flow, the discount rate was defined for the same Selic term structure. We used the Extended National Consumer Price Index (IPCA) to adjust all the consecutive monthly flows of releases to August 2009 values (the date of the first PSI releases).

Table 6 shows the results of the PSI cost-effectiveness analysis. We first note that the estimated direct fiscal cost of PSI is relevant in terms of the total disbursement of the program (reaching approximately R$ 9.5 billion). The most striking result, however, is that our cost-effectiveness indicator more than doubled in the comparison between the two years of the program.

Table 6. Cost-effectiveness analysis: economic approach

Period	Disbursement	Additionality coefficient	Investment added (A)	Direct fiscal cost (B)	Cost-effectiveness (B)/(A)
2009	9,180	1.18	10,832	1,778	0.16
2010	30,727	0.58	17,822	7,568	0.42
Total	**39,907**	**-**	**28,654**	**9,346**	**0.33**

Sources: PSI data were obtained internally; fiscal cost used Interbank Deposit Certificate (CDI) yield curve, defined according to Securities, Commodities and Futures Exchange (BM&FBovespa).

Notes: [1] R$ million and deflated with IPCA to values of 2009-2010. [2] Investment added (A) is obtained by multiplying Disbursement by the Additionality coefficient.

We present two explanations for this behavior. For the cost side, we note that, between 2009 and 2010, the elevation of the costs is proportionally superior to the increase of the disbursements. As the PSI financial conditions remained unchanged, the only explanation for this movement is a worsening in the Treasury cost of funding.[22]

For the benefit side, as PSI was less effective in adding investment in 2010, the rate of investment addition was lower than the growth rate of PSI disbursements between 2009 and 2010. These movements are capable of explaining why the cost-effectiveness indicator rose in the 2009-2010 period, achieving 0.42 in 2010 against 0.16 a year before.

Therefore, the analysis conducted here shows that PSI was much more cost--effective as a counter-cyclical program in its first year, as it displayed a considerable high additionality ratio at a relatively low fiscal cost (compared to 2010). The strong decrease in the additionality of the program in 2010 is the major factor explaining the increase in its cost-effectiveness ratio in 2010.

[22] The Selic rate started to rise in April 2010, and this cycle of monetary tightening lasted up to November 2011.

Unfortunately, we can just compare the cost-effectiveness PSI ratio between the years of the first phase of the program. This occurs because we do not have benchmark estimates that could be used for a comparison of the relative effectiveness of this instrument for achieving its goal in comparison with other available alternatives. Hence, we compare our cost-effectiveness estimates with a traditional fiscal counter-cyclical policy, the one that represents a direct expenditure of the government to increase the aggregate level of investment. In the best scenario, it is expected that such a direct instrument is able to increase investment in a proportion of one-to-one, resulting in a unitary cost-effectiveness indicator.

In this comparison, it is clear the program is better than the direct public investment alternative. Nonetheless, it is important to note that these alternatives are quite different in their potential to affect welfare, as public investment for example is associated with the presence of positive externalities, and private investment benefits exclusively private entrepreneurs.

7. Conclusion

Within a context in which GFCF did not recover the pre-financial crisis level, a more recent Brazilian economic debate has questioned the PSI capacity to influence aggregate investment in the economy. This study aimed to find evidence about the impacts of the program on the investment decisions of firms, by using methods that could address the classical selection bias problem.

This paper contributes originally to the literature of the effects of earmarked credit programs, especially to the discussion of their impacts on the investment of firms. In that sense, it is the first one that evaluates a specific counter-cyclical earmarked credit policy and also conducts a cost-effectiveness analysis of such a program.[23]

Accordingly, the main conclusions of the analysis carried out here can be summarized as follows: (i) PSI was an effective counter-cyclical policy in its first phase – it had a positive impact on the investment level of industrial firms for the 2009-2010 period, although the magnitude of the effects decreased over time; and (ii) the cost-effectiveness PSI indicator showed a quite strong elevation in this relative short period, as a result of a considerably lower additionality and higher opportunity cost of its funding in 2010.

[23] Some authors for the one side analysis the costs, for example Andrade and Lucas (2010), Feijó *et al.* (2014) and CBO (2015), or the effectiveness, for example, Machado, Parreiras and Peçanha (2011), Bronzini and De Blasio (2006), De Negri *et al.* (2011) and Da Mata and Resende (2015), of earmarked subsidized credit. But none of them have done a whole cost-effectiveness analysis.

It is known that the program has been extended since it was created, maintaining, with little variation, the financial incentives present in its first phase. Then, if we consider that the program works mainly through relaxing credit constraints of companies (presumably greater in 2009 than in 2010, when non-earmarked credit started to increase again), it is hard to think that its additionality would recover our 2009 estimates level. Besides, the Treasury cost of funding continued to rise after 2010, as the monetary policy became increasingly more restrictive.

In this scenario, there is a strong possibility that the cost-effectiveness indicator for PSI never recovered its 2009 level. The results suggest the program played a relevant role during the critical moment of the international financial crisis. However, its efficiency seems to decrease, once the economy returns to its normal conditions. Finally, it is essential to obtain an adequate benchmark policy, so one can compare the relative effectiveness of this instrument with other countercyclical measures.

The future research agenda intends to evaluate each of the possible causes of the decreasing additionality of the program. Besides, it is relevant to address possible indirect effects of the program on different outcomes, such as employment and productivity, so we can advance in a more robust cost-benefit analysis of the program.

Appendix A

This appendix presents the calculation of the PSI cost-effectiveness ratio based on a book value approach. We follow the method used by the Treasury to compute their estimates. For each month, the Treasury calculates the PSI cost of equalization rates based on the observed average cost of bond issuing over the last 12 months. The discount rate is equal to the cost of funding in this case.[1] Table 1 shows the results of the cost-effectiveness ratio based on the book value method.

Table 1. Cost-effectiveness analysis: bookkeeping approach

Period	Disbursement	Additionality coefficient	Investment added (A)	Direct fiscal cost (B)	Cost-effectiveness (B)/(A)
2009	9,180	1.18	10,832	1,738	0.16
2010	30,727	0.58	17,822	7,445	0.42
Total	**39,907**	**-**	**28,654**	**9,183**	**0.32**

Sources: PSI data were obtained internally; fiscal cost used CDI yield curve, defined according to BM&F.

Notes: [1] R$ million and deflated with IPCA to values of August 2009. [2] Investment added (A) is obtained by multiplying Disbursement by the Additionality coefficient.

Appendix B

Table 1. Estimates of the PSI impact on investment (in natural logarithms) of industrial companies using OLS for each year in the 2009-2010 period

Explanatory variable	*t*=2009			*t*=2010		
	Coefficient	Standard-deviation	p-value	Coefficient	Standard-deviation	p-value
dummy PSI^1	0.955***	0.043	0.000	0.963***	0.028	0.000
ln(net operating revenue)	1.124***	0.104	0.000	1.414***	0.101	0.000
ln(work productivity)	0.114*	0.061	0.060	0.003	0.074	0.968
ln(investment)	(0.326)***	0.010	0.000	(0.255)***	0.009	0.000
Rate of earnings	0.715***	0.075	0.000	0.650***	0.072	0.000
Rate of financial exposure	(0.077)	0.244	0.0751	(0.264)	0.206	0.200
ln(net operating revenue)^2	(0.016)***	0.003	0.000	(0.025)***	0.003	0.000
ln(work productivity)^2	(0.007)**	0.003	0.013	(0.001)	0.003	0.833
ln(investment)^2	0.028***	0.001	0.000	0.024***	0.001	0.000
Variation of net operating revenue	0.116**	0.041	0.004	(0.014)	0.036	0.697

(Continued)

[1] See *Monthly Report of Public Debt* of the National Treasury for more details of the approach adopted.

(Continuation)

Explanatory variable	*t*=2009			*t*=2010		
	Coefficient	Standard-deviation	p-value	Coefficient	Standard-deviation	p-value
Variation of work productivity	(0.056)***	0.017	0.001	(0.008)	0.015	0.613
Variation of investment	(0.022)***	0.003	0.000	(0.021)***	0.003	0.000
Constant	(2.557)	0.861	0.003	(4.548)***	0.837	0.000
N	13,966			14,942		
R^2 adjusted	0,618			0,637		

Source: Elaborated by the authors from PIA (IBGE) and internal data.

Notes: Dummy PSI takes on the value of 1 when the company used PSI resources in t. Values of all other covariates are observed in t-1.

* Significant to 10%. ** Significant to 5%. *** Significant to 1%.

Table 2. Characteristics of the sample in 2009

Variable	No PSI financing			PSI financing		
	N	Average	Standard-deviation	N	Average	Standard-deviation
ln(Investment)	16,970	12.260	2.381	1,461	13.692	2.132
ln(Work productivity)	16,970	10.814	1.279	1,461	11.036	1.042
ln(Net operational revenue)	16,970	15.985	1.775	1,461	16.864	1.655
Rate of financial exposure	16,970	(0.016)	0.057	1,461	(0.015)	0.041
Investment rate	16,970	0.193	0.416	1,461	0.282	0.470
Rate of earnings	16,970	0.062	0.212	1,461	0.093	0.147
Variation of investment	14,326	1.907	4.420	1,320	1.513	4.090
Variation of productivity	14,326	0.202	0.898	1,320	0.188	0.795
Variation of revenue	14,326	0.141	0.352	1,320	0.214	0.297

Source: Elaborated by the authors from PIA (IBGE) and internal data.

Table 3. Estimates of the Logit model for the probability of participation in PSI for each year in the 2009-2010 period

Explanatory variable	*t*=2009			*t*=2010		
	Coefficient	Standard-deviation	p-value	Coefficient	Standard-deviation	p-value
ln(net operating revenue)	2.745***	0.291	0.000	2.651***	0.199	0.000
ln(work productivity)	0.451**	0.215	0.036	1.518***	0.251	0.000
ln(investment)	(0.189)***	0.025	0.000	(0.0233)***	0.018	0.000
Rate of earnings	1.170***	0.192	0.000	1.128***	0.141	0.000
Rate of financial exposure	(0.643)	0.583	0.270	(2.155)***	0.378	0.000
ln(net operating revenue)^2	(0.076)***	0.009	0.000	(0.074)***	0.006	0.000
ln(work productivity)^2	(0.036)***	0.010	0.000	(0.084)***	0.011	0.000

(Continued)

(Continuation)

Explanatory variable	*t*=2009			*t*=2010		
	Coefficient	Standard-deviation	p-value	Coefficient	Standard-deviation	p-value
ln(investment)^2	0.015**	0.002	0.000	0.021***	0.001	0.000
Variation of net operating revenue	0.310***	0.090	0.001	0.233***	0.065	0.000
Variation of work productivity	0.055	0.039	0.160	0.035	0.027	0.197
Variation of investment	(0.016)**	0.007	0.035	(0.013)***	0.005	0.008
Constant	(27.712)***	2.527	0.000	(31.613)***	1.846	0.000
N	13,966			14,942		
Pseudo R^2	0,051			0,091		
Prob > chi^2	0.000			0.000		

Source: Elaborated by the authors from PIA (IBGE) and internal data.

Notes: All covariates are observed in *t-1*. Balance test of the propensity score was carried out in the common support of the sample. This specification of the model satisfied the balancing property in both years.

* Significant to 10%. ** Significant to 5%. *** Significant to 1%.

Table 4. Results of balancing sample *t* test – impact estimates of the PSI DIDM for each year in the 2009-2010 period

Explanatory variable	2009			2010		
	Control (average)	Treated (average)	Statistic *t* (module)	Control (average)	Treated (average)	Statistic *t* (module)
ln(investment)	13.34	13.69	10.15***	13.03	13.62	17.23***
ln(net operating revenue)	17.03	17.01	0.57	16.94	16.92	0.61
ln(work productivity)	11.09	11.08	0.52	11.10	11.09	0.57
Rate of earnings	0.09	0.09	0.16	0.09	0.10	0.60
Rate of financial exposure	(0.01)	(0.02)	0.51	(0.01)	(0.01)	0.04
ln(net operating revenue)^2	292.49	291.99	0.56	289.61	289.10	0.55
ln(work productivity)^2	123.98	123.78	0.55	124.21	123.94	0.74
Variation of net operating revenue	0.21	0.21	1.30	0.04	0.05	0.35
Variation of work productivity	0.19	0.19	0.22	0.08	0.07	0.19
N	18,431			18,442		

Source: Elaborated by the authors from PIA (IBGE) and internal data.

Notes: Test *t* for difference in sample averages was done in the region of common support in the sample during the pretreatment period (*t*-1).

* Significant to 10%. ** Significant to 5%. *** Significant to 1%.

Table 5. Definition of the variables used in the models

Name	Description	Formula
ln(investment)	Total gross investment (in natural logarithms)	Acquisitions and improvements – cost of acquisitions, production and improvements to fixed assets
ln(work productivity)	Work productivity (in natural logarithms)	Amount of industrial transformation / industrial staff employed
ln(net operating revenue)	Net operating revenue (in natural logarithms)	Total revenues – nonoperating revenues
Rate of financial exposure	Rate of financial exposure	(Financial revenue – financial expenses) / total revenue
Rate of investment	Rate of investment	Total gross investment / Amount of industrial transformation
Rate of earnings	Rate of earnings	(Earnings + depreciation – loss) / total revenue
Variation of investment	Annual variation of total gross investment (in natural logarithms)	Absolute variation of the level of investment
Variation of work productivity	Annual variation of work productivity (in natural logarithms)	Absolute variation of the work productivity
Variation of net operating revenue	Annual variation of net operating revenue (in natural logarithms)	Absolute variation of the net operating revenue

Source: PIA (IBGE).

Table 6. Summary of specifications estimated

Explained variable	Sub-sample	Method	Impact coefficient (2009)	Impact coefficient (2010)
ln(investment)	PSI	OLS	0.95***	0.96***
ln(investment)	PSI	PSM-NN	0.88***	0.85***
ln(investment)	PSI	PSM-Kernel	1.44***	1.07***
ln(investment)	PSI	PSM-Stratification	0.96***	0.9***
ln(investment)	PSI[1] alone	PSM-NN	0.84***	0.82***
ln(investment)	PSI	DIDM	0.33***	0.24***
ln(investment)	PSI[1] alone	DIDM	(0.18)	0.20**
Rate of investment	PSI	OLS	0.09***	0.10***
Rate of investment	PSI	PSM-NN	0.09***	0.10***
Rate of investment	PSI	PSM-Kernel	0.11***	0.11***
Rate of investment	PSI	PSM-Stratification	0.09***	0.10***
Rate of investment	PSI[1] alone	PSM-NN	0.10***	0.06***
Rate of investment	PSI	DIDM	0.02***	0.06***
Rate of investment	PS[1] alone	DIDM	0.01	0.06***

Source: Elaborated by the authors from PIA (IBGE) and internal data.

Note: [1] Sub-sample that eliminates firms that employed any other form of BNDES financing.

* Significant to 10%. ** Significant to 5%. *** Significant to 1%.

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