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DEVELOPMENT BANK OF LATIN AMERICA

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ABSTRACT

This paper aims to assess the innovation policy in Brazil after the edition of the innovation law, in 2004, and the fiscal subsidies to innovation law, in 2005. We use data from the Brazilian Innovation Survey and from the Annual Industrial Survey to measure the effect of the use of policy instruments on private R&D disbursements and on productivity. The report finds a positive effect of the innovation policy on private R&D when all instruments are pooled together, that is, innovation policy resources may be viewed as complementary to private resources and may be viewed as successful in fostering innovative effort. When separate instruments are analyzed, we find that direct intervention instruments such as credit for R&D investments and economic grants work very well. The effect of fiscal subsidies is not straightforward, however. It seems to increase the probability to perform R&D disbursements but does not have effect on the intensity of these disbursements. Other instruments such as credit for the acquisition of equipment and machinery and credit for the enhancement of university-industry linkages do not perform well. Policy instruments had an overall positive impact on labor productivity. Most instruments have maintained a positive and significant impact on productivity over all equations, with the sole exception of risk capital.

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EVALUACIÓN DE IMPACTO DE LAS POLÍTICAS DE FOMENTO A LA INNOVACIÓN EN BRASIL

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RESUMEN

Este artículo evalúa las políticas de fomento a la innovación en Brasil, luego de la instauración de la Ley de Innovación, en 2004, y la Ley de Incentivos Fiscales a la Innovación Tecnológica (Lei do Bem), en 2005. Utilizamos datos de la Encuesta de Innovación Brasilera y de la Encuesta Industrial Anual para medir el efecto del uso de estos instrumentos de política sobre la productividad y el gasto privado en investigación y desarrollo (I+D). Encontramos un efecto positivo de la política de innovación en el gasto privado en I+D considerando todos los instrumentos en conjunto, es decir que los recursos de políticas de innovación pueden ser considerados como complementarios a los recursos privados y, por ende, exitosos en promover el esfuerzo innovador. Cuando se analizan los efectos por separado encontramos que los instrumentos de intervención directa, como los créditos para inversiones en I+D y los subsidios económicos tienen muy buenos resultados. Sin embargo, el efecto de los subsidios fiscales no es directo: aparenta incrementar la probabilidad de efectuar gastos en I+D pero no muestra un impacto en la intensidad de estos gastos. Otros instrumentos como el crédito para la compra de maquinaria y equipamiento, y el crédito para promover vínculos universidad-industria no tienen buen desempeño. Los instrumentos analizados tuvieron un efecto conjunto positivo en la productividad laboral. La mayoría de los instrumentos mostraron un efecto positivo y significativo en la productividad en todas las especificaciones, con la sola excepción de los capitales de riesgo.

Impact Evaluation of Innovation Policy in Brazil

Carlos Frederico Rocha[1]

Abstract

This paper aims to assess the innovation policy in Brazil after the edition of the innovation law, in 2004, and the fiscal subsidies to innovation law, in 2005. We use data from the Brazilian Innovation Survey and from the Annual Industrial Survey to measure the effect of the use of policy instruments on private R&D disbursements and on productivity. The report finds a positive effect of the innovation policy on private R&D when all instruments are pooled together, that is, innovation policy resources may be viewed as complementary to private resources and may be viewed as successful in fostering innovative effort. When separate instruments are analyzed, we find that direct intervention instruments such as credit for R&D investments and economic grants work very well. The effect of fiscal subsidies is not straightforward, however. It seems to increase the probability to perform R&D disbursements but does not have effect on the intensity of these disbursements. Other instruments such as credit for the acquisition of equipment and machinery and credit for the enhancement of university-industry linkages do not perform well. Policy instruments had an overall positive impact on labor productivity. Most instruments have maintained a positive and significant impact on productivity over all equations, with the sole exception of risk capital.

1. INTRODUCTION

During the 2000's, Brazil has implemented a series of new innovation policy instruments that involved a great amount of public resources. These changes began by the promulgation of two very important laws: the Innovation Law, in 2005, and the Lei do Bem, in 2006. These laws allowed the development of new policy instruments and helped to channel resources of innovation funds created in the 90's to businesses. The new instruments involved new sources of credit mechanisms as venture capital and risk capital to allow firms to implement innovation in high risk involvements, credit to R&D projects, economic subvention and fiscal incentives. Furthermore, recovery plans to face the financial crisis of 2008 involved the availability of governmental resources for credit, mainly directed towards investment and that affected the acquisition of machinery and equipment for innovation.

The use of public resources has, nonetheless, to be investigated in terms of its effectiveness or else it may be simply a transference of public resources to privileged agents. This paper aims at testing the impact of innovation policy in Brazil on firms' behavior and performance. In terms of behavior, the paper will test the role played by policy in augmenting targeted companies' R&D intensity. In terms of performance, the paper will test the effect of innovation policy on labor productivity and total factor productivity.

The paper is organized in five sections, including this introduction. In section 2, we deal with the reasons to implement policy and describe the main features of the Brazilian innovation policy.

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In section 3, we test the effect of innovation policy on private R&D. In section 4, we test the effect of innovation policy on productivity. Section 5 derives the main conclusions of the paper.

2. ANALYTICAL FRAMEWORK

1.1. WHY INTERVENE

Knowledge is an intangible asset. It is not easily appropriated and displays some public good characteristics. On the one side, it is non-rival, in the sense that the use of knowledge by one individual/firm does not exclude its use by another firm, and partially non-excludable, though there are no property limits for the use of knowledge, the understanding and access to it may require previously accumulated capabilities, that is, one needs absorptive capacity (Cohen and Levinthal 1989). Furthermore, knowledge has tacit characteristics and its transmission require interaction and be costly. Third, knowledge has a cumulative character. Fourth, it is specific in the sense that it may be applied to certain pattern of solutions but not to others.

Innovative activities are also uncertain. Freeman (1989) argues that apart from effective demand uncertainty (common to physical capital investments), innovative activities are subject to two additional types of uncertainty: technological uncertainty and market uncertainty. Technological uncertainty is associated with the risk of not solving technological problems, for technology outcomes are unknown. Market uncertainty is the risk that a firm incurs over the acceptance of the new product by the market.

Due to these characteristics of knowledge and its relation to the innovative process, knowledge may be subject to non-Pareto allocations being provided at a lower level than it would be socially optimal. Some analysts believe that policies should correct for these market imperfections. Others understand policies should go deeper and focus on the enhancement of knowledge networks.

The correction for market imperfections may be achieved through: (i) the use of property rights legislation to guarantee appropriability; (ii) the establishment of fiscal incentives, meaning a reduction of the burden of the cost of the innovative process, (iii) the provision of special conditions of financing to overcome financial constraints; (iv) the partial or total payment for some of the inputs used in the system, such as the hiring of personnel or the subvention.

The second perception emphasizes the systemic character of innovative activities and stresses the importance of structuring innovation networks. In this view, policy should enhance flows of knowledge across actors that hold different and, most importantly, complementary competencies. Thus, firms and other actors inside a supply chain, a network, or an innovation system control different parts of knowledge that are necessary to carry out innovation. The mechanisms that achieve these information flows from one agent to another are a central part of the innovative process. Therefore, suppliers, clients, universities, research labs, and governmental institutions are part of an interactive network to generate innovation. Innovation is thus a collective achievement (Mazzucato 2011).

1.2. POLICY INSTRUMENTS

Different policy instruments will firm behavior and productive outcomes in different ways. The implementation of fiscal subsidies aims to reduce the price of innovative inputs. The defenders of this type of governmental intervention ill argue that it is a market-oriented response as it leaves the choice on how and what to spend to private firms, though it is not absence of drawbacks as some researchers find little complementarity of taxes exemptions and private innovative effort. International literature finds a positive relation with a price elasticity of around one (Hall and Reenen 2000).

Mission-oriented programs are on the other extreme of the policy intervention scenario and are probably the most antique mode of policy intervention, dating from the XVI century, when Henry VIII decided to fund activities to enhance England's military capabilities (Lundvall and Borrás 2005, Mowery 2012). Mission-oriented mechanisms are established whenever policymakers believe that the spillovers generated by public sector or private sector innovative activities are very high, and apart from military ends, they are widespread in Health matters as well.

In between these two extremes, a set of policy instruments have been built with diverse objectives. For instance, the provision of governmental grants to business firms to develop new products, such as in the US Small Business Innovation Research (Link and Scott 2009) is a way to provide resources to business firms that may guide research into specific areas that are of interest of the government.

Another mode of policy intervention is the provision of subsidized credit to companies. This is associated to the high uncertainty of investment in innovation and the risks that are associated with high disbursements, mostly in small firms. This is even more important when financial sectors are not well developed (see Rajan and Zingales 1998). Thus, the provision of public credit to innovation may be a way to influence innovative outcomes.

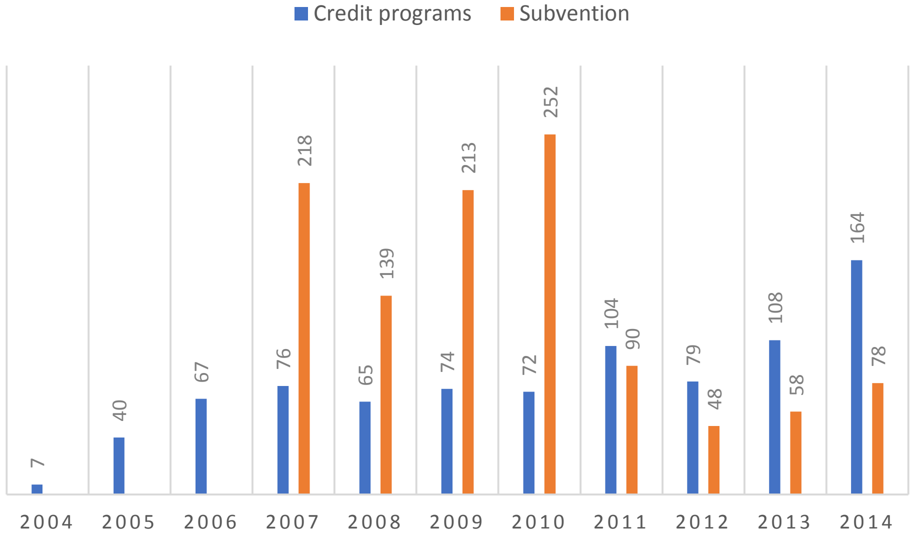
Policy may also influence demand. Instruments may be related to the financing of the purchasing of innovation, procurement policies, the establishment of regulatory environment, and others. Some policies will directly influence structure by, for instance, allowing market access for companies that are excluded from the market and others will even act directly on market incentives as is the case of property rights (Edler et al. 2012).

1.3. BRAZILIAN INNOVATION POLICY

In the beginning of the 2000's, the amount of supply of funds to innovation averaged less than R$ 1.5 billion a year. From 2004 on, the Brazilian innovation policy suffered a major shift and, in 2010, the governmental funds to innovation reached almost R$ 10 billion a year. The increase in the amount of expenditures was due to important policy initiatives carried out by the government. The Innovation, Technology and Trade Policy (PITCE) was the first governmental step in terms of a general innovation policy framework. Since then many policy instruments and regulations have been put in place to strengthen Brazil's science and innovation potential.

The Innovation Law (2004) was designed to strengthen the university–industry research relationships, to promote the shared use of science and technology infrastructure by research institutions and firms, to allow direct government grants for innovation in firms and stimulate the mobility of researchers within the system. The transfer of university knowledge to companies would be achieved mainly by means of the obligatory creation of Technological Innovation Nuclei (TIN) at universities and by the release of laboratories and equipment to be shared between science and technology institutions (STI) and companies. Furthermore, for the first time in the country the public resources could be transferred as non-refundable funds to enterprises, sharing the costs and risks of innovative activities. The enactment of this law thus permitted the creation of the Economic Subsidy program, in 2006, coordinated by FINEP, which provides resources for research and development (R&D) activities at the company. The number of firms that benefitted from financial programs and economic subvention programs carried out by FINEP appear in Graph 1.

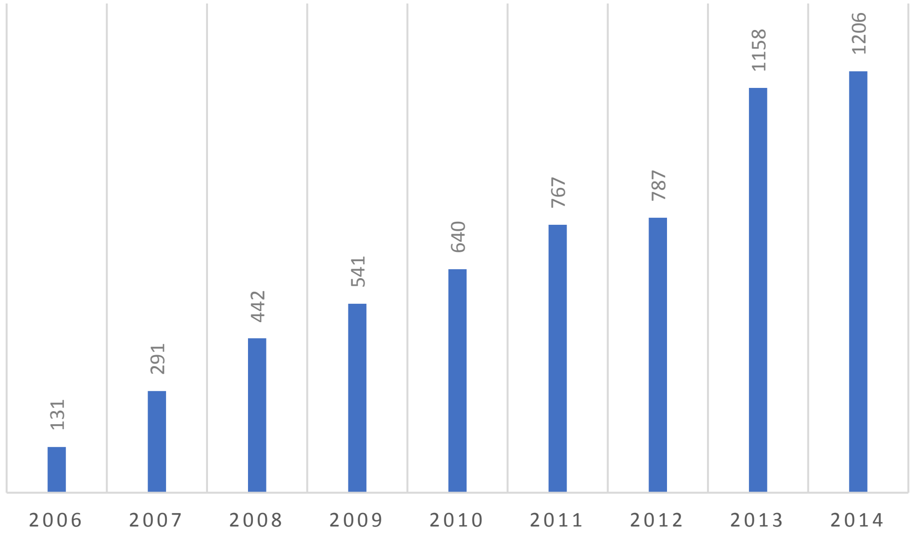
Graph 1. Number of Firms* that Obtained Credit and Subvention Benefits from FINEP, 2004-2014



Source: FINEP.
* The graph deals with the number of firms not the number of operations. A same firm may have received more than one treatment in the same year.

Law 11.196 was enacted in 2005 to reinforce advances of the Innovation Law. It was replaced in 2007 by Law 11.487, which became known as the "Goodwill Law" (Lei do Bem). This Law speeds up and expands incentives for investments in innovative activities, authorizing the automatic use of fiscal benefits for companies that invest in R&D and are within requirements, without any need of a formal request. The special tax regime and fiscal incentives for companies created by Lei do Bem stipulate, among others: deductions from income tax and social contributions on net profits due to expenses on R&D (between 60% - 100%), reductions in taxes on industrial products due to the purchasing of machines and equipment for the performance of R&D (50%), economic subsidies through scholarships for researchers in companies and an exemption from the Contribution for Intervention in the Economic Domain (CIDE) due to patent deposits. It also includes funding to firms who hire employees with Masters Degrees and PhDs. The subsidy can reach up to 60 per cent of the salary in the North East and Amazon regions and 40 per cent in the rest of the country for up to three years. Lei do Bem has been one of the most important policy instruments since 2005 (see 0).

Graph 2. Number of Firms that Received Lei do Bem Benefits, 2006-2014



Source: Brasil, Ministry of Science and Technology.

The Productive Development Policy (PDP) was launched in 2008 with the objective of sustaining the process of economic growth, increasing investment and economic growth rates. One of the main objectives of the strategy embodied in PDP, although not explicitly, was to raise the innovation capacity of the productive sector. In fact, it is not clear what is meant by innovation capacity and no indicators are offered in the policy document to measure the achievement of the objective. The main goal was to raise private business research and development (R&D) expenditures to 0.65% of the gross domestic product (GDP) by 2010, over 0.51% of GDP in 2005. In addition, the accessory objective set was to double the number of patent deposits of Brazilian enterprises in the local patent office (INPI) and triple the number of patent deposits abroad.

In 2011, the government launched the Plan Brasil Maior. Mostly, it maintained the measures and goals that were already present in PDP. There are however two important differences. First, the plan created EMBRAPII, inspired in the good historical results obtained by EMBRAPA in providing technology and innovation for the agricultural sector. The main objective of EMBRAPII is to provide support and connect science and technology institutions to business firms. It is a bridging institution that is supposed to link knowledge available in universities and R&D laboratories with the needs of the industrial sector.

The second novelty of the Plan Brasil Maior is the creation of INOVA EMPRESA. An analysis of the Brazilian innovation policies allows the conclusion that the changes that took place in of Lula's first term government were rich in providing supply instruments to innovation policy. However, there was no design for demand instruments. INOVA EMPRESA tries to fulfill this gap by linking supply instruments to demand. INOVA EMPRESA is therefore split into sectoral programs where governmental companies or regulating agencies organize the demand for innovation. One of the most important sectoral programs of INOVA EMPRESA is INOVA PETRO. INOVA PETRO unites financial funds available in FINEP and BNDES with the technical support available in PETROBRAS to define priorities and targets to be achieved by financing instruments in the oil and gas value chain. It therefore targets technologies associated with surface oil processing technologies, subsea technologies and equipment and oil wells installation technologies.

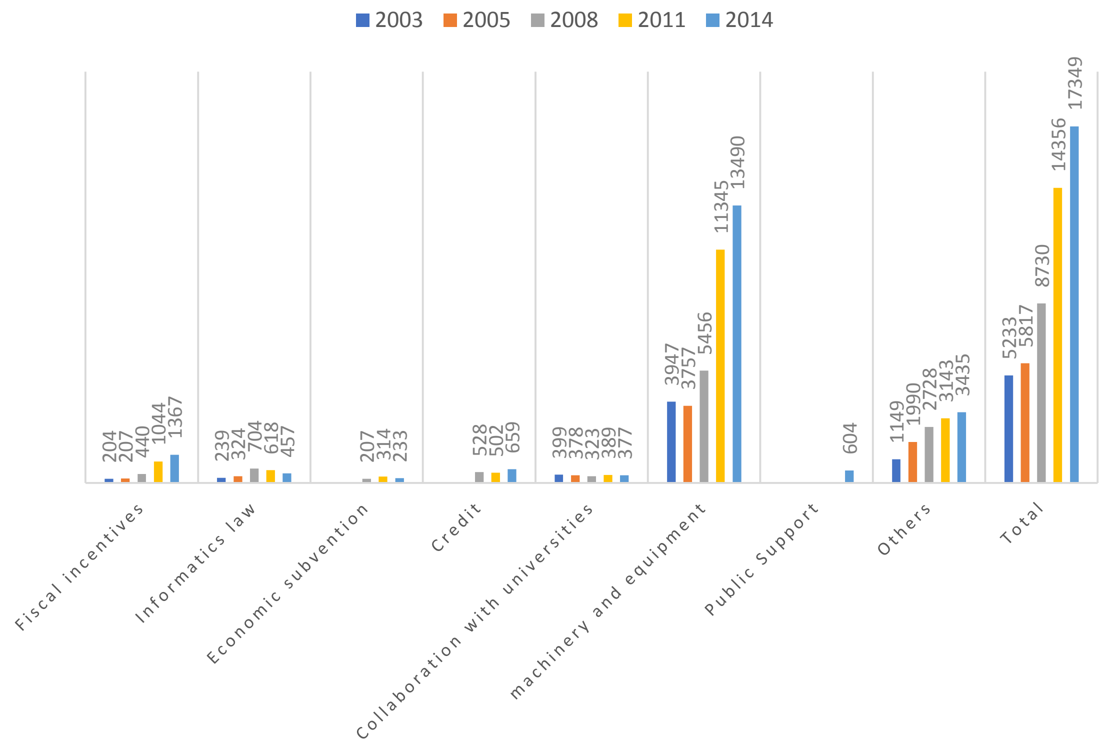
3. INNOVATION POLICY AND R&D ACTIVITIES

This section will test the role played by innovation policy on fostering innovative effort. ABDI (2013) has evaluated the impact of the Brazilian innovation policy after the Congress vote of the Innovation Law and Lei do Bem on innovative effort. ABDI (2013) holds that, though there has been greater diversification of instruments and larger resources, policy users are still mostly composed by large firms. The study also concludes that with exception of fiscal incentives and some cases related to economic subvention, most instruments fail to deliver a greater intensity of business innovation efforts.

3.1. METHOD

We will use data from PINTEC. PINTEC is available in six different editions for 2000, 2003, 2005, 2008, 2011 and 2014. The survey is designed to produce statistically significant samples of companies in the 10 to 29, 30 to 99, 100 to 249 and 250 to 499 employees' strata and attempts to cover all companies with 500 or more employees. The survey also builds statistically significant samples across two-digit sectors according to International Standard Industrial Classification (ISIC). It also departs from the view that innovation is an exceptional event and thus attempts to cover all firms that have received or applied for governmental financial support and patents. PINTEC 2000 does not have a section for governmental support. Graph 3 show the distribution of governmental support to innovation, by instrument, for all other years.

Graph 3. Firms Treated by Policy, According to PINTEC, 2003, 2005, 2008, 2011, 2014



Source: IBGE, PINTEC.

To test the effectiveness of innovation policy to enhance firms' innovative intensity, we'll compare the performance of treated firms with a quasi-experimental control sample built using matching procedures to control for selection biases. On average, targeted firms are larger and more innovative, they also hire more productive personnel and belong to specific sectors (see

Table 1 and Table 2). Thus, one may fail to distinguish if they perform better because they are better firms or because they have received public support. One way to deal with this is to build a control sample with similar characteristics to those of treated firms and see if they perform differently according to a certain variable. We have used coarsened exact matching to build the control sample, using the following variables:

(i) Year, using 2003, 2005, 2008, 2011 and 2014 (see Graph 4);
(ii) Size, according to IBGE's criteria, less than 5, 5 to 9, 10 to 29, 30 to 99, 100 to 249, 250 to 499, 500 to 999, and 1000 and over;
(iii) Innovative performance. This is a binary variable that assumes value 1, when the firm has declared to have innovated at least once in the three-year period covered by the PINTEC edition and 0, otherwise;
(iv) Wage, distributed in four different strata, lower than p25, p25 to p50, p50 to p75 and higher than p75; and
(v) Sectoral classification in 10 groups, according to ISIC3, divisions 10 to 14, 15 and 16, 17 to 19, 20 to 22, 23 to 25, 26 to 28, 29, 30 to 33, 35 to 35, 36 and 37.

Table 1. Descriptive Statistics, Treated and Non-Treated Firms, All Instruments

	Statistics	Number of employees	Innovative	wage	R&D	R&D/sales	Private R&D	Private R&D /sales
Non-treated	Count	38948	38948	38942	38948	38948	38948	38948
	mean	314.7	0.402	13967	189.7	0.00217	189.0	0.00216
	sd	936.7	0.490	14180	4278	0.0153	4278	0.0151
Treated	Count	8411	8411	8411	8411	8410	8411	8410
	mean	854.2	0.964	15458	4676	0.0127	4013	0.00935
	sd	2915	0.187	18000	51168	0.143	48294	0.0585
Total	Count	47359	47359	47353	47359	47358	47359	47358
	mean	410.5	0.502	14232	986.4	0.00405	868.2	0.00343
	sd	1508	0.500	14941	21976	0.0620	20769	0.0283

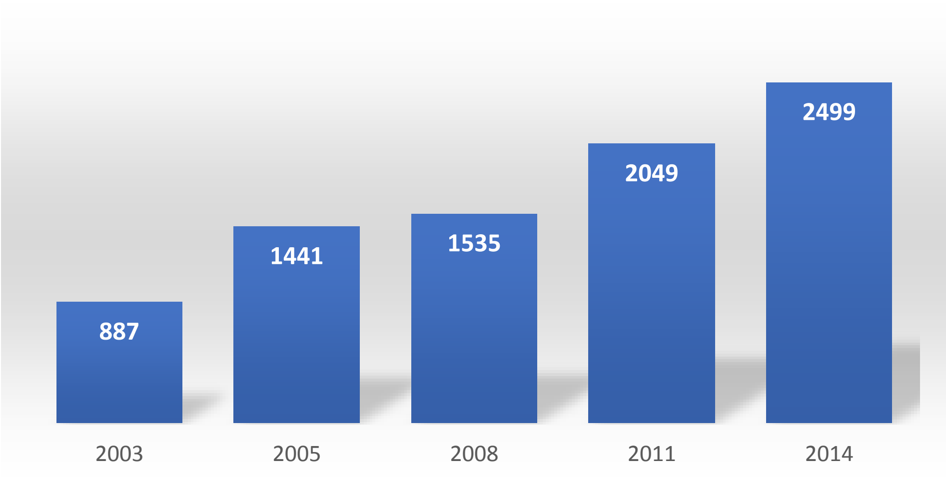
SOURCE: IBGE, PINTEC.

Table 2. Sectoral distribution of treated firms

cnae2	Description	Number of treated firms
10	Mining of coal and lignite; extraction of peat	6
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying	9
13	Mining of metal ores	18
14	Other mining and quarrying	91
15	Manufacture of food products and beverages	1266
16	Manufacture of tobacco products	9
17	Manufacture of textiles	231
18	Manufacture of wearing apparel; dressing and dyeing of fur	94
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	132
20	Manufacture of wood and of products of wood and cork	105
21	Manufacture of paper and paper products	223
22	Publishing, printing and reproduction of recorded media	43
23	Manufacture of coke, refined petroleum products and nuclear fuel	250
24	Manufacture of chemicals and chemical products	623
25	Manufacture of rubber and plastics products	369
26	Manufacture of other non-metallic products	399
27	Manufacture of basic metals	458
28	Manufacture of fabricated metal products, except machinery and equipment	334
29	Manufacture of machinery and equipment n.e.c.	1585
30	Manufacture of office, accounting and computing machinery	129
31	Manufacture of electrical machinery and apparatus n.e.c.	457
32	Manufacture of radio, television and communication equipment and apparatus	182
33	Manufacture of medical, precision and optical instruments, watches and clocks	265
34	Manufacture of motor vehicles	465
35	Manufacture of other transport equipment	92
36	Manufacture of furniture; manufacturing n.e.c.	556
37	Recycling	0
Total		8391

Source: IBGE, PINTEC.

Graph 4. Number of Treated Firms in the Database, per year



We ran separate CEM exercises for each instrument and for a sample including all instruments. We then ran regressions testing the influence of the instrument or policy on private R&D. Private R&D is defined as the total firms R&D less the share the firm declares to have been financed by government. In this case, if the sign of the regression is positive, we'll say that policy is complementary to private R&D. If the sign is negative, we'll affirm that policy or instrument is substitute to private R&D and if no sign is obtained, we'll say that the policy is neutral to R&D expenditures.

3.2. RESULTS

3.2.1. All Instruments

Table 3 shows the results from the coarsened exact matching when using all instruments. The number of employees is slightly greater in the treated sample than in the control sample due to the size of firms with more than 1000 employees. In all other variables, the results are very much like.

Equation (1) in 0 shows the results for the tobit regression using the samples of coarsened exact matching. The results suggest an increase in the intensity of private R&D of around 1.4 percentage point, arguing for a positive effect of innovation policy on private R&D. The size variable (natural logarithm of the number of employees) is positive and significant, suggesting that the level of R&D expenditures increases with size, confirming one of Schumpeter's hypothesis (Cohen and Levin 1989).[2] Also average wage is positively correlated with private R&D, indicating a positive effect of employees' capabilities on private R&D.

Table 3. Descriptive Statistics, Treated and Control Samples, after Coarsened Exact Matching

Samples	Statistics	Number of employees	Innovative	wage	R&D	R&D/Sales	Private R&D	Private R&D/Sales
Control	count	7919	7919	7919	7919	7919	7919	7919
	mean	552.7	0.962	14684	573.0	570.9	0.00538	0.00531
	sd	1600	0.192	15623	4376	4375	0.0232	0.0225
Treated	count	7919	7919	7919	7919	7919	7918	7918
	mean	725.0	0.962	14756	2917	2555	0.0126	0.00916
	sd	2635	0.192	15996	36664	34992	0.147	0.0600
Total	count	15838	15838	15838	15838	15838	15837	15837
	mean	638.8	0.962	14720	1745	1563	0.00897	0.00723
	sd	2181	0.192	15810	26135	24955	0.106	0.0453

Source: Own elaboration using IBGE, PINTEC.

[2] Actually, it is Galbraith's hypothesis. We have also run regressions for market concentration. However, no significant result was found.

Table 4. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel

		Two-part model		
All instruments	(1)	(2)	(3)	(4)
VARIABLES	Tobit	Probit	Marginal effect	OLS
policy	0.0143***	0.340***	0.124***	0.00491**
	(0.00106)	(0.0214)	(0.00777)	(0.00200)
ln(size)	0.00777***	0.326***	0.120***	-0.00796***
	(0.000373)	(0.00876)	(0.00322)	(0.000734)
wage	3.41e-07***	9.73e-06***	3.57e-06***	-3.31e-08
	(3.19e-08)	(6.81e-07)	(2.50e-07)	(5.30e-08)
Constant	-0.0855***	-2.486***		0.0657***
	(0.00222)	(0.0508)		(0.00457)
sigma	0.0544***			
	(8.01e-05)			
Observations	15,837	15,837	15,837	5,599
chi2	765.2	2162		
R2				0.022
N_unc	5596			
N_rc	3			
N_lc	10238			

SOURCE: IBGE, PINTEC.
*p<.10, **p<.05, ***p<.01

One important characteristic of the regression in equation (1) is the high number of left censored observations, that is, firms that have zero private R&D expenditures. The tobit model may be mixing two different effects: (i) the effect of innovation policy on the probability to perform R&D, and (ii) the effect on the increasing intensity of R&D. Equations (2) to (4) in 0 attempt to separate these two effects, using a two-part model. In the two-part model, we first run a probit regressions, then, we exclude those observations with zeros in the dependent variable and run a OLS regression. The probit model (equation (2)) shows that innovation policy increases the probability of performing R&D and the marginal effects in equation (3) estimates the average increase in probability in 12.4%. However, the effect on R&D intensity is smaller than presented in equation (1) and situated around 0.5 percentage point. The most striking difference is on the size variable. In the probit model, the size variable maintains the positive sign found in equation (1). However, in the OLS model, size assumes a negative and significant sign. So, size seems to be important in determining whether or not to perform R&D, but once firms have decided to perform it, smaller firms are more R&D intensive. This is a far from new result. The seminal paper by Cohen, Levin and Mowery (1988) found similar results testing Galbraith's hypothesis for the US. Rocha (2017) also finds the same results using data from RAIS for Brazil in a sample of oil and gas suppliers. Average wage maintains, in the probit model, the positive sign of the tobit model. However, in the OLS model the coefficient is non-significant.

3.2.2. Fiscal Incentives

This section is directed towards analyzing the effects of fiscal incentives to innovate on R&D expenditures. Lei do Bem, that consolidates the fiscal incentives to innovative efforts legislation, has an important bias towards large firms. Fiscal legislation in Brazil already gives a lot of benefits to small firms, mostly associated with the simplification of procedures, through small taxation on revenue. So, very rarely small firms opt to use the complete fiscal system. Large firms have nonetheless to use this more complex systems that applies taxes over profits. Lei do Bem is mainly directed towards tax benefits over profits. Therefore, most firms that apply for Lei do Bem's benefits are large.

The effect of fiscal incentives on innovative efforts is probably the most tested hypothesis of the Brazilian innovation policy, through the analysis of the effects of Lei do Bem (Kannebley, Shimada and De Negri 2016, Kannebley and Porto 2012, Colombo 2017 and ABDI 2013). The results suggest a positive impact on R&D. Kannebley and Porto (2012) using RAIS data build a PSM control sample and find a 7% to 11% increase in the number of scientific and technical employees for the users of Lei do Bem. Kannebley, Shimada and De Negri (2016) also using RAIS data and a PSM procedure to build the control sample find that Lei do Bem increases R&D private expenditures in average between 43% and 87% and the number of scientific and technical personnel in around 9%. Colombo (2017) uses data from PINTEC. He finds an average impact of Lei do Bem on private R&D of around 7% in the mean R&D expenditures of treated firms.

Table 5. Descriptive Statistics, Treated and Control Samples, Fiscal Incentives

Samples	Statistics	Number of employees	inov	wage	R&D	R&D/Sales	Private R&D
Control	count	1808	1808	1808	1808	1808	1808
	mean	1085	0.971	16090	1893	0.00728	1744
	sd	1935	0.169	20088	10116	0.0257	9916
Treated	count	1808	1808	1808	1808	1808	1808
	mean	1928	0.971	20704	13245	0.0210	11208
	sd	4843	0.169	23866	79933	0.119	73498
Total	count	3616	3616	3616	3616	3616	3616
	mean	1507	0.971	18397	7569	0.0141	6476
	sd	3712	0.169	22175	57246	0.0861	52648

Source: Own elaboration using IBGE, PINTEC.

Table 5 shows descriptive statistics for firms that received fiscal incentives from the Brazilian government and a control sample. Equation (1) in Table 6 shows the results for the tobit model testing for the effect of fiscal incentives on private R&D. The fiscal incentives show a positive effect of 3 percentage points. Size effect is positive as in the all instruments equation. However, average wage does not seem to affect private R&D. Thus, the results mostly agree with those presented by previous literature.

However, we still must separate the effect of fiscal incentives on the probability and/or intensity of R&D performance. We follow the same procedure carried out for the all case. We run a two-part model to separate the effect of fiscal incentives on the probability to carry out R&D activities and then we test with an OLS model the effect on R&D intensity. The results presented in equations (2) to (4) show that fiscal incentives are likely to have a positive role on the probability of the firm to engage on R&D activities. In fact, equation (3) estimates an average impact of 41% on the probability to perform R&D activities. However, equation (4) suggests that there is no significant effect of fiscal incentives on the intensity firms carry out R&D activities.

This result is quite important, because to apply for the fiscal incentives, a firm must have previously performed innovative activities, for, as described before, most fiscal exemptions occur with the ex post examination of accounting values of firm innovative activities. Thus, if the firm does not declare to have performed innovative activities, it is most more likely it is not fit to apply for fiscal incentives. Thus, the result questions the usefulness of fiscal incentives.

Table 6. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel, Fiscal Incentives

		Two-part model		
	(1)	(2)	(3)	(4)
VARIABLES	Tobit	probit	mfx	ols
Fiscal incentives	0.0297***	1.183***	0.411***	0.00586
	(0.00179)	(0.0477)	(0.0148)	(0.00460)
ln(size)	0.00159***	0.268***	0.0977***	-0.00681***
	(0.000514)	(0.0197)	(0.00711)	(0.00167)
wage	4.04e-09	2.31e-06**	8.41e-07**	-1.15e-07
	(3.96e-08)	(1.10e-06)	(4.00e-07)	(9.24e-08)
Constant	-0.0311***	-1.925***		0.0628***
	(0.00359)	(0.129)		(0.0116)
sigma	0.0492***			
	(8.91e-05)			
Observations	3,616	3,616	3,616	2,283
chi2	285.6	894.2		
N_unc	2280	0.665		
N_rc	3			
N_lc	1333			
R2				0.009
F				6.924

SOURCE: IBGE, PINTEC.
*p<.10, **p<.05, ***p<.01

3.2.3.Informatics Law

The informatics law is a fiscal incentive as well but it is treated separately in PINTEC. Kannebley and Porto (2012) compared the results from the informatics law with those obtained by Lei do Bem. They show little effect of the Informatics Law on the number of scientific and technical personnel and argue that, contrary to Lei do Bem, the Informatics Law establishes rigid patterns of behavior and has been verified as an inadequate instrument to foster R&D activities. .

Table 7 shows descriptive statistics after the CEM procedure for the informatics law. Using these treated and control sample, we repeat the procedures we adopted for the Fiscal Incentives case. The results are very similar to those obtained by fiscal incentives. The tobit model shows a positive impact of the informatics law on private R&D, around 4.6 percentage points and larger than the fiscal incentives. However, when we test the two-part model, we verify that the policy is successful in elevating the probability of performing R&D, but it is not successful in enhancing the intensity of R&D. Informatics law is also an ex post application policy. However, it's objective is not focused on increasing R&D, but in augmenting local content on firms associated with IT activities. Thus, contrary to fiscal incentives, the increase in the probability to carry out R&D activities is more meaningful.

Table 7. Descriptive Statistics, Treated and Control Samples, Informatics Law

	Statistics	Number of employees	inov	wage	R&D	R&D/Sales	Private R&D
Non-treated	Count	708	708	708	708	708	708
	mean	457.6	0.970	15982	1846	0.0298	1752
	sd	835.6	0.170	16021	12855	0.446	12777
Treated	Count	708	708	708	708	708	708
	mean	704.4	0.970	17971	5622	0.0396	4611
	sd	1851	0.170	17702	27327	0.189	25051
Total	Count	1416	1416	1416	1416	1416	1416
	mean	581.0	0.970	16977	3734	0.0347	3182
	sd	1441	0.170	16906	21430	0.342	19929

Source: Own elaboration using IBGE, PINTEC.

Table 8. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel, Informatics Law

		Two-part model		
		(2)	(3)	(4)
VARIABLES	Tobit	Probit	mfx	ols
Informatics law	0.0460***	0.750***	0.288***	0.0197
	(0.00500)	(0.0697)	(0.0255)	(0.0128)
ln(size)	0.000637	0.187***	0.0734***	-0.0123***
	(0.00151)	(0.0289)	(0.0114)	(0.00464)
wage	2.28e-07	5.04e-06**	1.98e-06**	-2.90e-07
	(1.46e-07)	(2.14e-06)	(8.41e-07)	(3.40e-07)
Constant	-0.0435***			
	(0.00922)			
sigma	0.0859***			
	(0.000459)			
Observations	1,416	1,416	1,416	796
chi2	86.11	172.5		
N_unc	793			
N_rc	3			
N_lc	620			
R2				0.014
F				3.647

Source: Own elaboration using microdata from PINTEC and PIA.
*p<.10, **p<.05, ***p<.01

3.2.4. Financial Resources for the Acquisition of Machinery and Equipment

The use of credit for the acquisition of machinery and equipment to innovate is the most widespread innovation policy instrument in the Brazilian industry. The instrument does not have direct effect on R&D and any possible effect should be a consequence of the need to complement the equipment investment with some innovative activity. So, one should expect a smaller impact on R&D activities when compared to other investments. Nonetheless, the question asked associates the investment in machinery and equipment to innovation. BNDES is the main supplier of these type of funds through its subsidiary FINAME (Agência Especial de Financiamento Industrial). Between 2005 and 2015, FINAME financed more than 2 million equipment acquisition operations (Grimaldi and Madeira 2016). This instrument is the most frequently used also by small firms and the mechanism has a top value limit of R$ 1 million (around US$ 300 thousands). Table 9 describes the result of the coarsened exact matching exercise and shows that applicant firms are smaller than the average firm that applies for public support to innovate.

The results of the tobit model in 0 suggest a small negative and significant impact of the credit for the acquisition of machinery and equipment on private R&D investments of the treated firms, indicating a substitute effect of this instrument with respect to R&D. The results of the two-part model confirm a small and negative impact on the probability to perform R&D and on the intensity of R&D. Dealing mostly with small companies, this result may be a consequence of a tight financial restriction of smaller firms that have to choose where to compromise resources.

Table 9. Descriptive Statistics, Treated and Control Samples, Financial Resources for the Acquisition of Machinery and Equipment

Samples	Statistics	Number of employees	inov	wage	R&D	R&D/Sales	Private R&D
Control	count	4875	4875	4875	4875	4875	4875
	mean	577.5	0.969	14699	1814	0.00716	1724
	sd	2424	0.174	15489	40333	0.0260	39213
Treated	count	4875	4875	4875	4875	4874	4875
	mean	576.3	0.969	12846	1516	0.00928	1006
	sd	1864	0.174	13010	14295	0.172	9029
Total	count	9750	9750	9750	9750	9749	9750
	mean	576.9	0.969	13773	1665	0.00822	1365
	sd	2162	0.174	14332	30257	0.123	28454

Table 10. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel, Financial Resources for the Acquisition of Machinery and Equipment

		Two-part model		
All instruments	(1)	(2)	(3)	(4)
VARIABLES	Tobit	Probit	Marginal effect	OLS
Acquisition of machinery	-0.00327***	-0.0487*	-0.0171*	-0.00224*
	(0.00125)	(0.0278)	(0.00973)	(0.00131)
ln(size)	0.00871***	0.367***	0.128***	-0.00647***
	-0.000508	(0.0116)	(0.00407)	(0.000520)
wage	3.49e-07***	9.89e-06***	3.46e-06***	-2.72e-08
	(4.12e-08)	(9.61e-07)	(3.36e-07)	(4.01e-08)
Constant	-0.0807***	-2.571***		-2.821***
	(0.00311)	(0.0657)		(0.0836)
sigma	0.0488***			
	(0.000673)			
Observations	9,749	9,749	9,749	3,124
chi2	479.2	1344		
N_unc	3124			
N_rc	0			
N_lc	6625			
R2				0.111
F				14.26

*p<.10, **p<.05, ***p<.01

3.2.5. University and Industry Collaboration

The use of public resources to implement industry and university collaboration is an innovation policy instrument that existed before the innovation law and was the only mode of public support to innovation that could use non-reimbursable resources. Thus, this is a thematic that has vast previous studies. In general, they find mixed resources of the impact of this activity. Carrijo and Botelho (2013) analyze the results of the governmental program that targets technological cooperative agreements between universities and small companies (PAPPE Inovação). They conclude that most firms engaged in PAPPE Inovação had previously developed ties with universities: “no new agreements between participants companies and other economic agents were found” (Carrijo and Botelho 2013: 442). However, the authors find qualitative evidence that firms had improved methods and deepen relationship after engaging in the program. Rapini, Oliveira and Silva Neto (2014) analyze the modes of interaction of 1,600 business firms that established agreements with the university. They conclude that firms that received governmental support cannot be distinguished from those that used their own resources with respect neither to the type of innovative disbursement, nor with respect to the type of information source used. However, they may be distinguished in their attitudes towards risk and with respect to the dimension of expenditures. They argue however that governmental lines of financial support usually are directed towards projects that imply large disbursements.

Table 11 presents the descriptive statistics of the control and treated samples after the use of coarsened exact matching. We’re dealing with above average size firms, comparable to those that use fiscal incentives. On average, treated firms have a R&D to sales ratio around 4.2% against .8% of the control sample. When we analyze the results of the tobit regression (0), we find that funding of university-industry collaboration may augment private R&D to sales ratio in about 2.5 percentage points. Size does not appear to influence R&D intensity. In the two-part model, the results are also similar to those obtained in the fiscal incentives case. Treatment appears to mainly influence the probability of performing R&D but not the intensity of its performance. Also like firms that apply to fiscal incentives, the performance of innovative effort appears to be a requisite to apply to the program and not a consequence. To establish collaborative agreements, firms must have previous innovative capabilities to know about what to collaborate. Thus, as the fiscal incentives, public resources to foster collaborative agreements are unlike to have fostered private R&D.

Table 11. Descriptive Statistics, Treated and Control Samples, Funding of University-Industry Collaborations

Samples	Statistics	Number of employees	inov	wage	R&D	R&D/Sales	Private R&D
	count	800	800	800	800	800	800
Control	mean	1131	0.973	18124	3795	0.00895	3420
	sd	2448	0.164	21041	16865	0.026	15328
	count	800	800	800	800	800	800
Treated	mean	1680	0.973	20160	16801	0.0426	13062
	sd	4709	0.164	21782	110682	0.426	103346
	count	1600	1600	1600	1600	1600	1600
Total	mean	1406	0.973	19142	10298	0.0258	8241
	sd	3762	0.164	21432	79410	0.302	74010

Table 12. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel, Financial Resources for the Acquisition of Machinery and Equipment

		Two-part model		
	(1)	(3)	(4)	(5)
VARIABLES	Tobit	probit	mfx	ols
University collaboration	0.0252***	0.748***	0.274***	0.00657
	(0.00289)	(0.0688)	(0.0241)	(0.00403)
ln(size)	0.00128	0.306***	0.114***	-0.00874***
	(0.000974)	(0.0246)	(0.00912)	(0.00133)
wage	1.21e-07*	5.65e-06***	2.11e-06***	-2.56e-08
	(6.65e-08)	(1.70e-06)	(6.35e-07)	(8.49e-08)
Constant	-0.0272***	-1.982***		0.0754***
	(0.00638)	(0.156)		(0.00925)
sigma	0.0534***			
	(0.000169)			
Observations	1,600	1,600	1,600	990
chi2	82.20	311.0		
N_unc	989			
N_rc	1			
N_lc	610			
R2				0.047
F				16.38

*p<.10, **p<.05, ***p<.01

3.2.6. The Supply of Risk Capital

There are two important policy initiatives with respect to the supply of risk capital to new technology based firms (NTBF). The first one occurred in 2000 and established the program Inovar Fundos (Fund to Innovate). This program aimed at supplying venture capital to NTBF using public resources and private equity resources, managed by FINEP. The second program was Inovar Semente that provided seed capital to startups. Also directed to small firms, the Juro Zero (Zero interest) program aimed at providing funds for management and marketing of process and product innovation initiatives.

Government also implemented a series of instruments to provide finance for high risk technological projects of already established firms. BNDES provided new funds through a set of new innovation support program, such as BNDES Inovação and transferred resources to FINEP with the same purpose (ABDI 2013).[3]

[3] These initiatives were more important after 2008 and were related to the Plano de Sustentação do Investimento (PSI) or the Investment Sustainability Plan, that transferred additional governmental resources to funding agencies such as BNDES and FINEP. Many of these initiatives, after 2011, became sectoral programs. Some of these programs, in the areas of pharmaceuticals and oil and gas, for instance, aimed at enhancing the interaction between firms and governmental agencies and state-owned companies. Others, such as in the vehicle industries, focused on environmental aspects.

This type of support is thus not directed to R&D but expresses the results of previously carried out innovative activities. Nonetheless, it is documented that in most cases the development and implementation phases consume more innovative resources than the research phase. So, we'd expect an increase in R&D activities.

Table 13 shows the results of the coarsened exact matching for the treated and control samples. On average, the control sample spends less than the treated sample in R&D activities. The regression results in 0 confirm this perception. The tobit regression (equation (1)) has the policy variable with a positive and significant sign, indicating an improvement in R&D of around 1.7 percentage points. Wage (capabilities) is positively correlated as the size variable. The two-part model (equations 2 to 4) suggest that treated firms have a higher probability to perform R&D (around 11%) and its R&D intensity increases in 1.1 percentage point (10% statistically significant).

Table 13. Descriptive Statistics, Treated and Control Samples, Supply of Risk Capital

Samples	Statistics	Number of employees	inov	wage	R&D	R&D/Sales	Private R&D
Control	count	241	241	241	241	241	241
	mean	753.5	0.963	14962	2546	0.00499	2207
	sd	1586	0.190	16042	13904	0.0133	13402
Treated	count	241	241	241	241	241	241
	mean	1059	0.963	14430	7019	0.0138	4831
	sd	3219	0.190	15653	46109	0.0397	25855
Total	count	482	482	482	482	482	482
	mean	906.5	0.963	14696	4782	0.00941	3519
	sd	2540	0.190	15834	34093	0.0299	20613

Table 14. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel, Supply of Risk Capital

		Two-part model		
	(1)	(3)	(4)	(5)
VARIABLES	Tobit	probit	mfx	ols
Risk Capital	0.0170***	0.292**	0.111**	0.0111*
	(0.00570)	(0.125)	(0.0472)	(0.00584)
ln(size)	0.00644***	0.379***	0.145***	-0.00917***
	(0.00200)	(0.0472)	(0.0181)	(0.00190)
wage	5.29e-07***	1.75e-05***	6.69e-06***	4.14e-08
	(1.64e-07)	(4.41e-06)	(1.69e-06)	(1.40e-07)
Constant	-0.0771***	-2.805***		0.0713***
	(0.0132)	(0.288)		(0.0130)
sigma	0.0516***			
	(0.00286)			
Observations	482	482	482	190
chi2	34.00	104.2		
N_unc	190			
N_rc	0			
N_lc	292			
R2				0.132
F				9.427

*p<.10, **p<.05, ***p<.01

3.2.7.Financial support to R&D

The most important program related to this line of financing was ADTEN that in 2009 became PRO-Inovação. In this case aimed at the financing of R&D activities. Contrary to the previous financial mechanism, the instruments here analyzed have two distinct characteristics. On the one hand, they not necessarily involve high risk investment, on the other hand, they are focused on investments related directly to innovative effort. In this case, it should be expected that these instruments would directly impact the outcome in terms of R&D.

0 shows the results of the coarsened exact matching for the treated and the control sample. It appers that, on average, the treated sample is much more R&D intensive than the control samples (6.6% against 1%). The tobit regression results (column (1) of Table 16) show a positive and significant correlation of treated firms towards R&D. On average, R&D intensity increases in almost 4 percentage points. When we analyze the two-part model, we conclude that the finance to R&D increases in 31% the probability to perform R&D and increases in 1.5 percentage points the intensity of R&D. These results are in line with previous studies, such as Avellar (2009), although it does not completelly agree with ABDI (2013).

Table 15. Descriptive Statistics, Treated and Control Samples, Financial Support to R&D

Samples	Statistics	Number of employees	inov	wage	R&D	R&D/Sales	Private R&D
	count	415	415	415	415	415	415
Control	mean	1252	0.966	18810	4829	0.00999	3962
	sd	3711	0.181	26443	16503	0.0280	13394
	count	415	415	415	415	415	415
Treated	mean	2603	0.966	19910	32230	0.0662	24362
	sd	8255	0.181	26450	169168	0.589	154563
	count	830	830	830	830	830	830
Total	mean	1928	0.966	19360	18530	0.0381	14162
	sd	6432	0.181	26436	120895	0.418	110110

Table 16. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel, Financing of R&D

		Two-part model		
	(1)	(3)	(4)	(5)
VARIABLES	Tobit	probit	mfx	ols
Finance for R&D	0.0391***	0.920***	0.322***	0.0149**
	(0.00468)	(0.0971)	(0.0318)	(0.00706)
ln(size)	0.00110	0.275***	0.0989***	-0.00738***
	(0.00151)	(0.0351)	(0.0124)	(0.00213)
wage	5.14e-08	4.96e-07	1.78e-07	4.52e-09
	(8.73e-08)	(1.85e-06)	(6.66e-07)	(1.21e-07)
Constant	-0.0300***	-1.707***		0.0656***
	(0.0101)	(0.221)		(0.0152)
sigma	0.0628***			
	(0.000293)			
Observations	830	830	830	537
chi2	69.25	164.5		
N_unc	536			
N_rc	1			
N_lc	293			
R2				0.032
F				5.893

*p<.10, **p<.05, ***p<.01

3.2.8. Economic Subvention

Innovation law allowed for the creation of the Economic Subvention Program. The subvention mode was carried out mainly by FINEP. From 2007 to 2016, FINEP financed 1,100 projects, valued in around R$ 2.8 billion. Table 17 shows descriptive statistics for the treated and the control samples for the economic subvention program. On average, treated firms have a R&D

to sales ratio 3.6 points higher than the control sample. Equation (1) in Table 18 shows the results for the tobit model. According to the model, firms that receive economic subvention have a greater R&D intensity in almost 5 percentage points. When using the two-part model, the results suggest an average increase in treated firms' probability of performing R&D of 40%, while the OLS model suggests that treated firms that perform R&D have an R&D intensity 1.8 percentage points higher than the control sample firms that perform R&D as well.

Table 17. Descriptive Statistics, Treated and Control Samples, Economic Subvention

Samples	Statistics	Number of employees	inov	wage	R&D	R&D/Sales	Private R&D
Control	count	358	358	358	358	358	358
	mean	1096	0.975	19985	3939	0.0100	2931
	sd	2695	0.157	23651	16489	0.0264	9924
Treated	count	358	358	358	358	358	358
	mean	1916	0.975	22787	22822	0.0458	17079
	sd	5424	0.157	25610	139690	0.121	130895
Total	count	716	716	716	716	716	716
	mean	1506	0.975	21386	13381	0.0279	10005
	sd	4299	0.157	24672	99840	0.0895	93027

Table 18. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel, Economic Subvention

		Two-part model		
	(1)	(3)	(4)	(5)
VARIABLES	Tobit	probit	mfx	ols
economic subvention	0.0496***	1.265***	0.400***	0.0181**
	(0.00528)	(0.113)	(0.0316)	(0.00788)
ln(size)	-0.00242	0.234***	0.0769***	-0.00990***
	(0.00172)	(0.0382)	(0.0124)	(0.00242)
wage	-9.39e-09	-9.74e-07	-3.20e-07	-1.18e-08
	(1.08e-07)	(2.31e-06)	(7.59e-07)	(1.49e-07)
Constant	-0.00764	-1.403***		0.0821***
	(0.0111)	(0.236)		(0.0164)
sigma	0.0665***			
	(0.000365)			
Observations	716	716	716	491
chi2	86.07	176.4		
N_unc	490			
N_rc	1			
N_lc	225			
R2				0.046
F				7.860

*p<.10, **p<.05, ***p<.01

3.2.9. Scholarships

FINEP established a program for supplying temporary grants for the hiring researchers to reduce the risk of firms to establish new lines of investigation. In this case, the characteristics of the instrument suggest that it should have direct impact on innovative effort. The results of the matching are shown in Table 19. When we measure the correlation between the use of the instrument and private R&D, we find a positive and significant sign (equation (1) of 0). When we split the effect over the probability to engage in R&D activities and the effect over R&D intensity in the two-part model, we find that treated firms have a 9% higher probability to engage in R&D activities than the control sample. However, the OLS equation (4) suggests a much smaller impact than the tobit equation (1).

Table 19. Descriptive Statistics, Treated and Control Samples, Grants

Samples	Statistics	Number of employees	inov	wage	R&D	R&D/Sales	Private R&D
Control	count	234	234	234	234	234	234
	mean	1074	0.966	15545	8266	0.00937	7883
	sd	3198	0.182	20362	67504	0.0213	64757
Treated	count	234	234	234	234	234	234
	mean	2304	0.966	19818	13806	0.0828	10241
	sd	9049	0.182	23577	42633	0.773	35691
Total	count	468	468	468	468	468	468
	mean	1689	0.966	17681	11036	0.0461	9062
	sd	6807	0.182	22108	56463	0.548	52242

Table 20. Regressions – Dependent Variable: Private R&D/Sales, Unbalanced pooled data panel, Grants

		Two-part model		
	(1)	(2)	(3)	(4)
VARIABLES	Tobit	probit	mfx	ols
Scholarships	0.0313***	0.247***	0.0902***	-0.00823***
	(0.00468)	(0.0459)	(0.0166)	(0.00141)
ln(size)	-0.00150	4.08e-06	1.49e-06	2.05e-08
	(0.00149)	(3.12e-06)	(1.14e-06)	(9.74e-08)
wage	1.13e-07	4.08e-06	1.49e-06	2.05e-08
	(1.04e-07)	(3.12e-06)	(1.14e-06)	(9.74e-08)
Constant	-0.00561	-1.515***		0.0688***
	(0.00959)	(0.277)		(0.00958)
sigma	0.0463***			
	(0.00198)			
Observations	468	468	468	299
chi2	47.73	79.20		
N_unc	299			
N_rc	0			
N_lc	169			
R2				0.135
F				15.36

*p<.10, **p<.05, ***p<.01

3.3. SUMMING-UP

We have tested the effectiveness of Brazilian innovation policy in enhancing private business R&D. The results for the pool of instruments used show a positive effect on the probability of performing innovative activities. When it comes to enhancing the intensity of these activities, the effect of the pooled instruments seems to be weak (less than .5 percentage point or around 30% of the average effort of the treated firms).

When we assess the effect by instrument, results seem to contrast with previous literature. ABDI (2013) has argued that fiscal incentives to innovation effort has been the most successful instruments amongst those used by Brazilian innovation policy. Our results suggest the contrary. Fiscal incentives have been successful in increasing the probability of firms performing R&D, but not its intensity. However, the previous performance of these activities seems to be a condition to apply and, so, we suggest the greater probability is a bias of the sample rather than a better performance. The same result was reproduced for the fiscal incentives of the informatics law and the support of university-industry agreements.

On the other hand, more focused instruments such as the financing of R&D activities, the provision of financial resources for high risk activities, the provision of research grants and subvention were found to have a better result, increasing not only the probability of performing R&D activities of treated firms, but the R&D intensity of targeted firms.

Finally, we find that the financing for the acquisition of machinery and equipment has a negative impact on R&D intensity.

4. THE EFFECT ON PRODUCTIVITY

This section measures the effect of innovation policy instruments on labor productivity. We use a diff-in-diff model represented by equation (2)

$$prod = \beta_1 + \beta_2 year + \beta_3 treatment + \beta_4 year * treatment + \varepsilon \quad (2)$$

where prod represents the firm's labor productivity, year is an year variable that assumes value one at the final year and zero, otherwise, treatment is the treatment variable that assumes value one for treated firms (before and after the treatment) and zero, otherwise and year*treatment is an interaction variable, that will have value one, in the final year for the treated firms and zero, otherwise. Our interest is on the interaction variable.

Productivity is measured as the ratio of value of industrial transformation (VTI) – a proxy for value added – to the number of employees. VTI and the number of employees are obtained from IBGE's Annual Industrial Survey. VTI has been deflated using FGV's IPA-OG at the three-digit level.[4]

We ran four diff-in-diff models. The first one takes 2005 as the initial year and 2014 as the final year. Treated firms are those that have declared to have received innovation policy instruments treatment either in the 2006-2008 (PINTEC 2008) and 2009-2011 (PINTEC 2011) periods. The second model uses treatment only in the 2006-2008 period the third model in the 2009-2011 period. The fourth model runs first a coarsened exact matching procedure, using the same strategy described in section 3.1 and then runs a diff-in-diff exercise with the same specification as in the first model.

Table 21 shows the results for the interaction variable in equation (2) for each of the four models. Model (1) in table 21 shows the effect of each treatment on productivity for the 2006-2008 and 2009-2011 periods. All coefficients are positive significant at the 1% level, except for risk capital which is positive and significant at the 10% level. Model (2) runs the same test but only firms that have declared to have used the instrument in the 2006-2008 period are considered treated. The interaction variable coefficient is positive and significant at the 1% level for the for most instruments, except for credit for the acquisition of equipment and machinery, which is positive and significant at the 5% level, and risk capital, positive and significant at the 10% level. In model (3), we deal only with firms that received treatment in 2009-2011. The results are again positive and significant at the 1% level for most instruments, except for credit for the acquisition of equipment and machinery, which is significant at the 10% level and risk capital, which in non-significant.

Finally, model (4) in table 21 runs the diff-in-diff model with we built a control sample through coarsened exact matching. In this case, the only instrument that has a positive and significant sign at the 1% level is fiscal subsidies. Most instruments however show a significant and positive coefficient sign at the 5% level and cooperation between university and firms is significant at the 10% level.

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[4] http://portalibre.fgv.br/main.jsp?lumPageId=402880811D8E34B9011D984D9EE23590. IPA-OG is supplied at the two-digit level and we made adaptations to take it to the three-digit level.

Table 21. Interaction Variable for the Diff-in-Diff Models, dependent variable labor productivity, 2005 and 2014

Instrument	Treated Firms in 2006-2008 & 2009-2011 (1)	Treated Firms in 2006-2008 (2)	Treated Firms in 2009-2011 (3)	Treated Firms in 2006-2008 & 2009-2011 after Coarsened Score Matching (1)
Fiscal Subsidies	296,542***	335,417***	298,942***	146,503***
Informatics Law	181,699***	249,537***	170,069***	104,261**
Credit for University-Firm linkages	217,489***	223,877***	250,422***	77,669*
Credit for the Acquisition of Machinery	41,857***	49,192**	42,170*	33,607***
Grants for hiring personnel	278,670***	216,322***	418,958***	155,587**
Risk Capital	101,960*	151,703*	57,680	124,437**
Economic Subvention	312,122***	351,345***	294,944***	127,554**
Credit for R&D activities	280,395***	315,087***	298,769***	126,231**

Source: Own elaboration using microdata from PINTEC and PIA.
*P<.10, **P<.05, ***P<.01

5. CONCLUSIONS

This report aimed at assessing the impacts of the Brazilian innovation policy on the carrying out of innovative efforts and on productivity growth. In the first thematic, the report may be contrasted with previous literature results, however, on the second, little previous work has been undertaken in Brazil.

In respect to innovative efforts, the report finds a positive effect of the innovation policy on private R&D when all instruments are pooled together, that is, innovation policy resources may be viewed as complementary to private resources and may be viewed as successful in fostering innovative effort. We find that, on average, targeted firms have a 1.4 percentage points higher private R&D intensity than the control sample. This is more than a 100% effect over the average treated sample private R&D intensity. However, one may observe that a large proportion of the total sample is composed by firms that do not perform R&D. This means that one effect of the policy may be the promotion of firms to carry out innovative activities, that is, increase the likelihood of firms to perform R&D and a second effect is the increase in R&D intensity, that is, augmenting the dedication of R&D performers. When we split these two effects, innovation policy increases in almost 15% the probability of firms carrying out innovative activities and increases in only 0.5 percentage point (or less than 1/3 the average effort of the treated firms) the intensity of R&D activities.

When we analyze the results by instruments, the picture is more complex and presents some contrasts with previous literature. ABDI (2013) has stated that:

> "when one observes measures of technological effort … most instruments are inefficient with the exception of Lei do Bem (fiscal incentives), and, in some cases, economic subvention" (ABDI 2013:102).

Very few previous work has been carried out on other instruments, however, in respect to fiscal incentives (Lei do Bem) probably due to its widespread use (see 0 and Graph 3) have suffered other evaluations. Colombo (2017), Kannebley, Shimada and De Negri (2016) and Kannebley and

Porto (2012) have argued for the effectiveness of this policy instrument. Their work has mostly been carried out using propensity score matching procedures and they have found significant impacts of the use of fiscal incentives on innovative effort intensity. Our preliminary results tend to confirm a positive impact whenever we do not separate the impact on the probability to perform innovative effort from the impact on effort intensity. However, when we split the two impacts, the probability to perform innovative effort increases in 41% and the impact on the intensity is found non-significant. In other instruments, this finding could mean that the instrument was effective in making firms R&D performers and should be preserved for such. However, Lei do Bem cannot be analyzed in this way for a couple of reasons. First, most tax exemptions are obtained *ex post*, that is, firms have carry out the effort and at the end of the year in the analysis of their accountancy, fiscal authorities decide if the firms' application is due to the fiscal benefits of the law. There is uncertainty about the allocation of fiscal resources to innovation and firms declare that. Second, the law is organized in a such way that only those who perform R&D can apply, that is, the performance is a precondition for the application. Third, the policy is targeted on large firms. Most large firms perform R&D activities. Very few small firms may apply for this instrument benefits, but amongst them only those that have a high rate of R&D activities will be stimulated to change accounting procedures to apply for the benefits of the fiscal incentives to innovation effort. We are thus arguing that there is a selection bias towards R&D performers and that this should be considered whenever dealing with this instrument. Thus, unlike most of previous literature, we argue that the impact of fiscal incentives is not as large as they argue.

The small impact on innovative efforts due to the split in the two effects may also be argued wit respect to fiscal incentives to IT and the collaboration with universities. In both cases, the probability to perform innovative efforts increases, but the effect on intensity is found non-significant.

In contrast to ABDI (2013), we find that the provision of credit to R&D activities and of venture and seed capital to high risk investments are very effective policies. In the tests we carry out, these instruments are found to increase R&D efforts and when we split the effects into the increase in the probability to perform the effort and the increase in the effort's intensity, we find both effects positive and significant (though there is loss of intensity and, in the case of the venture capital, the increase in intensity is significant only at the 10% level). In the case of finance of R&D activities, the increase in the probability to perform R&D is of similar amount to that in fiscal policy (32%).

Subvention also performs well and has positive and significant signs in all tests. It increases the probability to perform R&D in 40% and the intensity of R&D activities in 1.8 percentage points. When the two effects are coupled together in the tobit model, it increases R&D intensity in almost 5 percentage points.

Finally, the financing of the acquisition of equipment and machinery to innovate has a negative and significant sign with respect to private R&D efforts. The effect of policy seems to be substitutive of R&D investments. One possible explanation for this feature is the widespread use of the instrument by small firms that are non-R&D performers and that face greater R&D restrictions. As a matter of fact, this is a partial conclusion of ABDI (2013) that does not cover this instrument:

> "Though there has been an increase in the diversity of instruments, there has not been an increase in the variability of the characteristics of beneficiary firms" (ABDI 2013:101).

In sum, with respect to the effect on the intensity of private efforts, our results seem to pose some further questions on what previous literature has obtained assessing innovation policy. Our results shed new information and doubts over the effectiveness of fiscal instruments to foster innovation efforts and at the same time argues for a greater efficiency of more focused instruments such as venture capital credit, credit for R&D and economic subvention.

Looking at the results obtained for labor productivity, we can state that innovation policy has had an overall positive impact. Most instruments have maintained a positive and significant impact on productivity over all equations, with the sole exception of risk capital. Previous international research has shown a positive linkage between R&D efforts and productivity growth (Crépon, Duguet and Mairesse 1998). Their tests have been reproduced for Brazil by Cavalcante, Jacinto and De Negri (2015) and show a positive relationship between R&D efforts and productivity. Once innovation policy instruments have been shown to have a positive impact on R&D activities, one should expect this positive impact on productivity. Nonetheless, we may question some of the results. More specifically, the most consistent policy impact on productivity has come from fiscal subsidies. However, fiscal subsidies have been shown of low effectiveness whenever one excludes firms that have spent zero in R&D. In this case, one can advocate that part of the impact of fiscal subsidies are obtained by firms that perform R&D and would do it anyway, and not necessarily because of the positive impact of policy.

Whenever this kind of topic comes through one may question the type of selection innovation policy instruments have been through. As stressed above, ABDI (2013) has emphasized that policies have been biased towards the largest and most productive firms and, in this case, even though we have been trying to control for selection biases some of it may still be there.

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