Does governmental support to innovation have positive effect on R&D investments? Evidence from Brazil*

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Recebido: 30/07/2014 Versão Revisada (entregue): 31/01/2015 Aprovado: 16/03/2015

ABSTRACT

This paper aims to measure the effects of government support for innovative activities on manufacturing firms' R&D investments in Brazil. Using data from the 2005 and 2008 editions of the Brazilian Innovation Survey (PINTEC), the paper argues that government support does not seem to improve private R&D investment. This paper holds that governmental policies may be targeting private expenditures that would have taken place anyway. This paper suggests that this policy may have been out of focus and that a more systemic view of innovation policy should be adopted.

KEYWORDS | Innovation Policy; R&D Investments; Brazil

JEL-CODES | O31; O38; L5

* The author is grateful for the comments of two anonymous referees.

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Qual o efeito do apoio governamental à inovação sobre o gasto empresarial em P&D? Evidências do Brasil

RESUMO
Este artigo objetiva medir os efeitos do apoio governamental à inovação sobre o investimento em P&D das empresas da indústria de transformação do Brasil. O trabalho utiliza microdados da Pesquisa de Inovação Tecnológica, do IBGE, edições de 2005 e 2008. Observou-se que o apoio governamental não parece afetar positivamente os gastos em P&D, sugerindo, assim, que o apoio governamental vem sendo direcionado para iniciativas privadas que teriam ocorrido sem a interferência governamental. Argumenta-se, então, pela existência de um erro de foco na política de inovação e que uma postura mais associada à visão sistêmica da inovação deve ser adotada.

PALAVRAS-CHAVE | Política de Inovação; Investimentos em P&D; Brasil

CÓDIGOS JEL | O31; O38; L5

1. Introduction

Governmental support for innovative activities is usually justified because innovative activities are subject to characteristics that cause underinvestment. Imperfect appropriability, high level of uncertainty and the tacit character of knowledge justify governmental intervention. A large number of scholars have argued that innovation policies pay off (MAZZUCATO, 2011; BLOCK, 2008; PELEI, 2006). They hold that the rather liberal agenda of some states actually hide the existence of an entrepreneurial state that has provided knowledge and capabilities to the carrying out of innovative activities by business firms. In this case, they are prompt to argue that the government has played an important role in establishing the direction and in channeling resources towards certain innovative activities. However, another stream of the literature has dedicated efforts to measure the effects of R&D subsidies, either through grants and contracts, or through tax incentives, on private R&D investments (DAVID; HALL; TOOLE, 2000; HALL; REENEN, 2000; LINK; SCOTT, 2010; GELABERT; FOSFURI; TRIBÓ, 2009). This literature has a rather blurred picture of the effects of governmental subsidies on business firms' R&D investments. Some tests have shown governmental support to play a more complementary role in the channeling of resources towards innovative activities while others have shown a substitute role of governmental resources. Most importantly, some authors have called attention to the role of government procurement policies to explain the success of innovative policies.

In the last ten years, Brazil has made an important shift in its innovation policy. The supply of governmental resources for innovative activities has increased from R$ 1.5 billion, in 2000, to R$ 10 billion (current reais), in 2010 (BASTOS, 2012). Fiscal subsidies that represented less than 14% of total R&D expenditures, in 2002, climbed up to 33%, in 2008, and 24.2%, in 2012. Nonetheless, policy has failed to fulfill established targets. Government aimed to increase the share gross private R&D investments in GDP from 0.51%, in 2005, to 0.65%, in 2010. Brazilian Innovation Survey results show that in 2008 gross private R&D investments represented 0.58% of GDP and, in 2011, 0.59%. The ratio of R&D investment to sales in the manufacturing industry did not increase as was desired as well (1% in 2010). It was 0.55% in 2003, 0.58%, in 2005, 0.64%, in 2008, and 0.71%, in 2011. Though the percentage of innovative companies participating in governmentally supported programs increased from 19%, in 2003, to 22%, in 2008, and 35%, in 2011, the percentage of innovative firms did not show any substantial increase. Therefore, one important question seems to be raised: has innovation policy been well targeted?

This paper is dedicated to the measurement of this issue for Brazil. The relevance of this investigation emerges from its recent shift in innovation policy, improving governmental funding and grant mechanisms and the widening of opportunities for tax incentives to R&D. In this context, it is important to assess the impacts of the new policy. The paper aims then to measure the effects of governmental support for innovative activities on business firms' R&D investments in Brazil using microdata from the 2005 and 2008 editions of the Brazilian Innovation Survey (PINTEC).

The paper is organized in four sections, including this introduction. In the next section, we present the analytical and historical background of the paper. The database, method of analysis and results are presented in section three. Our main conclusions are presented in section four.

2. Analytical and historical background

2.1 Conceiving innovation policies

Innovative activities involve different sources of knowledge and multiple applications. Knowledge sources may be related to new scientific knowledge, but may also involve the transfer of knowledge from customers to companies or even across different business firms. Therefore, the innovative process involves a complex system of market and hierarchical relations (FAGERBERG, 2005). Knowledge has some important characteristics. First, it is an intangible asset, though it may be at least partially codified. Second, it is imperfectly appropriated and thus it has good public characteristics. It is non-rival, in the sense that the use of knowledge by one part does not affect its use by another part. It is also partially non-excludable. Partially non-excludability derives from the fact that in order to absorb knowledge it may be necessary to have previously accumulated capabilities and skills, and in some cases, new effort. Third, it is not perfectly codified; tacit knowledge is present and the transmission of knowledge may require interaction between agents and, most importantly, its transmission may be costly. Fourth, knowledge has a cumulative character. Therefore, the knowledge effort made today may have an effect on tomorrow's absorptive capacity. Fifth, it is specific in the sense that it may be applied to certain solution patterns, but not to others.

Innovative activities are also uncertain. The presence of uncertainty challenges Modigliani-Miller's hypotheses of perfect financial markets, by which internal or external financing will be provided, as long as the desired project has a positive net present value. In this sense, internal and external financing will not be neutral. Therefore, both lenders' and borrowers' risks would be affected. The presence of uncertainty may therefore deepen underinvestment.

These characteristics support the case for state intervention in innovative environments or activities. Examples of the role of technological learning and accumulation are given by Mazzucato (2011) that shows how the state in the US has engaged in Schumpeterian entrepreneurship due to the need to deal with uncertainty. Most importantly, Mazzucato stresses differences between two perceptions of governmental intervention towards innovation. On one hand, there are those that view policies as intervention mechanisms that **correct for imperfect markets**; on the other hand, there are those that perceive government intervention as **builders of networks**. Mazzucato treats those two perceptions as two different policy frameworks.

The first perception of innovative policies is generally focused on correcting market imperfections, such as uncertainty or lack of appropriablity. Proposed mechanisms to correct for these market imperfections are typically the structuring of property rights instruments and the correction of market prices under the effect of externalities. In this case, resources may be channeled through the financing of R&D activities, the building of financial mechanisms and institutions, such as venture capital funds, the supply of non-reimbursable funds or the implementation of subsidies and tax exemptions for innovative activities.

According to Mazzucato, this type of view has illuminated UK's innovation policy that has been focused in cost reducing mechanisms. As has been pointed out by Mazzucato (2011, p.93):

> *While it is important that the frontiers of science advance, and that economies develop the nodes and networks to enable knowledge to be transferred between different organisations and individuals, it does not follow that it is the best use of taxpayers' money to subsidise the activity of R&D per se within individual firms.*

Furthermore, there is always a risk that government will direct resources to support inept programs (LERNER, 2010). This risk is usually related to the quality of institutions. The practice of influence in the technological and political scene may lead to the waste of resources and agency problems may also arise. Thus, Lerner (2010) suggests that attention should be directed towards the understanding of non-technology and non-production obstacles to success and that market signals should be respected.

The second perception emphasizes the interactive character of innovative activities and therefore stresses the importance of structuring innovative networks. In this case, emphasis is directed towards the interaction between different set of actors such as universities, research institutions, small and large firms. Supply and demand tend to be linked.

Mazzucato (2011) shows how US government has defined new broad areas of technological development and has been able to interact with the business sector in order to build knowledge networks that have been capable of developing major technological breakthroughs.

Block (2008) argues that the US has kept hidden a developmental State that has implemented a series of successful interventions. The emergence of this developmental state is linked to the military disbursements for science and technology that played a key role in the development of computers, jet planes, civilian nuclear energy, lasers, and, ultimately, biotechnology. He claims that Pentagon's Advanced Research Project Agency (ARPA) was a key player in planning and defining what technologies to explore and that these methods have been adopted in other governmental programs and agencies. In the National Institute of Health, ARPA's methods were used to develop the main initiatives related to biotechnology and genetic experiments that gave the US a leading edge in these technologies. Block (2008) argues that other bills, such as the Small Business Investment Research (SBIR), have been proposed and efforts have been carried out to consolidate this developmental state. According to his research, the results are unchallenged and a large number of the main innovations in the US have followed projects that were funded by governmental agencies (BLOCK, 2008, p.187).

These US innovative programs were focused on the building of networks (MAZZUCATO, 2011). Even the SBIR, that distributed grants to small businesses, was carried out by governmental agencies that had their own projects, established their own goals for grants and then selected the most capable results. Lerner (1999) argues that SBIR enterprises are more likely to engage in financing by venture capital funds, mostly due to the previous selection by governmental agencies. One common feature in the studies carried out by Mazzucato (2011) and Block (2008) is the central role played by government procurement. In all these cases, the role of agencies defining future demand cannot be overemphasized.[1]

1 There are also plenty of examples outside the US. See Peilei (2006) for the Chinese telecommunications industry and Hansen, Rand and Tarp (2008) on firm growth in the Vietnamese case.

2.2 Studies of policy impact

While Mazzucato's, Lerner's and Block's work focus on the conception and general results of innovation policies, an extensive literature has tested the impact of policy instruments on innovative effort. Their goal has been to establish the complementary or substitute character of governmental support. They nonetheless pose a similar question to that already framed by Lerner and Mazzucato: does governmental support for innovation really increases the level of effort of the supported firms?

One stream of the literature investigates a particular type of governmental intervention: the use of governmental subsidies for R&D. Policy instruments in this case involve R&D grants, subvention, funding and tax incentives. As put by David, Hall and Toole (2000), the effects of governmental support are mainly on cost. In this specific case, the nature of R&D expenditures is crucial. Being a sunk cost, it is somewhat doubtful if positive impacts may be found.

In fact, David, Hall and Toole (2000)'s survey of the literature on the effect of government finance and grants on private R&D concludes for mixed results. They stress, however, that there are national characteristics that may change the results. Most importantly, studies tend to show correlation rather than causality (this topic will be better developed in the following section). Lichtenberg (1984, 1987, 1988) are probably amongst the pioneering studies that control for endogeneity of government support. Lichtenberg (1984) shows that the sign of the governmental support variable becomes insignificant, once you control for endogeneity, be it by using level regressions, be it by using first difference regressions. Litchenberg (1987) shows that the effect of federal funded R&D on private R&D was upwardly biased in studies that do not control for endogeneity effects. Using a sample of 187 US firms, Litchenberg (1987) tests the effect of federally financed R&D on R&D expenditures. He, however, controls for sales derived from governmental procurement. He concludes that the real effect on company R&D expenditures does not departure from governmentally funded R&D but from governmental procurement. This conclusion is clearly associated with increases in future revenues and therefore with the potential of public procurement to positively affect R&D expenditures. Lichtenberg (1988) uses a sample of 165 companies, controlling for industry characteristics and time variables. His focus is on whether competitive or non-competitive government procurement affects company R&D expenditures. He concludes that competitive procurement has positive an effect on R&D expenditures.

Wallsten (2000) analyzes the conceding of grants to innovative enterprises (SBIR). He argues that it is most likely that government officials fund projects that are commercially viable. These products would find their way to success by market means and therefore government intervention should be more likely to crowd out private R&D efforts. In the opposite direction, screening the same program, Link and Scott (2010) find that a high percentage of the research carried out by firms under the SBIR program grants would not have taken place if the grant were not to be conceded. Furthermore, Link and Scott (2010a) find that a high percentage of the program initiatives end up being commercialized but another part does not get into commercialization at all, suggesting that the selection procedure is not as targeted as suggested by Wallsten.

Gelabert, Fosfuri and Tribó (2009) have tested the impact of governmental support on private R&D of Spanish firms. They find a consistent positive effect of public support on private R&D investment, though the effect is dependent on the level of appropriability of the firm's sector.

Hall and Reenen (2000) survey the literature on the effect of subsidies on R&D. They find a positive tax elasticity of R&D that is around one, in the long run, and lower, in the short run, due to adaptation issues. Their conclusion is that it is worthwhile to provide tax incentives as social return to R&D tend to be greater than the private returns; therefore, an increase in these returns may take private R&D levels closer to optima public levels.

It can be then stated that no conclusive result can be obtained from the literature. However, after a thorough review, David, Hall and Toole (2000) argue that the most important impact of governmental procurement support is on the expectation on marginal revenues. They do not deny the impact on costs, but stress that the distinctive effect of this type of support is the reduction in uncertainty and the increase in the expectations on future demand and, as a consequence, on future revenue.

3. The Brazilian institutional framework

In the beginning of the 2000's, the amount of supply of funds for innovation averaged less than R$ 1.5 billion a year. From 2004 on, the Brazilian innovation policy suffered a major shift and, in 2010, governmental funds for innovation reached almost R$ 10 billion a year.[2] The increase in the amount of expenditures was due to important

2 In total, from 2000 to 2010, the Brazilian government directed more than R$ 50 billion to innovation funds. Most resources (55%) have been channeled to companies using fiscal subsidies, revealing a bias of these policies toward large firms. Most small firms use the SIMPLES (simple) option for collecting income taxes. In this modality, income taxes are a fixed percentage of total revenue, disregarding any specific conduct of the firm and not considering its costs and expenditures structures. Therefore, these firms are not eligible for fiscal incentives to innovative activities. This kind of bias is clear in the institutional framework that was developed during the last decade, which emphasized fiscal incentives.

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 a large number of 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, promoting the shared use of science and technology infrastructure by research institutions and firms, allowing direct government grants for innovation in firms and stimulating 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.

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 the Goodwill Law 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 for 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.

In order to broader the focus of the industrial policy, 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. The main challenges are the expansion of supply capacity in the country, preserving the robustness of the balance of payments, raising the innovation capacity and strengthening micro and small enterprises. Four priorities were to be achieved by 2010: the increase of investment rate, the expansion of Brazilian exports in world trade, the increase of R&D expenditures and the increase in the number of SME exporters. PDP also includes the establishment of spending targets and tax breaks for key sectors like IT, biotechnology and energy as well as plans to increase international trade from 1.18 per cent in 2007 to 1.25 percent by 2010, with an emphasis on high tech exports. Targets include boosting the number of micro and small businesses that export goods and services by more than 10 per cent in 2010. One of the main objectives of the strategy embodied in PDP, although not explicit, is 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 set is to raise private business research and development (R&D) expenditures to 0.65% of gross domestic product (GDP) by 2010, over 0.51% of GDP in 2005. In addition, the accessory objective set is to double the number of patent deposits of Brazilian enterprises in the local patent office (INPI) and triple the number of patent deposits abroad.

These measures in the last ten years have tremendously improved innovation policy in Brazil. For instance, for the first time, non-reimbursable funds have been made available. However, little attention has been directed towards demand issues of innovation policy. Procurement policies of governmental companies and agencies have been dissociated from innovation policies. This characteristic may have consequences on innovative behavior.

2.4 Studies of policy impact in Brazil

In Brazil, there are still few studies on the complementary and substitute character of governmental support for innovation. 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; BOTELHO 2013, p. 442). However, the authors find qualitative evidence that firms had improved methods and deepen relationship after engaging in the program. Rapini, Oliveira e 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.

Avellar (2009) measures the impact of three governmental programs – the National Fund for Development of Science and Technology (FNDCT), the Industrial Technological Developing Program (PDTI) and the Support Program for Technological Development of National in Companies (ADTEN) – on R&D expenditures and total innovation expenditures. She uses PINTEC 2003 and propensity score matching techniques to build a control sample. Her main results point to a significant impact of the programs on R&D expenditures, but not on total innovation expenditures. Araujo et al. (2012) measure the impact of the use of the resources from FNDCT on the number of employees dedicated to R&D.[3] They argue that R&D expenditures of the treated group grow at a higher rate than R&D expenditures of the control group. They also find that effects seem to be cumulative and that treated firms tend to become more and more technology intensive as they keep using the fund resources. Kannebley and Porto (2012) analyze the impact of fiscal incentives to innovative activities on innovative efforts. They focus on the comparison of the results of fiscal incentives from the Information Technology Law (1991) and the Goodwill Law (2005). On the qualitative side, they find that fiscal exemptions from the Goodwill Law substituted private resources. However, as they gave rise to larger profits, they ended up providing private resources to maintain innovative activity continuously. On the quantitative side, they find that firms that apply for the use of the Information Law do not appear to be more technology intensive than the control sample. Nonetheless, results for the Goodwill Law show greater technology intensity in firms that use these fiscal incentives. They argue that the information law's targets on national content deviates behavior, while the market orientation of the Goodwill Law should be more favorable for a more technology intensive strategy.

Again, evidence suggests mixed results for governmental innovation policy on R&D expenditures. Nonetheless, the Brazilian literature seems to show some regularities. First, firms that have applied for governmental programs were firms

3 It should be stressed that most of the aid provided by FNDCT is directed towards cooperative projects between firms and universities.

that had previously performed innovative activites. Therefore, it is not surprising the stagnation of the innovative rate of the Brazilian industry. Second, the larger availability of resources and the use of new policy instruments have been able to provide positive results to companies.

3. Testing for complementarity of governmental support for innovative activities

3.1 The database

This paper uses data from the Brazilian Innovation Survey (PINTEC) 2005 and 2008 editions. 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). In addition, PINTEC attempts to cover all companies that have received any governmental support or companies that have declared to carry out formal R&D efforts or that have applied for patents. PINTEC 2005 covered a sample of 13,575 firms; and PINTEC 2008 a sample of 14,355. These samples may be statistically expanded to over 100,000 firms.

The 2005 and 2008 editions ask whether companies have used: (i) fiscal incentives to R&D (Law 8.661 and Law 11.196); (ii) the Law of informatics incentives (Law 10.664 and Law 11.077); (iii) governmental grants for R&D performance (Law 10.973 and Law 11.196); (iv) governmental financial support for R&D activities; (v) governmental financial support for the acquisition of machinery and equipment used to introduce innovation; (vi) grants for the hiring of researchers from governmental support agencies; (vii) governmental support to risk capital. The distribution of these benefits across firm size is presented in Table 1. Firms were considered to have received treatment from the government if they answered yes to at least one of these questions. It should be stressed that this paper does not distinguish across governmental programs. Firms that engage in any of the above programs are treated equally. This choice has the advantage of including all incentives, but has the shortcoming of treating them equally.

TABLE 1
Number of events of governmental support to innovation, per type of support, segundo firm size
Brazil – 2008

Firm size (number of employees)	Fiscal incentive R&D	Fiscal incentives (information technology law)	Economic subvention	Financial funds to entreprises	Financial funds for cooperation with universities	Financial funds for acquisition of machinery and equipment	Other
10 to 29	127	487	89	360	151	3 273	1 714
30 to 49	37	36	10	19	56	846	362
50 to 99	19	89	27	63	28	694	284
100 to 249	28	37	20	19	22	359	182
250 to 499	34	16	11	11	15	139	76
500 or more	193	38	49	56	50	145	110
Total	**440**	**704**	**207**	**528**	**323**	**5 456**	**2 728**

Source: IBGE. Pesquisa de Inovação Tecnológica – PINTEC 2008.

3.2 Selection biases

One important issue to tackle when evaluating governmental innovative policies is selection biases. The aim of government support for innovative activities is to increase the number of firms performing and/or the intensity of these activities. Therefore, governmental programs should not fund activities that would happen anyway, but focus on activities that would not occur if governmental funding were not available (WALLSTEN, 2000). In the former case, governmental support would be substitute for private initiatives, while in the latter case it would be complementary.

Selection biases occur first because governmental officials would be inclined to choose firms that they are sure would present results, and therefore focus would be directed to firms that are more likely to carry out innovative activities. A second type of selection bias would emerge from the behavior of innovative firms. In this case, firms would look for the cheapest way to perform innovative activities. Table 2 illustrates the occurrence of selection bias using data from PINTEC 2005 and 2008. Firms that received governmental support are more R&D intensive. Nevertheless, they are also more likely to be exporters and importers and are, on average, larger.

TABLE 2
Descriptive statistics, innovative firms, according to governmental support to innovation
Brazil – 2005-2008

2005					
govern_05	**Descriptive statistics**	**R&D intensity (%)**	**Exports (US$ millions)**	**Imports (US$ millions)**	**Size (number of employees)**
Did not receive support	Mean	0.60	13.50	7.76	341
	SD	5.05	62.90	33.10	812
	N	4895	2139	2121	4926
Received support	Mean	3.02	58.40	34.10	775
	SD	52.61	347.00	289.00	2453
	N	1619	918	945	1628
Total	Mean	1.20	27.00	15.90	449
	SD	26.61	198.00	163.00	1423
	N	6514	3057	3066	6554
2008					
govern_08	**Descriptive statistics**	**R&D intensity (%)**	**Exports (US$ millions)**	**Imports (US$ millions)**	**Size (number of employees)**
Did not receive support	Mean	0.63	14.20	7.20	367
	SD	4.99	118.00	49.50	1167
	N	6712	2711	2787	6759
Received support	Mean	2.20	49.60	31.60	710
	SD	9.51	308.00	284.00	2562
	N	2000	844	927	2041
Total	Mean	0.99	22.60	13.30	447
	SD	6.35	183.00	149.00	1609
	N	8712	3555	3714	8800

Source: IBGE. Microdata from Pesquisa de Inovação Tecnológica – PINTEC 2005, 2008.

Many procedures can be carried out in order to correct for selection biases. One way to partially overcome these biases is to refine even more our sample. Table 3 narrows down the sample to cover only those firms that have positive R&D. This procedure helps to reduce heterogeneity. As a result, both supported and non-supported firms have more or less the same probability to export, but there are still sizes differences.

Table 3 also reports a mean difference t-test for R&D intensity. In 2005, firms that did not receive governmental support invested 2.18% of their revenues in R&D against 7.95% for those that did. Nonetheless, one should perceive that the standard deviation of firms that receive support is very large and the mean difference test does not show statistical significance, indicating the presence of a few very high technology intensive firms amongst the supported sample biasing the mean average results.

The third column in Table 3 shows a gapped R&D intensity variable for firms in each year's sample. One can see that not every firm present in a PINTEC edition was also present in the previous PINTEC edition. This may be due to two phenomena. The first one is that the PINTEC sampling strategy may cause differences in sampling choices for firms with less than 500 employees. However, this is mostly unlikely when firms are amongst R&D performers for PINTEC's strategy targets firms that have declared R&D activities. The second one is firm entry. All small high technology firms entering the industry will be targeted if they receive governmental support. The Innovation Law allowed a very high number of mechanisms that could turn small firms into very high R&D intensive performers. Firms that were present in 2005 and were responsible for the very high standard deviation of the R&D expenditures of governmentally supported firms in this year, were also present as non-supported firms in 2008. This can be confirmed by examining figures for the gapped R&D expenditures for 2005 and 2008. This indicates that probably a few high tech firms entered the market receiving government incentives in 2005, biasing the data for R&D for supported firms, and then ceased to receive R&D in the next period.

The 2008 sample also shows higher R&D intensity of the supported firms and, in this case, there is statistical relevance of the result. Therefore, Table 3 suggests the occurrence of an improvement in policy. In 2005, those that receive support from the government have greater R&D intensity, though differences are not statistically significant, in 2008, differences are relevant. Still, size differences found in Table 3 suggest that there are still selection biases that should be eliminated.

TABLE 3
Descriptive statistics, by governmentally supported firms and non-supported firms, firms with positive R&D (R&D>0), mean average test for R&D expenditures
Brazil – 2005-2008

2005					
	Descriptive statistics	**R&D intensity (%)**	**Exports (US$ millions)**	**Imports (US$ millions)**	**Size (number of employees)**
Did not receive support	Mean	2,18	33,9	20,5	1046
	SD	5,12	119	60,2	2001
	N	369	300	313	369
Received Support	Mean	7,95	142	72,9	1983
	SD	97,88	592	477	4697
	N	352	298	321	352
Total	Mean	5	87,8	47	1503
	SD	68,5	429	343	3608
	N	721	598	634	721
t-test mean difference		-1,13			

2008					
	Descriptive statistics	**R&D intensity (%)**	**Exports (US$ millions)**	**Imports (US$ millions)**	**Size (number of employees)**
Did not receive support	Mean	3,16	44,3	15,9	826
	SD	8,55	277	68,3	2686
	N	674	444	471	674
Received Support	Mean	5,38	98,8	61,5	1712
	SD	14,05	477	439	4776
	N	495	336	375	495
Total	Mean	4,1	444	471	1201
	SD	11,26	377	298	3741
	N	1169	780	846	1169
t-test mean difference		-3,342			

Source: IBGE. Microdata from Pesquisa de Inovação Tecnológica – PINTEC 2005, 2008.

3.3 The model

In order to overcome problems associated with selection biases, most of the literature that measures the effects of governmental support for innovation on R&D and other variables use instrumental variables in two or three stages least square models. Therefore, they usually compare OLS estimates with these models.

Another treatment used to overcome selection biases is to build a control sample with the same characteristics as the sample that has received treatment from the government. Propensity score matching models attempt to find the exact double of individuals to build a control sample. We have chosen a different way. We use the same firms (twins) but in different periods, that is, we have chosen to evaluate the conduct of firms in one period when they received the treatment and in another period when they did not receive it.

This paper selected companies that received treatment from the government in only one survey, that is, either received support in 2005 OR received support in 2008. An additional criterion was that the firm should have performed R&D in BOTH surveys, that is, R&D>0. The reason for this latter procedure was to try to evaluate a more uniform set of firms. In total, 243 firms were selected. One hundred and thirty eight received governmental support to innovative activities in 2005 and 105 received support in 2008.

The size distribution of these firms is presented in Table 4. On average, firms on this sample are larger than average innovative firms (1,869 employees against 446, in the 2008 PINTEC, and 449, in the 2005 PINTEC, see Table 2 and Table 5). They are also greater exporters and importers and are on average older than the average sample of innovative firms. Most importantly, they are much more R&D intensive. On average, they spend 5.4% of their sales on R&D.

It is, however, important to stress the inexistence of differences between firms, not mattering whether they receive support or not. They present similar exporting and importing behaviors, their size is not different as well. The only possible distinguishing variable between supported and non-supported firms in Table 6 is R&D intensity. Firms that received governmental support are more R&D intensive. However, due to very high standard deviations amongst supported firms, differences are statistically insignificant.[4]

Using this sample, the paper runs OLS regressions to measure the effect of governmental support on R&D per sales ratio, estimating the following equation: $\frac{R\&D}{Sales} = constant + \beta_i X_i + dummy + \epsilon$, where, X_i is a vector of firms' characteristics, and the dummy variable assumes value one, whenever the firm receives governmental support and zero, otherwise.

4 As it has been explained above, this is probably due to the entrance of start-ups that received governmental support in 2005 and did not receive it in 2008. Therefore, these small companies were very intensive in R&D in 2005, but did not appear to be as intensive in 2008.

TABLE 4
Firms selected per size, according to the number of employees
Brazil – 2005-2008

Firm size (number of employees)	No support	Support	Total
Less than 10	11	15	26
10 to 29	8	5	13
30 to 99	16	18	34
100 to 249	31	28	59
250 to 499	35	35	70
500 or more	142	142	284
Total	**243**	**243**	**486**

Source: IBGE. Microdata from Pesquisa de Inovação Tecnológica – PINTEC 2005, 2008.

TABLE 5
Descriptive statistics, selected companies, according to governmental support to innovatio
Brazil – 2005-2008

Governmental intervention	Variable	R&D intensity (%)	Exports (US$ million)	Imports (US$ million)	Size	Age
Did not receive governmental support	Mean	1.47	78	29	1887	28
	SD	2.89	363	92	4277	14
	N	243	243	243	243	243
Received governmental support	Mean	9.39	78	29	1851	27
	SD	117.47	363	92	3752	14
	N	243	243	243	243	243
Total	Mean	5.43	78	29	1869	28
	SD	83.10	362	92	4019	14
	N	486	486	486	486	486
Mean difference		0.1	0.0	0.0	-35.6	-0.4
t-statistics		1.1	0.0	0.0	-0.1	-0.3

Source: IBGE. Microdata from Pesquisa de Inovação Tecnológica – PINTEC 2005, 2008.

4. Results and discussion

Table 6 presents two OLS regression tests for complementarity or substitution between governmental support for innovation and private expenditures on R&D.

Equation (1) regresses R&D intensity on size, represented by the natural logarithm of the number of employees, the natural logarithm of age and a dummy that assumes value 1 whenever the firm exported and assumes a value of zero otherwise. For the number of employees and age, a quadratic form is included. Equation (2) also presents an OLS equation but uses only those variables that are found significant in equation (1).

Firm size holds a negative and significant sign in the two equations. Its quadratic form is positive and significant, suggesting a U-shaped relationship. However, the values in the equation suggest that, in practice, values will be negative through the whole range of firms in our sample. Mostly, then, size has a negative but decreasing effect on R&D intensity. It is well documented that, in Brazil, larger firms are usually more innovative (see KUPFER; ROCHA, 2005) and mostly more technology intensive (KANNEBLEY, PORTO, 2013). However, it is also well known that amongst a selection of high performance firms, small firms tend to be more technology intensive (see BRÍGIDO; ALBUQUERQUE, 1997; JENSEN; MENEZES; SBRAGIA, 2004). As shown in Table 5, an important share of our sample is formed by very small firms (less than ten employees). Due to PINTEC's selection procedures, these are most likely startups with very high R&D intensity. Therefore, the negative relationship between size and R&D intensity is not surprising.

In both equations, the coefficient for governmental support is positive. Although the coefficient is quite high, suggesting an impact of governmental support of 7.4% on R&D intensity, it shows no statistical significance. It calls, therefore, for a rejection of the complementarity hypothesis. The results contrast with part of the literature surveyed above that argues for the effectiveness of the new policy measures (AVELLAR, 2009; ARAÚJO et al., 2012; KANNEBLEY; PORTO, 2013). There are some reasons why these results are so different. First, Avellar (2009) Araújo et al. (2012) and Kannebley and Porto (2013) deal with very specific programs, while this paper deals with firms that have used at least one out of the many governmental support instruments. As presented in Figure 1, there is a wide range of governmental support programs. This includes the Information Technology Law, which Kannebley and Porto (2013) have found to be of no effectiveness at all with respect to the increase of R&D personnel, and the financing of equipment for innovation, which has no direct effect in R&D and is the most frequently used program according to Table 1. Therefore, there may be some programs that show effectiveness and others that do not. Moreover, firms that are in the control group of their samples, though not included in the specific programs which effects they are measuring, may have applied for some of the other programs here under analysis. Thus, some attention should still be directed to analyzing specific programs.

Second, both Araújo et al. (2012) and Kannebley and Porto (2013) use the number of employees in R&D and not R&D intensity as dependent variable. This procedure creates two types of bias. First, while we have been dealing with intensity, they are dealing with the size of the effort, though they have an independent variable controlling for size (this is not the case of Avellar, 2009). Second, though Araújo et al. (2012) show a correlation between their dependent variable and R&D expenditure of 0.9, they are still different indicators and some results may be different when changes are made.

The use of the same firm in two different periods as a control group has a good effect of reducing heterogeneity in many ways, however, in one way it may create a bias. There are two situations being measured. In one case, the firm has obtained support in 2005, but not in 2008. In the other case, the firm has obtained support in 2008, but not in 2005 (see Table 4). In the latter case, the fact that the firm obtained support does not affect its previous performance; however, in the former case, obtaining support in 2005 may affect the firm's performance in 2008. Thus, results may be biased against the performance provided by the 2005 governmental intervention. Furthermore, it could be the case that the support obtained in 2005 rendered no results and that could be the reason why the firm did not apply for the same support three years later. This could be the case, for instance, of cooperation with universities, where the literature surveyed showed the feeblest results. Moreover, the adopted procedure eliminates the case of those firms that have obtained support in both years. In this case, it should be weighed that the continuity of support may provide better results than its interruption. For instance, Araújo et al. (2012) argue for cumulative effects of continuing using FNDCT funds. This type of firm is not covered in the test we provide.

Finally, period is relevant. Most of the new programs created in the 2000's were not effective in 2005 and some of them had not yet fulfilled their main goals in 2008. Thus, policy analysis should account for these differences.

Having made these remarks, the results do not confirm effectiveness of governmental innovation policy and one may speculate about the occurrence of a crowding out effect. This result is in line with part of the literature that claim for the substitutability of government funded R&D for privately funded R&D. Some analysts would argue that Lerner's (2010) points state that the cons of governmental intervention may outrun the pros. Analysts would then argue that tax payers' money are being wasted and that innovation policy initiatives should be revisited and possibly demobilized.

However, another way to look at the results is that innovation policy has not matched the right design. Most governmental initiatives did not have a clear focus. Procurement policies were not achieved and network view type of policy was not implemented. It seems that Brazilian innovation policy has most of these faults. It does not foster interaction between different agents and even when it allows for this interaction to happen, the Brazilian innovation policy does not provide the instruments for this achievement. As a result, another innovation policy view would require the achievement of innovation policy through governmental procurement programs. However, this latter proposition of shift in innovation policy may require a major change in governmental approach towards industrial policy as a whole: the choice of sectors and niches.

TABLE 6
OLS regression – R&D intensity as dependent variable

	(1)	**(2)**
Governamental support	7.4	7.4
	(1.00)	(1.00)
ln(employees)	-0.568	-0.581
	(-3.87)	(-4.27)
ln(employees)^2	0.041	0.042
	(3.61)	(3.84)
Ln(age)	0.192	
	(0.45)	
Ln(age)^2	-0.030	
	(-0.39)	
Dummy for export	-0.056	
	(-0.48)	
_cons	1.623	1.928
	(2.21)	(4.61)
F	4.08	8.03
R2	0.0488	0.047
N	484	484

Source: IBGE. Microdata from Pesquisa de Inovação Tecnológica – PINTEC 2005, 2008.

5. Conclusions

This paper has attempted to measure the impact of governmental support for innovation in business companies' R&D intensity. The paper used a sample of 243 firms from PINTEC 2005 and 2008 editions that carried out R&D in both years and that had either received governmental support for innovation in 2005 or 2008.

The results do not give support for the hypothesis that firms' R&D intensity was affected by governmental support. It raises doubts about the complementary character of governmental resources towards R&D. Nonetheless, this result may be a consequence of the wide variety of instruments used by Brazilian innovation policy that may have different levels of effectiveness. In fact, previous literature that analyzes specific instruments finds a positive effect for some of these instruments. Therefore, a first consequence of this analysis would be to recommend a more selective approach towards innovation policy in the sense that the effectiveness of instruments should be weighed.

Moreover, the paper argues that innovation policies should not be understood as simply correcting for market imperfections as some authors have treated them (LERNER, 2010). On the contrary, the paper argues that innovation policies should be focusing on increasing interaction across different agents. In this sense, the lack of a systemic view seems to be the major shortcoming of Brazilian innovation policy. Again, selection of instruments and focus on sectors seem to be a way to overcome some of the deficiencies of present innovation policy. Furthermore, as international literature links effectiveness of innovation policy to demand, policymakers should be aware of the need to link innovation instruments and interaction between suppliers and customers. However, innovation policy in Brazil has very feebly been driven towards demand requirements. Linking demand to supply instruments seems to be the great challenge to be matched in next policy steps.

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