Evaluating the Impacts of Innovation Policy: Evidences from Brazil

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Abstract

The objective of this paper is to evaluate the impact of public policies of fiscal incentives and financial support in the innovative effort of Brazilian firms. The methodology applied to evaluate the effects of different instruments in private expenditures on R&D and innovation activities is propensity score matching, using data from PINTEC (2010). This research contributes to the empirical literature by providing firm-level evidence from Brazil, and discussing the effectiveness of the different instruments to support innovation. The conclusions suggest that the two types of instruments evaluated generate positive effects con innovative effort of firms. However, the fiscal incentive impact is higher than the financial support.

Keywords: Innovation Policy, Evaluation, Matching, Brazil.

Resumo

O objetivo desse artigo é avaliar o impacto das políticas públicas de incentivos fiscais e financeiros sobre o esforço inovativo das empresas brasileiras. A metodologia utilizada para avaliar os efeitos desses diferentes instrumentos nos gastos privados em P&D e em atividades inovativas é propensity score matching, usando dados da PINTEC (2010). Essa pesquisa contribui para a literatura empírica apresentando evidências no nível da firma para o Brasil e discutindo a efetividade desses diferentes tipos de instrumentos de apoio à inovação. As conclusões sugerem que os dois tipos de instrumentos avaliados geram efeitos positivos sobre o esforço inovativo das empresas. Todavia, as políticas de incentivos fiscais são mais efetivas em relação às políticas de incentivos financeiros.

Palavras-Chave: Política de Inovação, Avaliação, Matching, Brasil.

JEL classification: 032, 038, C12.

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1 Introduction

The innovation policy has been actively practice among several countries aiming at both strengthening their own technological capacity, by stimulating private investments and, simultaneously, creating an institutional environment with adequate infrastructure to encourage interaction among enterprises, universities and research institutions. Therefore, the governments apply various policy instruments to promote R&D and innovation in the business sector.

In this context, the main concern of governments and policy-makers in many countries would be to identify the best policy to stimulate the innovation activities of the country, disregarding the public policy as a replacement for a market with static imperfections, but as a supporting agent in resource allocation, while assuring the competitiveness, in termsof dynamics. Consequently, the discussion about the public intervention in the economy is losing importance to the discussion abouthow the public policy should intervene in the promotion of technological development.

To accomplish this, a number of policy instruments could be applied by the policy-makers to stimulate the innovative behavior of the firms: tax credit, public subsidies, target credit and intellectual property system, venture capital, and every one can generate different impact on the private innovative expenditure. For example, tax credit to R&D is consider an *ex-post* instrument, because its do not anticipate financial support to technological activities but only refund expenses already done, which exclude many firms that cannot afford this investment. This mechanism is different of the public subsidies because do not cause any effect on risk perception ofthe firm, affecting its expenses structure only.

Based on this debate, this article aims to evaluate the impact of the two innovation programs applied in Brazil: fiscal incentive (Law n. 8661, Law n.11196, Law n. 10664 and Law n. 11077) and financial support (provide funding for expenditures on R&D, new machines and equipment, training, software), and to discuss about the effectiveness of each instrument, taking into account their characteristics and specificities of the beneficiaries firms. The data come from the Brazilian Innovation Survey (2010) that provides information on government support programs and also some indicators of innovation.

By means of a comparative evaluation of these cases, for the period 2006-2008, it will be possible to identify if the kind of instrument explains its impact on the expenditure behavior of firms engaged in innovating activities. This study will estimate the impact of these programs using quasi-experimental technique, in order to control for a possible selection bias, to compare beneficiaries and non-beneficiaries firms to reduce any selection bias.

The impact will be evaluated on the innovation variables: expenditure on R&D (ER&D), expenditure on innovative activities (EIA), expenditure on R&D in relation to the net revenue of sales (ER&D/NRS) and expenditure on innovative activities in relation to the net revenue of sales (EIA/NRS).

The results show that these two instruments – fiscal incentives and financial support - in fact have a positive impact on innovation performance of the firms. On the beneficiaries firms the behavior of these innovation variables is higher than twin non-beneficiaries firms.

This paper is organized in five sections. After this introduction, section 2 presents the literature review about evaluation of innovation program presenting some cases of the international literature. Section 3 summarizes some characteristics of the beneficiaries firms of the two Brazilian innovation programs: fiscal incentives and financial support. Section 4 shows the database that was used and the methodological notes with the description of the

methodology adopted in this research. Finally, section 5 gives the empirical results and section 6 presents some concluding remarks.

2 Theoretical and empirical literature

The quantitative evaluation of impact of innovating policy using econometric models started with Mansfield and Switzer (1985), who carried out a research with R&D business to understand the perception of the group in relation to tax incentive. The results show that the 1% R&D cost reduction culminates in a 0.3% increase in R&D expenditure, of the firms. Hall (1992) comes to an even more expressive result when he observes, based on data of the United States, that a 1% R&D cost reduction leads to a short term increase of 0.84% in R&D spending of the firms and to a long term increase of 1.5%.

However, this matter is not restricted to the analyses only of tax incentive effects, but also involves the analyses of other incentive policies of innovation like the financial support.

The studies presented on table 1 show a predominance, in the international literature, of researches which report the existence of the positive effect of the public policies in the analyzed cases of different countries where government incentive policies aimed at increasing private expenditure in innovating activities. These results suggest that the participation in innovation programs stimulate the R&D expenditures on beneficiary firms.

Busom (1999) evaluate the impact of the financial program to R&D expenditures in Spanish firms applied in 1998. The author estimate a probit model to analyses the effects in 154 firms. The result shows that the financial public support is capable to increase the private R&D investment, and do no occur crowd out effect. However, the author emphasizes the heterogeneity of the effects, considering the characteristics of the beneficiaries firms.

David *et al.* (2000) developed this discussion and presented a summarize of the literature review. The results show that in the major of the studies analyzed the financial public support promotes the additionality effect on private expenditures.

Wallsten (2000) evaluated the impact of the American financing program *Small Business Innovation Research Program* (SBIR) between 1990 and 1992. In 1998, for example, approximately one billion US dollars had been allocated to the financing of projects. This study deserves prominence for showing the presence of the crowding out effectbetween public and private expenditure in R&D. In other words, the study indicates that private investment would occur regardless of government financing. The author justifies this result by the selection itself of the programs by the executing agency, as priority is given to projects that *a priori* show high probability of market success, thus allocating a role of little importance to the policy.

Hall and Van Reenen (2000) contributed to this discussion through a comparative study on the effects caused different incentive policies of innovation carried out by countries of the OECD such as Canada, Germany, France, Italy, The United Kingdom and Belgium, among others. They compare the effects of financing programs to tax incentive and conclude that the latter is more efficient when it comes to stimulating private expenditure in R&D.

Lach (2002) evaluates the effects of the R&D financing projects in Israel and suggests the absence of the crowding out effect of public expenditure by private expenditure in R&D. Panel data analysis is used for firms from 1990 to 1995 and identifies an increase in R&D spending in firms that receive federal R&D support, especially smaller firms. The evaluated financing program had a 310 million dollar budget in 1990.

Czarnitzki and Fier (2002) investigate the effects of government financing on R&D activities in 210 firms in Germany between 1994 and 1998. The matching method is used and they conclude that a €1,0 financing generates an increase of €1,3 to €1,4 in private expenditure. In other words, they reject the hypothesis of a crowding out effect between public and private expenditure in the case that was investigated.

Bloom *et al* (2002) evaluate some experiences of the fiscal incentives to R&D using panel data for analyses different countries. It is observed the presence of a relative international consensus upon the effects of this instrument: it is expected that a 10% reduction in the cost of activities of R&D provides a 1% inR&D expenses in the short term (2 or 3 years) and a 10% raise in the long term.

Almus and Czarnitzki (2003) use the matching method to find out if the participation of the firms in federal supported innovation programs contributed to an increase in R&D expenditure of firms in Germany. The study here shown, indicates that the effect of the program is significant, positive and different from zero, indicating more intense R&D activities in beneficiary firms in relation to the control group consisting of similar firms that were non-beneficiary. In monetary terms, financings of 100,000 monetary units can generate private R&D investments of 4,000 monetary units (4%).

Duguet (2004) carries out an analysis of the effects of federal financing on private expenditure on R&D in firms in France. After the investigation of more than 1,600 firms in France from 1985 to 1997, the author concludes to absence of the crowding out effect, but confirms the presence of the additionality effect as complementary private expenditure occurs in relation to public expenditure, except for the year 1987.

Aerts and Czarnitzki (2004) present an analysis similar to the one carried out by Bloom et al. (2002) for the specific case of Belgium using the database of the Community Innovation Survey (CIS) of 2001. After several econometric studies, they conclude that the hypothesis of crowding out effect must be rejected when it comes to innovating firms.

Kaiser (2006) developed an evaluation by means of the matching method and the model of Heckman for the Danish R&D financing program, consisting of data from 1974 to 1995. He reached no conclusive results as regards thecrowding out effects between public, and private expenditure. Lööf and Hesmati (2005), similar to Kaiser (2006), make an analysis for the Swedish R&D financing program from 1998 to 2000. They come to the conclusion that the additionality effect occurs, or in other words, there is complementary expenditure, but only in small beneficiary firms.

The table 1 shows that the international studies of microeconometric evaluation are concentrated in cases of the developed countries policies. Hall and Maffioli (2008) organized the first research to evaluate the effects of innovation programs in emerging countries. They evaluate the Technology Development Funds (TDF) in Argentina, Brazil, Chile and Panama, and the empirical results shows that the effectiveness of the innovation program in found to depend on the financing mechanism used and on the characteristics of the target beneficiaries. Using different methods the paper shows that the impacts of the programs are different and the public subsidies were more effective than grants.

Especially about the Brazil´s case, some recent empirical studies of the evaluation of innovating policies show the efficiency of these policies to intensify the innovating efforts of the benefited firms in relation to those which were not benefited. Avellar (2008) evaluates the Program of Technological and Industrial Development (PDTI) and concludes that the participation of a company in the program culminated in a 190% increase in spending on technological activities, including R&D expenditures, new machines and tools expenditures

and training expenditures. This proves that the PDTI managed to reach its objective of increasing the spending of beneficiary firms on innovation activities.

Table 1. International Studies of Microeconometric Evaluation of the effects of the public policies to private R&D expenditure

Year	Author	Country	Period	Incentive	Method
1993	Leyden and Link	US, Japan, Canada, Sweden	1987	Fiscal	OLS
1997	Lattimore	Australia	1985-1996	Fiscal	Cost-Benefit OLS
2000	Busom	Spain	1998	Financial	OLS
2000	Wallsten	USA	1990-92	Financial	IV
2002	Lach	Israel	1990-95	Financial	Panel
2002	Czarnitzki and Fier	Germany	1994-98	Financial	OLS
2003	Almus and Czarnitzki	Germany	1995, 97 e 99	Financial	Matching
2002	Bloom et al	9 OECD countries	1979-97	Fiscal	Panel data
2003	Hussinger	Germany	1992-2000	Financial	Matching and Heckman
2004	Duguet	France	1985-97	Financial	Matching
2004	Czarnitzki et al	Canada	1997-98	Fiscal	Matching
2004	Aerts and Czarnitzki	Belgium	2001	Financial	Matching
2005	Lööf and Hesmati	Sweden	1998-2000	Financial	Matching
2006	Kaiser	Denmark	1998-2000	Financial	Matching
2008	González and Pazó	Spain	1990-1999	Financial	Matching
2008	Hall and Maffioli	Emerging countries	Different periods	Financial	Matching, Panel Data

Source: Personal Elaboration.

Based on this debate, the present article will present the results of the evaluation of two innovation public programs implemented in Brazil. Initially in the next section, there will be present the characteristics of the beneficiaries firms on these programs of incentive to innovation.

3 Data and descriptive analyses

The aim of this section is to present the characteristics of the beneficiaries firms and to show some details about the Brazilian programs evaluated. This study is based on database Technological Innovation Research (PINTEC), from the Brazilian Institute of Geography and Statistics (IBGE) published in 2010, including questions about the period 2006-2008. The variables used are described in table 2.

Table 2. Variable definitions

Variables	Definition
Size	Number of Employees
Net Sales Revenue (NRS)	Net Sales Revenue in 2008 (R$ 1000)
Expenditure on R&D (ER&D)	Expenditure on R&D in 2008 (R$ 1000)
Expenditure on Innovative Activities (EIA)	Expenditure on Innovative Activities, including R&D, Machine and Equipment, Training, Software (R$ 1000)
Labor Productivity	(Net Sales Revenue – Production Cost) / Number of Employees in 2008

	(R$ 1000)
Skill	Full Time Workers Completed High School (%)
Market share	Sales each Firm / Total Sales Sector
Foreign Capital	Firms with more than 10% of foreign capital (%)
Group	Firms that participate in business group (%)
R&D Continuous	Firms with R&D continuous (%)
Innovation Product	Firms that innovate in product (%)
Innovation Process	Firms that innovate in process (%)
Patent	Firms that register patent (%)

Source: PINTEC (2010).

The table 3 shows the participation of beneficiaries firms on innovation programs by size. The small firms (10-29 employees) have a big representation on the beneficiaries firms. In the case of fiscal incentives, the second group of benefited firms is with more than 500 employees. However, in financial support program, the second group more benefited is the firms with 100-249 employees.

Table 3.Number of Beneficiaries Firms on Innovation Programs by Size - PINTEC 2008

Size (number of employees)	**Fiscal Incentives**	**Financial Support**
10 - 29	620	3,766
30 - 49	79	1,010
50 - 99	102	788
100 - 249	79	423
250 - 499	61	172
More than 500	235	229
Number of Firms	1,176	6,388

Source: PINTEC (2010).

Table 4 presents the characteristics of the beneficiaries firms, on average, by the programs. It is possible to observe the heterogeneity of the characteristics of the beneficiaries firms by program, and consequently is possible suppose that effects of these programs on private R&D expenditure could be different in each one. The financial support covers more firms than the fiscal incentives (1,176 firms and 6,388 firms, respectively) during the period 2006-2008.

In relation to the profile of the firms participating in the programs, it can be verified, as regards the average size of the firms, that the participants of the financial support present profiles smaller (135 workers) than the firms of the fiscal incentives (737 workers). However, this fact is not exclusive of this study as the majority of the firms that have already benefitted from fiscal incentives, for innovating activities, are mostly large firms. Data of PINTEC 2003 show that over 70% of R&D resources are allocated to firms with more than 500 workers.

Considering the net revenue of sales (NRS), the firms of the financial support have smaller revenues, an average, in relation to the firms of other programs, with R$ 64.8 million and R$ 533 million, respectively. The participation of multinational firms is high in fiscal incentives.

In relation to the innovating profile of participating firms in the both programs, it can be observed that the innovative efforts - expenditure on R&D (ER&D) and expenditure on innovative activities (EIA) - of beneficiaries firms on fiscal incentives are higher than firms

on the financial support. However, 64% of the firms on the financial support possessed, in 2008, some patent. The firms of the fiscal incentives, in turn, only 28.8% possessed some patent in 2008.

Regarding labor, the proportion of workers with 3rd degree education is of about 5.8% in firms of the fiscal incentives, 1.7% in firms participating of the financial support.

In summary, is possible to find differences between the beneficiaries firms by program. The financial support is a program that target a high number of firms (6,388 firms), with a small number of employees (135 employees), with small effort to innovation (expenditures on R&D), but that find important innovative results (new products, process and patents). By other side, the firms benefited by fiscal incentives are bigger, with higher net revenue of sales (R$ 533 million) and labor productivity, more intensive in qualified employees, with more foreign capital and higher innovative effort (expenditures on R&D and on innovative activities).

Table 4. Characteristics of Beneficiaries Firms by Program - PINTEC 2008

Variables	**Fiscal Incentives**	**Financial Support**
Size (number of employees)	736.7 (121.06)	134.62 (28.99)
Net Revenue of Sales (R$ 1000)	533,319.52 (227,966.56)	64,800.84 (58,675.66)
Expenditures on R&D (R$ 1000)	9,154.91 (3,473.45)	1,272.71 (921.44)
Expenditures on Innovative Activities (R$ 1000)	16,359.23 (4,533.35)	3,179.93 (1,207.86)
Productivity (R$ 1000)	118.28 (16.06)	54.13 (4.35)
Skill (%)	5.82%	1.74%
Market share (%)	1.9%	2.9%
Foreign Capital (%)	49.50%	29.96%
Group (%)	23.89%	42.42%
P&D Continuous (%)	32.24%	62.22%
Innovation Product (%)	17.33%	58.52%
Innovation Process (%)	12.16%	70.59%
Patent (%)	28.80%	63.97%
Number of Firms	1,176	6,388

Source:PINTEC (2010).

In this way, based on the presentation and a brief comparison of the two programs of incentive to innovation one cannot disregard the existence of an effort made by Brazilian public policies to stimulate the accomplishment of innovating activities. It is, however, fundamental to identify the effects of these programs on the decision of expenditure on R&D activities of the firms and of expenditure in innovative activities, so as to measure their innovating efforts.

It is important to mention the unfamiliarity with systematic and more elaborate evaluations of the effects of these programs on the behavior of participating firms as regards expenditure on innovating activities, and specifically on R&D activities. To bridge this gap, this paper presents, as follows, an application of the evaluation methods for the Brazilian cases.

4 Estimation method

To evaluate the impact of these Brazilian innovation programs on the innovative effort of beneficiaries firms, will be applied a counterfactual method to reduce potential selection bias (HALL and MAFFIOLI, 2008). Imbens and Wooldridge (2009) present a recent survey about econometrics methodology to evaluation program.

Propensity score matching[1] is a technique to determine quasi experiments, based on balancing algorithms for pertaining individuals of distinct groups with the purpose of evaluating the effects of a determined treatment. The technique consists in a probit model on vary of classification of observations and later use of estimated probabilities ($\phi(X'\beta)$) to form a controlling group. In 1983, Rosenbaum and Rubin published their seminal paper that first proposed this approach.

According to Deheja and Wahba (1998), deals with the inference in samples with selection bias in non-experimental units in which some units of the non-experimental group are compared to the ones that received the treatment.

Dependent variable is defined as being the participation of firms in the fiscal incentives and financial support to innovation. In present article, the use of matching technique will result in 4 groups:

(1) Beneficiary firms of the program which do not have similar characteristics with any other firms (Singular Beneficiaries)

(2) Beneficiary firms of the program which have similar characteristics with other non-beneficiary firms (Non-Singular Beneficiaries)

(3) Non-beneficiary firms of the program which have similar characteristics with other non-beneficiary firms (Non-Singular Non-Beneficiaries)

(4) Non-beneficiary firms of the program which do not have any similar characteristics with other beneficiary firms (Singular Non-Beneficiaries)

A late analysis of matching will be done through a comparing test of averages and regression models and will focus on group (2) and (3) firms, comparing comparable firms.

Formally, considering the practice of an experiment, indexing the interested population as *i*. If Y_{i1} is the variable value of interest when the same unit *i* subject to the treatment application and Y_{i0} the variable value of interest when the unit is subject to the use of controlling or absence of treatment.

The effect of treatment (τ) for a unit is defined through $\tau_i = Y_{i1} - Y_{i0}$ and the expected effect of treatment in all population will be:

$$\tau|_{T=1} = E(Y_{i1} - Y_{i0}|T_i = 1) = E(Y_{i1}|T_i = 1) - E(Y_{i0}|T_i = 1) \quad (1)$$

Where $T_i = 0.1$, means that the same experimental unit has been undergone to controlling treatment.

[1]We used the *psmatch2* program developed by Leuven and Sianesi (2003), available in software *Stata 11*.

As highlighted by Deheja and Wahba (1998), the main problem in non-experimental situations is that it can be estimated $E(Y_{i1}|T_i=1)$, although it is not possible to obtain $E(Y_{i0}|T_i=1)$ and the difference $\tau^b = E(Y_{i1}|T_i=1) - E(Y_{i0}|T_i=0)$ is a biased estimator for τ.

Once the units of treatment and controlling systematically differ in their characteristics, observing $Y_{i0}|T_i=0$ do not correctly estimate Y_{i0} for control group. The purpose of an experiment is to prevent this bias. However, as it is shown through the use of a co-variable group in which $(Y_{i1}, Y_{i0}) \perp\!\!\!\perp T_i|X_i, \forall i$, being $Y_i = T_i Y_{i1} + (1-T_i)Y_{i0}$ and the independence among groups symbolized by $\perp\!\!\!\perp$.

Giving the probability of a unit i been submitted to treatment defined as $p(X_i) \equiv \Pr(T_i=1|X_i) = E(T_i|X_i)$, demonstrated in Deheja and Wahba (1998), the value of the variable of interest Y_{i0} e Y_{i1}, will be independent of the use of treatment or, in other terms, $(Y_{i1}, Y_{i0}) \perp\!\!\!\perp T_i|p(X_i), \forall i$. The estimator $\tau^b = E(Y_{i1}|T_i=1) - E(Y_{i0}|T_i=0)$, become unbiased for τ, depending on the probability of inclusion in the treatment. $p(X_i) \equiv \Pr(T_i=1|X_i)$.
The matching estimator applied is the nearest neighbor (NN), considered in the literature the most straightforward matching estimator (IMBENS and WOOLDRIDGE, 2009). Considering *T* the set of received treatment units and *C*the set of control units.Being Y_i^T e Y_i^C the observed answer of the treated units and the control units, respectively. $C(i)$is the set of units of control group matched with the units of treatment group, with a score of p_i. The matching of the nearest neighbour chooses:

$$C(p_i) = \min|p_i - p_k| \qquad (2)$$

This means an exclusive matching for each unit of treatment (BECKER and ICHINO, 2004).

In addition of propensity score matching method, the literature shows others methods that can be applied to evaluate the innovation programs, for example, difference in difference estimation, instrumental variable estimation and panel estimation (HECKMAN *et al*., 2000; BLUNDELL and COSTA-DIAS, 2008; CALIENDO and KOPEINIG, 2005; IMBENS and WOOLDRIDGE, 2009).

5 Empirical Results

The aim of this section is reports the empirical results of the innovation programs effects on R&D investment of beneficiaries firms.Based on the analysis procedure called propensity score matching, a *t test* was run for the comparison of the means of beneficiaries firms of the complete sample (all firms' beneficiaries of the three programs) of the fiscal incentives and of the financial support, and firms that were non-beneficiaries, before data matching.

It must be considered that the group of firms that were not benefited present in this analysis is centered in the group of innovating firms according to PINTEC concepts, in other words, they are the ones who declared being involved in some kind of innovating activity, between 2006 and 2008, or who in this period had incomplete innovating projects. If the group of non-beneficial firms consisted of the total number of firms in this research (innovating and non-innovating), the difference between the two groups would be even bigger.

It is worth mentioning that the results that are reported in Tables 4 and 6, as follows, show the behavior (before and after matching) of the four innovation variables: expenditure on R&D (ER&D), expenditure on innovative activities (EIA), expenditure on R&D in relation to the net revenue of sales (ER&D/NRS) and expenditure on innovative activities in relation to the net revenue of sales (EIA/NRS).

The results presented in table 5 show that all differences are significant before the matching, for the two programs evaluated. Within group of firms, those who participated in the fiscal incentives, on average, present higher of three innovation variables (ER&D, EIA, ER&D/NRS) in relation to the benefited firms of the other program.

This result was foreseen, once participating of a tax incentives program is only possible, if the participant company has carried out expenditure on R&D, being therefore a company that is already predisposed to innovate. Different behavior is expected of the firms who receive resources through the financial incentives and who a priori had carried out none, or low activity of R&D.

Table 5. Test *t* for Comparison Averages of the R&D Expenditures and Innovative Activities Expenditures (R$ a thousand) of the Beneficiary Firms by Program – PINTEC 2008

Programs		**Average Difference**	**Signif.**	**No Benefic.**	**Benefic.**
Fiscal Incentives	Expenditure on R&D (ER&D)	20,888	***	223.4	21,112
	Expenditure on Innovative Activities (EIA)	36,191	***	1.602	37,793
	Expenditure on R&D/ NRS (ER&D/NRS)	0.058	**	0.005	0.063
	Expenditure on Innovative Activities /NRS (EIA/NRS)	0.095	*	0.050	0.145
	Number of Firms			*13,522*	*426*
Financial Support	Expenditure on R&D (ER&D)	5,067	***	441	5,508
	Expenditure on Innovative Activities (EIA)	12,466	***	1,673	14,139
	Expenditure on R&D / NRS (ER&D/NRS)	0.042	***	0.003	0.045
	Expenditure on Innovative Activities /NRS (EIA/NRS)	0.194	***	0.037	0.231
	Number of Firms			*12,791*	*1,157*

Source: PINTEC (2010). *** Significant at 1%; **Significant at 5%; * Significant at 10%; *ns.* Non-significant.

The second stage of this first procedure resides in the estimation of the probabilistic model which is identical to the one used in the previous chapter. A likelihood ratio test was carried out for the verification of the null hypothesis, $H_0 : \beta_1 = \ldots = \beta_k = 0$. The statistics of likelihood account for the comparison between the complete model and a model with only the intercept, where $\Phi^{-1}(\pi) = \beta_0$.The result of the likelihood tests shows rejection of the *probit* model containing only the intercept and the validity of at least one of the variables used in the model. More specifically the likelihood statistics compares the complete model and a model only with the intercept.

$$\Phi^{-1}(\pi) = \beta_0 + \beta_1 Size + \beta_2 Export + \beta_3 ForeignCapital + \beta_4 MarketShare + \beta_5 HighTech + \alpha_j \quad (3)$$

versus $\Phi^{-1}(\pi) = \beta_0$ (4)

The selected explanatory variables for the probabilistic model were:

Size: Logarithm of the number of persons employed by the firm,to evaluate the size firm effect on the probability of participating in the public program.

Export: *Dummy* for the firm as an indicator for international competitiveness.

Foreign Capital: *Dummy* to indicate the foreign capital on the firm.

Market Share: Firm revenue participation in the sector of economic activity as an indicator of national competitiveness.

High Tech: *Dummy* for the firm that is classified as a high technology sector, according to the technological intensity classification of the OECD.

α_j: Geographical localization region of the company, considering the five largest regions of the country.

Among the variables used in the set of explanatory variables the *market share* of the firms was constructed through the net firms' revenue participation on the net total revenue of the economic activity sector, defined according to the three digits classification from the CNAE (economic activity national classification). The model has also included the geographical region localization (α_j) considering the largest five regions in Brazil and the economic activity sector (γ_k) according to the technological intensity classification from the OECD.

Table 6.Probit Models on Fiscal Incentives and Financial Support

Variables	**Fiscal Incentives**	**Financial Support**
Size	0.49227	0.20239
	*(0.04525)****	*(0.02520)****
Foreign Capital	0.00559	-1.108375
	(0.13137)n.s.	*(0.13592)****
Export	0.81721	0.07699
	*(0.14827)****	*(0.07080)n.s.*
Market Share	28.110	8.63689
	*(4.3089)****	*(2.4888)****
High Technology	-1.8996	-0.59262
	(0.12094) n.s.	*(0.06678)****
Geographic Region 01	0.20701	0.20871
	(0.3669) n.s.	*(0.24212)n.s.*
Geographic Region 02	-0.41645	-0.35308
	(0.4449) n.s.	*(0.24212) n.s.*
Geographic Region 03	-0.23408	-0.03062
	(0.40810) n.s.	*(0.19132) n.s.*
Geographic Region 04	-0.43930	-0.18950
	(0.36440) n.s.	*(0.16856) n.s.*
Constante	-5.53856	-2.8785
	*(0.418730)****	*(0.19773)****
N. Observations	13,948	13,948
Pseudo R^2	0.2297	0.0316
Log pseudo-likelihood	-1467.9428	-3861.7715

The pseudo R^2, obtained by comparing the maximum likelihood function of the complete model with the maximum likelihood of the model with only the intercept, was 22.97% in the

fiscal incentives model and 3.16% in the financial support model, indicating a moderate degree of explanation of the model and compatible with the goals of the model adjustment.

In both cases, the probit models presented in table 6 shows a significant and positive impact for the variables size and market share. The variable export firm has a positive impact in the probability to firm participate of fiscal incentives program, and the variable foreign capital has a positive impact in the probability to firm participate of financial support. The non-significance of some classes for region of localization shows that they do not differ among them with respect to the probability of participating in the financing program.

The post-matching test presented in table 7 shows that the R&D expenditure variable has a relevant contribution to the two programs for remaining significant in relation to the t test before the matching. The expenditures on R&D (ER&D) and innovative activities (EIA) of beneficiary firms remain superior to the expenditures on R&D of the non-beneficiary through the programs after the matching.

The results of the two models as regards the behavior of the ER&D, EIA, ER&D/NRS and EIA/NRS variables are presented in table 7. The results show that all the differences of these four innovation variables remain significant after the matching. The beneficiary firms of the fiscal incentives and financial support present the biggest median difference in relation to the group of twin firms, but which had not participated of the program.

Table 7. *Post-Matching*: Test *t* for Comparison Averages of the R&D Expenditures and Innovative Activities Expenditures(R$ a thousand) of the Beneficiary Firms by programs –PINTEC 2008

Programs		**Average Difference**	**Signif.**	**No Benefic.**	**Benefic.**
Fiscal Incentives	Expenditure on R&D (ER&D)	14,994	**	6,118	21,112
	Expenditure on Innovative Activities (EIA)	20,867	**	16,926	37,793
	Expenditure on R&D / NRS (ER&D/NRS)	0.058	**	0.005	0.063
	Expenditure on Innovative Activities /NRS (EIA/NRS)	0.095	*	0.050	0.145
	Number of Firms			*426*	*426*
Financial Support	Expenditure on R&D (ER&D)	4,716	**	792	5,508
	Expenditure on Innovative Activities (EIA)	11,110	***	3,029	14,139
	Expenditure on R&D / NRS (ER&D/NRS)	0.041	***	0.004	0.045
	Expenditure on Innovative Activities /NRS (EIA/NRS)	0.179	***	0.052	0.231
	Number of Firms			*1,157*	*1,157*

Source: PINTEC (2010). *** Significant at 1%; **Significant at 5%; * Significant at 10%; *ns.* Non-significant.

In conclusion, the public programs evaluated increase the innovative effort of Brazilian firms.[2] For expenditure on R&D (ER&D), expenditure on innovative activities (EIA) and ER&D/NRS, the fiscal incentives increase more the innovative efforts of the firm than the financial support program. However, the financial support program generates a higher EIA/NRS compared with the fiscal incentive impact.

In general, the impact of the fiscal incentives shows superiority to the impact generated by the financial support. A possible explanation for this result could be that the first one is a tax incentive program whose profile of participant firms is concentrated in firms that are already innovative, and for being an ex-post benefit, which is well argued in international literature.

[2]In this empirical study we also applied others matching estimators, such as: Kernel, Mahalanobis and Caliper estimators. The results obtained with theses estimators are consistent with the Nearest Neighbor estimator.

Differently, the financial support programscan finance new innovative firms who are still initiating their R&D activities, which could subestimate the measurement of the immediate results of this program as regards the technological behavior of these beneficiary firms.

6 Concluding remarks

Many studies concentrated to measure the effects of public support on business R&D have been realized and the empirical literature continues to increase. Some of these studies usually apply quasi-experimental (propensity score matching) to comparing the behavior of beneficiary firms in relation to non-beneficiary firms.The practice of evaluation the impact of public support to private R&D expenditures in Brazil is still an initial stage, but the institutions responsible for R&D planning and management were established this practice.

According to what has been exposed, it can be concluded that the government policies of promotion to innovation in Brazil are stimulating changes in the behavior of the firms as regards expenditure on R&D and innovative activities, because in the cases evaluated, the effect of the public support is positive, increasing the innovative effort. However, the fiscal incentive impact is higher than the financial support. A possible explanation for this result is that the first is a tax incentive program, an ex-post benefit, and the target is innovative firms.

It can also be concluded that the type of instrument is important, mainly for dealing with heterogeneous target public and temporality. Therefore, the effectiveness of the innovation program depends on the financing mechanism used and on the characteristics of the target beneficiaries. In Brazil case the empirical evidences show that if the country wants to deep the intensity of the innovative effort of the previously innovative firms, it's appropriate applied fiscal incentives. And if the public policies want to enlarge the base of innovative firms, increasing the number of innovative firms, the financial support to R&D, to buy machines and equipment, software and training, could be more appropriate.

The next step of this research is to evaluate other financing programs of innovative activities to Brazilian firms (scholarship for researchers in firms, venture capital, for example) using new methodologies, to bring new contributions regarding the effects of innovative public policies in Brazil.

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