HOW EFFECTIVE ARE INNOVATION SUPPORT PROGRAMS TO STIMULATE INNOVATION? EVIDENCE FROM PARAGUAY

Diego Aboal

Gustavo Rojas

Belén Servín

Paz Queraltó

LATIN AMERICAN AND THE CARIBBEAN ECONOMIC ASSOCIATION

April 2019

LACEA WORKING PAPER SERIES No. 0026 April 2019

How Effective are Innovation Support Programs to Stimulate Innovation? Evidence from Paraguay

Diego Aboal
CINVE - Centro de Investigaciones Económicas; Universidad ORT Uruguay, and Facultad de Ciencias Económicas y Administración, Universidad de la República de Uruguay
aboal@cinve.org.uy

Gustavo Rojas
Centro de Análisis y Difusión de la Economía Paraguaya
grojas@cadep.org.py

Belén Servín
Centro de Análisis y Difusión de la Economía Paraguaya
bservin@cadep.org.py

Paz Queraltó
CINVE - Centro de Investigaciones Económicas
mpazqueralto@cinve.org.uy

ABSTRACT

In this paper we evaluate the impact of two programs to support innovation in micro, small and medium enterprises in Paraguay. This article has two contributions to literature. First, the evidence on the impact of this type of programs in developing countries is still scarce. Second, we evaluate the impacts on some variables that have been largely overlooked in the literature, such as innovation activities other than R&D. The evaluation finds positive and significant effects on the probability of carrying out various innovation activities, on the probability of achieving different types of innovation and on the incorporation of technical personnel to the firms. A negative effect on R&D was found, which might be showing a displacement effect of this innovation activity by others. The most robust results are those related to the impact of the program on process and product innovation. The impacts on innovation activities and employment are less robust to alternative specifications and samples.

JEL Classification: O31, O32, O38, C21

Keywords: innovation support programs, innovation, impact evaluation, Paraguay

ACKNOWLEDGEMENTS AND FINANCIAL DISCLOSURE

The authors are very grateful to Joyce Vázquez for her excellent research assistance. We thank the financial support of CONACYT and the comments of Idelin Molina, Juan Pablo Ventura and participants of a CONACYT seminar in Asunción in November 2017, participants of the second Conference of the Latin American and Caribbean Network on Economics of Innovation and Entrepreneurship in Buenos Aires, July 2018 and LALICS Conference in Ciudad de México in November 2018. All remaining errors and limitations are our responsibility.

1. Introduction

The building of technological capabilities and innovation are considered key factors for economic growth. On them relies the competitiveness of a country, the creation of decent employment, the increase of its human capital and the capacity to use it efficiently in order to face the different challenges that arise in the process of productive development. The need for public support for innovation, in particular financial support, is based on the assumption that innovation is a non-rival good and, at least partially, not excludable. As a result, firms cannot fully internalize the return on their investments in innovation. This produces a gap between the social and private return to innovation and, therefore, firms tend to invest less than the social optimum.

There is evidence that imitations are not free and that they can cost between 50% and 75% of the original investment in research and development (R&D) (Hall and Lerner, 2010). While this could mitigate the problem of excludability mentioned above, it partially persists because the original investor can not completely internalize the returns on his investment.

It is important to note that the argument in favor of public financial support goes beyond the stated externalities problem. Even when this problem can be solved through intellectual property protection or other means, investment in innovation presents other characteristics that justify public financing. In particular, investment in innovation is very uncertain and the asymmetry of information between the innovator and the investor could be greater than in other types of investments, which translates into greater problems of moral hazard and adverse selection. Therefore, credit restrictions and high loan costs are likely to affect the level of investment in innovation.

In several countries, these theoretical considerations have stimulated public interventions with the aim of increasing investment in innovation activities (i.e. innovation efforts), innovation and productivity. However, there are several reasons why innovation policies may not have positive or significant effects at firm or aggregate level. Andrews and Criscuolo (2013) mention some of them. First, innovation policies could increase the cost of innovation (for example, by increasing the remuneration of scientists that perform R&D). Second, incentives to innovation could lead

to duplication of investments, crowding-out of private investment or even to the reclassification of existing non-innovative activities as activities of that type. Third, innovation agencies may have limited capacity to direct funds to projects with a potentially high productivity impact. Finally, incentives are sometimes assigned to firms with little likelihood of producing indirect effects (spillovers) that generate aggregate productivity gains. Therefore, impact evaluation of this type of programs is of essential importance.

In this paper we evaluate the impact of two public programs (PROCIT and DETIEC; for their Spanish acronym) to support innovation in micro, small and medium enterprises in Paraguay. This article has two main contributions to literature. First, the evidence on the impact of this type of programs in developing countries is scarce. Second, we evaluate the impacts on some variables that have been largely ignored in the literature, such as innovation activities other than R&D.

Most of the available empirical literature has focused on public financing policies for R&D activities in developed countries[1] and has paid less attention to the evaluation of innovation support programs in a broader sense and in developing countries[2]. R&D is just one of the activities that can be carried out to achieve innovations and possibly not the most relevant for firms in developing countries, where the incorporation and adaptation of technology, training and contracting of consultancies, seem to be of key importance to generate innovations.

Only few studies in the literature measure the impact of innovation support programs on the same outcome variables as our study does. As an example, no documents have been found that measure the impact on innovative efforts other than R&D, such as investments in personnel training and consulting with the aim of introducing innovations, and few studies have been found that measure impacts on innovation results such as product and process innovation. No studies have been found that estimate the impact on organizational and marketing innovations.

Only few studies in the literature measure the impact of innovation support programs on the same outcome variables as our study does (see next section). As an example, no documents

[1]David, Hall and Toole (2000) examined this literature extensively. Other studies along the same line include Almus and Czarnitzki (2003), Duguet (2004), González and Pazó (2008) and Czarnitzki and Fier (2002).
[2] Some exceptions are Aboal and Garda (2015) and Crespi, Maffioli and Meléndez (2011).

have been found that measure the impact on innovative efforts other than R&D, such as investments in personnel training and consulting with the aim of introducing innovations, nor that estimate the impact on organizational and marketing innovations. Only few studies have been found that measure impacts on innovation results such as product and process innovation.

Next section presents a brief literature review. Section 3 describes PROCIT and DETIEC programs. Section 4 shows the source of data and some descriptive statistics. Section 5 discusses the methodology. Section 6 shows the results. Finally, section 7 concludes.

2. Literature review

In this section we review papers that evaluate the impact of innovation programs on different firm-level outcome variables.

The papers presented here can be classified into three large groups according to the outcome variables. In the first place, there are works that measure the impact on innovation inputs or innovation efforts, such as R&D, training, acquisition of ICT, etc. A second group measure impacts on innovation results such as product and process innovation or number of patents obtained. Finally, the third group identifies the impact on firms´ performance variables (sales, productivity, employment). In some cases, the studies cover more than one of these groups.

Most of the available evidence in the literature is about developed countries and measures the impact on R&D expenditures. Recent studies have focused on analyzing the possible crowding out effect of private investment in innovation policies. Several studies have found evidence that there is no crowding out effect; indeed, there is evidence that public programs to support innovation increase private expenditures in innovation activities. Gonzalez, Jamandreu and Pazó (2005) use a sample of Spanish manufacturing firms to find the effects of the subsidies and conclude that the percentage of firms that carry out innovative activities within the beneficiaries increases. Binelli and Maffioli (2006) find a 12% increase in R&D expenditures, while Czarnitzki and Hussinger (2004) find a 45% increase in R&D expenditures. There are several works for Argentina that show an increase in R&D expenditure as a result of different innovation support programs. Chudnovsky, López, Rossi, and Ubfal (2006) and Sanguinetti

(2005) find a positive effect in R&D spending but not on innovation. Hall and Maffioli (2008) find significant impacts on R&D spending for Argentina and Brazil. Czarnitzki and Fier (2002) find that subsidies for innovation increase the intensity of R&D activities in a panel of German service firms. Bukstein, Hernández, Monteiro and Vaz (2017) find that beneficiary firms in Uruguay increase their probability of carrying out R&D activities by 18%.

With regard to the impact on innovation results, Hall and Maffioli (2008) carry out a study to evaluate innovation support policies in four countries: Argentina, Brazil, Chile and Panama, but only find significant impacts on these types of variables in two countries. Specifically, using a panel of Brazilian firms from 1999 to 2003, they find an increase of 5% in the probability of obtaining patents in the beneficiary firms. In the case of Panama, they find an impact on product and process innovation of 8 and 10 percentage points respectively. Alvarez, Bravo and Zahler (2013) evaluate innovation programs in the service sector of Chile, and find an increase of 16 percentage points in the probability of making a product or process innovation. Benavente, Crespi and Maffioli (2007), also analyzing the Chilean case find an increase of 11 percentage points in the probability of product innovation. Crespi, Maffioli and Melendez (2011) evaluating COLCIENCIAS' support for innovation in Colombia find a 12% increase in the introduction of new products. Bernheim, Bukstein and Hernandez (2014) conclude for Uruguay that there is an increase in the probability of product innovation of between 20% and 23% for beneficiary firms, but there is no significant impact on the probability of introducing processes innovations.

Finally, with respect to the performance of firms, for the case of Brazil, De Negri, Borges Lemos and De Negri (2006) study the impact of an innovation support program in the industrial sector and find an increase in the sales growth rate of 64 percentage points, but they do not find effects on productivity. Kohon (2012) analyzes a panel of SMEs firms in Argentina and finds an increase in productivity. Lopez-Acevedo and Tan (2010) also study the impact on SMEs but in this case for Mexico, Chile, Colombia and Peru, finding significant impacts on different performance variables such as sales, productivity and profits. For the case of Costa Rica, Monge-Gonzalez and Rodríguez-Álvarez (2013) find a significant positive impact on real wages and Linares et al. (2007) find a positive effect on employment for Colombian firms. Finally, Hall

and Maffioli (2008) find significant positive impacts on employment and sales in Brazil, and a positive impact on sales in Panama.

3. Science, technology and innovation in Paraguay and PROCIT and DETIEC programs

In the recent period, the Paraguayan economy has shown significant growth in its income and exports. The GDP average growth during the period 2006-2015 was 5% (World Bank Data). Despite this good performance, the economy shows productivity problems, reflecting the lags in the efficiency with which firms operate. The information from the Enterprise Surveys of 2010, shows that the typical local manufacturing firm has a productivity of only 28% of the best productive practice at a global level.

On the other hand, the aggregate indicators of science and technology exhibited a relatively favorable trend in recent years. The R&D spending went form US dollars 6.5 million in 2006 (0.08 of the GDP) to 31.9 million (0.1 of the GDP) in 2014. In this context, it should be noted that the public support system for science, technology, research and innovation in the country has been strengthened, mainly since the implementation in 2008 of the PROCIT program and in 2012 of the DETIEC program in the orbit of CONACYT in Paraguay.

The PROCIT program started in 2006. One of the components of PROCIT was the financial support for innovation projects. The program granted non-reimbursable co-financing to innovation projects of private firms based in Paraguay, aimed at improving competitiveness, productivity and profitability through new or improved products or processes.

On the other hand, in mid-2012 the execution of DETIEC began. One of the components of the project includes the co-financing of innovation projects in firms with the aim of strengthening their technological capacity. The target population of the Project was the micro, small and medium enterprises, which submitted proposals individually or in association with other firms or research institutions.

The funding has varied over time, but most of the projects have received contributions in the order of USD 40,000 to 50,000. In all cases, firms provided a minimum counterpart, which ranges between 20% and 30% of the total amount awarded.

The number of projects awarded by PROCIT and completed is 16. In the case of DETIEC, the number of projects awarded increases to 20, of which 8 were completed at the moment of the evaluation. In most cases the duration of the projects was between one and two years.

In Diagram 1 we summarize the logical framework of the program. We expect to find effects of the innovation programs at different lengths of time. In the short and medium run (the period of time in which we perform this evaluation) we expect to identify effects on innovation activities such as R&D, acquisition of machinery and equipment/hardware, acquisition of software, acquisition of disembodied technology, consultancies, training of personnel, activities of engineering and industrial design and market research, and also, on innovation variables and employment.

A second group of outcome variables includes those which differences between beneficiaries and non-beneficiaries are expected to be found after the changes are more consolidated. Such variables are associated with competitiveness of the firm (e.g. labor productivity).

In this paper we focus on the first group of variables.

Diagram 1. Logical framework of innovation programs in Paraguay

Problems	Activities/Actions	Short and medium term results	Long term results
• Productivity Problems • Investment in R&D lower than that of its peers in the region • Lack of funding • Lack of collaboration between firms and with universities	• Design of an innovation projects window • Calls, evaluation, approval and follow-up of innovation projects. • Conformation of an evaluators' network. Hiring of external evaluators • Training of innovation projects managers. • Hiring of trainers for innovation projects preparation and management courses. • Granting of subsidies	• Greater innovation efforts • More innovation • Increase in skilled labor	Improved competitiveness of Paraguayan firms

4. Data and descriptive statistics

In order to collect information about the firms that signed up for the programs, a survey of all the firms that applied to PROCIT and DETIEC (beneficiaries and non-beneficiaries) was conducted. The survey was specifically designed for this evaluation and is a simplified version of the Paraguay innovation survey. The survey collected information since 2007, year in which the first call for projects took place[3]. Thus, data for each firm was surveyed throughout all the years from 2007 to 2016, with the exception of those firms that were created after 2007.

In terms of content, the survey implemented, on the one hand, a series of questions aimed at gathering general characteristics of the firm and then another series of questions that seek information on variables that may have been affected by the program.

Table 1 summarizes the total number of firms that applied to funding, the number of surveys answered, and within them, how many correspond to beneficiaries and non-beneficiaries.

Table 1. Field work results

Total firms that applied	112
Accepted to answer survey	57
Beneficiaries	26
Non-Beneficiaries	31

Source: own elaboration based on survey and administrative records of CONACYT

As shown in Table 1, of a total of 112 firms that applied for funding, 57 firms agreed to respond to the survey, that is, 51%. Therefore, the final database has 57 firms, of which there are 26 beneficiary firms and 31 non-beneficiary firms. These 26 beneficiary firms correspond to 72% of the total beneficiaries.

In addition to the survey, we have a database with administrative data, provided by CONACYT. This database has information about the type of project, area of activity of the firm, date of beginning and end of the project, and the amount allocated to it. It also points out pertinent

[3] The call began in December 2007 and continued at the beginning of 2008. Therefore, 2008 is considered as the first year of the program.

observations about project delays, disbursement dates, etc. With this information a variable year of treatment is created. It takes value 0 in all the years previous to the start of the project and 1 since the first year of treatment.[4]

Table 2 shows the year in which firms applied to/started the program. Given this distribution of firms, on average we have data for a period of 3.9 years after the start of the program (with a minimum of 1 year and a maximum of 9 years). This why we interpret the results presented in next section as short to medium run effects. We do not have application year information for 2 non-beneficiaries firms.

In terms of geographical location, Table 3 shows that most firms come from the capital, Asunción.

Table 2. Number of firms that applied to/started the program, by year

	2008	2009	2010	2011	2012	2013	2014	2015	2016	**Total**
Beneficiaries	3	0	2	3	3	0	2	9	4	26
Non-beneficiaries	5	6	0	1	1	2	4	5	5	29
Total	8	6	2	4	4	2	6	14	9	55

Source: own elaboration based on survey and administrative records of CONACYT. We only include in this table the firms that answered the survey.

Table 3. Geographical Location

Location	**Non-Beneficiaries**	**Beneficiaries**
Alto Paraná	1	2
Asunción	25	17
Canindeyú	1	0
Central	3	7
Cordillera	1	0

Table 4 shows the means of different variables for the year before treatment (beneficiaries) or year of application to the program (non-beneficiaries). The column following the means,

[4] When the start of the project is from October to December, it is assumed that the Project started the following year.

column "N", shows the number of firms that answer each question. Questions were not mandatory and therefore the response rate varies.

It is interesting to note that there is only one variable for which the difference between groups is significant at 5% (i.e. belongs to a business group). Therefore, it could be said that the characteristics of both groups at the time of application for a grant, at 5% confidence level, are in general similar[5]. The fact that in general both groups are similar prior to the intervention, together with the fact that the pre-treatment trend of the different variables in both groups is in general parallel (see section 5) is positive from the point of view of the empirical strategy that we will discuss in the next section.

Table 4. Descriptive statistics

	Non-Beneficiaries		**Beneficiaries**		
Variable	**Mean**	**N**	**Mean**	**N**	**Difference**
Age of firm	13	29	16	26	**3**
Urban area	90%	30	92%	26	**2pp**
Belongs to a business group	29%	31	4%	26	**-25pp***
Has foreign capital participation	3%	31	8%	26	**4pp**
Is a subsidiary	6%	31	12%	26	**5pp**
Number of premises	1.4	30	1.4	26	**0.05**
Exports to South America	18%	28	12%	26	**-6pp**
Exports to the Rest of the World	11%	28	8%	26	**-3pp**
Employees	17.7	24	21.4	21	**4**
Professionals	9.5	24	6.2	20	**-3**
Technicians	4	23	8.2	18	**4**
R&D	79%	28	83%	24	**5pp**
Machinery and equipment or hardware	39%	28	38%	24	**-2pp**
Software	21%	28	29%	24	**8pp**
Disembodied technology	4%	28	8%	24	**5pp**
Consultancies and technical assistance	29%	28	17%	24	**-12pp**

[5] We performed a test of difference of means, which assumes the equality of means. For all cases, except for "belongs to a business group", the p-value is greater than 0.05, which implies that the hypothesis of equality of means at that level of significance is in general not rejected at 5% level. At 10%, the difference of means of the variable "process innovation" is also significant.

Engineering and design activities	29%	28	21%	24	**-8pp**
Training	36%	28	46%	24	**10pp**
Market research	4%	28	13%	24	**9pp**
Product innovation	46%	28	54%	24	**8pp**
Process innovation	14%	28	38%	24	**23pp**
Organizational innovation	21%	28	35%	26	**13pp**
Marketing innovation	11%	28	4%	24	**-7pp**

Notes: mean of different variables for the year previous to treatment (beneficiaries) or year of application to the program (non-beneficiaries), pp=percentage points, N=number of answers, *significant at 5%. The values of the means are rounded.

5. Methodology

The database that we use has an attribute that is important for the impact evaluation: its longitudinal nature. It allows observing the behavior of a sample of beneficiary and non-beneficiary firms over several years during the period 2007-2016.

The identification of the program's impact is based on the assumption that participation in the program depends both on observable characteristics of the firms and on unobservable characteristics that persist over time. Therefore, the average effect of the program can be identified using the differences-in-differences method. That is, estimating by fixed effects the following equation for the result variable Y_{it}:

$$Y_{it} = \beta D_{it} + \gamma X_{it} + \delta_t + u_i + e_{it} \qquad (1)$$

where $\mathrm{D_{it}}$ is 1 from the moment when the firm receives the benefit of the program and 0 otherwise, $\mathrm{X_{it}}$ is a vector of control variables not affected by the program, δ_t is a time fixed-effect, $\mathrm{u_i}$ is a firm fixed-effect and $\mathrm{e_{it}}$ is an error term, independent of the other regressors.

For β to be a consistent estimator of the treatment effect, the key assumption is that the trends of the outcome variables, in the absence of treatment, are the same between the individuals in the treatment group and those in the control group. If there are significant differences observed between the control and the beneficiaries group in the pre-treatment period, there is a sign that this assumption is not credible.

Another variant to consider is the one used in Castillo et al. (2014). We assume that the expected value of the potential result in absence of treatment, conditional on the value of the lagged outcome variable and the other observables, is independent of the participation in the program. In this case, a more restrictive assumption is imposed, which is the non-correlation between u_i and the treatment variable. This implies to estimate the following equation:

$$Y_{it} = \sum_k \alpha_i Y_{it-k} + \beta D_{it} + \gamma X_{it} + \delta_t + e_{it} \qquad (2)$$

Angrist and Pischke (2009) show that the estimator of β by random effects in (2) provides a lower bound of the program effect. Thus, it offers a conservative estimation of the impact of the program, and it is also informative even in the absence of the assumption of no correlation between D_i y u_i.

The validity of the identification strategy can be reinforced by restricting (or replacing) the non-beneficiary sample so that it is more similar to the sample of beneficiaries. This can be done by matching treatments and controls based on the observed characteristics prior to treatment. In any case, as it has been discussed in section 3, it cannot be rejected at 5% confidence level that the beneficiaries and non-beneficiaries groups have the same characteristics in the observable variables in the year prior to the intervention (with the exception of only one variable). This gives some confidence that the 2 groups are similar and therefore, it is not necessary to restrict the sample. This is important, considering the loss of observations if the sample is restricted.

To address the validity of the control group and, therefore, the robustness of our estimates, we evaluate whether the pre-intervention trends for participants and non-participants are different using the following equation:

$$Y_{it} = \varphi_1 D_{it}^1 + .. + \varphi_m D_{it}^m + \beta D_{it} + \gamma X_{it} + \delta_t + u_i + e_{it} \qquad (3)$$

Where D^m takes the value 1 for the treated firms m-years before the intervention and 0 otherwise. In the estimates presented below, we evaluate whether the outcome variable presents different trends using a m = 2. Under the null hypothesis of common trends, all coefficients φ must be statistically equal to zero. This is the condition that must be verified in order to validate our identification strategy of fixed effects.

Finally, our identification strategy can be criticized along the following line. Even though the rate of response of the survey among beneficiaries is high (72%), the rate among non-beneficiaries is relatively low (41%). This could imply that firms that are in the non-beneficiaries group could be a selected group.

To overcome this criticism, and given that not all beneficiaries enter the program at the same time, we can run regression (1) restricting the sample to beneficiaries firms. In other words, beneficiaries firms can be used as control firms in the periods before receiving the subsidies. If results are similar to those obtained without restricting the sample, we can be relatively confident that this source of bias is not operating. In Table 8, in the next section, we run this robustness check.

6. Results

In table 5 we present the estimation of equation (1). In regression 1 only firm and time fixed-effects are included. In the regression 2 we add exogenous controls: age and age squared.

The coefficients of the variable Detiec_Procit (dummy D in the equation 1) are the estimation of the impact of participating in the program on the variables that appear in the heading of columns (1) - (15) of Table 5. In other words, the coefficients reported in Table 5 are estimates of the parameter β in equation (1).

With respect to the impacts on employment (first 3 columns) there is a positive and significant impact of 1 additional technician. The estimated impact on total employment is also close to 1, but it is not significant. No impact is found on professionals.

When we focus on innovation activities carried out by the firms (columns (4) - (11) of Table 5) we find positive and significant impacts on the probability of making investments in Machinery (+22 percentage points), Software (+11 percentage points) and Consulting (+10 percentage points). There is a negative effect (-10 percentage points) on the probability of R&D. The latter may be reflecting a substitution of this strategy for one or more of the 3 innovation activities mentioned above. No significant impacts are found on the probability of investing in disembodied technologies, engineering and design, training or market research.

These results are generally robust to the inclusion of the variables age and age squared in the regression (Regression 2, Table 5). The only changes that occur are: i. the Software variable is no longer significant, although the value of the coefficient is the same, and ii. the Market Research variable becomes significant (+8 percentage points).

The support to innovation from CONACYT through PROCIT and DETIEC programs has had a positive and significant impact on the probability of innovation in products (+20 percentage points), in processes (+30 percentage points) and marketing innovation (+11 percentage points) (columns (12), (13) and (15) of Table 5). The impact on the probability of organizational innovations is positive, but not significant (column (14)).

We have also estimated equation (2). The estimation of equation (2) gives a lower-bound of the impact.

In these estimates (see table 6) we find positive effects only on the probability of investing in Machinery (+15 percentage points) and on the probability of achieving product innovation (+12 percentage points) and process innovation (+ 12 percentage points). When we control for age and age squared, we find also a positive and significant effect on the probability of carrying out training activities (+6 percentage points).

In table 7 we show the estimates of equation (3). There we can see that with the exception of the variable disembodied technology, all the other variables pass the placebo tests. Training does not pass the placebo test at 10% only when controlling for age and age squared. Therefore, we can be relatively confident in our identification strategy.

Finally, in Table 8, we run regression (1) restricting the sample to beneficiaries firms. The results with respect to Product Innovation, Process Innovation and Marketing Innovation remain roughly the same as in Table 5, both in magnitude (except for process innovation; smaller coefficient in Table 8) and significance. For the innovation activities variables, the changes are more pronounced. Even though the effects are similar, in general they are smaller in Table 8 than in Table 5. Moreover, only Machinery and Market Research are significant in Table 8. We cannot rule out that the significance problem could be related to a small sample problem.

Table 5. Effects of the programs PROCIT and DETIEC on different variables

VARIABLES	(1) Employees	(2) Professionals	(3) Technicians	(4) R&D	(5) Machinery	(6) Software	(7) Technology	(8) Consultancy
Regression 1								
Detiec_Procit	1.208	0.673	0.954**	-0.105**	0.221***	0.109*	0.064	0.103*
	(1.559)	(0.900)	(0.485)	(0.046)	(0.073)	(0.063)	(0.040)	(0.058)
Regression 2								
Detiec_Procit1	1.227	0.616	0.963**	-0.089**	0.190**	0.106	0.069	0.116**
	(1.550)	(0.875)	(0.487)	(0.043)	(0.075)	(0.065)	(0.042)	(0.058)
Observations	398	408	376	481	485	485	483	482
R2 Reg. 1	0.88	0.79	0.96	0.76	0.53	0.62	0.58	0.64
R2 Reg. 2	0.88	0.79	0.96	0.77	0.54	0.62	0.58	0.65

Notes: Regression 1 only with temporary dummies and fixed effects, Regression 2 includes temporary dummies, fixed effects, age and age squared. Robust standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Cont.

VARIABLES	(9) Engineering & design	(10) Training	(11) Market research	(12) Product Innovation	(13) Process Innovation	(14) Organizational Innovation	(15) Marketing Innovation
Regression 1							
Detiec_Procit	0.044	0.063	0.062	0.200***	0.301***	0.066	0.114***
	(0.045)	(0.053)	(0.041)	(0.057)	(0.063)	(0.061)	(0.043)
Regression 2							
Detiec_Procit	0.031	0.086	0.076*	0.203***	0.304***	0.071	0.122***
	(0.045)	(0.054)	(0.042)	(0.059)	(0.062)	(0.062)	(0.044)
Observations	482	482	481	481	479	492	472
R2 Reg. 1	0.70	0.78	0.54	0.71	0.61	0.49	0.37
R2 Reg. 2	0.70	0.79	0.55	0.71	0.61	0.49	0.37

Notes: Regression 1 only with firm and time fixed-effects, Regression 2 includes in addition age and age squared. Robust standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Effects of the programs PROCIT and DETIEC on different variables (lower-bound impact)

VARIABLES	(1) Employment	(2) Professionals	(3) Technicians	(4) R&D	(5) Machinery	(6) Software	(7) Technology	(8) Consultancy
Regression 1								
Detiec_Procit	1.392	0.595	0.407	-0.008	0.149***	0.058	0.017	0.049
	(0.862)	(0.621)	(0.314)	(0.028)	(0.050)	(0.045)	(0.016)	(0.039)
Regression 2								
Detiec_Procit	1.507	0.598	0.412	-0.002	0.147***	0.064	0.019	0.059
	(0.934)	(0.610)	(0.304)	(0.028)	(0.051)	(0.046)	(0.018)	(0.041)
Observations	352	361	331	425	426	426	425	425
R2 Reg.1	0.94	0.86	0.96	0.75	0.36	0.47	0.43	0.56
R2 Reg.2	0.94	0.86	0.96	0.75	0.37	0.48	0.44	0.56

Notes: Regression 1 only with firm and time fixed-effects, Regression 2 includes in addition age and age squared. Robust standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Cont.

VARIABLES	(9) Engineering & design	(10) Training	(11) Market research	(12) Product Innovation	(13) Process Innovation	(14) Organizational Innovation	(15) Marketing Innovation
Regression 1							
Detiec_Procit	0.024	0.049	0.000	0.125***	0.125***	0.031	0.032
	(0.026)	(0.039)	(0.021)	(0.044)	(0.047)	(0.041)	(0.023)
Regression 2							
Detiec_Procit	0.023	0.060*	0.003	0.122***	0.122**	0.03	0.033
	(0.027)	(0.036)	(0.022)	(0.45)	(0.048)	(0.044)	(0.024)
Observations	425	425	425	422	422	435	417
R2 Reg.1	0.60	0.70	0.46	0.58	0.47	0.33	0.32
R2 Reg2.	0.60	0.70	0.46	0.58	0.47	0.33	0.32

Notes: Regression 1 only with temporary dummies and fixed effects, Regression 2 includes temporary dummies, fixed effects, age and age squared. Robust standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Placebo Test of parallel trends before treatment

VARIABLES	(1) Employment	(2) Professionals	(3) Technicians	(4) R&D	(5) Machinery	(6) Software	(7) Technology	(8) Consultancy
Regression 1								
φ_2	1.318	0.352	-0.036	0.024	0.021	-0.042	0.124**	0.070
	(2.244)	(1.011)	(0.623)	(0.052)	(0.089)	(0.070)	(0.056)	(0.072)
φ_1	1.759	-0.074	0.324	-0.03	0.017	-0.017	0.099*	0.051
	(2.025)	(0.781)	(0.597)	(0.073)	(0.083)	(0.090)	(0.053)	(0.070)
Regression 2								
φ_2	1.385	0.225	-0.008	0.010	0.043	-0.040	0.121**	0.062
	(2.238)	(0.974)	(0.615)	(0.052)	(0.089)	(0.070)	(0.057)	(0.072)
φ_1	1.784	-0.054	0.347	-0.009	0.017	-0.017	0.100*	0.052
	(2.016)	(0.811)	(0.593)	(0.070)	(0.082)	(0.090)	(0.053)	(0.070)
Observations	398	408	376	481	485	485	483	482
R2 reg.1	0.88	0.79	0.96	0.76	0.53	0.62	0.59	0.64
R2 reg.2	0.88	0.79	0.96	0.77	0.54	0.62	0.59	0.65

Notes: Regression 1 only with temporary dummies and fixed effects, Regression 2 includes temporary dummies, fixed effects, age and age squared. Robust standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Cont.

VARIABLES	(9) Engineering & design	(10) Training	(11) Market research	(12) Product Innovation	(13) Process Innovation	(14) Organizational Innovation	(15) Marketing Innovation
Regression 1							
φ_2	-0.016	-0.082	0.056	-0.094	0.060	0.048	-0.018
	(0.041)	(0.053)	(0.047)	(0.083)	(0.094)	(0.078)	(0.035)
φ_1	-0.028	-0.050	0.080	-0.054	0.113	0.082	0.038
	(0.058)	(0.075)	(0.059)	(0.076)	(0.083)	(0.083)	(0.044)
Regression 2							
φ_2	-0.008	-0.096*	0.048	-0.098	0.058	0.043	-0.024
	(0.042)	(0.052)	(0.046)	(0.082)	(0.093)	(0.078)	(0.036)
φ_1	-0.028	-0.049	0.080	-0.054	0.112	0.082	0.037
	(0.058)	(0.075)	(0.060)	(0.076)	(0.083)	(0.083)	(0.044)
Observations	482	482	481	481	479	492	472
R2 reg.1	0.70	0.78	0.54	0.71	0.61	0.49	0.37
R2 reg.2	0.70	0.79	0.55	0.71	0.61	0.49	0.37

Notes: Regression 1 only with temporary dummies and fixed effects, Regression 2 includes temporary dummies, fixed effects, age and age squared. Robust standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 8. Effects of the programs PROCIT and DETIEC on different variables (only beneficiaries firms in the sample)

VARIABLES	(1) Employees	(2) Professionals	(3) Technicians	(4) R&D	(5) Machinery	(6) Software	(7) Technology	(8) Consultancy
Regression 1								
Detiec_Procit	1.469	0.001	0.647	-0.095	0.168*	0.039	-0.040	0.080
	(2.748)	(0.761)	(0.823)	(0.058)	(0.094)	(0.088)	(0.051)	(0.063)
Regression 2								
Detiec_Procit1	1.455	0.013	0.648	-0.075	0.139	0.036	-0.035	0.097
	(2.694)	(0.766)	(0.824)	(0.054)	(0.095)	(0.090)	(0.053)	(0.065)
Observations	174	184	161	226	230	230	228	227
R2 Reg. 1	0.91	0.90	0.96	0.75	0.45	0.50	0.43	0.64
R2 Reg. 2	0.91	0.90	0.96	0.77	0.48	0.50	0.43	0.65

Notes: Regression 1 only with temporary dummies and fixed effects, Regression 2 includes temporary dummies, fixed effects, age and age squared. Robust standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 8. Cont.

VARIABLES	(9) Engineering & design	(10) Training	(11) Market research	(12) Product Innovation	(13) Process Innovation	(14) Organizational Innovation	(15) Marketing Innovation
Regression 1							
Detiec_Procit	0.064	0.047	0.094*	0.203***	0.172*	-0.024	0.105*
	(0.065)	(0.064)	(0.055)	(0.075)	(0.092)	(0.075)	(0.056)
Regression 2							
Detiec_Procit	0.049	0.068	0.106*	0.213***	0.174*	-0.021	0.112*
	(0.066)	(0.064)	(0.056)	(0.075)	(0.092)	(0.077)	(0.060)
Observations	227	227	226	226	224	237	217
R2 Reg. 1	0.70	0.78	0.61	0.65	0.57	0.62	0.23
R2 Reg. 2	0.70	0.79	0.62	0.65	0.57	0.62	0.23

Notes: Regression 1 only with temporary dummies and fixed effects, Regression 2 includes temporary dummies, fixed effects, age and age squared. Robust standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

7. Conclusions

The objective of this paper is to evaluate the impact that innovation programs in Paraguay have had on small and medium enterprises.

Two are the main contributions of this paper. First, we add to the scarce literature on the impacts of this type of programs in developing countries. Second, we evaluate the impacts on some variables that have been largely ignored in the literature, such as innovation activities other than R&D.

We found positive and significant effects on the probability of carrying out various innovation activities, on the probability of achieving different types of innovation and on the number of technical personnel of the firms. A negative effect on R&D was found, which may be showing a displacement effect of this innovation activity by others.

The impacts found for PROCIT and DETIEC on the probability of generating product and process innovation, 20 and 30 percentage points respectively, are above those identified in the literature review for developing countries.

We run different robustness checks. The most robust results are those related to the impact of the program on process and product innovation. The impacts on innovation activities and employment are less robust to alternative specifications and samples.

References

Aboal, D., Garda, P., (2015), "Does public financial support stimulate innovation and productivity? An impact evaluation. *CEPAL Review* 115: 42-62.

Almus, M. and Czarnitzki, D. (2003), "The effects of public R&D subsidies on firms' innovation activities: the case of Eastern Germany", *Journal of Business and Economic Statistics*, vol. 21, No. 2, American Statistical Association

Álvarez, R., Benavente, J., Contreras, C., Contreras, J. (2010), "Consorcios Tecnológicos en América Latina: Una primera exploración de los casos de Argentina, Chile, Colombia y Uruguay". Washington, D.C. Banco Interamericano de Desarrollo.

Álvarez, R., Bravo, C., Zahler, A. (2010),"Impact Evaluation of Innovation Programmes in the Chilean Services Sector". CINVE

Andrews, D. and C. Criscuolo (2013), "Knowledge based capital, innovation and resource allocation", OECD Economics Department Working Papers, No. 1046, Paris, OECD Publishing.

Benavente, Crespi y Maffioli (2007), "Public Support to firm level innovation: an evaluation of the Fontec Programme" *OVE Working Papers 0507*, Inter-American Development Bank, Office of Evaluation and Oversight (OVE).

Bernheim J., Daniel B. y E. Hernandez (2014). "Documento evaluación de ANII: instrumentos de promoción de la innovación empresarial 2009/2012". Montevideo, ANII

Binelli, C. y Maffioli, A. (2006), "Evaluating the Effectiveness of Public Support to Private R&D: Evidence from Argentina", OVE Working Papers 1106, Inter-American Development Bank, Office of Evaluation and Oversight (OVE).

Bukstein, D., Hernández, E., Monteiro, L., Vaz, M.(2017), "Documento evaluación de ANII: instrumentos de promoción de la innovación empresarial 2007/2015". ANII, Montevideo.

Chudnovsky D., López, A., Rossi M. y Ubfal, D. (2006a), "Evaluating A Program Of Public Funding Of Private Innovation Activities, An Econometric Study of FONTAR in Argentina", OVE

Working Papers 1606, Inter-American Development Bank, Office of Evaluation and Oversight (OVE).

Conacyt (Consejo Nacional de Ciencia y Tecnología) (2012), "Reportes de avances de Programas de apoyo a la ciencia, tecnología e innovación en Paraguay", Asunción

Conacyt (Consejo Nacional de Ciencia y Tecnología) (2014), "Guía para la presentación de proyectos de innovación en empresas: ventanilla abierta", Asunción

Conacyt (Consejo Nacional de Ciencia y Tecnología) (2014), "Guía para la ejecución de proyectos de innovación en empresas: ventanilla abierta", Asunción

Conacyt (Consejo Nacional de Ciencia y Tecnología), "PROCIT: anuario final 2008-2009", Asunción

Crespi, G., A. Maffioli and M. Meléndez (2011), "Public support to innovation: the Colombian colciencias' experience", *Technical Notes*, No. IDB-TN-264, Washington, D.C., Inter-American Development Bank.

Czarnitzki, D. and A. Fier (2002), "Do innovation subsidies crowd out private investment? Evidence from the German service sector", *zew Discussion Paper*, No. 02-04, Mannheim, Centre for Economic European Research (zew).

Czarnitzki, D. and K. Hussinger (2004), "The link between r&d subsidies, r&d spending and technological performance",*zew Discussion Paper*, No. 04-056, Mannheim, Centre for Economic European Research (zew).

David, P., B.H. Hall and A.A. Toole (2000), "Is public r&d a complement or substitute for private r&d? A review of the econometric evidence", *Research Policy*, vol. 29, No. 4-5, Amsterdam, Elsevier.

De Negri J., Borges Lemos y De Negri, F. (2006), "The Impact of University Enterprise Incentive Program on the Performance and Technological Efforts of Brazilian Industrial Firms". OVE Working papers Inter-American Development Bank, Office of Evaluation and Oversight (OVE).

Duguet, E. (2004), “Are r&d subsidies a substitute or a complement to privately funded r&d? Evidence from France using propensity score methods for non-experimental data”, *Revued’Économie Politique*, vol. 114, No. 2, Dalloz.

González, X. and C. Pazó (2008), “Do public subsidies stimulate private r&d spending?”, *Research Policy*, vol. 37, No. 3,Amsterdam, Elsevier.

González, X., J. Jaumandreu and C. Pazó (2005), “Barriers to innovation and subsidy effectiveness”, *rand Journal of Economics*, vol. 36, No. 4, The Rand Corporation.

Hall, B.H. and A. Maffioli (2008), “Evaluating the impact of technology development funds in emerging economies: evidence from Latin America”, OVE Working Papers, No. 0108, Washington, D.C., Inter-American Development Bank.

Hall, B.H. and J. Lerner (2010), “The financing of r&d and innovation”, *Handbook of the Economics of Innovation*, B.H.Hall and N. Rosenberg (eds.), Amsterdam, Elsevier.

Kohon,F. (2012), “El impacto de las actividades de innovación financiadas por el FONTAR en Pymes industriales de Argentina”. Argentina

López-Acevedo, G. and H. Tan (2010), “Impact evaluation of sme programs in Latin America and the Caribbean”, Washington,D.C., World Bank.

Monge-Gonzalez y Rodríguez-Álvarez (2013), “Impact Evaluation of Innovation and Linkage Development Programs in Costa Rica: The cases of PROPYME and CR Provee (2013)”. IDB Working Paper Series, No. IDB-WP-461 Costa Rica

Sanguinetti, P. (2005), “Innovation and R&D Expenditures in Argentina:Evidence from a firm level survey”. Departamento de Economía de la Universidad Torcuato Di Tella.

Appendix

Table A1. Definition of variables

Variable	Type of variable	
Age of firm	Numeric	Age of the firm
Urban area	Dummy	Takes value 1 if firm belongs to urban area, 0 otherwise
Belongs to a business group	Dummy	Takes value 1 if firm belongs to business group, 0 otherwise
Has foreign capital participation	Dummy	Takes value 1 if firm has foreign capital participation, 0 otherwise
Is a subsidiary	Dummy	Takes value 1 if firm is a subsidiary, 0 otherwise
Number of premises	Numeric	Number of premises the firm has
Exports to South America	Dummy	Takes value 1 if firm exports to South America, 0 otherwise
Exports to the Rest of the World	Dummy	Takes value 1 if firm exports to the Rest of the World, 0 otherwise
Detiec_Procit	Dummy	Takes value 1 after treatment for treated firms, and 0 otherwise
Employees	Numeric	Total people employed in the firm
Professionals	Numeric	People with a university level degree
Technicians	Numeric	People who have a specialization in the task they develop in the firm
R&D	Dummy	Takes value 1 if firm carry out the activity, 0 otherwise
Machinery and equipment or hardware	Dummy	Takes value 1 if firm carry out the activity, 0 otherwise
Software	Dummy	Takes value 1 if firm carry out the activity, 0 otherwise
Disembodied technology	Dummy	Takes value 1 if firm carry out the activity, 0 otherwise
Consultancies and technical assistance	Dummy	Takes value 1 if firm carry out the activity, 0 otherwise
Engineering and design	Dummy	Takes value 1 if firm carry out the activity, 0 otherwise
Training	Dummy	Takes value 1 if firm carry out the activity, 0 otherwise
Market research	Dummy	Takes value 1 if firm carry out the activity, 0 otherwise
Product Innovation	Dummy	Takes value 1 if innovation is achieved, 0 otherwise
Process Innovation	Dummy	Takes value 1 if innovation is achieved, 0 otherwise
Organizational Innovation	Dummy	Takes value 1 if innovation is achieved, 0 otherwise
Marketing Innovation	Dummy	Takes value 1 if innovation is achieved, 0 otherwise