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THE PERFORMANCE AND TECHNOLOGICAL
EFFORTS OF BRAZILIAN INDUSTRIAL FIRMS**

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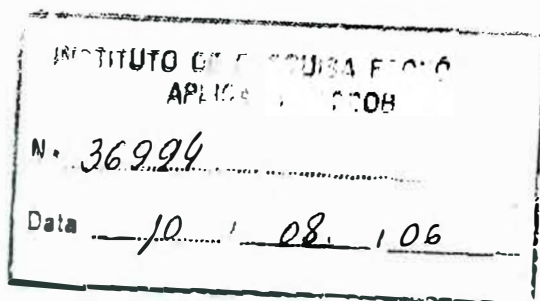
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IMPACT OF THE ADTEN PROGRAM ON THE PERFORMANCE AND TECHNOLOGICAL EFFORTS OF BRAZILIAN INDUSTRIAL FIRMS

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ABSTRACT

Public policies that promote R&D in firms are evaluated on a regular basis in developed countries. This type of study is relatively rare in Brazil, and no econometric analyses have been published that use this kind of information on firms. The present study, which assesses the impact of the National Technological Development Support Program (ADTEN) – supported by Research and Projects Financing (FINEP) – on the technical performance and strength of Brazilian industrial firms, is unprecedented in its content and method. It shows that ADTEN reaches a relatively limited number of firms, considering the magnitude of the Brazilian industrial sector. The program reaches only 0.07% of Brazilian industrial firms with over 10 employees, and the volume of resources that firms borrowed within the program's framework was only 1.6% and 3% of their R&D expenditures in 2000 and 2003, respectively. It was found evidences that ADTEN had a positive influence on companies' private expenditures for R&D from 1996 to 2003 or, at least, that the crowding out hypothesis can be rejected. There are also strong indications that the program has positively influenced the growth of firms, their productivity and patent applications, although results are not conclusive for these two indicators.

1 INTRODUCTION

The consolidation of the science and technology institutions in Brazil occurred at a time when the country's economic growth and industrialization strategy was characterized by the so called "national developmentalism". It is important to take into consideration the link between scientific and technological policies and the national development project to understand the success and effectiveness of the scientific and technological policy of the 1970s, and its decline in the 80s and 90s. The creation of the Scientific and Technological Development Fund (FNDCT) was an essential instrument in the Strategic Development Plan of 1968.

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The fund was undoubtedly a powerful mechanism for stimulating scientific and technological development in Brazil, mainly starting in 1971, when the Studies and Projects Financing Entity (FINEP) became its executive secretary. There was no radical change in the country's institutional science and technology framework in the 80s, despite the fiscal crisis and the exhaustion of outside funding sources.

FNDCT's volume of resources grew rapidly in the early 70s and FINEP moved to establish a different way of operating the fund. The National Technological Development Support Program (ADTEN) was created in this context. Major resources from the FNDCT were allocated to the program between 1976 and 1978. ADTEN was and continues to be a reimbursable funding program for companies that are particularly relevant to the FINEP. Historically, the program's funding comes from the Treasury Department, from returns from earlier loans, and from multilateral organizations, mainly the Interamerican Development Bank (IDB) and the National Development Fund. In the late 70s, the resources reallocated to ADTEN were about 30% of the FNDCT's ⁴ total resources. In 1987, at the pinnacle of the program's expenditures, it was lending about US\$ 150 million.⁵

The consolidation of FINEP and the firms was greatly motivated by the creation of ADTEN. From the very beginning, the program prioritized engineering projects, research and development centers in companies, innovative products and processes, marketing, the purchase of national or foreign technology, and the creation of quality control processes. The resources available through the program were especially advantageous for companies because the currency fluctuation that affected the loans was reduced. Equalization represented about 40 to 60% of inflation until 1980⁶. This decreased over time until, starting in 1987, the financial adjustment of loans was complete. It is worth noting that ADTEN was considering different ways of risk capital financing. The most widely used methods were loans that could be amortized using royalties and sales revenue. In 1991 there were about 60 risk capital operations.

Today, ADTEN is still one of the instruments through which FINEP finances or invests in development projects, or in technology improvement projects for products and processes that have been executed by a company's own technical team, engineering firms, national consulting firms, universities and research institutions. Projects that are eligible for financing are: basic engineering projects with a technological development element, establishment of research and development centers, the purchase and incorporation of technology from Brazil or abroad, quality control and management, and innovative marketing. The program has a grace period of up to three years, and an amortization period of up to seven years, with FINEP participating in up to 80% of the project. Guarantees are established for each operation. There are currently no loan subsidies and the financial charges are the same as on the market. There is a long-term interest rate (TJLP) on the loans, which is currently 9.00% per annum (Jan/2006), with an average spread of 5% per annum and an opening credit line tax of 1%.

The authors of this study are not aware of any published work that seeks to evaluate the impact of ADTEN or any other similar program on the performance and expenditures of companies for research and development (R&D). That is exactly what this paper will attempt to achieve. More specifically, it seeks to contribute to the process

⁴ Guimarães 1993.

⁵ Naidin *et al.*

⁶ CGEE (2001) – Apoio direto à inovação - Programação do fundo verde e amarelo 2002-2003. (Direct support for innovations – Green and Yellow Fund Program 2002-2003).

of evaluating public policies that focus on stimulating technologically innovative activities by answering the following questions: Is there substitution or complementarities between public funds from ADTEN and private funds used for R&D? In other words, is there crowding in or crowding out effects of the public funds to financing R&D activity?⁷ Is the economic/financial performance of beneficiaries of the ADTEN program superior to that of non-beneficiaries?

This report is divided into four sections besides the Introduction. In Section 2, we present the methodological procedures and data that will be used in the evaluation. The extent of ADTEN's reach is analyzed, considering the magnitude of Brazilian industry, in section 3. In Section 4, we attempt to verify the program's impact on company expenditures for R&D in order to seek whether there is substitution or complementarity between public funds from ADTEN and the companies' own private funds, or funds of other companies on the market. In the same section 4, the program's impact on a company's growth and productivity is also evaluated. The final remarks appears in Section 5.

2 DATA AND METHODOLOGY

One of the reasons for the lack of evaluation work on ADTEN 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 an original data base from the Institute for Applied Economic Research (IPEA). IPEA's⁸ data combines information from: i) Annual Industrial Survey (PIA), 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 External 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) Data about patents register and applications, from National Institute of Industrial Property (INPI).⁹

Of all the sources of information available, two databases will be the principal ones. The first one is the Annual Industrial Survey (PIA), that contains the income and expenditure structure of Brazilian industrial firms, as well as their sector of activity. Based on the information available from PIA, one can establish indicators of a firm's productivity and growth, for example. PIA is available since 1996 until 2003.

The second one is the Technological Innovation Survey (PINTEC) in 2000. This survey collate information on technological innovations in the Brazilian industrial sector and on technological efforts of Brazilian firms. PINTEC 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 ongoing, whether the firm has an R&D department, the number and qualification of the individuals working in R&D, etc); b) if

⁷ David, P. A., B. and Foray, A. A. (2000) provide a comprehensive review of the econometric evidence about crowding in and crowding out effects.

⁸ For details on the database see De Negri (2003). IPEA does not have legal title to the information used in this study. However this and other work has been made possible through the partnerships established between IPEA, IBGE, MTE, BACEN, MPO, SECEX/MDIC and FINEP

⁹ Access to the necessary information rigorously followed the procedures that guarantee the secrecy of restricted information.

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.

Other database that deserves a detailed description is the Annual Social Information Report (RAIS). This data base 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.

This information should provide a rather complete profile of all of the Brazilian industrial firms. With the possibility of combining these data bases using a code that identifies each firm one can find out, for each firm: if it is innovative; the amount of its expenditures for R&D; its expenditures, and income structure and profitability; whether it is a foreign or national firm; 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 data base is composed of a sampling of approximately 80,000 industrial firms with over 10 employees and five million workers. These firms are responsible for approximately 95 % of the added value in 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 ADTEN from 1997 until 2005, and to perform the evaluation of the program.

2.1 *Methodological issues*

The empirical analysis of this structure of data requires microeconomic 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 fore 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_{1i} the outcome variable (economic or technological performance for example) with the treatment, and Y_{0i} 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_{0i} and Y_{1i} 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 political variable (P_i) that will distinguish beneficiaries from non-beneficiaries.

Formally, we have:

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

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 funding¹⁰. With regard to the firms, it is possible that only the most technologically suitable, or those more inclined to make greater technological 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

¹⁰ Busom (2000) discusses the determining factors for firms that seek public support, as well as the decision of financing agencies to grant funding.

is why this models generates 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 agencies responsible, 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 agreement, 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 wealth 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 kind of databases, we will use various different methods in order to perform the evaluation. Related to the impact of ADTEN in technological efforts of beneficiary firms, the database used will be the Innovation Survey of 2000, that 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 Annual Industrial Survey. The methods will be described in details to follow.

2.2 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 programs¹¹.

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

¹¹ Meyer (1995) provides a good description of the procedures for natural and quasi-experiments in economics and Wooldridge (2002) describes the mean treatment effect.

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.

So, one of the econometric procedures that will be used in this study consist 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 follow:

- Linking information from FINEP about firms that receive support from ADTEN, with information from the others datasets available.
- Establishing and estimating a probabilistic model to obtain the estimated probability of whether or not the firm was a beneficiary of the program from 1997 to 1999.
- 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 a total sample of industrial firms and two other sub-samples: of innovative industrial firms and 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 innovative firms and a third would be a sample of firms with R&D. These would be the three contrafactuals used in the next step. In each sub-sample, the restrictions of 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 expenditures for R&D, productivity and size of the firms in 2000.

2.3 *Difference-in-differences*

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*¹²” (my 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:

$$\delta_1 = (\bar{Y}_{1t} - \bar{Y}_{1t-1}) - (\bar{Y}_{0t} - \bar{Y}_{0t-1}) \quad (2)$$

where \bar{Y}_{0t-1} is the sample mean of the outcome variable resulting from the first year for non-beneficiaries, and \bar{Y}_{0t} is the same mean for the non-beneficiaries (control group) the second year. \bar{Y}_{1t-1} and \bar{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 series 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 those that the treated firms would have had if they not been treated.

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.

¹² Also see Wooldridge (2002).

2.4 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:

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

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:

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

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

where $\phi(\cdot)$ is the density function and $\Phi(\cdot)$ 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 all the 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 of 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 ($Y_i^{predict} = E\{Y_i | P = 1\}$) with their potential outcome, which are those predict using the coefficients estimated for the non-participants ($Y_i^{potential} = E\{Y_i | P = 0\}$). The $Y_i^{potential}$ 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:

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

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

where β_1 is the vector of estimated coefficients for participating firms; β_0 are the estimated coefficients for non-participating firms and X_i are the regressors of participating firms¹³. 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:

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

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

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

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.

¹³ 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.

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 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).

3 SCOPE OF THE ADTEN PROGRAM IN BRAZILIAN INDUSTRY

Table 1 presents the volume of resources disbursed within the framework of ADTEN and the number of firms that benefited from the program from 1997 until May 2005. During this period, 457 different firms were benefited from the program, in 506 credit operations. The number of firms is different from the number of operations because 49 of the firms had more than one project approved in the period 1997-2005.

For the period in question, a decrease was observed in the number of firms that benefited annually from the program. Over 90 firms benefited from the program in 1997, increasing to 128 firms in 1998, and dropping to 18 firms in 2004. The amount disbursed by FINEP also decreased slightly, but not as much as the reduction observed in the number of firms. This significantly increased the average amount lent to each beneficiary firm, especially during the past four or five years of the period under consideration. In 2005, each firm borrowed an average of over R\$11,000,000.

TABLE 1. NUMBER OF FUNDING OPERATIONS, FIRMS BENEFITED AND AMOUNT OF FUNDING DISBURSED BY ADTEN FROM 1997 TO 2005.

Year	Number of firms	Number of operations	Amount disbursed (in constant R\$)	Average disbursement per firm (in constant R\$)
1997	93	95	243,648,303	2,619,874
1998	128	132	268,616,840	2,098,569
1999	55	56	101,794,268	1,850,805
2000	36	36	59,862,400	1,662,844
2001	41	41	127,419,766	3,107,799
2002	52	52	221,133,444	4,252,566
2003	27	27	178,759,394	6,620,718
2004	18	18	128,764,033	7,153,557
2005	48	49	573,603,177	11,950,066
1997 to 2005	457*	506	1,903,601,624	4,165,430

Source: FINEP. * The total number of firms isn't equal to the sum of firms in each year, because some firms had received ADTEN funds in more than one year. That also is the reason because the number of operations is greater than the number of firms benefited by the program in each year.

ADTEN's impact on stimulating innovative activities becomes clear when one compares its disbursements with just one type of expenditure for innovative activities: R&D. In 2000, Brazilian industrial firms invested R\$ 3.7 billion in R&D internally. In

2003, they spent R\$ 5.1 billion on the same activity. In 2000, ADTEN spent R\$ 59.8 million, or 1.6% of the total expenditure for R&D of companies in Brazil. In 2003, the program spent R\$178.7 million, which amounts to around 3% of the investments of Brazilian firms in R&D. Considering that FINEP is one of the principal funding agencies for technological innovations in Brazil, and that it has the capacity to evaluate and fund R&D projects and activities of industrial firms, the figures would seem to indicate that the availability of public credit may be limited in Brazil for innovative activities in general, and especially for R&D. Even private sources of credit seems to be very low in Brazilian industry, as one can see in the figures of sources of credit to innovation activities: about 90% of spends in R&D in Brazilian industry are financed by innovative firm's own resources¹⁴.

The second relevant indicator regarding the effect of the ADTEN program is the number of companies funded. In Brazilian industry, there are approximately 80 thousand industrial firms with more than 10 employees. From 1998 until 2003, an average of about 23 thousand firms produced technological innovations. Out of all the firms that produce product or process innovations, over 7000 had annual internal company expenditures for R&D. Between 1998 and 2003, ADTEN financed an average of 57 firms per year, amounting to 0.2% of the innovative firms and 0.8% of the firms that invested in R&D. Considering the total number of industrial firms with over 10 employees, ADTEN funded only 0.07% of Brazilian firms.

With ongoing expenditures of a little over R\$1.5 billion between 1997 and May 2005, and with a small number of firms actually benefiting, it seems that the impact of the program, and its potential to significantly improve national technological production, is rather limited. It therefore would not be realistic to expect a spillover effect of this program on non-beneficiary firms. This implies that the evaluation of the program will be limited to only the program's direct impact on actual beneficiary firms.

What are the characteristics of the firms that are beneficiaries of ADTEN? In this respect, this paper will analyze just firms in industrial sector, because information about R&D spending and innovation is provided only to industrial firms. This is one of the reasons why the number of firms was decreased from 457 to 95. Another reason is that the industrial innovation survey (PINTEC) is a representative sample of all industrial firms with more than 10 employees. In this sense, not all participants firms are in this survey. Finally, we are only evaluating the performance of the firms that had participated of the program until 2000.

Table 2 shows a few indicators for industrial firms that are beneficiaries of ADTEN compared to those that are not. Statistics are also presented only for innovative firms and only for firms that had invested in R&D in 2000¹⁵.

Firms that are beneficiaries of the program clearly perform much better economically and technologically than those that do not. They are much larger than the others in terms of the number of workers as in terms of turnover.

The same may be observed for variables such as productivity, workers' average level of education, number of patent applications, value of exports, and R&D spending.

¹⁴ According to the Brazilian Innovation Survey (PINTEC) in 2003.

¹⁵ It is worth noting that the number of beneficiary firms that are part of the sample decreases after comparing information about firms that benefit from ADTEN with the PINTEC sample. This was to be expected due to the sample procedures used by PINTEC, and also because among the beneficiaries there are firms from the service sector that are not part of the industrial research of PIA and PINTEC.

The total amount of expenditures for R&D of firms that benefited from the program is substantially higher than the expenditures for R&D of those that did not. When measured as a proportion of the net income from sales the expenditure for R&D of the beneficiaries equals 1.2% of the revenue, compared to a national average of 0.7%. However, when compared only with innovative firms or with firms that have R&D spending, the share of R&D in revenue of the beneficiary firms is lower than the other two groups.

With regard to external performance, in 2000, beneficiary firms exported an average of R\$87.6 million compared to an average of R\$8 million for other Brazilian industrial firms. Once again, firms with R&D spending are the group that comes closest to the ADTEN beneficiaries, with average exports of approximately R\$ 17 million in 2000.

TABLE 2. SELECTED INDICATORS OF BRAZILIAN INDUSTRIAL FIRMS THAT WERE OR WERE NOT BENEFICIARIES OF ADTEN - 2000.

Indicators	Beneficiaries of ADTEN	Non-beneficiaries of ADTEN		
		Total	Innovative Firms ¹	Firms with R&D spending
		Average	Average	Average
Number of employees	743	68	116	207
Turnover (R\$ 1000)	157,030	8,488	18,934	41,738
Labour productivity ² (R\$)	57,847	18,335	23,740	31,722
Number of years employees attended school	8.37	7.14	7.56	7.81
Stock of patent applications	1.48	0.09	0.21	0.48
Stock of patent applications (per 100 employees)	0.76	0.12	0.21	0.42
Participation of foreigners (%)	10%	3%	6%	9%
Average Value of exports (R\$ 1000) ³	87,579	8,004	11,676	17,132
Export coefficient ³	0.16	0.15	0.14	0.12
R&D spending ⁴ - Total (R\$)	2,940,360	55,810	157,050	441,719
As a share of turnover (%)	1.2%	0.7%	1.9%	5.4%
R&D spending ⁴ - Private resources (R\$)	2,586,011	54,163	152,412	428,673
As a share of turnover (%)	1.1%	0.7%	1.9%	5.2%
Share of private resources on total R&D spending	88%	97%	97%	97%
Number of firms (sample)	95	10,231	5,333	2,600
Number of firms (population)	138	71,859	24,581	9,079

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 exporter 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.

Despite these differences, it is still not possible to confirm that the beneficiaries performed better because of the program. The fundamental question is whether the program truly improved the economic performance and technological outputs of beneficiary firms, or if these firms were already more competitive and would have invested more in R&D even without access to the program. This is a basic problem of public policies that stimulate innovative activities, principally those focused on promoting R&D in firms. To broaden this evaluation of ADTEN in order to shed light on these uncertainties, the next sections use statistical tools that are frequently cited in international literature to evaluate the program's effective impact on variables such as R&D spending, productivity and growth of the firms.

4 RESULTS

Although the ADTEN program reaches only a limited number of firms, it is important to know if its disbursements stimulate or simply shift private investments in R&D, particularly in the case of public R&D incentive programs that involve subsidies. Although this is not the case of ADTEN, and despite the fact that it does not only finance R&D, the question is just as applicable because the program can also have a positive impact on private expenditures for R&D. To determine whether ADTEN stimulates or simply shifts private investments in R&D, a phenomenon known as "crowding out" in economic literature, two methodological procedures were used, based on Innovation Survey in 2000: propensity score matching (described in section 2.2) and selection models (section 2.4). These two procedures will also be used in order to evaluate whether the productivity is higher in participating firms comparing to the non-participating ones.

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 of the program and whether they show a higher growth rate of productivity. In order to perform this evaluation, the procedure used, based on Industrial Survey since 1996 until 2003, is the difference-in-difference method (described in section 2.3).

As one can see, we have two different data sets that will be used. One is a cross sectional database (the Innovation survey in 2000) and another is a longitudinal one (the Industrial survey from 1996 to 2003). Therefore, two selection equations will be estimated in order to construct the control group to participant firms. One of them will be estimated in 1996 in order to do the difference and difference analysis and other selection equation will be estimated in 2000.

4.1 Propensity Score Matching

The first step of propensity score matching is estimate a model for estimating the probability of participating in the ADTEN program. That is the *selection equation* and also will be used in the selection models next section. The PROBIT uses several variables that are relevant for explaining the firm's access to ADTEN:

- 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 of 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 the sector – high technology sectors versus low ones – and region where the firm is located.

Table 3 shows the results of probabilistic models – that is, the selection equations – used in propensity score matching to create control groups. The signs from the parameters generally corresponded with what was expected. The statistical significance of the parameters was good and the statistics of the models showed consistency in the selection of explanatory variables. Table 3 presents the results of estimates for three different samples: i) the entire sample, ii) the sub sample of innovative firms, and iii) only for firms R&D spending greater than zero.

The models indicate that size is generally a relevant variable in the probability that the firm is a beneficiary of ADTEN. The firms' performance characteristics – such as insertion in foreign markets and carrying out continuous R&D activities – also have a major influence on access to the program, possibly showing the existence of self-selection in the sample. The firm's age, a variable used in different studies as an important factor for accessing technological activity funding programs, was also relevant, as was the firm's sector of activity. Firm's geographical region, therefore, wasn't statistically significant. Lastly, foreign firms are less likely to obtain loans from ADTEN.

The purpose of estimating the model only for innovative firms or simply firms that spend in R&D activities was to select more homogenous groups of firms. It is reasonable to believe that innovative firms and firms that spend in R&D are different than the average industrial firm. The selection procedure for the control group therefore becomes more rigorous in a more homogenous group of firms.

TABLE 3. ESTIMATE OF PROBABILITY WHETHER OR NOT A FIRM RECEIVED FUNDING FROM ADTEN – 2000 (PROBIT MODEL).

Explanatory variables	Total sample		Innovative firms		Firms with positive R&D spending	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Intercept	-4,19 ***	0,22	-3,72 ***	0,25	-3,85 ***	0,33
Employees (LOG)	0,23 ***	0,03	0,20 ***	0,04	0,19 ***	0,05
Dummy variable CR1 (first quintile of expenditures with interest/turnover)	-0,44 ***	0,11	-0,39 ***	0,13	-0,46 ***	0,17
Dummy variable CR2 (second quintile of expenditures with interest/ turnover)	-0,49 ***	0,15	-0,60 ***	0,18	-0,95 ***	0,31
Dummy variable CR4 (fourth quintile of expenditures with interest/ turnover)	0,13	0,09	0,07	0,11	0,05	0,13
Dummy variable CR5 (fifth quintile of expenditures with interest/ turnover)	0,10	0,10	-0,02	0,12	-0,05	0,14
Age of firm (LOG)	0,09 **	0,04	0,01	0,05	0,13 **	0,06
Market Share	0,29	0,69	0,56	0,71	0,60	0,74
Foreign firm (dummy variable)	-0,51 ***	0,12	-0,60 ***	0,14	-0,66 ***	0,17
Exporter firm in 1998 (dummy variable)	0,39 ***	0,08	0,50 ***	0,09	0,28 **	0,12
Continuous R&D (dummy variable)	0,29 ***	0,08	0,20 ***	0,09	0,24 **	0,11
Intensive technology sector (dummy variable)	0,20 ***	0,07	0,22 ***	0,08	0,19 *	0,10
South or Southeast Region (dummy variable)	0,09	0,08	0,11	0,10	0,06	0,12
Beneficiaries (n / N)	94 / 135		77 / 110		58 / 76	
Non-beneficiaries (n / N)	9.884 / 69.463		5.214 / 25.006		2.600 / 8.138	
Log likelihood	-703,5		-544,9		-340,6	
R ²	0,3		0,25		0,24	

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.

After estimating the selection equation, a matching procedure that follows what was suggested in section 2.2 was applied to the data. After that, the difference between

firms that benefit from ADTEN and the control group for each category were compared. The number of beneficiary firms analyzed was reduced to 92 in the complete sample, to 73 in the sub-sample of innovative firms, and to 52 in the sub-sample of firms with positive R&D spending. The reason for this is, first of all, the lack of proximity between some of the beneficiaries and the non-beneficiaries, which precludes the creation of a consistent contra factual for these firms. Another reason is that the two sub samples (innovative firms and firms with R&D spending) are minors that the complete sample, including in the group of beneficiaries¹⁶.

TABLE 4. TEST OF DIFFERENCES IN AVERAGES ACCORDING TO SELECTED VARIABLES FOR FIRMS THAT RECEIVE SUPPORT FROM ADTEN AND THE CONTROL GROUP. YEAR 2000.

Variables	Total sample			Innovative 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)	152,633	147,983	0.06	84,988	161,675	-1.39	118,188	200,984	-1.04
Employees	773	816	-0.20	800	697	0.51	686	876	-0.91
Labour productivity ¹ (R\$)	49,639	59,400	-0.96	38,124	64,421**	-2.44	57,782	67,307	-0.63
R&D spending ² - Total (R\$ 1000)	1,689	1,504	0.13	468	1,849*	-1.93	796	2,329	-1.58
As a share of turnover (%)	0.53	1.36**	-2.01	1.50	1.68	-0.31	1.65	2.23	-0.85
R&D spending ² - Private resources (R\$ 1000)	1,663	1,454	0.15	407	1,785*	-1.94	747	2,240	-1.52
As a share of turnover (%)	0.52	1.18**	-2.17	1.44	1.46	-0.05	1.57	1.92	-0.71
Number of firms	92	92		73	73		52	52	

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 relevant variable in the analysis of the policy's impact on the expenditures of beneficiary firms of ADTEN for R&D is the expenditure for R&D as a proportion of the net income from sales (RLV). In the model with a complete sample, there is a positive and statistically significant difference in the relationship between R&D/RLV between the group of firms that receive funding from ADTEN and the control group. In this case, the beneficiary firms of ADTEN invested 2.3 times more than the firms that were not beneficiaries of the program. In this case, we are considering only private resources. If one analyze the expenditures for R&D of public and private resources, the difference is even grater. When we analyze the sub-sample of innovative firms and firms with R&D spending, this difference is no longer significant. However, in this group of firms there is a statistical significant difference in labour productivity and in

¹⁶ The criteria of being innovative or having positive R&D spending were applied also to participant firms.

the amount of expenditure for R&D (in R\$ 1000). In the sub-sample of firms with R&D spending, no variable was significantly different.

These results indicate that in 2000, investments made in R&D by firms were greater among those that received support from ADTEN. This is evidence of crowding in, because access to ADTEN influenced private expenditures for R&D of beneficiary firms. Although this evidence has not been statistically proven in the model for innovative firms and firms with R&D spending, most likely because the difference disappears when we observe more homogenous samples, it is important to note that expenditures for R&D of firms that receive support from ADTEN continue to be positive in these two models, and do not show any evidence that would support the existence of crowding out effects.

4.2 Two step selection model

The second methodological procedure utilized to test the impacts of ADTEN on the firms' expenditures for R&D is a two-stage selection model, inspired on Heckman (1979) and described above. This method was also used by Busom (2000) and Jarmin (1999).

The first phase of the procedure consists of assessing the probability that the firm is a participant of ADTEN. As in the previous procedure, the criteria was adopted to estimate a selection equation (PROBIT) using a sub-sample of firms with expenditures for R&D greater than zero. Thus, the selection equation used is the same of table 3. The only difference is that the control group was constructed only for firms that had spent in R&D. After this procedure, Mill's inverse ratio is calculated for each firm, following the procedures described in section 2.4 (equations 4 and 5).

The second phase consists of estimating an OLS model, with Mill's inverse ratio acting as one of the explanatory variables. This procedure would correct the selection bias observed. The significance of this variable in the model would prove whether or not there is indeed selection bias.

Table 5 presents the results of the OLS estimates with and without correction for selection bias. The dependent variable is the logarithm of companies' private expenditures for R&D. The first regression is a simple OLS model that will be used to compare the results of the selection models. The other three equations are the models with selection bias correction, according to section 2.4. There are two equations, one of them estimated for participants and non-participants separately and another one for the complete sample.

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 3) and in the treatment equation (table 5). Thus, in one hand, in the treatment equation the dummies that seeks to assess 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 years that employees had studied, that is a proxy for the labour qualification at the firm and for firm's technology.

The results show that the explanatory variables are significant for the most part and show the expected signs. The statistical significance of Mill's inverse ratio indicates the existence of selection bias.

TABLE 5. REGRESSION MODELS FOR LOGARITHM OF TOTAL EXPENDITURES IN R&D (ONLY FOR FIRMS WITH POSITIVE R&D EXPENDITURES) - 2000.

Explanatory variables	OLS		Selection models					
			Beneficiaries		Non-beneficiaries		All firms	
	β	t value	β	t value	β	t value	β	t value
Intercepto	5.11 ^{***}	24.70	18.16 ^{***}	3.36	5.55 ^{***}	19.93	5.29 ^{***}	19.67
Dummy for Beneficiaries	0.36	1.22	-	-	-	-	5.43 ^{***}	5.08
Employees (LOG)	0.67 ^{***}	25.47	0.06	0.17	0.62 ^{***}	18.74	0.67 ^{***}	22.40
Average time employees studied	0.14 ^{***}	8.65	0.29 ^{**}	2.01	0.23 ^{***}	12.61	0.23 ^{***}	12.94
Age of firm (LOG)	0.19 ^{***}	4.91	-0.11	-0.20	0.05	1.01	0.05	1.18
Firms with patents (in 1998)	0.36 ^{***}	3.45	0.32	0.65	0.19 ^{**}	2.32	0.23 ^{***}	2.82
Export company (in 1999)	0.32 ^{***}	4.40	-0.48	-0.69	0.07	0.93	0.13 [*]	1.79
Foreign company	0.46 ^{***}	4.36	1.91 [*]	1.88	0.59 ^{***}	6.22	0.45 ^{***}	5.09
South and Southeast Region	0.19 ^{***}	2.88	-0.76	-1.27	0.04	0.57	0.03	0.49
Technology intensive sector	0.56 ^{***}	9.11	-0.25	-0.41	0.53 ^{***}	7.84	0.56 ^{***}	8.50
Lambda (Mills inverse ratio)	-	-	-3.12 ^{***}	-2.51	-4.89 ^{***}	-6.07	-2.23 ^{***}	-4.82
F value	283.4		4.0		248.6		227.0	
Adjusted R ²	0.51		0.33		0.48		0.48	
Number of firms	2485		57		2428		2485	

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.

To estimate the average treatment effect (ATE) we follow the calculation described in section 2.4. 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 2.4). 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 2.4.

Table 6 synthesizes the results of the ADTEN program's effects on expenditures for R&D according to the OLS model and to the selection models.

TABLE 6. EFFECT OF TREATMENT ON R&D EXPENDITURES FOR FIRMS.

Model	Impact of ADTEN program		
	ATE		t value
OLS	0.36	(ns)	1.22
ATE1 - Selection model (beneficiaries X non-beneficiaries)	0.33	***	3.70
ATE2 - Selection model (all firms)	0.25	***	3.08

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.

Results show that there is evidence that the program has both positive and significant impacts on the beneficiary firms' expenditures for R&D. According to selection models, firms that receive funding from ADTEN spend an average of 28% to 39%¹⁷ more on R&D than firms that do not benefit from this program. This result shows a positive impact of ADTEN in R&D spending of participant firms, like in propensity score matching, even for a sub-sample of more homogenous firms: those with expenditures for R&D greater than zero. Although there is a bias, the difference between the estimates of the effect of the treatment on selection models and on OLS is small, once that in simple OLS model the ATE is around 43%. In both estimates the program has positive impacts on R&D expenditures. In conclusion, there is concrete evidence that the ADTEN program stimulates private investments in R&D.

And how about the impact of ADTEN at productivity of participant firms? To answer this question the study has applied the same procedure (selection models) to other dependent variable: the logarithm of firm's productivity. For this we used, in order to calculate the Mill's inverse ration, the same selection equation expressed in table 3. 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. The results for the OLS and selection models for productivity are given in Table 7.

The specification of treatment equation is the same used to R&D spending of firms. However, in treatment equation for productivity, the Mill's inverse ration was not statistically significant, showing that there is no selection bias in the sample when we analyze the impact on productivity. In this way, the impact of ADTEN on firm's productivity may be calculated by the simple OLS model.

Therefore, the results of this procedure are consistent with those found when propensity score matching with different averages was used. In other words, although the evidence was positive in both procedures, the results are not conclusive because the parameters are not statistically significant.

¹⁷ Once that the dependent variable is expressed in terms of logarithm, the percentual impact results from the following equation: $[\exp(\beta)-1]*100$.

TABLE 7. REGRESSION MODELS FOR ESTIMATING DETERMINANTS OF FIRMS' PRODUCTIVITY (IN LOGARITHM) - 2000.

Explanatory variables	OLS		Selection models					
			Beneficiaries		Non-beneficiaries		All firms	
	β	t value	β	t value	β	t value	β	t value
Intercepto	6.54 ^{***}	51.50	10.19	5.5	5.83 ^{***}	41.33	5.79 ^{***}	42.90
Dummy for Beneficiaries	0.50	1.28	-	-	-	-	-0.51	-0.57
Employees (LOG)	0.11 ^{***}	5.99	-0.13	-1.18	0.13 ^{***}	7.25	0.14 ^{***}	8.44
Average time employees studied	0.11 ^{***}	11.81	0.22 ^{***}	4.96	0.16 ^{***}	15.60	0.16 ^{***}	15.90
Age of firm (LOG)	0.19 ^{***}	8.30	0.08	0.46	0.31 ^{***}	12.49	0.31 ^{***}	12.60
Firms with patents (in 1998)	0.33 ^{***}	2.61	-0.19	-1.12	0.11	1.48	0.11	1.55
Export company (in 1998)	0.59 ^{***}	9.43	-0.02	-0.1	0.48 ^{***}	10.07	0.49 ^{***}	10.90
Foreign company	0.66 ^{***}	5.83	0.29	0.12	0.56 ^{***}	8.33	0.53 ^{***}	8.27
Technology intensive sector	0.45 ^{***}	9.49	0.02	0.12	0.34 ^{***}	7.73	0.35 ^{***}	8.02
South and Southeast Region	0.18 ^{***}	4.94	-0.01	-0.05	0.14 ^{***}	3.56	0.14 ^{***}	3.63
Lambda (Mills inverse ratio)	-	-	-0.45	-1.28	-0.35	-0.71	0.30	0.85
F value	134		5.01		252.5		232.3	
Adjusted R ²	0.11		0.28		0.19		0.19	
Number of firms	9831		94		9737		9831	

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.

4.3 Difference in difference method

Another major goal is to measure the impact of ADTEN 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 2.3.

The selection of control groups was made in 1996, in other words, the PROBIT for estimating the firm's likelihood of benefiting from ADTEN was estimated using data from 1996. The treatment period was from 1997 to 2002. The year of comparison for verifying the difference between groups was 2003, in other words, the rates of variation were from 1996 to 2003.

Table 8 presents the results of a probabilistic PROBIT model, with the dependent variable being whether the firm is a beneficiary or not of the ADTEN program. This is the same model used in table 3. The difference is that the year used for

the estimate is 1996 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 8. ESTIMATE OF PROBABILITY THAT THE FIRM IS A BENEFICIARY OF THE ADTEN PROGRAM - YEAR 1996. (PROBIT MODEL ONLY FOR FIRMS WITH MORE THAN 30 EMPLOYEES).

Variáveis	All firms	
	Coefficient	Standard error
Intercept	-3.97 ***	0.35
Employees (LOG)	0.22 ***	0.04
Dummy variable CR1 (first quintile of expenditures with interest/turnover)	-0.23 *	0.13
Dummy variable CR2 (second quintile of expenditures with interest/ turnover)	-0.13	0.13
Dummy variable CR4 (fourth quintile of expenditures with interest/ turnover)	0.07	0.11
Dummy variable CR5 (fifth quintile of expenditures with interest/ turnover)	-0.02	0.11
Age of firm (LOG)	0.03	0.07
Market Share	0.49	0.61
Foreign firm (dummy variable)	-0.47 ***	0.15
Exporter firm in 1995 (dummy variable)	0.39 ***	0.09
Firm with patents register in 1995 (dummy variable)	0.27 **	0.13
Intensive technology sector (dummy variable)	0.23 ***	0.08
South or Southeast Region (dummy variable)	0.16 *	0.09
Beneficiaries (n)	126	
Non-beneficiaries (n)	11519	
Log likelihood	-596.65	
R ²	0.15	

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 2.2. After that, we have estimated a difference in averages test on the rate of increase of turnover, productivity, number of employees and average wage of the firms¹⁸. Table 9 shows the statistics for the average difference between 1996 and 2002 for the group of companies that received support from ADTEN and the control group.

¹⁸ The rate of increase of this variables is calculated as [(value in 2003 - value in 1996) / value in 1996] for all the variables in table 9.

TABLE 9. RATE OF INCREASE OF REPRESENTATIVE VARIABLES FOR THE PERFORMANCE OF FIRMS THAT RECEIVED SUPPORT FROM ADTEN AND THE CONTROL GROUP FROM 1996- 2003.

Variables	Rate of increase		
	Control group	Beneficiaries	t value
Turnover	0.12	0.76	-2.58***
Employees	-0.04	0.75	3.32***
Average Wage	1.67	1.61	0.98
Labour productivity	0.15	0.14	0.11
N	118	118	

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).*

Results show greater growth for firms that were beneficiaries of ADTEN. This can be inferred from the net income (turnover) and number of employees variables. The null hypothesis that the rate of increase in the control and treatment groups were equal between 1996 and 2003 was rejected for these two variables.

In the case of the productivity, 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 1996-2003. The period of analysis is most likely still too short to verify significant changes in these characteristics of the firm's performance. Moreover, the theoretical literature about technological innovation and technological efforts shows that innovative firms can loose productivity immediately after the innovation. Productivity gains would require, therefore, a greater time lag to occur.

In conclusion, the ADTEN program had a positive impact on the firms' growth. However, results are not conclusive with regard to other performance criteria such as productivity, although evidence indicates that ADTEN also had positive impacts on firms for this variable.

5 FINAL REMARKS

Evaluations of public policies that focus on stimulating innovative technological activities, especially R&D in firms, are relatively common in international literature from developed countries. However, these studies are comparatively rare in developing countries like Brazil. Moreover, no econometric study has been published using information on firms. This study seeks to make a contribution in this area. It evaluates the impact of the Technological Development Support Program (ADTEN) of the FINEP on the performance and technological efforts of Brazilian industrial firms. This work is unprecedented in its content and procedure, given that it is also the first time that information from firms has been utilized to analyze the impact of technological innovation support programs in Brazil.

The study has shown that ADTEN reaches a relatively limited number of firms, considering the magnitude of Brazilian industry. It reaches only 0.07% of Brazilian industrial firms with over 10 employees. The volume of resources borrowed by firms

within the framework of the program amounts to only 1.6% and 3% of the companies' expenditures used for R&D in 2000 and 2003, respectively.

Table 10 shows a synthesis of the evidences found about the impact of ADTEN in the performance of Brazilian Industrial Firms, considering the methods and outcome variables that were analyzed.

TABLE 10. IMPACT OF ADTEN PROGRAMA ON THE PERFORMANCE AND TECHNOLOGICAL EFFORTS OF BRAZILIAN FIRMS, ACCORDING DIFFERENT METHODS: 1996 TO 2003.

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

The program was evaluated between 1996 and 2003 from two points of view. The first was to see if there was complementarity or substitution between public and private resources in the firms' expenditures for R&D. Compelling evidence was found that ADTEN positively influences a firm's private expenditures for R&D. The second was to assess the impact of ADTEN on a firm's overall performance. Three indicators were analyzed: growth and productivity. Results indicate that there is clear evidence that the program positively influences the growth of firms, which was measured by the rate of increase of net income from sales and number of employees. There is also evidence that ADTEN has a positive impact on productivity and patent applications, although the results are not conclusive as the parameters are not statistically significant.

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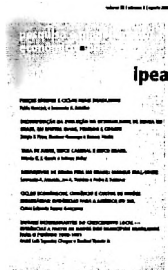
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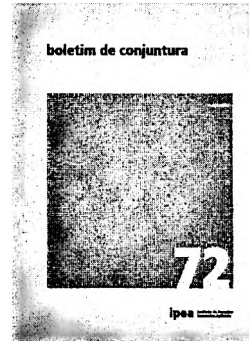
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