DOES GOVERNMENTAL SUPPORT TO INNOVATION HAVE POSITIVE EFFECT ON R&D INVESTMENTS? EVIDENCE FROM BRAZIL[#]

Frederico Rocha[*]

Resumo

O artigo objetivo mensurar os efeitos do apoio governamental às atividades inovadoras nos investimentos em P&D das empresas no Brasil. O trabalho usa dados da Pesquisa de Inovação Tecnológica (PINTEC) nas edições de 2003, 2005 e 2008. Usando um modelo de efeitos aleatórios em painel, o trabalho conclui que o apoio governamental é a variável mais relevante para explicar o gasto em P&D das empresas inovadoras no Brasil.

Palavras-chave: política tecnológica; investimentos em P&D; avaliação de políticas

Abstract

This paper aims to measure the positive effects of governamental support to innovative activities on business firms' R&D investments in Brazil. The paper uses data from the Brazilian Innovation Survey (PINTEC) 2003, 2005 and 2008 editions to run a random effects panel data model that concludes that governmental support is the most significant explanatory variable of business firms' R&D effects. The effect on R&D intensity reaches 2.7 percentage points in the best fit equation.

Keywords: technology policy; R&D investments; policy assessment

JEL: O31; O38; L5

[#] The author is grateful for the support of the Ford Foundation.

[*] Associate professor at the Instituto de Economia at the Universidade Federal do Rio de Janeiro.

1. Introduction

This paper aims to measure the positive effects of governamental support to innovative activities on business firms' R&D investments in Brazil using microdata from the Brazilian Innovation Survey 2003, 2005 and 2008 editions.

Governmental support to innovative activities is usually justified on the grounds that innovative activities are subject to characteristics that cause underinvestment. Imperfect appropriability, high level of uncertainty and the tacit character of knowledge justify governmental intervention.

On the one hand, a large number of scholars have argued that governmental intervention on the technology environment has paid off (Mazzucato 2012, Block 2008, Pelei 2006). They base their assertions on the existence of an entrepreneurial state that has provided knowledge and capabilities to the carrying out of innovative activities of business firms. On the other hand, 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. This latter literature has got a rather blurred picture about the effects of governmental subsidies on business firms' R&D investments (David, Hall and Toole 2000, Hall and Reenen 2000).

This paper is dedicated to the measurement of this latter issue for Brazil. The relevance of this investigation is that in recent years Brazil has strongly shifted its technology policy, improving governmental funding and grants mechanisms and extending tax incentives to R&D to the whole business scenario. It is therefore important to assess the impacts of this shift to contribute for policy making.

The paper is organized in five sections, including this introduction. In the next section we present our analytical and historical background. The database and method of analysis are described in section three. Section four shows and discusses the results from the analysis. Section five is dedicated to driving some conclusions.

2. Analytical and Historical Background

2.1. Reasons for public support to innovative activities

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 knowledge has public good 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 nonexcludability derives from the fact that in order to absorb knowledge it may be necessary previously accumulated capabilities and skills and in some cases new effort. In this sense R&D is characterized by having two faces: one that is dedicated to new solutions and the other that is characterized by the constitution of absorptive capacity (Cohen and Levinthal 1989). Third, it is not perfectly codified; tacit knowledge is present and the transmission of knowledge may require interaction between agents and, mostly important, the 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 pattern of solutions but not to others.

Innovative activities are also uncertain. Freeman (1989) relates investment in R&D and other innovative activities to high level of uncertainty. He 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 about the acceptance of the new product by the market.

The presence of uncertainty challenges Modigliani-Miller's hypotheses of perfect financial markets, by which internal or external financing would 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, either lenders' and/or borrowers' risks would be affected.[1] The presence of uncertainty may therefore deepen underinvestment.

These characteristics stress the cause for state intervention in innovative environments or activities. Pavitt (2005) lists some cases where governmental policies have directly influenced and funded research in some areas. ICT and civil aviation in the US have been developed through projects that have their origin in Ministry of Defense programs; high speed trains in France and Japan have been developed having governmental programs to support them. Pavitt (2005) also establishes the lines of argument for framing pros and cons of governmental support, stressing, on the one hand, the presence of pressure groups and opportunity costs, and, on the other hand, the occurrence of commercial constraints and the gains and externalities of early technological learning and accumulation for international competition.

Examples of the role of technological learning and accumulations are given by Mazzucato (2012) that shows how the state in the US has engaged in Schumpeterian entrepreneurship due to the need to deal with uncertainty. Therefore, US government

[1] See Ughetto (2008) for a list of the five main sources for the preference for the use of internal sources in R&D investments.

has defined new broad areas of technological development and has been able to provide the business sector with knowledge necessary to develop major technological breakthroughs.

Block (2008) argues that 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 this 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 Company, have been proposed and efforts have been carried out to consolidate this developmental state. According to his research, the results are unchallenged:

> "For forty-five years, R&D Magazine has been recognizing the one hundred most innovative commercial products introduced in the previous year. In 1975, forty-seven out of eighty-six domestic innovations were produced by Fortune 500companies, and forty of these involved no outside partners. By 2006, the big firms were responsible for only six out eighty-eight innovations, and in most cases, they had partners. In 2006, fifty of these innovations were the products of researchers at U.S. government laboratories, universities, or other public agencies, working alone or in collaboration with private firms. Another eleven innovations came from supported spin-offs," relatively new firms started by scientists or technologists that had received considerable Federal funding both before and after thefirm's founding. Of the remaining twenty-seven innovations that belonged to private sector organizations, at least another sixteen involved Federal dollars" (Block 2008:187).

There are also plenty of examples outside the US. Peilei (2006) argues for the central role of government in the technological development of the Chinese telecommunications industry that took the country from a net importer of telecommunication equipment to being a net exporter. Hansen, Rand and Tarp (2008) show a positive effect of different types of government intervention on firm growth in the Vietnamese case.

On the other hand, Lerner (2010) argues that, although uncertainty and externalities are present, there is always a risk that government will fail to direct resources to support inept programs. This risk is usually related to the quality of institutions. Furthermore, influence of some actors in the technological and political scene may lead to waste of resources and agency problems may arise. Thus, Lerner (2010) suggests that caution should be taken in understanding non-technology and non-production obstacles to success and that market signals should be respected. Lerner (2010) also uses case studies as well to question the wisdom of wide governmental intervention in innovative efforts.

Another stream of the literature investigates a second type of governmental intervention: the use of government subsidies for R&D. Policy instruments in this case involve R&D grants, subvention, funding and tax incentives. A large set of studies attempt to measure the effect of governmental intervention regressing some measure of innovativeness, firm growth or productivity growth on governmental intervention or subsidies.

David, Hall and Toole (2000) survey the literature on the effect of government finance and grants on private R&D showing mixed results. They stress however that most studies find a positive relationship between these variables, although, as argued by Wallsten (2000), they may show correlation rather than causality. Wallsten (2000) analyzes the conceding of grants to innovative enterprises. He argues that it is most likely that government officials fund projects that are commercially viable and that would find their way to success by market means and therefore that 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 was 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, showing that the selection procedure is not as targeted as suggested by Wallsten. Gelabert, Fosfuri and Tribó (2009) have tested the issue of 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 final 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.

2.2. The Brazilian Institutional Framework

The Brazilian governmental support to innovations involves the supply of non-reimbursable and reimbursable funds, equity emission and equity sharing agreements to the supply of risk capital for small and medium enterprises, and fiscal incentives for innovation (Bastos 2012). 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, the governmental funds to innovation reached almost R$ 10 billion a year.[2] 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 step taken by Luis Inácio Lula da Silva's government in terms of a general framework of innovation policy. Articulated to the general framework of the PICTE, a number of policies 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 b 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 for 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 from expenses on R&D (between 60% - 100%), reductions in the tax on industrial products for purchasing machines and equipment for R&D (50%), economic subsidies through scholarships for researchers in companies and an exemption from the

[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.

Contribution for Intervention in the Economic Domain (CIDE) for 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.

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 established 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 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 per cent by 2010, with a emphasis in 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 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.

3. Methodology

3.1. The Database

The paper uses data from the Brazilian Innovation Survey (PINTEC) 2003, 2005 and 2008 editions. PINTEC has been published in four different editions, for the years 2000, 2003, 2005 and 2008. PINTEC sample design produce statistically significant samples for companies in the 10 to 29, 30 to 99, 100 to 249, 250 to 499 and covers all companies with 500 or more companies. The samples are also built in order to have statistically significant representation per two-digit International Standard Industrial Classification (ISIC). Also, PINTEC attempts to cover all companies that have received any governmental support, declared to have formal R&D labs or applied for patents. PINTEC 2003 covered a sample of 10,000 manufacturing and mining firms; 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. From 2005 on, PINTEC has included service firms in their sampling. **We restrict our analysis to Mining and Manufacturing firms**.

The paper selects and uses only innovative companies that were interviewed in the three PINTEC editions. Firms are considered innovative if they have introduced process or product innovations that consist in novelty to their previously used processes or previously produced products in at least one of the three editions. 2,601 firms fell into those criteria. Table 1 shows the size characteristic of the sample. On average, companies have over 900 employees. In 2008, the average size of firms in the Manufacturing and Mining Industries was less than 30 employees. Therefore, our sample is biased towards large firms.

We have chosen a conduct variable, R&D intensity, represented by the ratio of R&D expenditures to sales, to capture the effect of governmental policies and to be the dependent variable of our regressions. The sample has an average R&D to sales ratio of 0,8% (see Table 1). The standard deviation is quite high, due to the large number of events where firms appear with zero R&D expenditures: 4,380. It should be stressed that half of the variance is explained by within group effects, that is, there are quite large variations in firms' own R&D intensity across the years.

As has been stated in the previous section there are a large number of options funding assistance to innovative investments, R&D grants and fiscal subsidies to innovative activities that the innovative firms can engage into.

The 2003, 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 Figure 1. Fiscal incentives seem to dominate the setting in larger firms and acquisition of machinery equipment in smaller firm sizes. So, in some cases, selection biases may exist, but in others they are unlikely to be present. Some of the selection biases will be related to innovative capabilities, but others will not.

We have chosen to approach the subject by building a dummy variable that takes value one if the firm has received governmental support and value zero if it did not receive governmental support. Table 1 shows the average number of firms that are being supported in the whole sample and the overall, between and within group variance in our sample. It is shown that about 40% of the overall variance is explained by within group variance, that is, firms that have received governmental support in one period and have not have received governmental support in some other period, while 60% of the variance is explained by between group variance. This characteristic is quite important for we are capturing effects of governmental intervention in firms' own R&D portfolio as much as we are capturing differences across firms.

Table 1. Descriptive Statistics

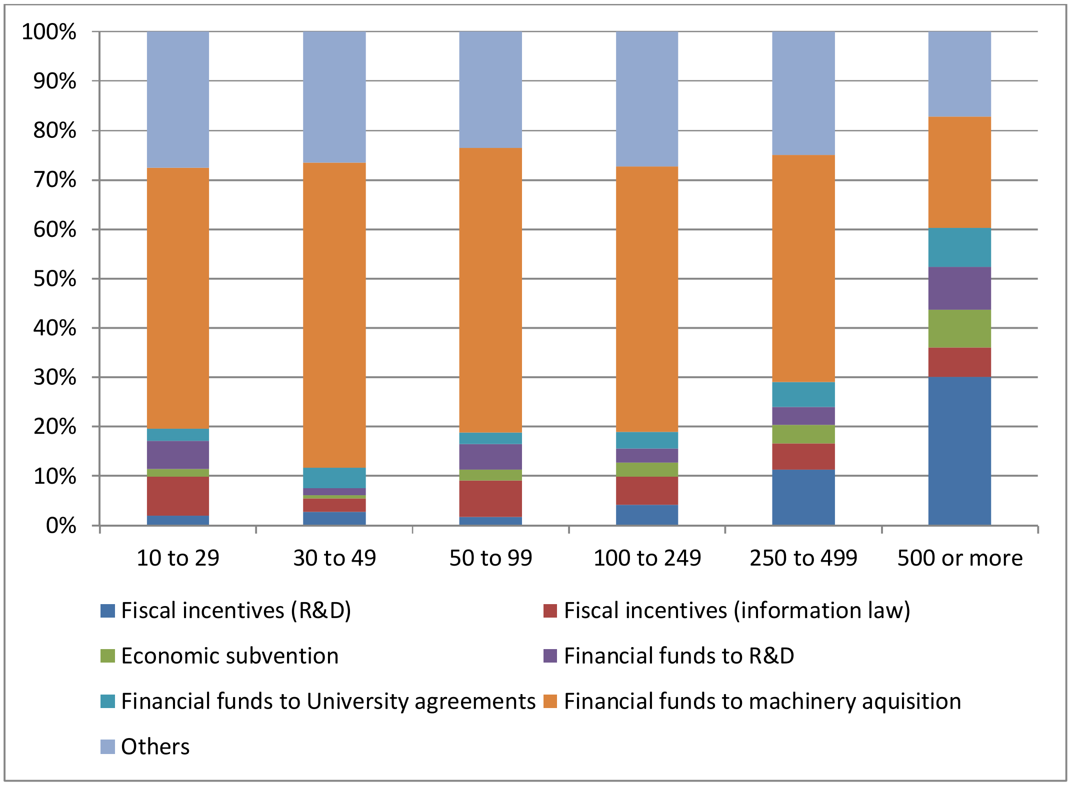
Variable		Mean	Std. Dev.	Obs
R&D intensity	overall	0.008	0.035	7797
	between		0.024	2601
	within		0.025	2.998
multinational	overall	0.215	0.411	7797
	between		0.392	2601
	within		0.124	2.998
Number of employees	overall	903.576	2203.104	7797
	between		2126.487	2601
	within		574.320	2.998
Age	overall	26.184	12.284	7797
	between		12.113	2601
	within		2.055	2.998
HH	overall	0.058	0.097	7797
	between		0.090	2601
	within		0.037	2.998
Product	overall	2.123	0.923	7797
	between		0.450	2601
	within		0.810	2.998
Government support	overall	0.235	0.424	7797
	between		0.330	2601
	within		0.266	2.998

Source: Own elaboration using PINTEC 2003, 2005, 2008.

Table 2 shows by two-digit ISIC code the number of times firms have been classified as supported and non-supported in our sample. In average, 23.51% times we have classified firms as governmentally supported. It should also be observed that governmental support is unevenly distributed across sectors and across size (see Figure 2).

Since Schumpeter's Capitalism, Socialism and Democracy, economists have been worried and have formulated hypotheses about the relation between innovative behavior and firm size and innovative behavior and market structure (Cohen and Levin 1989). There are two Schumpeterian hypotheses. The first one states that firms with greater market power are more likely to be innovative and therefore more concentrated markets should be able to deliver greater innovativeness and firms in these markets should have higher R&D expenditures. The second Schumpeterian hypothesis was actually formulated by Galbraith and states that larger firms should be able to carry out greater innovative efforts and therefore to be more innovative. The paper includes firm size and market concentration variables to deal with these hypotheses. Firm size is represented by the natural logarithm of the firm's number of employees and market structure is represented by the Herfindahl-Hirschman index of the firms' market share at Brazilian Economic Activities Classification (CNAE 1) .

Figure 1. Distribution of the Number of Events of Governmental Support to Innovation, per firm size, 2008



Source: IBGE, PINTEC.

Table 2. Number of times that firms in our sample were qualified as having received governmental support for innovative activities, 2003, 2005 and 2008, by two digit ISIC code

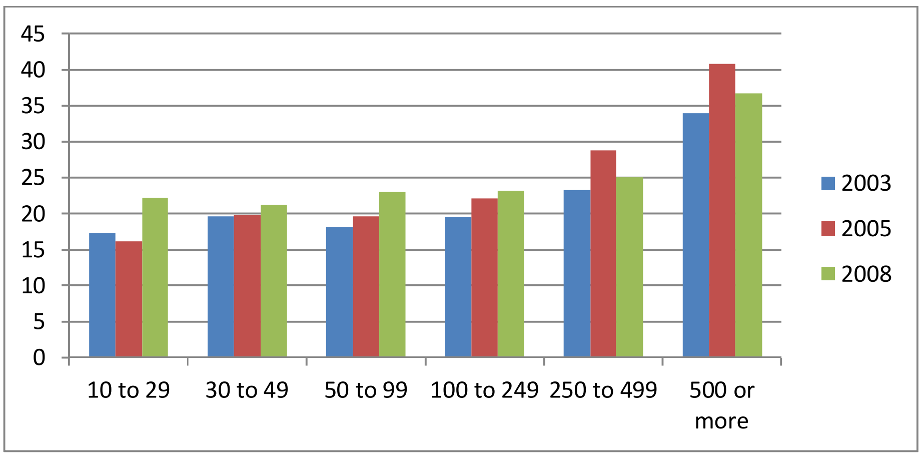
ISIC	Sector Name	Governmental Support to Innovative Activities				Total
		Non-Supported		Supported		
		Number	%	Number	%	
10	Mining of coal and lignite	9	100.00	0	0.00	9
11	Extr. oil, natural gas and related service	24	100.00	0	0.00	24
13	Mining of metal ores	13	72.22	5	27.78	18
14	Other mining and quarrying	68	87.18	10	12.82	78
15	Food products and beverages	1,152	78.05	324	21.95	1,476
16	Tobacco products	26	86.67	4	13.33	30
17	Textiles	439	87.62	62	12.38	501
18	Wearing apparel	251	90.94	25	9.06	276
19	Leather products	301	86.49	47	13.51	348
20	Wood products	167	85.64	28	14.36	195
21	Paper and pulp	166	75.80	53	24.20	219
22	Publ., print. and reprod. recorded media	76	87.36	11	12.64	87
23	Coke, refined petroleum prod., nuclear fuel	129	81.13	30	18.87	159
24	Chemicals and chemical products	494	75.54	160	24.46	654
25	Rubber and plastics products	314	80.51	76	19.49	390
26	Non-metalic metals products	230	82.44	49	17.56	279
27	Basic metals	187	71.65	74	28.35	261
28	Fabricated metal products	269	79.59	69	20.41	338
29	Machinery and equipment n.e.c.	489	73.53	176	26.47	665
30	Office, account. and computing machinery	27	23.89	86	76.11	113
31	Electrical machinery and apparatus n.e.c.	199	62.38	120	37.62	319
32	Communication equipment and apparatus	96	48.48	102	51.52	198
33	Instruments	125	61.27	79	38.73	204
34	Motor vehicles, trailers and semi	273	68.08	128	31.92	401
35	Other transport equipment	104	86.67	16	13.33	120
36	Furniture; manufacturing n.e.c.	330	76.92	99	23.08	429
37	Recycling	6	100.00	0	0.00	6
Total		5,964	76.49	1,833	23.51	7,797

Source: Own elaboration using PINTEC 2003, 2005 and 2008.

However, technological regimes may affect the effect of firm size and market concentration on innovative behavior and performance. Different types of firm and market structures will have different interactions with different technological regimes (Malerba and Orsenigo 1996, Malerba 2005, Breschi, Malerba and Orsenigo 2000).Furthermore, technological regimes may affect the size of the effect of governmental support on R&D (Gelabert, Fosfuri and Tribó 2009). In order to control for these effects, we include two-digit CNAE1 sectoral sectoral dummies.

We also include three additional firm level variables: (i) the rate of change of product in the market, which is the answer to PINTEC's question number 7, that asks the duration of the product in the market. We value the answer from 0 to 3, three being the fastest rate; (ii) the age of the firm in number of years; and (iii) the nationality, a dummy that values 1, if the firm is a multinational, and 0, otherwise. Table 1 presents descriptive statistics for the variables.

Figure 2. Proportion of Firms Receiving Governmental Support for Innovative Activities per Firm Size, 2003, 2005, 2008



Source: IBGE, PINTEC.

3.2. Empirical Strategy

The paper presents two sets of models. First, it runs a tobit pooled data model in the form:

$$RD_{it}^{*} = \max(0, \boldsymbol{x}_{it}\boldsymbol{\beta} + u_{it}) \qquad (1)$$

Tobit pooled data models maintains an specified relation between u_{it}, the error term, and $\boldsymbol{x}_{it}$, the vector of independent variables. It also does not account for serial correlations between the error term and the dependent variable.

Second, the paper estimates a tobit random effects panel data model:

$$RD_{it}^{*} = \max(0, \boldsymbol{x}_{it}\boldsymbol{\beta} + c_i + u_{it}) \qquad (2)$$

where $c_i$is an unobserved variable.

The estimation of the effects of governmental support on private R&D suffers from problems due to self-selection and governmental official selection problems, that is, first, private companies, mostly small ones, may be attracted to present themselves for governmentally financed programs In order to access easy money. This may be the main source of income in some of these companies due to their overall activity and R&D intensity. Therefore, these programs are more likely to attract R&D intensive firms. Second, governmental officials tend to select firms that are more likely to innovate to prove the effectiveness of their programs. These effects should however be more relevant whenever dealing with grants and governmental financing of R&D activities. In the case of tax incentives, they should not be present, though there could be some important cost transfer problems.

Still, the paper uses the random effects panel data and the sampling strategy to tackle problems related with selection biases in three fronts:

(i) They deal with unobserved individual variables, the $c_i's$, that is, variables that may be affecting the results but are not included in the regression;
(ii) They provide a more homogeneous set of firms by choosing only innovative firms and therefore reducing selection biases; and
(iii) They provide counterfactual cases both within and between groups.

The paper first presents for each of the models the results for firm specific characteristics and then it introduces concentration variables and, finally, sectoral dummies to account for differences in technological regimes.

4. RESULTS

The results to the regressions are presented in Table 3. Equations (1) through (3) present Tobit pooled data models, while equations (4) through (6) present random effects models. Equations (1) and (4) deal only with firm specific variables, equations (2) and (5) include market concentration variables and equations (3) and (6) include apart from market concentration, two-digit sectoral dummies. Random effects equations add explanation. The rho value in equations 4, 5 and 6 is positive and shows that random effects add an explanation to the whole variance of higher than 30%.

Before discussing the result for the governmental support it is interesting to point out that the equations reject both Schumpeterian hypotheses. Firm size is always negatively related to R&D intensity and though the quadratic form has a positive sign, the returns do not become negative until firms are over 90,000 employees, which cover the whole sample of firms. Concentration is positively correlated with R&D intensity, but it loses significance when sectoral dummy variables are introduced. Age is, as expected, negatively correlated with R&D and the multinational dummy assumes a positive value, though it loses significance in equation 6, again when sectoral dummies are introduced.

In all six equations, governmental support is the most significant explanatory variable. The effect on R&D intensity varies from 2.7 (in equation 6) to 3.8 (in equation 1) percentage points. It can be observed that as one includes more control variables, the effect of the governmental support variable decreases. The result is on line with most of the early studies (see David, Hall and Toole 2000) that show a positive effect of governmental support on R&D intensity. Some important comments should be made on this result. First, the result does not measure a real per real relationship rather the relation between a dummy variable and an R&D intensity variable. The paper does not strike the effect that a monetary unit of subsidy will have on net business firms' R&D expenditures. Therefore, one important issue treated by David, Hall and Toole (2000) and Wallsten (2000) on the complementarity/substitutability of public and private expenditures is not assessed in this paper. However, the dimension of the coefficient suggests that effects are quite high and that probably complementarity applies. Second, the paper does not separate by type of subsidy. Therefore, some further work is still to be carried out in order to fully qualify the results. Third, one may raise suspicion that there are still endogenous features to be cut off from the analysis.

However, the paper presents some lessons to be followed. In section 3, we have stressed the occurrence of a major shift in technology policy in Brazil. Policies were first focused on a few sectors and concentrated on tax incentives. From 2004 on, new instruments have been created and firms have been able to adhere to new policy lines. Figure 3 shows that there was a sharp increase in the number of firms covered by governmental programs. The number of firms covered by governmental programs almost doubled in 2008, compared to 2003. These doubling also came with a structural shift. In 2003 most of the governmental support to innovation occurred through the acquisition of machinery – which is mostly related to embodied technology and has very few effects on the production of new knowledge inside the corporation – and through tax incentives. In 2008, two new types of programs have appeared: economic subvention and finance to autonomous projects. This shows a quality shift as well. Based on the results of this paper, one can argue that the shift in policy has been on the right direction. Governmental support to innovation seems to obtain positive results in terms of R&D investment.

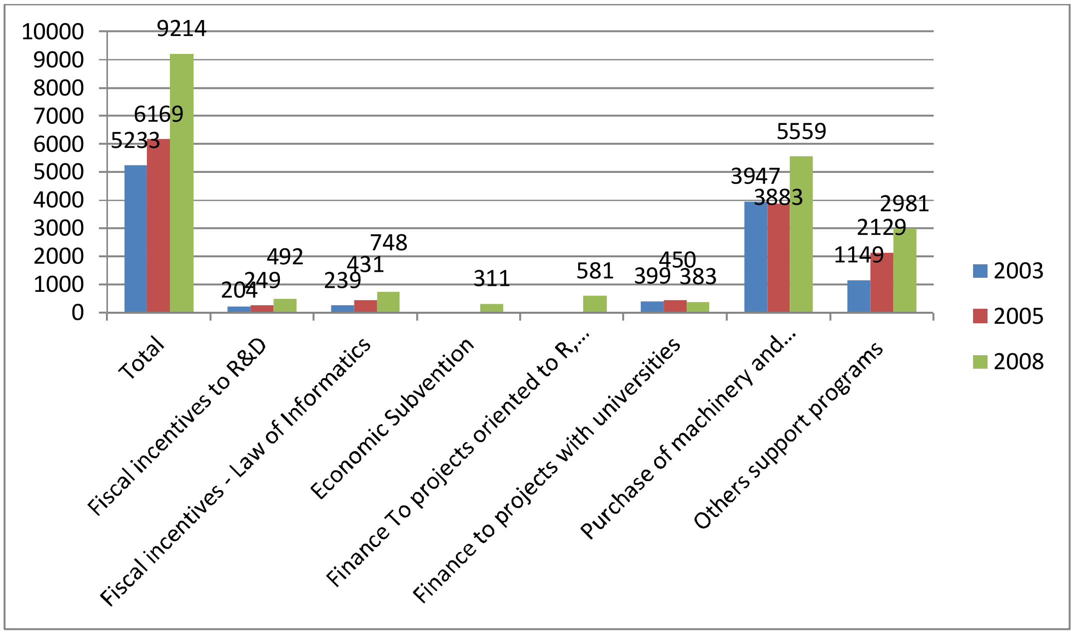
One should furthermore focus some attention on the problems suffered by these policies with high percentage of large firms involved (see Figure 2). Some attention must be driven to the fact that technology policy has mostly targeted large firms and that positive effects can be obtained if more emphasis is put on firms of smaller size. Though policy lines have shifted, still little has been obtained and, as shown by Bastos (2012) most resources still go to tax incentives where only large firms are benefited.

Table 3. Tobit Random Effects Panel Data Regressions: dependent variable R&D intensity

	Tobit Pooled data regressions			Tobit Panel Data Random effects regressions		
	Firm level data (1)	Firm level + HH (2)	Firm level + HH + sectoral Dummies (3)	Firm level data (4)	Firm level + HH (5)	Firm level + HH + sectoral Dummies (6)
ln(employees)	-0.041*	-0.039*	-0.033*	-0.046*	-0.045*	-0.038*
	(-11.26)	(-10.73)	(-9.11)	(-10.81)	(-10.47)	(-8.99)
ln(employees)^2	0.003*	0.003*	0.003*	0.004*	0.004*	0.003*
	(10.93)	(10.34)	(9.81)	(10.49)	(10.11)	(9.52)
Ln(age)	-0.849*	-0.860*	-0.725)	-1.046*	-1.046*	-0.915*
	(-6.11)	(-6.19)	(-5.18)	(-5.95)	(-5.98)	(-5.36)
Multinational	0.016*	0.014*	0.004#	0.016*	0.015*	0.005#
	(8.19)	(7.43)	(1.91)	(6.86)	(6.39)	(1.95)
Speed of product change	0.007*	0.007*	0.003*	0.004*	0.004*	0.002+
	(7.16)	(7.21)	(3.72)	(4.12)	(4.28)	(2.15)
Governmental support	0.038*	0.037*	0.028*	0.034*	0.033*	0.027*
	(20.68)	(20.13)	(15.14)	(17.31)	(17.08)	(13.71)
HH		0.112*	0.033		0.101*	0.029
		(5.91)	(1.48)		(4.68)	(1.19)
HH^2		-0.125*	0.040		-0.112*	0.033
		(-4.69)	(1.19)		(-3.65)	(0.91)
_cons	6.515*	6.589*	5.343*	8.024*	8.019*	6.989*
	(6.16)	(6.23)	(5.05)	(6.01)	(6.03)	(5.39)
Obs.	7230	7230	7230	7230	7230	7230
Number of groups				2600	2600	2600
Left censored	4380	4380	4380	4380	4380	4380
uncensored	2850	2850	2850	2850	2850	2850
Right-censored	0	0	0	0	0	0
LR-Chi2	748.54	785.36	1259.36			
Min. Groups				1	1	1
Aver. Groups				2.8	2.8	2.8
Max groups				3	3	3
Wald-Chi2				504.01	526.73	848.75
rho				0.376	0.370	0.315

z-statistics in parenthesis. * Significant at the 1% level. + Significant at the 5% level. # Significant at the 10% level.

Figure 3. Total number of firms covered by governmental support programs and number of firms covered by each program



Source: IBGE, PINTEC.

A final topic to be addressed from the results here obtained is the tradeoff between policies. The paper has argued that business firms alter their behavior in the willing direction in response to policy incentives. If resources are scarce, a further step would be to assess the results of different science and technology instruments to optimize the allocation of governmental resources. In this sense, some further work may be carried out in order to see the benefits of alternative allocations of science and technology resources.

5. Conclusions

This paper has aimed to measure the effects of governmental support to innovative activities on private R&D. The paper has used data from PINTEC 2003, 2005 and 2008 editions to capture these effects. The main conclusion of the paper is that governmental support has a positive effect on R&D expenditures.

The paper then addressed some issues related to science and technology policy. The paper argues that technology policy is still imperfect and that some attention should be driven to the asymmetries between large and small firms. Larger firms seem to be privileged by governmental policies, though recent shifts have attenuated this shortcoming. Furthermore, the paper recommends further assessments on concurrent instruments in order to better shape Brazilian technology policy.

REFERENCES

Bastos, V. (2012) 2000-2010: uma década de apoio federal à inovação no Brasil. *Revista do BNDES* 37, junho, 127-176.

Block F, (2008) Swimming against the current: the rise of a hidden developmental state in the US. *Politics and Society* 3(2).

Breschi, S. Malerba F. and Orsenigo L. (2000) Technological Regimes and Schumpeterian Patterns of Innovation. The Economic Journal, 110, 388-410.

Cohen,W.M. e Levinthal, D.A., (1989) Innovation and learning: the two faces of R&D. *The Economic Journal* , 99, 569–596.

David, P., Hall, B. and Toole, A. (2000) Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. *Research Policy* 29 , 497–529.

Fagerberg, J. (2005) Innovation: A guide to the literature. In Fagerberg, J., Mowery, D. and Nelson, R. (eds) *The Oxford Handbook of Innovation*. Oxford University Press, Oxford.

Freeman, C. (1985) La Teoria Económica de la Innovación Industrial. Alianza Universitaria, Madrid.

Gelabert, L., Fosfuri, A. and Tribó, J. (2009) Does the effect of public support for R&D depend on the degree of appropriability? *The Journal of Industrial Economics*, LVII (4), 736-767.

Hall, B. and Reenen, J. 2000 How effective are fiscal incentives for R&D? A review of the evidence. *Research Policy* 29, 449–469.

Hansen, H, Rand, J. And Tarp, F. (2009) Enterprise Growth and Survival in Vietnam: Does Government Support Matter? *Journal of Development Studies*, 45, 1048-1069.

Lerner, J. (1999). The government as venture capitalist: The long-run impact of the SBIR program. The Journal of Business, 72, 285–318.

Lerner, J. (2010) The future of public efforts to boost entrepreneurship and venture capital. *Small Business Economics*, 35, 255-264.

Mazzucato, M. (2012) The Entrepreneurial State. http://www.demos.co.uk/files/Entrepreneurial_State_-_web.pdf.

Peilei, F. (2006) Promoting Indigenous Capability: The Chinese Government and the Catching-Up of Domestic Telecom-Equipment Firms. China Review, Spring 2006, v. 6, iss. 1, pp. 9-35.

Malerba, F. and Orsenigo, L. (1996) Schumpeterian patterns of innovation are technology-specific. *Research Policy* 25, 451-478.

Malerba, F. (2005) Sectoral Systems of Innovation. In Fagerberg, J., Mowery, D. and Nelson, R. (eds) The Oxford Handbook of Innovation. Oxford University Press, Oxford.

Pavitt, K. (2005) The Innovation Process. In Fagerberg, J., Mowery, D. and Nelson, R. (eds) *The Oxford Handbook of Innovation*. Oxford University Press, Oxford.

Ughetto, E. (2008) Does internal finance matter for R&D? New evidence from a panel of Italian firms. Cambridge Journal of Economics, 32, 907-925.

Ughetto, E. (2009) Industrial districts and financial constraints to innovation. International Review of Applied Economics 23(5), 597-624.

Wallsten, S. (2000) The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation Research program. RAND Journal of Economics Vol. 31, No. 1, Spring.