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THE IMPACT OF UNIVERSITY ENTERPRISE INCENTIVE PROGRAM ON THE PERFORMANCE AND TECHNOLOGICAL EFFORTS OF BRAZILIAN INDUSTRIAL FIRMS

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The Impact of University Enterprise Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms

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ABSTRACT

This study is an unprecedented effort in Brazil to evaluate the effectiveness of public incentive programs to develop technological capacity of firms. There are currently no empirical evaluations that have explored the impacts of this type of program on the performance of the Brazilian industrial firms in greater depth, particularly for those beneficiaries of these programs. This study therefore evaluates the FNDCT's impact, particularly its cooperative modality, which comprises a joint university-enterprise project for technological innovation. The results indicate that the FNDCT has positive impacts on private R&D expenditures of beneficiary firms. This rejects the hypothesis of crowding out and strengthens the hypothesis of the existence of crowding in between public and private funds. The results on the economic performance of beneficiary firms are, however, inconclusive.

INTRODUCTION

The purpose of this study, which is unprecedented in Brazil, is to evaluate the impact of the country's public science and technology support programs. It especially seeks to assess the impact of the Scientific and Technological Development Fund (FNDCT) that is administered by the Research and Projects Financing Agency (FINEP). FNDCT is a non-reimbursable scientific and technological research support fund to stimulate partnerships between universities and enterprises created in 1999.

To carry out this study, we used a integrated database from the Institute for Applied Economics Research (IPEA). IPEA's[1] database combines information from: i) Annual Industrial Survey (PIA) and Technological Innovation Survey (PINTEC), both from the National Census Bureau (IBGE); ii) Annual Social Information Report (RAIS) of the Ministry of Labor (MTE); iii) data of Foreign Trade from Foreign Trade Secretary (SECEX) of the Ministry of Industrial Development and Foreign Trade (MDIC); iv) the Census of Foreign Capitals in Brazil, from Central Bank (BACEN); v) patent data from National Institute of Industrial Property (INPI)..[2]

The database is a sample of approximately 80,000 industrial firms with over 10 employees and five million workers. These firms are responsible for approximately 95 % of the value added in the Brazilian industry. The analysis covers an eight-year period, from 1996 to 2003. With FINEP's collaboration, it was possible to identify the beneficiary firms of the FNDCT-Cooperative from 2000 to 2005 and to conduct the evaluation of the program.

The indicators of technological innovations and expenditures in research and development (R&D) for Brazilian firms are relatively lower than those of developed countries, and even lower than those of other emerging countries. One of the major obstacles to innovatiion technology, in Brazil as well in other countries, is the high cost and risks that are characteristic of innovation projects, combined with the scarcity of adequate financing sources for these projects[3].

[1] Details about this data base may be found in De Negri (2003)

[2] IPEA does not have physical ownership of the information used in this study, which was only possible thanks to the partnerships established between IPEA, IBGE, MTE, Bacen, MPO, SECEX/MDIC and FINEP. Access to information necessary for this study rigorously followed the procedures that guarantee the secrecy of restricted information.

[3] Data from PINTEC indicate three main obstacles, according to the firms, to the realization of technological innovations. They are in order of importance: 1. the projects' economic risk, 2. high costs 3. exhaustion of funding sources.

However, programs for financing scientific and technological development have the potential to significantly increase technological efforts and consequently, the country's level and rate of innovation.

This study looks for answers to some specific questions. First of all, what is the effect of the program on the technological strength of the beneficiaries? In particular, the study seeks to discern whether the program's existence stimulates or discourages private investments in R&D, which are called effects of crowding in and crowding out in international literature. Second of all, the study seeks to estimate whether the program has a significant impact on the firm's economic performance.

Brazilian legislation does not permit the allocation of non-reimbursable funds, such as those from FNDCT, to private firms. It is possible, however, for these companies to participate in the program if they join with universities and research centers, in what are called cooperative projects. Therefore, for the purposes of this study, we will evaluate this cooperative scheme, which is characterized by the funding of projects executed by universities and research centers together with public or private firms.

The study is organized as follows. The next section presents the history of the FNDCT and its main characteristics, in terms of target public and fundable projects. Section 3 shows the database and methodology used in order to perform the evaluation. Section 4 seeks to characterize the beneficiaries and evaluate the scope of the FNDCT cooperative. The results of the evaluation of the program's impacts on both R&D expenditures and performance of industrial firms are in section 5. Finally, section 6 presents the main conclusions.

I. THE FNDCT [4]

The National Fund for Scientific and Technological Development (FNDCT) was created by the Brazilian government in 1969, with the objective of financing national scientific and technological research. Ever since its creation, the fund was administered by the Studies and Projects Financing Agency (FINEP), a public institution linked to the Ministry of Science and Technology (MCT). Its resources are budgetary, fiscal incentives, donations and loans, mainly from multilateral institutions such as the Interamerican Development Bank (IDB).

The establishment of the FNDCT was a major step forward in the creation of science and technology incentive policies in Brazil, by granting "financial autonomy to the national science and technology system by giving it actual budgetary resources and outside loans" (Pereira, 2005). One of the main criticisms to the Brazilian science and technology funding system is the instability and lack of continuity of available resources that are effectively allocated to FNDCT, which is highly dependent on budgetary sources (Bastos, 2003 and Pereira, 2005). It turns difficult to make long-term plans for scientific and technological research. During the 80s and 90s the program´s fiscal constrains worsened. According to Bastos (2003) "the fiscal restriction not only affected the supply of resources from the Treasury, it also affected external loans, due to the requirements of the local counterpart."

Based on the conclusion that the instability of resources was one of the biggest funding problems for science and technology in Brazil, an attempt was made to obtain funding for FNDCT through a special tax, and by linking this with S&T expenditures that were not subject to the legal restrictions of this type of association. This was the logic behind the creation of sectoral funds, whose resources would be allocated through the FNDCT and managed by FINEP. The first experience with this was CTPetro, whose sources came from petrol royalties.

According to the Ministry of Science and Technology (MCT), the objective of sectoral funds is to "guarantee the increase and stability of funding for science and technology." In addition, it aims at strengthening partnerships between universities, research centers and the Brazilian enterprises, "to encourage private investments in S&T and to stimulate technological involvement in the relevant sectors."

[4] This section is mainly based on Bastos (2003) and Pereira (2005).

The main operational characteristics of the Sectoral Funds (SF's) are[5]: 1) linking of revenues, in other words, the resources cannot be transferred between funds; 2) pluri-annuity, the duration of the projects being supported can be longer than one fiscal exercise; 3) shared management between representatives of ministries, regulatory agencies, and the scientific and business communities; 4) diversification of funding sources; 5) stimulation of knowledge chains, that is, resources may be used to support projects directed to the entire chain of knowledge, starting with basic science and going all the way to areas that are more directly linked to the productive sector.

There are hence different actions that may be financed by the funds, such as: i) research and technological development projects; ii) scholarships for capacity building, together with research and development projects; iii) events, congresses, workshops, etc., that contribute to the definition of policies, market analyses, knowledge transfer, technology evaluation, and establishment of partnerships and alliances; iv) studies on the necessities and prognoses of opportunities, carried out as needed.

The box below presents a synthesis of all the Sectoral Funds that exist at present, their funding sources and respective regulation data:

Box 1: Sectoral Funds, regulation data and funding sources

Fund	Date of regulation	Source of funds
Petroleum	30/11/1998	25% of the royalties that exceed 5% of the petrol and natural gas production
Information Technology	20/04/2001	Minimum of 0.5% of companies' turnover benefited by the TI Law
Infra-structure	26/04/2001	20% of the resources of each sectoral fund
Energy	16/07/2001	0.75% to 1% gross income from concessions
Mineral	16/07/2001	2% of financial compensation (Cfem) pays for firms with access to minerals
Water	19/07/2001	4% of the financial compensation used for power generators
Space	12/09/2001	25% of income used for orbital positions; total income from licenses e authorizations from the Brazilian Space Agency
Health	25/02/2002	17.5% from CIDE*
Biotechnology	07/03/2002	7.5% from CIDE
Agribusiness	12/03/2002	17.5% from CIDE
Aeronautic	02/04/2002	7.5% from CIDE

[5] idem

Fund	Date of regulation	Source of funds
Yellow Green Fund	11/04/2002	50% from CIDE, 43% from the income from IPI stemming from products benefited by the TI Law
Transportation	06/08/2002	10% of the income from the National Transport Infrastructure Department (contracts for the use of ground transport infrastructure)
Amazon	01/10/2002	Minimum of 0.5% computer firms' turnover in the Manaus Duty-free Zone
Telecommunications	30/01/2001	0,5% of the net income of telecommunications companies and 1% of gross income related to phone calls events.
Naval	22/10/2004	3% of tax collection for the renewal of Merchant Navy (AFRMM).

*Source: Adapted from Pereira (2005). "Fundos Setoriais: Avaliação das estratégias de implementação e gestão".("Sectoral Funds, Evaluation of implementation and management strategies.") TD n. 1136, IPEA. *CIDE (Tax on fuel consumption).*

Of the SFs listed above, two have horizontal characteristics and are not strictly linked to a single productive sector or region (as is the case with Amazon Sectoral Fund). One of them is the Infra-structure Fund mainly directed to academic research and the improvement of the research support infrastructure. The second horizontal fund is the Green Yellow Fund, which is particularly important within the framework of this study because it stimulates the implementation of cooperative research projects between universities, research centers and enterprises as well as the increase in firms' R&D expenditures.

The main beneficiaries of FNDCT resources were traditionally universities and research institutions, while funding for firms was always provided by FINEP's own sources (Bastos, 2003). The fact that the productive sector was neglected was frequent criticism of the S&T policies in Brazil. In this sense, the SFs are the sign of a new trend in traditional funding mechanisms towards stimulating interactions between companies, universities and research centers. Pereira (2005) emphasizes that the "Brazilian legal framework does not open the possibility of supporting firms with non-reimbursable resources for the implementation of ST&I activities. He also states:

> *"The SFs were introduced with the perspective of adopting a new rationale for financing ST&I that breaks with the hegemony of academia and encourages the Innovation System (…) with the process of innovation being more focused to firms' in-house research. There is a clear leaning towards developing processes and products that may be potentially competitive on the market, as shown in the passages in its*

directives, and in the type of research that is being proposed for funding." (Pereira, 2005).

The SFs therefore anticipate the participation of private firms, especially through so-called cooperative projects, in which public and private companies can combine efforts in research projects that are implemented by universities and public or private non-profit research institutions. These institutions are the intermediaries between the firms and FINEP to carry out R&D projects funded by the FNDCT cooperative. The companies, on the other hand, provide the private funds to complement the program's non-reimbursed funds. Usually, the amount of the private and non-reimbursed funds is equivalent[6].

Since the SFs were created in 1999, over R$2.3 billion were disbursed in non-reimbursable form to finance projects to universities and non-profit research centers, with or without the participation of companies (Table 1).

Table 1. Sectoral funds – amount disbursed between 1999 and 2005*

Year	Current Amounts (R$)
1999 (1)	37,240,000
2000	134,411,665
2001	315,993,601
2002	315,447,090
2003	564,261,623
2004	593,971,911
2005 (2)	403,119,664

Source: MCT- http://www.mct.gov.br/fontes/fundos/Recursos/Recursos_Default.htm. (access on 25/01/06). (1) in 1999, only Petroleum Fund was operational. (2) until November.

With few exceptions, still no evaluation has been done on cooperation projects between universities and enterprises (the so-called cooperative projects) where these resources are effectively applied. Pereira (2005) sought to evaluate the participation of firms in three of the sectoral funds, Petroleum, Green Yellow and Energy Fund. His conclusions indicate that there is considerable participation on behalf of the private sector in the Sectoral Funds (SFs), although it is still quite small, given the funds' sizeable objectives.

[6] See Table 1 in the next section.

Along similar lines, absolutely nothing is known about the effect of cooperative projects on the technological and economic performance of firms that participate in these projects. Thus, the objective of the next sections will be to evaluate the importance of cooperative projects within the FNCDT, and their impact on the economic and especially technological performance of participating firms.

II. DATA AND METHODOLOGY

One of the reasons for the lack of evaluation work on public policies to finance private R&D, specifically on FNDCT, is possibly the dearth of information that could be used to compare firms that receive support from the program to those that don't. To conduct this study, however, we worked with the special database of the Institute for Applied Economics Research (IPEA) which integrates five different original databases, as said before.

A. Database

The main databases are the Annual Industrial Survey (PIA) and the Technological Innovation Survey (PINTEC). PIA provides data by sector of activity on output and expenditure of Brazilian industrial firms and it is available since 1996 until 2003. PINTEC is survey that collect information on technological innovations of the Brazilian industrial firms. It follows the Community Innovation Survey model (CIS) and contains information such as: a) characterization of the firms' innovative efforts (expenditures for internal and external R&D, acquisition of R&D, if these expenditures are occasional or recurrent, whether the firm has an R&D department, the number and qualification of the individuals working in R&D, etc); b) if the firm has introduced technological innovations on the market; c) what are the sources of information used for introducing the innovations; d) what are the funding sources for the innovations, etc. Information available from PINTEC and PIA will be merged with the other databases having the firm as the common information link.

Other database that deserves description is the Annual Social Information Report (RAIS). This database contains information related to the profile of the labor force that works in the firms: age, gender, level of education, how long employed by the firm, when recruited and when left, remuneration, position within the firm. The information covers the period from 1996 to 2003, also on an annual basis.

The set of information that integrates all these databases should provide a rather complete profile of the Brazilian industrial firms. With the possibility of integrating these databases using a code that identifies each firm, it is possible to know whether a specific firm is innovative; the amount of its expenditures for R&D; its expenditures, and output structure and profitability; whether it is foreign or national; if it has registered a patent; how it finances its innovation-related activities; if it cooperates with other institutions to introduce an innovation; the profile of its workers, etc.

The database is a sample of approximately 80,000 industrial firms with over 10 employees and five million workers. These firms are responsible for approximately 95 % of the value added in the Brazilian industry. The analysis covers an eight-year period, from 1996 to 2003. With FINEP's collaboration, it was possible to identify the firms that were beneficiaries of FNDCT from 2000 until 2005, and to perform the evaluation of the program.

B. Methodological Procedures

The empirical analysis of this structure of data requires micro-econometric tools capable of eliminating some problems related to the evaluation of public policies. These methods seek to evaluate if the performance of the beneficiaries or policy participants is better than it would be without public incentives.

This question brings to the forefront one of the principal methodological problems in the evaluation of public policies, of which technological development incentive programs are a part. In order to measure the impact of these programs, the evaluator should know what would have happened to the beneficiaries if they had not had access to the program. The evaluator can only observe the performance of non-beneficiaries compared to that of beneficiaries. However, the performance of the beneficiaries, in the case that they had not had access to the program is a non-observed variable for the evaluator, just as the performance of the non-beneficiaries is not observed in the case they had had access to the program.

The treatment to which a group of companies is subjected is the actual participation in the technological program. We can formally call Y_{i1} the outcome variable (economic or technological performance for example) with the treatment, and Y_{i0} the outcome without the treatment. It is not possible that the individuals evaluated belong to the two groups simultaneously, therefore it is not possible to observe both results Y_{i0} and Y_{i1} for the same individual *i*. Hence, the problem that we encounter in the evaluation is related to missing data (Wooldridge, 2002).

The principal methodological question consists of constructing an adequate counterfactual for evaluating the program's impact (Klette *et al*, 2000; Arvanitis, 2002). Arvanitis (2002) lists a series of problems that could make the construction of this counterfactual difficult.

First of all, given the policy's explicit objectives, the evaluator needs to know whether it will influence the companies' results directly or indirectly, through another economic variable (for example, if public research complements private investments in R&D, therefore improving the companies' performance by stimulating private investment). In addition, the evaluator must be able to identify other determining factors, besides public policy, for the performance variable being evaluated. In other words, it is necessary to construct a vector (X_i) of explanatory variables that are theoretically relevant to explain the firm's performance, as well as a policy variable (P_i) that will distinguish beneficiaries from non-beneficiaries.

Formally, we have:

$$Y_i = \alpha_i + \beta_{0i}(X_i) + \beta_{1i}P_i + \mu_i \qquad (1)$$

where: Y_i is an outcome variable that should be positively affected by the public policy; X_i is a vector of explanatory variables that are theoretically relevant in determining the outcome; P_i is a variable of the policy that discriminates between participants and non-participants and μ_i is the error term.

Second of all, Arvanitis (2002) refers to the existence of positive externalities, which are not taken into account by the evaluator. This problem indicates that it is possible that the program's non-participating firms are being benefited by the spillover effects resulting from the program's participants, which could cause the estimated effects of the program to be underestimated.

Finally, the third and most serious problem has to do with selection bias: "since neither the firms receiving support, nor those not applying for government-sponsored projects can be considered random draws, the construction of a valid control group is a challenging task to be performed by the evaluator". The relevant issue is that, to analyze the impact of the program by a simple comparison between beneficiaries and non-beneficiaries, both groups must be chosen randomly from the universe of the companies. In the absence of randomness, it becomes more difficult to construct a valid control group.

This randomness of access to technological programs is not feasible, neither for the companies that require public support nor for the agencies responsible for granting the funding[7]. With regard to the firms, it is possible that only the most technologically suitable, or those more inclined to make greater technological

[7] Busom (2000) discusses the determining factors for firms that seek public support as well as the decision of financing agencies to grant funding.

efforts, seek government support for realizing technological projects. For the funding agencies, there are possibly a series of prerequisites for the companies before they can take part in the program.

According to Blundell and Costa Dias (2000), "an individual's participation decision is probably based on personal characteristics that may well affect the outcome Y as well". If this is true, there should be some correlation between the participation in the policy variable (P) and the error term. To summarize, the variable P_i, which identifies the participants and non-participants in the policy, is not a random variable, contradicting one of the prerequisites of the ordinary least squares (OLS) models. That is the reason why these models generate biased estimates in the parameters of the equation (Hussinger, 2003).

Busom (2000) adds another problem that is in a way closely related to selection bias: the problem of the endogeneity of public funding. This problem stems from the fact that for most of the financing agencies, the decision to grant funding may be based on certain performance indicators for firms that are also, possibly, the firms' own performance indicators, which will be evaluated later to determine the effectiveness of the programs. Funding would therefore be granted on a priority basis, for example, to more productive firms, which would make the evaluation of the impact of the funding on the productivity of these firms later on much more difficult. In this way, once again, there will be a correlation between the P_i variable and the error term, due to the non-randomness of the participation in the policy. The firm's participation in a given policy would actually be a function of a vector of variables related to the determinants of those seeking to participate in the program, on the part of the firms, and the determinants of the funding grant, on the part of the funding agencies.

There are different methods available for correcting problems related to the evaluation of the impact of public funding programs, especially selection problems. According to Blundell and Costa Dias (2000) "the appropriate methodology for non-experimental data depends on three factors: the type of information available to the researcher, the underlying model and the parameter of interest". In this sense, the range and quality of available information play an essential role in the selection of adequate models. Longitudinal data allow less restrictive models to be applied, due to the existence of information from the same company at distinct moments in time, in other words, before and after participating in the program.

As we have these two kinds of databases, we will use various different methods in order to perform the evaluation. Related to the impact of FNDCT in technological efforts of beneficiary firms, the database used will be the

Technological Innovation Survey (PINTEC) of 2000, which is a cross section database. Thus, the methods applied will be the Propensity Score Matching and a Selection Model. Regarding to the impact of the program over productivity and growth of beneficiary firms, the difference-in-difference method will be applied to longitudinal data of the Annual Industrial Survey (PIA). The methods will be detailed as follow.

C. Propensity Score Matching

One of the methods commonly used to analyze the impact of public policies is propensity score matching (PSM). The quasi-natural experiments generally use this technique, which is also largely used to evaluate social programs[8].

The main objective of PSM is to perform counterfactual evaluations to respond what would have happened if those that did not receive a given treatment had received it. In other words, 'what is the mean treatment effect'? In case the distribution of the treatment was random within a given sample (for example if the experiment were natural), this question would have a simple answer: it would suffice to test the difference in the means of the variable that is supposedly impacted by the treatment for case groups (consisting of those receiving the treatment) and control groups (composed of those who are not receiving the treatment)".

The PSM technique is actually a probabilistic model that seeks to correct the fact that the distribution of the treatment group is not random, as it constructs control groups based on the probability that the firm has received the treatment. In this case, the probability that the firm has received the treatment is estimated using a probabilistic model with independent variables selected in accordance with theoretical assumptions.

According to the procedures in the literature, PSM does a matching of the estimated probabilities of each individual. This matching considers two types of individuals: one that receives the treatment and one that does not. Consider *i* the individual that received the treatment and $\hat{p}_i(X)$ its probability of receiving the treatment. Consider *j* the individual that does not receive the treatment and $\hat{p}_j(X)$ its probability of receiving the treatment. If within a small radius based on $\hat{p}_i(X)$ there is at least one $\hat{p}_j(X)$, i and j, they will form a pair of treatment-control individuals.

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[8] Meyer (1995) provides a good description of the procedures for natural and quasi-experiments in economics and Wooldridge (2002) describes the mean treatment effect.

So, one of the econometric procedures that will be used in this study consists to find a control group using propensity score matching, following the same procedures described in Aerts and Czernitski (2004). After that, a test of difference between two means will be implemented, comparing the two groups of firms: beneficiaries and control group. The steps are the followings:

- Linking information from FINEP about firms that received support of FNDCT, with information from the other available databases.
- Establishing and estimating a probabilistic model to obtain the estimated probability of whether or not the firm might be a beneficiary of the program from 2000 to 2003.
- Based on estimated probabilities, calculating the Mahalanobis distance between each of the beneficiary firms and all the non-beneficiary firms.
- Choosing the non-beneficiary that is closest to each beneficiary firm, in order to get the best control group possible.
- The previous steps were carried out using the whole sample of industrial firms and two sub-samples, of innovative industrial firms and of industrial firms with positive R&D spending.
- This set of beneficiary firms would thus have three control groups, one consisting of a complete sample, another would be a sample of innovating firms and a third would be a sample of firms with R&D spending. These would be the three counterfactuals used in the next step. In each sub-sample, the restrictions of either being innovative or having positive R&D spending will be applied also to the beneficiaries firms in order to avoid that control group be more innovative that the treatment one.
- Establishing a t-test between the averages of these groups for variables such as R&D expenditures, productivity and size of the firms in 2003.

D. Difference-in-Differences Model

The difference-in-differences method is also widely used in the evaluation of the impact of public policies, specifically incentive policies (subsidies) to R&D. Contrary to "two step selection model", which is more useful in cross-section data but could also be used satisfactorily with longitudinal data, this method can only be used for the latter (longitudinal data).

Also known as a natural experiment, this method, according to Blundell and Costa Dias (2000) "typically considers the policy reform itself as an experiment and tries to find a naturally occurring comparison group that can mimic the properties of the control group in the properly designed experimental context".

The method consists of evaluating changes in the average behavior or performance of the individuals "treated" before and after the policy being evaluated, and comparing these changes with those on the control group. So, the first step of this procedure is to apply the PSM in order to get a control group for the participants firms.

According to Arvanitis (2002), for empirical procedures that use panel data, this estimator, constructed based on temporal change of the differences between beneficiary and non-beneficiary firms, is one of the most widely adopted procedures. "Under certain conditions, this approach can be used to recover the average effect of the programme on those individuals who entered into the programme (…) thus measuring the *average effect of the treatment on the treated*[9]" (our italics). This way, the method manages to remove the individual non-observable effects.

Formally, the coefficient that it will measure, in this case, the impact of the policy, is δ_1 and could be defined as:

$$\delta_1 = (\overline{Y}_{1t} - \overline{Y}_{1t-1}) - (\overline{Y}_{0t} - \overline{Y}_{0t-1}) \qquad (2)$$

where $\overline{Y}_{0t-1}$ is the sample mean of the outcome variable resulting from the first year for non-beneficiaries, and $\overline{Y}_{0t}$ is the same mean for the non-beneficiaries (control group) the second year. $\overline{Y}_{1t-1}$ and $\overline{Y}_{1t}$ are defined in a similar way for the treatment group. This method does nothing more than expurgate the temporal effects caused by non-observable variables.

This method would get around the problem of the lack of information on the beneficiaries in case they would not have received the treatment. To estimate this effect, the method starts out with the supposition that once a set of the firms' characteristics that can influence its outcome variable (like productivity or size) is controlled, the value of this variable for the firms of the comparison group are the same as that the treated firms would have had if they had not been treated.

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[9] Also see Wooldridge (2002).

One of the method's disadvantages is that it adopts two important and rather restrictive hypotheses: i) that the temporal effects are the same for the two groups (treated and non treated); and ii) that there are no changes in the composition of the two groups.

E. Two-Step Selection Models

This type of model, inspired in Heckman (1979) is more adequate for cross-section data and consists of estimating, in the first stage, the likelihood that the firm is participating in a given program. In the second stage, an outcome equation will be estimated with the selection bias correction.

Formally, the first step would estimate, using a Probit model, the following equation:

$$P_i = \gamma Z_i + \varepsilon_i \ , \qquad (3)$$

This is the ***selection equation***, where P_i is the observed variable that says whether a firm is participating in the funding program or not and Z_i is a vector of relevant explanatory variables.

Busom (2000) lists some determining factors for access to R&D funding programs, such as the size of the firm, origin of capital, external and technological performance, among others. With regard to the determining factors for the funding agency as to whether to grant the funding or not, this depends greatly upon each program's specific characteristics. To illustrate this point, Busom mentions some possible determining factors, such as the sector in which the firm operates, the existence of major or minor positive externalities resulting from the investment in a specific project, the size of the company, etc.

Based on equation (3), estimates of the inverse Mill's ratio will be obtained for each individual from the sample as shown by:

$$\lambda_{i1}(Z_i\gamma) = \frac{\phi(Z_i\gamma)}{\Phi(Z_i\gamma)} \text{ for the firms participating in the program and} \qquad (4)$$

$$\lambda_{i0}(Z_i\gamma) = -\frac{\phi(Z_i\gamma)}{1-\Phi(Z_i\gamma)} \text{ for non-participating firms;} \qquad (5)$$

where $\phi(.)$ is the density function and $\Phi(.)$ is the cumulative distribution function of the standard normal distribution N(0, 1) .

The inverse Mill's ratio is an instrument that will be used to correct the selection bias in the second stage, which consists of estimating the objective equations (6) and (7) through the ordinary least squares (OLS) model for all the sample and for the group of participants and non-participants separately (Jarmin, 1999 and Busom, 2000). The equations are:

$$Y_{ik} = \alpha_k + \beta_k X_{ik} + \lambda_{ik}(Z_i \gamma) + \mu_{ik} \quad (6)$$

$$Y_{ik} = \alpha_k + \delta_{ik} P_{ik} + \beta_k X_{ik} + \lambda_{ik}(Z_i \gamma) + \mu_{ik} \quad (7)$$

Equation (6) is the ***treatment equation*** that will be estimated for each group (beneficiaries and non-beneficiaries) separately and equation (7) will be the ***treatment equation*** estimated for whole sample. In both equations, k = 0 for non-participants and k = 1 for the firms that participate in the program; X_{ik} is a vector of explanatory variables; $\lambda_{ik}(Z_i \gamma)$ is the Mill´s inverse ratio and P_{ik} is the dummy variable for firms that participate in the program.

The existence of selection bias can, therefore, be corrected and tested based on the statistical significance of the term λ in equations (6) and (7). After estimating the treatment equations, it is necessary to estimate the Average Treatment Effects (ATE).

There are at least two ways of estimating ATE. One of them can be found in Busom (2000). The author seeks to evaluate the effect of the R&D subsidy on the actual R&D effort of beneficiary firms, in order to estimate the effects of crowding in and crowding out. What this paper seeks to do is very similar. The procedure consists of estimating equation 6 for the two groups of firms (participants and non-participants in the subsidy policy) separately, using the firms' R&D expenditures (or productivity) as a dependent variable. After that, we compare the predict value of dependent variable (R&D expenditure or productivity) for participating firms ($Y_1^{predict} = E\{Y_1 \mid P = 1\}$) with their potential outcome, which are those predict using the coefficients estimated for the non-participants ($Y_1^{potential} = E\{Y_1 \mid P = 0\}$). The $Y_1^{potential}$ constitutes the policy's necessary counterfactual, and the comparison with the predict expenditures would measure the impact of the policy on the firms' R&D efforts. Formally, the ATE based on equation (6) will be:

$$ATE1 = Y_1^{predict} - Y_1^{potential} = E\{Y_1 \mid P = 1\} - E\{Y_1 \mid P = 0\} \text{ or} \quad (8)$$

$$ATE1 = X_1\beta_1 - X_1\beta_0 \quad (9)$$

where β_1 is the vector of estimated coefficients for participating firms; β_0 are the estimated coefficients for non-participating firms and X_1 are the regressors of participating firms[10]. The treatment effects will be estimated only to participating firms, that is, it is the "average treatment effects on treated".

Another way to calculate the average treatment effects is based on equation (7), that is, the treatment equation estimated for the complete sample. In this equation, there will be a dummy variable to identify the participants of the program. The average treatment effect is very similar to the first one. According to Greene (2000, p. 933), it can be estimate as follows:

$$ATE2 = E\{Y_1 \mid P = 1\} - E\{Y_1 \mid P = 0\} \text{ or, in this case} \quad (10)$$

$$ATE2 = \left[\beta_i X_i + \delta + \varphi\left(\frac{\phi(Z_i\gamma)}{\Phi(Z_i\gamma)}\right)\right] - \left[\beta_i X_i + \varphi\left(-\frac{\phi(Z_i\gamma)}{1-\Phi(Z_i\gamma)}\right)\right] \quad (11)$$

$$ATE2 = \delta + \varphi\left[\frac{\phi_i}{\Phi_i(1-\Phi_i)}\right] \quad (12)$$

where δ is the estimated parameter for the dummy variable of program participation (P_i), like in equation (7); φ is the estimated parameter for Mill's inverse ratio (lambda) and the terms $\left(\frac{\phi(Z_i\gamma)}{\Phi(Z_i\gamma)}\right)$ and $\left(-\frac{\phi(Z_i\gamma)}{1-\Phi(Z_i\gamma)}\right)$ are the Mill's inverse ratio for participants and non-participants, respectively. Again, we will calculate the ATE2 only for participating firms, that is, the average treatment effect on treated.

One of the principal advantages of the two step selection models, to correct the selection bias, is the fact that it can be applied in cross-section data. Moreover, it

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[10] The Mill's inverse ratio is one of the regressors. However, in the second term of right side of equation (9), the Lambda that will be used will be that calculated for non-participating firms in equation (5), like in Greene (2000), p. 933.

can demonstrate that the procedure produces asymptotically consistent and non-biased estimates of the regression parameters. Anyway, we always will estimate a simple OLS model in order to provide a benchmark for the results of the selection models.

In general, there can be some overlap between the Probit and regression variables and the model will continue to be identified, once the residuals are normal and the model is correct. However, if vector X (equation 6 and 7) was equal to vector Z (equation 3), there could be a high correlation between inverse Mill's ratio ($\lambda_{ik}(Z_i\gamma)$) and $\beta_k X_{ik}$, which could result in very high standard errors for the estimates of the parameters (Hussinger, 2003).

III. SCOPE OF FNDCT COOPERATIVE[11]

In the FNDCT cooperative, private or public firms (called intermediaries) work together with universities and public or private non-profit research centers in joint research projects. The universities/research centers are the executors of the project, while the firms are responsible for the technical and financial counterpart of the resources disbursed by FINEP.

Between 2000 and October 2005, 356 intermediaries (public or private firms and even public agencies) joined 168 implementing institutions (universities and research centers) in approximately 693 non-reimbursable funding operations, which comprise the study project sample (Table 2). These joint projects include 483 researchers from universities and research centers. The number projects funded was greater than the number of intermediary firms due to the fact that many of the firms benefiting from the program were associated with more than one research institution and/or more than one project. The same holds true for the research institutions.

Table 2. Number of funding operations, institutions and researchers involved and amount of FNDCT funding: 2000- 2005*

Year	Intermediaries (firms)	Research institutions	No. of researchers	No. of operations	Disbursements FINEP (R$)	Private complementary funds (R$)
2000	19	29	67	77	28,790,976	26,296,737
2001	11	24	46	61	36,636,358	20,183,446
2002	140	73	131	183	46,468,896	44,540,208
2003	32	25	33	41	15,589,19	18,043,038
2004	157	97	220	277	103,045,432	101,423,073
2005	39	34	39	54	25,419,375	12,833,494
Total	356	168	483	693	255,950,156	223,319,996

Source: FINEP

Table 2 also shows the volume of resources disbursed by FINEP for a selection of cooperative projects, which amounted to approximately R$ 256 million between 2000 and 2005 (current value). Although this figure does not correspond to the total number of cooperative projects funded by the FINEP, it is an indication of the low participation in projects involving the private sector in the total amount of resources disbursed by the FNDCT (see Table 1). Despite the fact that the creation of the SFs opened a new window of opportunity for the private

[11] The results presented here refer to a sample of projects that are supported by the FNDCT cooperative, selected by invitation letters, specifically from the Petroleum, Green Yellow and Energy Funds. These are the SFs with the greatest participation in the cooperative projects.

sector to participate in S&T financing in Brazil, its participation is still negligible compared to that of academia in these funds. When we speak of FNDCT cooperative projects, we are talking about percentages that are no more than 20% of the total resources of the FNDCT from 2000 to 2005.

In terms of the volume of resources contributed as well as the number of firms benefited, FNDCT has a small role in the R&D expenditures of the Brazilian firms. The Brazilian industrial firms invested R$ 3.7 billion and R$5.1 billion in R&D in 2000 and 2003, respectively.

Also, it is worth noting that among the intermediaries are not only private firms or firms from the productive sector. Among these beneficiaries there are also non-governmental organizations, public research and development foundations, that are connected or not to public universities, and public entities such as ministries or secretariats of state governments etc. In other words, despite the fact that the FNDCT cooperative stimulates partnerships between universities and companies, only part of its beneficiaries are actually companies involved in productive activities (Table 3).

Table 3. Distribution of resources and beneficiaries of the FNDCT cooperative, according to sector of activity: 2000-2005 (in order of value disbursed by FNDCT).

Sector (based on National Classification of Economic Activities)		Participant firms	Value FNDCT (R$*)	Private complementary funds (R$*)
60	Ground transport	1	75,272,095	87,776,967
24	Chemical products	30	34,725,747	24,301,070
75	Public administration, defense and social	26	17,776,245	17,589,630
32	Electronics and communications equipment	4	12,789,388	9,147,388
74	Productive Services to firms	21	12,616,794	9,823,040
91	Associative activities	29	12,395,342	5,587,402
29	Machines and equipment	14	10,838,617	8,318,895
72	Computer activities and related services	25	10,157,337	4,887,023
30	Manufacture of office machines and	8	9,045,982	6,279,675
73	Research and development	8	7,279,881	7,021,968
35	Manufacture of other transport equipment	2	6,158,619	2,400,616
27	Basic metallurgy	9	4,456,204	5,450,411
34	Automotive vehicles, trailers and car bodies	5	3,804,563	2,857,520
31	Electrical machines, instruments and	9	3,646,937	2,354,679
40	Electricity, gas and hot water	13	3,592,079	4,714,967
Other sectors		152	31,394,325	24,808,745
Total		356	255,950,156	223,319,996

*Source: FINEP and RAIS (2000 e 2003). * Amounts are expressed in current values for the year that funding was granted.*

Table 3 shows the distribution of the disbursements of the FNDCT[12] cooperative per sector, as well as the participating institutions/firms. Most of the resources and beneficiaries are concentrated in the sectors of chemicals and public administration. In fact, 26 public institutions, such as ministries or state secretaries participated as intermediaries together with universities and research centers in projects funded by the FNDCT during the period.

Other important sectors are electronics and communications equipment, firm-related services and associative activities, including NGOs and class associations. Thus, it appears that the group of firms that is effectively involved in these projects is still smaller than what one would have imagined based on the data collected. If one just takes the manufacturing industry, out of the 356 participating firms, about 135 are industrial. These 135 firms participated in projects that cost FINEP approximately R$ 97 million out of the R$ 256 million disbursed for this FNDCT cooperative sample. Other important sectors, in terms of number of participant firms, are: i) non-metallic minerals, with 16 participant firms; ii) education (9 firms); iii) food and beverages (9); iv) wholesale; (9) and v) agriculture (8).

Besides this limited reach in manufacturing, there is a high geographical concentration of FNDCT resources in few Brazilian states. In fact, 84% of the firms and 79% of the research institutes that benefit from FNDCT are located in only eight states. This is possibly not a reflection of a policy to stimulate institutions, but rather the actual concentration of scientific and technical research structures in the country.

TABLE 4. Distribution of the research institutions benefited and Participants per state

State	Participant Firms	Research Institutions
São Paulo	19%	21%
Santa Catarina	16%	7%
Rio Grande do Sul	13%	9%
Rio de Janeiro	12%	17%
Minas Gerais	8%	9%
Paraná	5%	6%
Pernanbuco	5%	4%
Bahia	5%	6%

Source: FINEP

[12] This information was obtained from crossing the data base of beneficiaries of FNDCT cooperative with the Social Information Annual Report.

The main states that benefit from the FNDCT cooperative, in terms of the number of participants are Sao Paulo, Santa Catarina, Rio Grande do Sul and Rio de Janeiro. Most of the beneficiary research institutions are located in the states of Sao Paulo, Rio de Janeiro, Minas Gerais and Rio Grande do Sul.

In order to find out what kind of industrial firms had access to cooperative FNDCT, we gather information about the 135 industrial firms that participate in the projects selected using the database described in section 3. By this sample the beneficiaries dropped to 50 firms in the manufacturing industry[13]. Its characteristics, like those of other firms in the manufacturing industry and the two industrial subgroups – innovating firms and firms with positive R&D spending – are described in Table 5.

Table 5. Characteristics of FNDCT beneficiary and non-beneficiary industrial firms: 2003.

Indicators	Beneficiaries of FNDCT	Non-beneficiaries of FNDCT		
		Total	Innovating Firms 1	Firms with R&D spending
	Average	Average	Average	Average
Number of employees	1969	64	99	286
Turnover (R$ 1000)	2,206,840	10,985	22,469	88,955
Labour productivity 2 (R$)	156,230	25,214	30,553	56,246
Employees' schooling (years)	10.1	7.7	8.02	8.75
Stock of patent applications	5.83	0.08	0.15	0.6
Stock of patent applications (per 100 employees)	0.37	0.10	0.13	0.37
Participation of foreign firms (%)	12%	2%	3%	10%
Average Value of Exports (R$ 1000) 3	515,649	1,792	4,021	17,058
Export coefficient3	16.9	17.1	15.9	12.20
Total R&D spending 4 (R$)	23,310,000	50,205	140,022	742,333
R&D share of turnover (%)	4.0%	0.6%	1.6%	8.3%
Private R&D spending 4 (R$)	21,701,195	48,116	134,195	711,443
R&D share of turnover (%)	3.8%	0.6%	1.6%	8.2%

[13] This decrease in the sample was expected as a result of the sample procedures of PINTEC and the fact that this research is a census only for firms with over 500 employees. Another and more important reason is that we are evaluating just the firms that received funds of FNDCT between 2000 and 2003, because this is the last year for which the industrial surveys are available.

Indicators	Beneficiaries of FNDCT	Non-beneficiaries of FNDCT		
		Total	Innovating Firms [1]	Firms with R&D spending
	Average	Average	Average	Average
Share of private resources on total R&D spending	93%	96%	96%	96%
Number of firms (sample)	50	10,466	4,806	1,776
Number of firms (population)	70	83,164	30,127	5,683

Source: IBGE, Directorate of Research, Industrial Coordination, Industrial Research – Technological Innovation Survey **-** *2000. Developed by authors based on the processing of data received from the source and with the incorporation of data from Annual Industrial Survey (IBGE), External Trade Database (SECEX/MDIC), Census of foreign capitals in Brazil (BACEN), Annual Social Information Register (MTE) and FINEP. (1) Innovative firms are those that had some type of innovation between 1998 and 2000 or had incomplete or unfinished innovation projects during this period. (2) Value added by employee. (3) Only for export firms. (4) The total R&D spending include internal R&D and acquisition of external R&D and is divided in private and public resources.*

First of all, the size of the beneficiary firms of FDCT in terms of number of employees is clearly much greater than the average size of Brazilian industrial firms. This differential persists even if we consider the subgroups that are more technologically dynamic in industry, which are the innovating firms and firms that had spent in R&D activities.

The beneficiary firms are also substantially more productive than other firms in the manufacturing industry. The same can be observed for the average value of exports of these firms in 2003. Despite this fact, the export coefficient of beneficiaries is less than that of innovative firms.

Beneficiary firms also have a more educated labor force, as is shown in the length of schooling, which measures the average number of years the firm's workers spent in school.

Lastly, one of the main variables that will be analyzed in the next sections is the firms' technological efforts. In absolute as well as relative terms (such as the proportion of turnover), beneficiary firms clearly make greater technological efforts than non-beneficiaries. These firms spent an average of R$23 million on R&D in 2003, which represents approximately 4% of their turnover. Moreover, the average R&D expenditure of the Brazilian manufacturing industry is approximately R$50 thousands per firm, which is 0.6% of the turnover of these firms. The only exception for this better performance of participant firms regarding the technological efforts is related with the R&D spending as a share of turnover of firms that have positive R&D spending. For these firms, the technological efforts are greater than for participant firms, as proportion of turnover.

Obviously one cannot yet confirm this to be an indication of the program's success in terms of an incentive for private funds in R&D. There is possibly a substantial bias in the selection of beneficiaries of FNDCT insofar as firms that are already innovative and already have considerable technological efforts are the main candidates for R&D incentive programs. In the next section, we will attempt to neutralize the effect of this potential selection bias in order to evaluate the true impacts of the program on the technological efforts of beneficiary firms.

IV. RESULTS

Despite FNDCT's limited scope, an important question is still whether the program stimulates or simply shifts private investments in R&D in firms associated with the projects funded. This is a relevant question in the case of R&D public incentive programs that involve subsidies, despite the fact that the FNDCT requires a financial counterpart for participating, which tends to reduce the possibility of crowding out. To assess whether the FNDCT provokes effects of crowding in or crowding out in the R&D private expenditures, two procedures were used: propensity score matching and a two-stage selection model (both described in sections 3.2 and 3.4). It is worth noting that the beneficiary firms that will be included in this evaluation are those that received the FNDCT between 2000 and 2003. However, we excluded the firms that had access to the program between 2004 and 2005 from the sample of beneficiaries, due to the fact that the most recent information available on expenditures in R&D of Brazilian firms is from 2003[14].

Another set of questions regards to the evolution of some economic indicators of the beneficiary firms, like productivity and growth. That is, the dynamic aspects of firm's performance. The question is whether the participant firms grew more than those who did not participate in the program and whether they show a higher growth rate of productivity. In order to perform this evaluation, the procedure used, based on the Annual Industrial Survey since 1999 until 2003, is the difference-in-difference method (described in section 3.3).

As one can see, we have two different data sets that will be used. One is a cross sectional database (the Innovation survey in 2003) and another is a longitudinal one (the Industrial Survey from 1999 to 2003). Therefore, two selection equations will be estimated in order do construct the control group to participant firms. One of them will be estimated in 1999 in order to do the difference and difference analysis and other selection equation will be estimated in 2003.

A. Propensity Score Matching

The first econometric procedure utilized was to find a control group through propensity score matching, following the same steps described in Aerts and Czernitzki (2004)[15]. The first step in this procedure is to estimate a selection

[14] Even for firms that received funding in 2003, it is possible that the impact of the program has not yet had enough time to manifest itself. Even so, it was decided not to take more of these observations from the sample.
[15] See section 3.2

equation (PROBIT model) for the probability of a firm to participate in FNDCT program. The ***selection equation*** also will be used in the two step selection models next section. The explanatory variables selected for the probabilistic model were:

- i) Size, measured by the logarithm of number of employees in the firm;
- ii) an indicator of the firm's solvency, expressed in dummies CR1 to CR4, which measure the relationship between payments with interest and the firm's turnover. Solvency is one of FINEP's criteria for granting funding;
- iii) The logarithm of firm's age;
- iv) The market share of the firm.
- v) A dummy variable to identify foreign firms;
- vi) A dummy variable to represent export firms. In order to avoid simultaneity between participating in the program and being a export firm, we have used the dummy with a lag of two years.
- vii) The past technological efforts of the firms will be assessed by a dummy variable to identify firms that execute continuous R&D activities.
- viii) Dummies relative to sector – high technology sectors versus low ones – and region where the firm is located.

Table 6 shows the results of the probabilistic models used in propensity score matching to manage the control groups. The signs of the parameters generally concurred with what was expected. Table 3 presents the results of the estimates for the three models: i) the entire sample, ii) only for innovating firms and ii) only for firms that have positive R&D spending.

The models show that size is generally a relevant variable regarding the probability that the firm is a beneficiary of the FNDCT, as the descriptive statistics suggest for beneficiaries and non-beneficiaries. Firms' performance characteristics, such as existence of continuous R&D activities and insertion in the foreign market, also have a significant impact on access to the program, possibly showing evidence of the existence of self-selection in the sample.

TABLE 6. Estimates of the probability that the firm is a beneficiary of FNDCT (probit models): total sample, innovating firms, and firms with R&D spending, 2003.

Explanatory variables	Total sample		Innovative firms		Firms with positive R&D spending	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Intercept	-4.73 ***	0.42	-4.79 ***	0.53	-4.49 ***	0.60
Employees (LOG)	0.16 ***	0.05	0.15 ***	0.05	0.15 ***	0.06
Dummy variable CR1 (first quintile of expenditures with interest/turnover)	-0.28	0.19	-0.28	0.20	-0.25	0.22
Dummy variable CR2 (second quintile of expenditures with interest/ turnover)	0.19	0.15	-0.31	0.22	-0.32	0.23
Dummy variable CR4 (fourth quintile of expenditures with interest/ turnover)	-0.11	0.16	-0.13	0.17	-0.30	0.19
Dummy variable CR5 (fifth quintile of expenditures with interest/ turnover)	0.04	0.14	0.01	0.16	0.00	0.16
Age of firm (LOG)	0.06	0.08	0.08	0.10	0.10	0.11
Market Share	2.03 ***	0.77	2.13 **	0.86	2.07 **	0.88
Foreign firm (dummy variable)	-0.62 ***	0.16	-0.74 ***	0.19	-0.75 ***	0.20
Export firm in 1998 (dummy variable)	0.69 ***	0.14	0.46 ***	0.16	0.43 **	0.17
Continuous R&D (dummy variable)	0.71 ***	0.11	0.74 ***	0.13	0.40 **	0.16
Intensive technology sector (dummy variable)	0.36 ***	0.10	0.50 ***	0.13	0.54 ***	0.14
South or Southeast Region (dummy variable)	0.04	0.12	0.22	0.16	0.18	0.17
Beneficiaries (n / N)	49 /	69	41 /	56	40 /	53
Non-beneficiaries (n / N)	10,237 /	81,371	4,725 /	29,612	1,751 /	5,557
Log likelihood	-346.5		-256.97		-231.87	
R^2	0.39		0.38		0.26	

Source: IBGE, Directorate of Research, Industrial Coordination, Industrial Research – Technological Innovation Survey - 2000. Developed by authors based on the processing of data received from the source and with the incorporation of data from Annual Industrial Survey (IBGE), External Trade Database (SECEX/MDIC), Census of foreign capitals in Brazil (BACEN), Annual Social Information Register (MTE) and FINEP.

Obs. (*), (**), (***): significant variables at 10%, 5% and 1%, respectively. (ns) Non-significant variable. The number of firms (n) refers to the observations in the sample of Innovation Survey and (N) regards the number of observations in the population.

On the other hand, the firm's age, a variable used in different studies as an important factor in the access to funding programs for technological activities, did not appear significant in determining whether or not the firm had access to FNDCT. The same was true for the variables that reflect the firm's degree of debt, which is also an element used in the international literature to explain access to programs that stimulate innovation technology. Since one of the goals of the FNDCT is to finance universities and research centers as project implementers, and not directly as firms, and since it is a non-reimbursable program, the lack of statistical significance of this variable seems to be consistent with the program's profile.

Lastly, foreign companies are less likely to benefit from the FNDCT cooperative. However, if a firm belongs to a high tech sector, it can positively influence its access to the program.

The objective of estimating the model only for innovating firms or firms that have applied for patents was to select control groups based on more homogenous sub-samples of firms. It is reasonable to believe that innovating firms and firms that have already some R&D efforts constitute a group of firms that is different than the industrial mean, which tends to make the results of the procedures more convincing. The next step after the matching procedure is to compare the differences between the groups of firms, the group of FNDCT beneficiaries and the control group, within the total sample and each sub-sample used. The results of these tests appear in Table 7.

Table 7. Test of average differences to selected variables for firms that receive support from FNDCT and the control group. Year 2003.

Variables	Total sample			Innovating firms			Firms with positive R&D spending		
	Control Group	Bene-ficiaries	t value	Control Group	Bene-ficiaries	t value	Control Group	Bene-ficiaries	t value
Turnover (R$ 1000)	275,923	703,829**	-1.84	912,640	821,575	0.18	405,971	774,383	-1.15
Employees	1,183	1,624	-0.89	1,567	1,609	-0.06	1,953	1,372	0.57
Labour productivity[1] (R$)	80,921	132,203**	-2.25	115,678	144,340	-0.80	87,797	156,020**	-2.05
Total R&D spending [2] (R$ 1000)	1,276	3,672**	-2.29	6,935	4,320	0.44	996	4,327***	-2.85
R&D share of turnover (%)	1.12	3.00**	-2.15	0.96	3.67**	-2.57	2.62	3.94	-0.71

Variables	Total sample			Innovating firms			Firms with positive R&D spending		
	Control Group	Bene-ficiaries	t value	Control Group	Bene-ficiaries	t value	Control Group	Bene-ficiaries	t value
Private R&D spending [2] (R$ 1000)	1,252	3,510**	-2.18	4,935	4,121	0.48	848	4,165***	-2.87
R&D share of turnover (%)	1.11	2.74**	-1.99	0.96	3.35**	-2.42	2.41	3.60	-0.66
Number of firms	44	44		35	35		33	33	

Source: IBGE, Directorate of Research, Industrial Coordination, Industrial Research – Technological Innovation Survey - 2000. Developed by authors based on the processing of data received from the source and with the incorporation of data from Annual Industrial Survey (IBGE), External Trade Database (SECEX/MDIC), Census of foreign capitals in Brazil (BACEN), Annual Social Information Register (MTE) and FINEP. (1) Value added by employee. (2) The total R&D spending include internal R&D and acquisition of external R&D and is divided in private and public resources
Obs. (*), (**),(***): significant variables at 10%, 5% and 1%, respectively.

The number of beneficiary firms analyzed dropped from the 49 present in the probabilistic model, to 44 in the difference of means tests in the complete sample, down to 35 in the sub-sample of innovative firms, and 33 in the sub-sample of firms with patents. This decrease occurred due to the difficulty in finding firms that are very similar to the beneficiaries that could form the control group. Thus, firms that are very different from the rest of the industry or the rest of the firms in the two sub-samples constitute a kind of "outlier" and cannot in principle be utilized in the matching procedure.

With regard to the impact of the FNDCT on a firm's R&D expenditures, Table 7 shows that, in absolute terms, the beneficiary firms are significantly different from the control group in the complete sample and in the sample of firms with R&D spending. When we compare the technological efforts of the firms, measured according to their expenditures for R&D as a share of the turnover, the beneficiary firms show technological efforts far superior to firms in the control group in the complete sample and in sub-sample of innovative firms. This is not true, however, in the sub sample of firms that spend in R&D.

With regard to economic performance indicators for firms, such as productivity and turnover, the participant firms are significantly different from the control group in the complete sample and in the sample of firms with R&D spending. Regarding turnover, the difference is only significant in the total sample.

Although the above results suggest that FNDCT has a positive impact on the technological efforts and on productivity of the beneficiaries, it would be hasty to draw any definite conclusion on this, based on a single statistical procedure.

It was thus decided to conduct another methodological procedure to test the impacts of the FNDCT on firms' R&D expenditures. This procedure was a two-stage selection model inspired on Heckman (1979) and used in Busom (2000) and Jarmin (1999). It will be done next section.

B. Selection Models

The first phase of the procedure consisted of estimating the probability that the firm is a participant of the FNDCT. Thus, like in the previous procedure, criteria were adopted to select a more homogeneous sub-sample of firms within Brazilian industry to perform the estimates. In this case, the two-stage selection model would be implemented only for firms whose R&D expenditures are above zero. The first stage consisted of estimating a probabilistic model as to whether a dependent variable is a beneficiary of FNDCT or not. For that, we will use the same probabilistic model estimated in previous section (table 6), however, only for firms with R&D spending greater then zero. Based on the PROBIT, Mill's inverse ratio would be calculated for each firm in the sample, according to the formula described in section 3.4 (equations 4 and 5).

The second phase consisted of estimating two OLS models to explain the firms' R&D expenditures, one of them for beneficiary firms, other for non-beneficiaries and other yet for all firms. Mill's inverse ratio is used as one of the explanatory variables in these models, which are called the ***treatment equations***. This procedure would correct the eventual selection bias observed and the significance of this variable in the model would indicate the existence or inexistence of selection bias.

Table 9 also shows the results of an OLS model that utilizes a dummy variable for FNDCT beneficiary firms. A dependent variable of the three models presented in this table is the logarithm of value of R&D private expenditures of firms in 2003.

The explanatory variables used in the model are very similar to that used in the selection equation. However, in order to avoid identification problems in the equation, some variables must be different in the selection equation (table 6) and in the treatment equation (table 9). Thus, in one hand, in the treatment equation the dummies that will estimate the contribution of the solvency of the firm are not used, even because there is no economic sense in using these variables in the treatment equation. In the other hand, a new variable is used in the treatment equation – the employees' years of schooling, that is a proxy for the labour qualification at the firm and for firm's technology.

Table 9. Regression Models for Logarithm of private expenditures in R&D (only for firms with positive R&D expenditures) - 2003.

Explanatory variables	OLS		Selection models					
			Beneficiaries		Non-beneficiaries		All firms	
	β	t value	β	t value	β	t value	β	t value
Intercept	6.53 ***	0.24	19.83 ***	5.07	6.29 ***	0.33	5.95 ***	0.31
Dummy for Beneficiaries	1.03 ***	0.32	-	-	-	-	5.45 ***	0.80
Employees (LOG)	0.66 ***	0.03	0.2	0.27	0.57 ***	0.03	0.62 ***	0.03
Employees' schooling	0.16 ***	0.02	0.28 **	0.12	0.25 ***	0.02	0.26 ***	0.02
Age of firm (LOG)	-0.03	0.04	-0.25	0.51	-0.04	0.05	-0.03	0.05
Firms with patents (in 2002)	0.18 *	0.10	0.20	0.39	0.18 **	0.08	0.21 ***	0.08
Export company (in 2002)	0.35 ***	0.08	-1.21	0.77	0.11	0.09	0.18 **	0.08
Foreign company	0.25 **	0.11	1.56 *	0.78	0.47 ***	0.10	0.31 ***	0.09
South and Southeast Region	0.23 ***	0.07	-1.33 ***	0.48	0.12	0.07	0.14 ***	0.08
Technology intensive sector	0.55 ***	0.06	-0.66	0.67	0.41 ***	0.08	0.52 ***	0.07
Lambda (Mills inverse ratio)	-	-	-2.89 ***	0.75	-4.91 ***	0.88	-2.10 ***	0.36
F value	223.3		15.5		194.9		190.0	
Adjusted R^2	0.53		0.77		0.50		0.51	
Number of firms	1,785		40		1,745		1,785	

Source: IBGE, Directorate of Research, Industrial Coordination, Industrial Research – Technological Innovation Survey - 2000. Developed by authors based on the processing of data received from the source and with the incorporation of data from Annual Industrial Survey (IBGE), External Trade Database (SECEX/MDIC), Census of foreign capitals in Brazil (BACEN), Annual Social Information Register (MTE) and FINEP.

Obs. (*), (**),(***): significant variables at 10%, 5% and 1%, respectively.

The first relevant consideration regarding the results of Table 9 is that the significance of the lambda parameter shows the existence of selection bias in the sample of participant firms. The set of explanatory variables also demonstrates the expected signs and a great number of them are statistically significant in the two models where the degrees of freedom are greater.

The effects of the treatment that were calculated based on a conventional OLS model and the selection models, are reported in Table 10, which shows that the beneficiary firms have higher R&D expenditures than similar non-beneficiary firms. To estimate the average treatment effect (ATE) we follow the calculation described in section 3.4. The first way to calculate the treatment effect uses the two equations of selection models estimated to participant and non participant firms separately. Therefore, the average treatment effects in this case – that we call ATE1 – is based on equations 8 and 9 (section 3.4). The second approach is to calculate the average treatment effects (ATE2) based on equation estimated to all firms. This calculation follows the procedures described in equations 10 to 12 of section 3.4.

Table 10. Effect of the treatment on firms' private R&D expenditures.

Model	Impact of the FNDCT program	
	ATE	t value
OLS	1.03 ***	3.22
ATE1 - Selection model (beneficiaries X non-beneficiaries)	0.64 ***	5.07
ATE2 - Selection model (all firms)	0.41 ***	2.97

Source: IBGE, Directorate of Research, Industrial Coordination, Industrial Research – Technological Innovation Survey - 2000. Developed by authors based on the processing of data received from the source and with the incorporation of data from Annual Industrial Survey (IBGE), External Trade Database (SECEX/MDIC), Census of foreign capitals in Brazil (BACEN), Annual Social Information Register (MTE) and FINEP.Obs. (*), (**),(***): significant variables at 10%, 5% and 1%, respectively. (ns) Non-significant variable. ATE1 is based on equations 8 and 9; ATE2 is that on equations 10 to 12.

With regard to the impacts of the FNDCT on firms' R&D expenditures, results have been observed that are consistent with those obtained in the previous procedure. In other words, one can observe, also in this procedure, positive and significant effects of the program private R&D expenditures of firms. The treatment effect shows that participant firms spend in R&D something around 50% to 90% more then non-participant firms, in the selection models.

In addition to measuring the effects of FNDCT on firms' R&D expenditures, the objective of this study is also to verify the existence of possible impacts on the firms' economic performance, especially productivity. For this we used, in order to calculate the Mill's inverse ration, the same selection equation expressed in table 6. The difference is that, in the estimate of the treatment equation we use the complete sample and not the sub sample of firms with positive R&D spending.

Table 12 shows the results of the second phase of the procedure: the estimate of the OLS models that use the correction for the eventual selection bias, as well as the estimate of a conventional OLS model for the set of firms that use one binary variable per FNDCT beneficiary firm. The dependent variable, now, is the logarithm of productivity of firms.

Unlike in the case of the two-stage selection model for firms' R&D expenditures, in this model, the lambda parameter, which indicates the existence of selection bias, was not significant. The impact of the program on the productivity of the firms could therefore be an estimated measure of the parameter of the dummy variable for FNDCT beneficiary firms, that is not significant.

The result of the OLS model in Table 12 seems to indicate the program's positive impacts on the productivity of beneficiary firms. However, this estimate cannot be considered statistically significant, which suggests that these results are not conclusive in this regard.

In fact, it may not have even been possible to expect different results than this. First of all because the period of time between the access to the FNDCT and this evaluation is at most three years, and impacts on the firms' productivity would probably take more time before they are felt. Secondly because the program's actual design is not to increase the beneficiaries' productivity, but to stimulate their technological strength in R&D and in the innovation of products and processes. Impacts on productivity would thus be much more indirect and require more time than we have today.

Table 12. Regression Models for estimating determinants of firms' productivity (in logarithm) - 2003.

Explanatory variables	OLS		Selection models					
			Beneficiaries		Non-beneficiaries		All firms	
	β	t value	β	t value	β	t value	β	t value
Intercept	7.54 ***	0.11	8.78 ***	2.08	6.22 ***	0.11	6.22 ***	0.11
Dummy for Beneficiaries	0.78	0.49	-	-	-	-	0.65	0.7
Employees (LOG)	0.11 ***	0.01	0.002	0.12	0.22 ***	0.01	0.22 ***	0.01
Employees' schooling	0.06 ***	0.01	0.32 ***	0.05	0.14 ***	0.01	0.14 ***	0.01

Explanatory variables	OLS		Selection models					
			Beneficiaries		Non-beneficiaries		All firms	
	β	t value	β	t value	β	t value	β	t value
Age of firm (LOG)	0.10 ***	0.02	0.32	0.24	0.20 ***	0.02	0.20 ***	0.02
Firms with patents (in 2001)	0.11	0.09	0.01	0.18	-0.05	0.05	-0.06	0.05
Export company (in 2001)	0.54 ***	0.05	-0.46	0.33	0.44 ***	0.04	0.43 ***	0.04
Foreign company	0.79 ***	0.11	0.45	0.32	0.48 ***	0.06	0.48 ***	0.05
South and Southeast Region	0.26 ***	0.03	-0.85 ***	0.19	0.24 ***	0.03	0.23 ***	0.03
Technology intensive sector	0.56 ***	0.04	-0.35	0.28	0.38 ***	0.03	0.37 ***	0.03
Lambda (Mills inverse ratio)	-	-	-0.49	0.30	0.32	0.56	0.07	0.26
F value	142.5		16.8		406.0		375.9	
Adjusted R^2	0.11		0.75		0.26		0.27	
Number of firms	10,144		49		10,095		10,144	

Source: IBGE, Directorate of Research, Industrial Coordination, Industrial Research – Technological Innovation Survey - 2000. Developed by authors based on the processing of data received from the source and with the incorporation of data from Annual Industrial Survey (IBGE), External Trade Database (SECEX/MDIC), Census of foreign capitals in Brazil (BACEN), Annual Social Information Register (MTE) and FINEP.Obs. (*), (**),(***): significant variables at 10%, 5% and 1%, respectively. (ns) Non-significant variable.

C. Difference in Difference

Another major goal is to measure the impact of FNDCT on the dynamic performance of firms. In other words, we wish to know whether participant firms have a major rate of growth of productivity and size then non participants ones. Despite the program's limited reach, this is a particularly relevant issue for public policies. In order to do this evaluation, the best procedure is the difference in difference method, described in section 3.3.

The PROBIT for estimating the firm's likelihood of benefiting from FNDCT – the selection equation – was estimated using data from 1999. The treatment period was from 1999 to 2003. The year of comparison for verifying the difference between groups was 2003, in other words, the rates of variation were from 1999 to 2003.

Table 13 presents the results of a probabilistic PROBIT model, with the dependent variable being whether the firm is a beneficiary or not of the FNDCT program. This is the same model used in table 6. The difference is that the year used for the estimate is 1999 and the database used is the Annual Industrial Survey. Therefore, we don't have, in this case, variables of technological efforts of firms and we have a major sample that in the Technological Survey. The signs and meaning of the parameters are consistent with that was expected.

Table 13. Estimate of probability that the firm is a beneficiary of the FNDCT program - Year 1999. (PROBIT model only for firms with more than 30 employees).

Variables	All firms	
	Coefficient	Standard error
Intercept	3.99 ***	0.45
Employees (LOG)	0.25 ***	0.06
Dummy variable CR1 (first quintile of expenditures with interest/turnover)	-0.07	0.22
Dummy variable CR2 (second quintile of expenditures with interest/ turnover)	-0.43 *	0.26
Dummy variable CR4 (fourth quintile of expenditures with interest/ turnover)	-0.04	0.15
Dummy variable CR5 (fifth quintile of expenditures with interest/ turnover)	-0.07	0.15
Age of firm (LOG)	-0.05	0.08
Market Share	1.69 **	0.65
Foreign firm (dummy variable)	-0.39 **	0.17
Exporter firm in 1998 (dummy variable)	0.41 ***	0.14
Firm with patents register in 1998 (dummy variable)	0.23	0.14
Intensive technology sector (dummy variable)	0.32 ***	0.11
South or Southeast Region (dummy variable)	-0.03	0.13
Beneficiaries (n)	48	
Non-beneficiaries (n)	15,418	
Log likelihood	-262.84	
R^2	0.19	

Source: IBGE, Directorate of Research, Industrial Coordination, Industrial Research – Technological Innovation Survey - 2000. Developed by authors based on the processing of data received from the source and with the incorporation of data from Annual Industrial Survey (IBGE), External Trade Database (SECEX/MDIC), Census of foreign capitals in Brazil (BACEN), Annual Social Information Register (MTE) and FINEP.Obs. (*), (**),(***): significant variables at 10%, 5% and 1%, respectively. (ns) Non-significant variable.

The next step is to create a control group using again the propensity score matching procedure, as described in section 3.2. After that, we have estimated a difference in averages test on the rate of increase of turnover, productivity and number of employees[16]. Table 14 shows the statistics for the average difference between 1996 and 2002 for the group of companies that received support from FNDCT and the control group.

Results doesn't show any significant difference between beneficiaries and non-beneficiaries of FNDCT. The null hypothesis that the rate of increase in the control and treatment groups were equal between 1999 and 2003 was accepted for all three variables.

Table 14. Rate of increase of representative variables for the performance of firms that received support from FNDCT and the control group from 1999- 2003.

Variables	Rate of increase		
	Control group	Beneficiaries	t value
Turnover	-0.001	0.20 ns	-1.6
Employees	0.07	0.19 ns	-1.3
Labour productivity	-0.049	0.27 ns	-1.28
N	41	41	

Source: IBGE, Directorate of Research, Industrial Coordination, Industrial Research – Technological Innovation Survey - 2000. Developed by authors based on the processing of data received from the source and with the incorporation of data from Annual Industrial Survey (IBGE), External Trade Database (SECEX/MDIC), Census of foreign capitals in Brazil (BACEN), Annual Social Information Register (MTE) and FINEP.Obs. (*), (**),(***): significant variables at 10%, 5% and 1%, respectively. (ns) Non-significant variable. Turnover, wage and productivity were deflated by the wholesale price index. Turnover, wage and productivity were deflated by the wholesale price index (IPA).

In the case of the productivity, for instance, the performance of the beneficiaries was better than the control group. In this instance it was not possible to reject the null hypothesis regarding the groups' equality in the period 1999-2003. The period of analysis is most likely still too short to verify significant changes in these characteristics of the performance of firms. Moreover, the theoretical literature about technological innovation and technological efforts shows that innovating firms can loose productivity immediately after the innovation. Productivity gains would require, therefore, a greater time lag to occur.

[16] The rate of increase of this variables is calculated as [(value in 2003 - value in 1999) / value in 1999] for all the variables in table 14.

V. FINAL REMARKS

The FNDCT is a fund whose purpose is essentially to support scientific and technological research in universities and research centers. In this sense, the participation of companies in the FNDCT is restricted to what is called the FNDCT cooperative, which represents a very small part of the fund's total disbursements.

With the creation of Sectorial Funds, from 1999 onwards, the directives of the FNDCT moved to prioritize scientific and technological research that focuses on the interests of productive sectors and stimulates partnerships between universities and public or private companies. The participation of companies therefore continues to be rather restricted even within the FNDCT cooperative.

In spite of this, the results reported in this study show evidence that suggests that the program has had a positive impact on the technological efforts of beneficiary firms.The same cannot be confirmed however with regard to the program's impacts on the economic performance of beneficiary firms, particularly their productivity. In fact, the results do not indicate a significantly higher performance in terms of productivity for beneficiary firms compared to non-beneficiaries, whit exception of one single method: the propensity score matching. This result is rather predictable. Increases in productivity are not the program's focus and much more time span is needed than what is currently available to assess the direct impacts of R&D activities on productivity. A synthesis of the results obtained in all the procedures are in table 15.

Table 15. Impact of FNDCT programa on the performance and technological efforts of Brazilian Firms, according to different methods: 2000 to 2003.

Method	Impacts of ADTEN on		
	Growth	Productivity	Technological efforts
Propensity Score Matching		+	+
Selection models		Ns	+
Difference in Difference	Ns	Ns	

Obs. ***(Ns*)*** *means that, despite of in one sample the difference of averages was significant, in other two samples the difference was non significant.* ***(Ns)*** *means a non significant difference and* ***(+)*** *means a positive and statistically significant difference between participants and non participants of ADTEN.*

Evidence therefore indicates that FNDCT's positive impact on the innovation efforts of the Brazilian business enterprises was not greater because of the negligible participation in this sector in the total amount of FNDCT disbursements. In addition, even if we consider the totality of the program's resources, they are a very small percentage of what the Brazilian enterprise is investing in R&D, and much less than what the Brazilian industrial sector requires.

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