Effects of BNDES PSI on Investment of Brazilian Industrial Companies: impact estimates based on a matching approach[*]

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Abstract

The *Programa de Sustentação do Investimento* (BNDES PSI) was structured by the Brazilian Government at 2009, with the explicit aim of stopping the aggregate investment plummet, observed at 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 burst investments, since the 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 in 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 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 in between 2009 and 2010.

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Keywords: BNDES; PSI; Investment; Industrial Companies; Matching

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Introduction

Since July 2009, PSI has offered financial incentives to the acquisition of capital goods, with conditions that vary, among other factors, according to aggregate investment trends in the Brazilian economy. In general, the PSI can be understood as a reduction in the final price of domestic capital goods (price of the goods added to the financing cost), which represents an incentive for Brazilian companies to allocate more resources for investment.

Due to its large-scale allocation budget and its rather low interest rate on financing, the PSI has come under question in relation to its capacity to influence investment in the country, within a context in which the Gross Fixed Capital Formation (GFCF) of the Brazilian economy has not recovered to the levels recorded before the financing crisis. Therefore, it seems natural that current Brazilian economic debate should focus on the cost-benefit ratio of the program.

Due to the classic problem of selection that hampers the impact evaluation of public policies, widely discussed in Heckman et al (1997, 1998), it is not a simple task to identify to what extent the PSI stimulus has effectively been converted into investment. To evaluate PSI effects on industrial companies' investments, widely used matching estimators, such as Propensity Score Matching and Conditional Difference-in-Difference Matching, were applied. Such methods allowed the comparison of companies receiving PSI support with those that did not. The database used in this evaluation were: i) the IBGE's Industrial Survey (PIA) from 2007 to 2010; and ii) information on financing offered within the scope of the BNDES PSI (1st phase) from 2009 to 2010.

Results show a positive and significant impact of the PSI on the level of investment in the companies in 2009 and 2010. 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 at 2010, when compared with 2009. This robust result was achieved through several specifications of the applied methods, based on a progressive control of the selection bias.

The paper is structured in five sections, besides this introduction. The Program section contextualizes and describes the PSI in its first phase. The Strategy Identification section presents the econometric approach used to estimate the impact of the program. In the Database section, the sources of researched information are presented, as well as the descriptive statistics of the basis used. The results of the estimated models are presented in the Results section and the Final Considerations section discusses the main findings and implications of the results found.

The Program

To understand the goals of PSI, it is necessary to assess the context for its creation. Between the 3Q08 and the 1Q09, the GFCF fell approximately 20% in nominal terms[3], 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.

[3] Ipeadata.

It was in this scenario that the BNDES' PSI was launched, in July 2009. With an initial allocation budget of R$ 40.1 billion, the program consisted fundamentally of a change to the then-existing financing conditions for BNDES Finame, targeted at stimulate the acquisition and production of capital goods manufactured in Brazil. The goal was to employ more favorable financing conditions to reverse the investment decline that had occurred.

Table 1 summarizes the financing conditions for operations using the BNDES PSI between July 2009 and June 2010, a period in which Phase 1 of the program remained in effect. For comparison, it is worth recalling that BNDES Finame's traditional financing conditions for machinery and equipment established a financial cost comprising the long-term interest rate (TJLP - then at 6.25% p.a.), a spread for the BNDES of 0.9 % p.a., and a spread negotiated directly between the end customer and the financial agent of the operation.

Table 1: Financing conditions of the PSI Phase 1 per group of equipment and per company size

	Buses and trucks (MSME)	Buses and trucks (Large)	Other capital goods (MSME)	Other capital goods (Large)
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

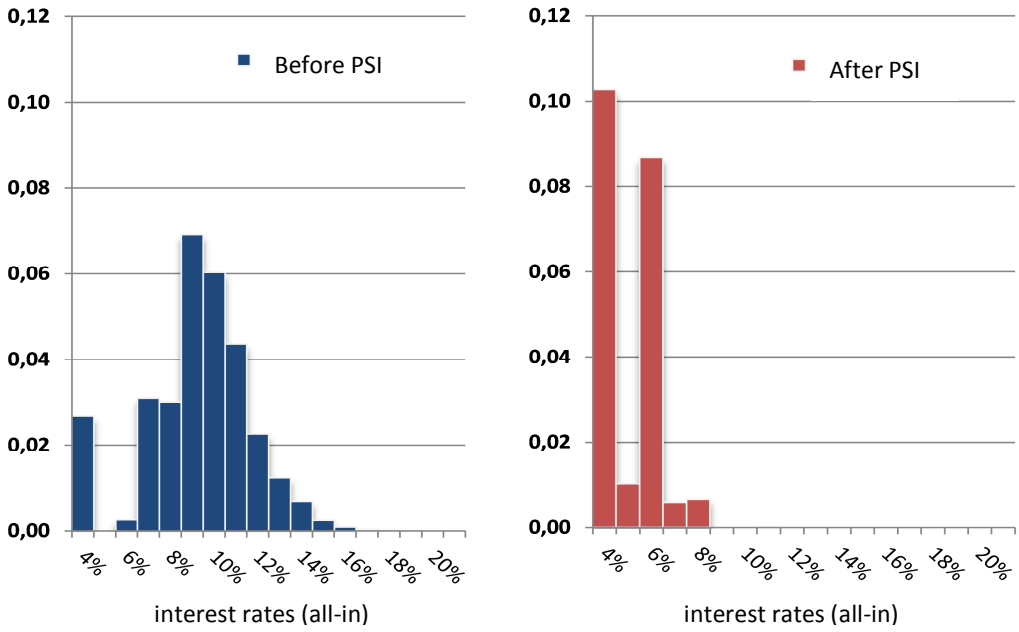
Note: MSME - micro, small and medium-sized companies.
Source: BNDES. Elaborated by the authors.

In practice, this new set of conditions meant a substantial reduction in the interest rate for financing to purchase machinery and equipment, while eliminating, for the buyer, the uncertainty regarding the final financial cost of the operation by introducing a fixed interest rate.

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 Finame loans to 4.5% p.a. in PSI . It is also possible to note that the distribution of loan terms is denser in PSI loans with more than 100 months than in Finame loans with the same loan term.

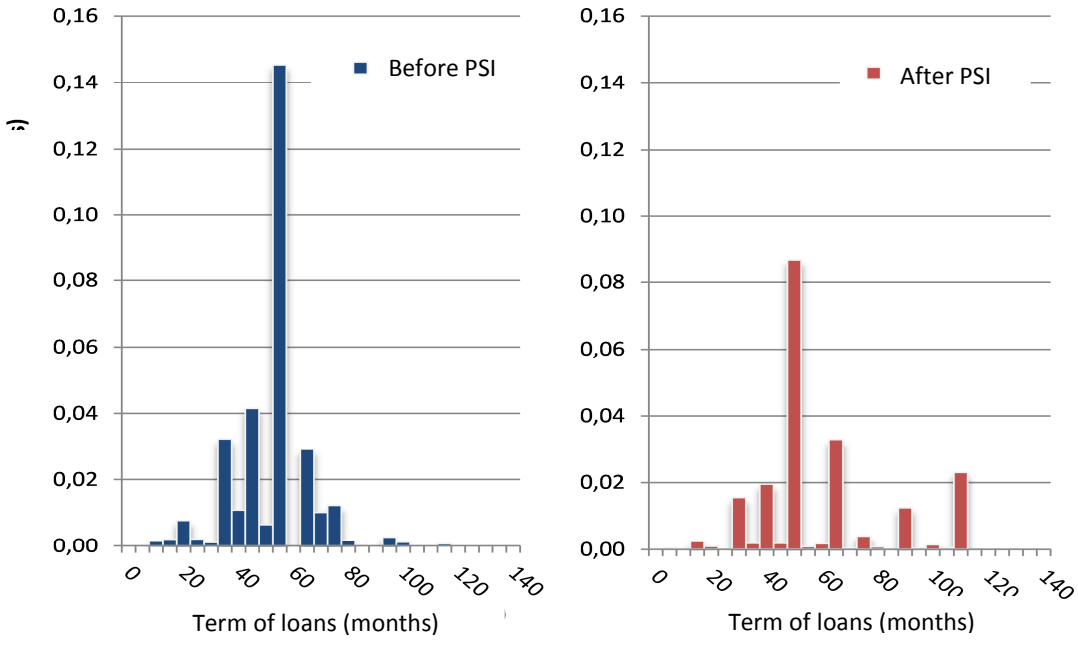
That is, BNDES PSI, from a theoretical point of view, can be understood as a reduction in the final price of capital goods (price of the good plus the cost of financing), which should work as an incentive for Brazilian companies to allocate more resources for investment. Therefore, the program's incentive mechanisms 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)



Note: For BNDES-Finame, the period between January 2007 and June 2009 was used, immediately prior to the launch of the PSI.
Source: PAC-Estatístico (BNDES). Elaborated by the authors.

Chart 3: Distribution of operations per term of loan



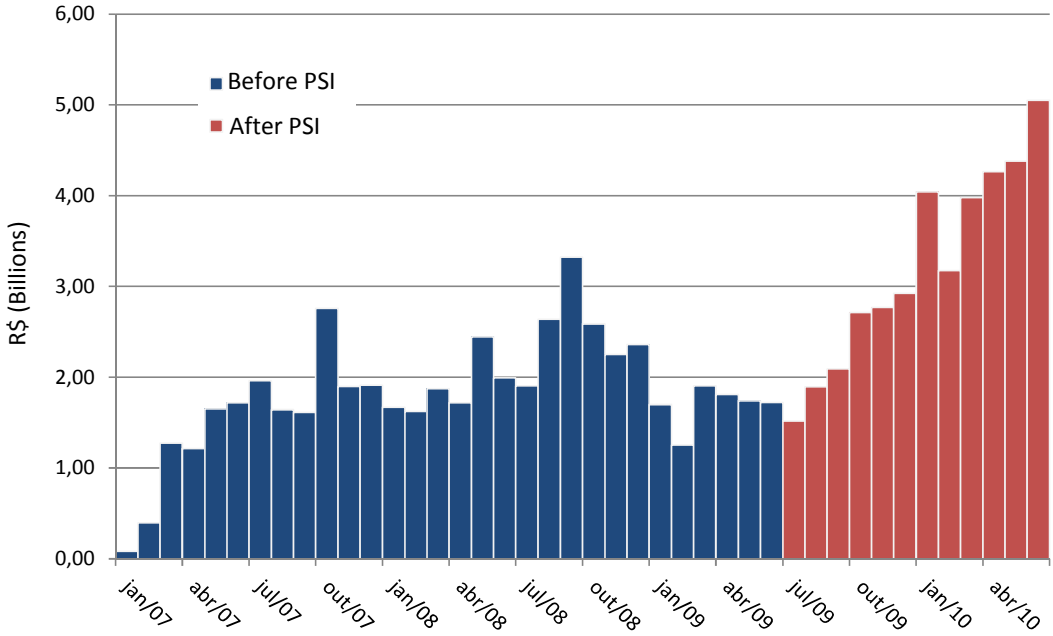
Note: For the BNDES-Finame, the period between January 2007 and June 2009 was taken into consideration, immediately prior to the PSI launch.
Source: PAC-Estatístico (BNDES). Elaborated by the authors.

Chart 4 suggests that the Brazilian companies considered that program's most advantageous financial conditions 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 the 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, changes to regulation etc. It is not reasonable to evaluate the results of PSI based solely at the behavior of macroeconomic series - which consolidate not only the impact of PSI, but a set of other economic variables.

It is at the microeconomic level that BNDES PSI should be assessed. This means adopting 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.

Chart 4: Evolution of monthly disbursments from BNDES Finame between Jan. 2007 and June 2010



Note: Financing operations contracted within the scope of BNDES PSI are made operational by the BNDES Finame financing product.
Source: PAC-Estatístico (BNDES). Elaborated by the authors.

Identification strategy

While discussing methods for public policy evaluations, Heckman et al (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 non-treated. 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 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[4], in their turn, select companies to which they grant credit, based on an analysis of credit risk and in compliance with the program's legal and regulatory requirements.

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 non-treated 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.[5]

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 $P(X_i) = P(d_i = 1|X_i)$, 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 $\hat{p}(X_i)$ an

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

[5] The use of propensity score for matching was motivated by the work by 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.

estimator of $P(d_i = 1|X_i)$, which can be obtained by estimating a parametric model such as a *logit* or *probit* (more details in Blundell and Dias, 2009).

Having obtained $\hat{p}(X_i)$ for the sample of companies used[6], the second step is to estimate the Average Treatment Effects on the Treated (ATT).[7] This estimator is formally defined in [1] below:

$$\hat{\alpha}^{PSM} = \sum_{i \in T}\{y_i - \sum_{j \in C}\tilde{w}_{ij}y_j\}w_i \quad [1]$$

$\hat{\alpha}^{PSM}$ is the measure of impact of PSI on current investments of treated companies (y_i). Moreover, T and C represent the treatment groups and control, 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 re-consideration that recovers the outcome variable for the treated sample. [8]

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]:

$$y_i^0 \perp d_i|P(X_i) \quad [2]$$

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_i is associated with $\hat{p}(X_i) = 1$, 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.

$$P[d_i = 1|X_i] < 1 \quad [3]$$

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 et al (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 can be understood as a variation of PSM, which may be applied when there is longitudinal data available for treated and controls groups.

[6] Implementing the method requires specification of the estimated model of the propensity score to satisfy the balancing property of the sample. This verification is based on a test *t* 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 $\hat{p}(X_i)$. For details, see Becker and Ichino (2002).

[7] The term treated comes from the initial application of this technique, which aimed to identify the effect of medical treatments by comparing the performance of treated patients (called the treatment group) with that of the untreated group (called the control group). In our case, access to PSI resources can be considered a kind of "treatment".

[8] 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.

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 for evaluate PSI, since literature has shown it is capable of deal with selection bias, caused by unobservable variables (provided they are time invariant).

Formally, the identification hypothesis the method assumes 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 from the status of treatment:

$$(u_{it} - u_{i,t-1}) \perp d_{it}|X_i \text{ [4]}$$

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

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

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:

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

In which notation is similar to that used previously. It is expected that this method is able to better control a possible selection bias associated with program participation when compared to the PSM, as Heckman et al, 1997 have demonstrated.

Database

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 and, on the other, consolidated a set of economic characteristics for a large group of firms, a requirement for determining comparable groups of non-treated.

A list of companies who used the program was obtained through a consolidated database from the 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 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 approximately R$ 8.6 billion in 2010, totaling just over R$ 10 billion in disbursements during the first phase of the program.

To obtain reliable economic characteristics on program users, this study chose to use the Industrial Survey (PIA Enterprise) of the Brazilian Institute of Geography and Statistics (IBGE), which is the most important source of micro-data from Brazilian Industrial Sector. In this study, we took into consideration data from this Survey for the years 2007 – 2010[9] and worked solely with firms surveyed in Right Stratum[10], because there are more detailed economic and financial information, required to implement the identification strategy adopted.

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[11]. 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 the 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 and, therefore, would not serve 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[12]. The intention was to exclude companies that reported a volume of investment incompatible with 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 received resources from PSI in 2009 and, in 2010, that number rose to approximately 3,700 companies. Tables 4 and 5 aim to show the characteristics of groups of firms financed in comparison with the group of non-financed 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 at 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] At the time of this work, the last PIA Enterprise available was for the year 2010.
[10] All industrial enterprises with 30 or more employees in the year prior to the survey reference year.
[11] Each observation concerns a company in a given year.
[12] Observations with investment rate at the first or last percentile of the distribution of this variable.

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: PAC-Estatístico (BNDES). Elaborated by the authors.

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

Porte	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: PAC-Estatístico (BNDES). Elaborated by the authors.

Table 4: Characteristics of the sample in 2009

Variable	No PSI financing			PSI financing		
	N	Average	Standard-deviation	N	Average	Standard-deviation
In(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

Note: variable of industrial firms in t-1.
Source: PAC-Estatístico (BNDES) and PIA Enterprise (IBGE). Elaborated by the authors.

Table 5: 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
ln(work productivity)	14,645	10.791	1.268	3,777	11.067	1.021
ln(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

Note: variables of industrial firms in t-1.
Source: PAC-Estatístico (BNDES) and PIA Enterprise (IBGE). Elaborated by the authors.

Results

Table 6 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 periods. Besides PSM and DIDM estimates[13], it also shows basic OLS estimates to discuss the selection bias problem. The first point to note is that all results presented in Table 6 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.[14]

Table 6: Impact Estimates of PSI on the Investment Level of Brazilian Industrial Firms

	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

Notes: Dependent variable is the natural logarithm of the current investment level of the company. *** Statistically significant at 1%. PSM based on "Nearest Neighbor". T-Statistic (OLS and PSM) and Z-Statistic (DIDM). Standard-Deviation of the PSM and DIDM estimates obtained by bootstrapping (n=50).
Sources: PAC-Estatístico (BNDES) and PIA Enterprise (IBGE). Elaborated by the authors.

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.[15]

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 next.

Table 7 approaches the magnitude of the PSI impact on the companies' investment level. Firstly, it shows the average investment in the sample for companies that used the program - which reached approximately R$ 1.2 million in the two reference years (column A). Column B uses the DIDM coefficients to estimate the counterfactual investment level for

[13] Propensity Score of the company estimated by Logit. The annex 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), and DIDM, see Villa (2011).

[14] 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 the result was a positive and statistically significant impact. Tables 12 and 13 in the Annex offer the results of all tested specifications.

[15] 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 Annex.

each year in the analysis. It follows that, in 2009, the program's impact reached approximately R$ 352,000 per supported firm, considering that average firm. This number represents an increase of 40% compared to what would have occurred in the absence of PSI. Looking at 2010, this number fell to R$ 272,000 – representing an increase of 28% (values shown in column C).[16]

Table 7: Comparison of the Effect on Investment with PSI Disbursement

Year	Annual Total Investment		"Created" Investment (C)=(A)-(B)	BNDES Disbursements (observed) (D)	Effect per Disbursement (E)=(C)/(D)
	With PSI (observed) (A)	Without PSI (estimated) (B)			
2009	1,228,986	876,507	352,479	298,492	1.18
2010	1,261,989	989,742	272,247	465,422	0.58

Notes: estimates based on average sample values (in Brazilian Reais) using the coefficients estimated by DIDM.
Sources: BNDES and PIA Enterprise (IBGE). Elaborated by the authors.

The decrease in the average impact of PSI was accompanied by a rise in the program's average disbursements for the period, which reached R$ 465,000 in 2010 - against R$ 298,000 a year earlier (column D in Table 7). These two combined movements generated a strong fall at the Effect per Disbursement ratio (column E in Table 7). Thus, on average, every R$ 1 of PSI disbursement generated an impact of R$ 1.18 on company's investment in 2009. In the next year, the same R$ 1 disbursed were 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, in 2010, it is possible to observe some degree of substitution, with PSI disbursements taking the place of other capital sources. That dynamic suggests that PSI potential effect decreased during the analyzed period. Three possible causes for this behavior were 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 is 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.

A second possible explanation is the existence of a negative relationship between the marginal effect of the policy (created investment) and the treatment dose (amount of disbursements). If treatment dose matters, the reducing policy effectiveness might be, at

[16] 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 at Table 7, we reach 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.

least in part, a consequence of an increase of PSI resources share inside company's total investment.

Such explanation is consistent with a theoretical model in which each firm has a limit to its potential investment expansion. In this scenario, when a company's total investment is below this potential level, the policy would encourage the firm to expand its investments, but only up to a certain point. When this limit is reached, additional doses of the treatment would merely replace financing sources in the firms' capital structure, rather than promoting the expansion of its investment level.

Hence it is possible to suppose the existence of an efficient point for the participation of PSI resources in company's total investment. Beyond that point, additional resources would be marginally less efficient in creating investment. One possible implication of this view is that the effectiveness of the program could be increased simply by reallocating PSI resources among firms - reducing PSI's share in the capital structure of companies that received more than would be optimal, and increasing the share for those that received less.

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

Final Considerations

Within a context in which GFCF did not recover the pre-crisis level, recent Brazilian economic debate has questioned PSI's capacity to influence aggregate investment in the economy. This study aimed to find evidence about the impacts of PSI using methods that could correctly address the selection bias problem. The main conclusion is the program had a positive impact on the investment level of industrial firms for the 2009-2010 periods.

However, the decreasing estimated effect during the analyzed period has raised a number of questions, which still need to be investigated. It is known that the program has been extended since it was created, with financial incentives that have varied according to the behavior of investment in the economy. Hence it is essential to investigate whether this public policy is still capable of affecting investments of financed companies.

In order to do so, 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.

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Appendix

Table 8: Estimates of PSI's impact on investment (in natural logarithms) of industrial companies using OLS for each year in the 2009-2010 period

Explanatory variables	t=2009			t=2010		
	Coefficients	**Standard-deviation**	**p-value**	**Coefficients**	**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	0.751	-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 met operating revenue	0.116**	0.041	0.004	-0.014	0.036	0.697
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		

Notes: 1 *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%.
Source: PIA (IBGE) and PAC-Estatístico (BNDES). Elaborated by the authors.

Table 9: Estimates of the Logit model for the probability of participation in PSI for each year in the 2009-2010 period

Explanatory variables	t=2009			t=2010		
	Coefficients	**Standard-deviation**	**p-value**	**Coefficients**	**Standard-deviation**	**p-value**
ln(met 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	-0.233***	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***	0.367	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
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 > chi²	0.000			0.000		

Notes: All covariates are observed in t-1. Balance test of the Propensity Score carried out in the common support of the sample. This specification of the model satisfies the balancing property in both years.
* Significant to 10%; ** significant to 5%; *** significant to 1%.
Source: PIA (IBGE) and PAC-Estatístico (BNDES). Elaborated by the authors.

Table 10: Results of balancing sample t test - impact estimates of the PSI DIDM for each year in the 2009-2010 period

Explanatory variables	2009			2010		
	Controls (Average)	Treated (Average)	Statistic t (module)	Controls (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			18,422		

Notes: Test t for difference in sample averages done in the region of common support in the sample in the pretreatment period (t-1).
* Significant to 10%; ** significant to 5%; *** significant to 1%.
Source: PIA (IBGE) and PAC-Estatístico (BNDES). Elaborated by the authors.

Table 11: 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 – non-operating 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). Elaborated by the authors.

Table 12: 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****	*0.08****
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	*PSI[1] alone*	*DIDM*	*0.01*	*0.06****

Note: [1] Sub-sample that eliminates firms that employed any other form of BNDES financing.
Sources: PIA (IBGE) and PAC-Estatístico (BNDES). Elaborated by the authors.