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DEVELOPMENT BANK OF LATIN AMERICA

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ABSTRACT

We evaluate the impact of public financial support, both subsidies and credit, on different types of innovation in Colombian industry. We compare it with the effects of financing innovation with own resources and with private loans, and analyze the issue of crowding-out, for different classes of innovation. To control for potential selection bias, we apply Propensity Score Matching (PSM) techniques to a sample of 9173 manufacturing firms for the period 2011-2012, combining data from two available sources (Development and Technological Innovation Survey –EDIT6- and Annual Manufacturing Survey –EAM-). Results show that public financial support has a significant positive effect on products new for the international market and on process innovations. We further find that allocation of own resources of the firm to innovation activities has a positive effect on a wide variety of forms of innovation. Notwithstanding, its impact is substantially smaller than that of public funding in the cases of products new for the international market and on new processes. Commercial loans for innovation activities have no significant effects on either product or process innovations. Finally, we find that public funding increases the probability of allocating own resources to finance innovation activities, but reduces the probability of using private external sources.

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APOYO FINANCIERO PÚBLICO E INNOVACIÓN EN EMPRESAS MANUFACTURERAS COLOMBIANAS

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RESUMEN

Evaluamos el impacto del apoyo financiero público, tanto de subsidios como de créditos, sobre los diferentes tipos de innovación en la industria colombiana. Lo comparamos con los efectos de financiar la innovación con recursos propios y con préstamos privados, y analizamos si hay un desplazamiento de recursos privados para diferentes clases de innovación. Para controlar el sesgo de selección potencial, aplicamos las técnicas de *Propensity Score Matching* (PSM) a una muestra de 9173 empresas manufactureras para el periodo 2011-2012, combinando datos de dos fuentes disponibles (Estudio de Desarrollo e Innovación Tecnológica -EDIT6- y Encuesta Anual Manufacturera -EAM-). Los resultados muestran que el apoyo financiero público tiene un efecto positivo y significativo en los productos nuevos para el mercado internacional y en las innovaciones de procesos. Además, consideramos que la asignación de recursos propios de la empresa a actividades de innovación tiene un efecto positivo en una amplia variedad de formas de innovación. No obstante, su impacto es sustancialmente menor que el de la financiación pública en los casos de productos nuevos para el mercado internacional y en los nuevos procesos. Los préstamos comerciales para actividades de innovación no tienen efectos significativos en las innovaciones de productos o procesos. Finalmente, encontramos que la financiación pública aumenta la probabilidad de asignar recursos propios para financiar actividades de innovación, pero reduce la probabilidad de utilizar fuentes externas privadas.

Public financial support and innovation in Colombian manufacturing firms [2]

Fernando Barrios Aguirre, Clemente Forero Pineda and Guillermo Perry Rubio[3]

May 2017

Abstract

We evaluate the impact of public financial support, both subsidies and credit, on different types of innovation in Colombian industry. We compare it with the effects of financing innovation with own resources and with private loans, and analyze the issue of crowding-out, for different classes of innovation. To control for potential selection bias, we apply Propensity Score Matching (PSM) techniques to a sample of 9173 manufacturing firms for the period 2011-2012, combining data from two available sources (Development and Technological Innovation Survey –EDIT6- and Annual Manufacturing Survey –EAM-). Results show that public financial support has a significant positive effect on products new for the international market and on process innovations. We further find that allocation of own resources of the firm to innovation activities has a positive effect on a wide variety of forms of innovation. Notwithstanding, its impact is substantially smaller than that of public funding in the cases of products new for the international market and on new processes. Commercial loans for innovation activities have no significant effects on either product or process innovations. Finally, we find that public funding increases the probability of allocating own resources to finance innovation activities, but reduces the probability of using private external sources.

1 Introduction

Empirical studies conclude that differences in Total Factor Productivity (TFP) are strongly associated with differences in long-term GDP growth[1] and explain a higher fraction of the variance in growth rates than differences in factor accumulation. In particular, the lower Latin American average growth rates from 1960-2000, in comparison to those of either

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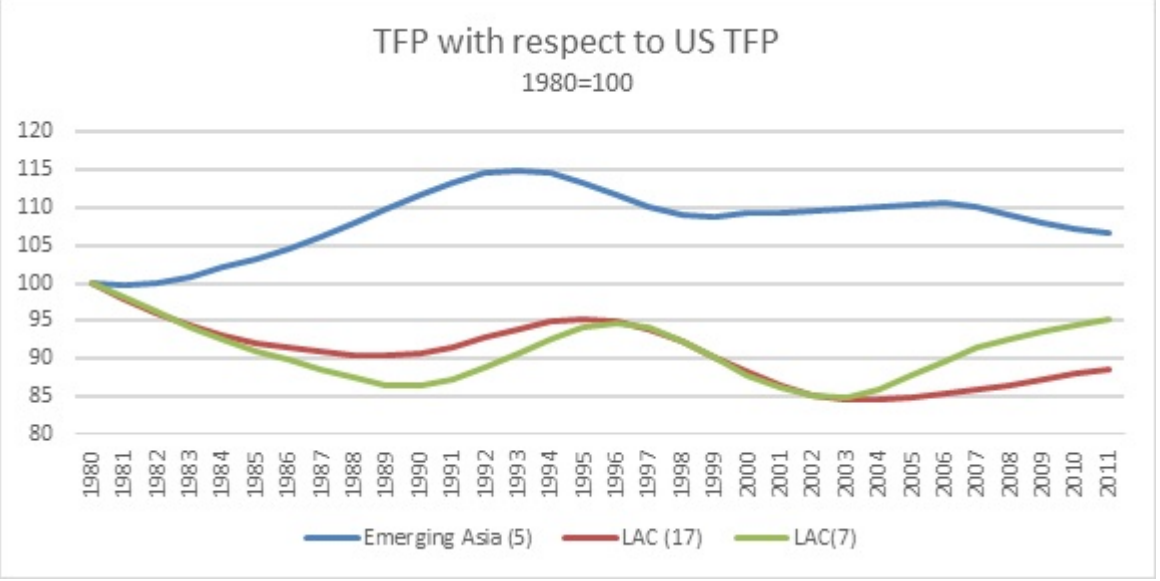
[1]Barro, Sala-i-Martin (1999), Loayza et al (2005)

industrialized or East Asian countries, can be explained mostly by differences in TFP growth rates between the two regions. See Figure 1.

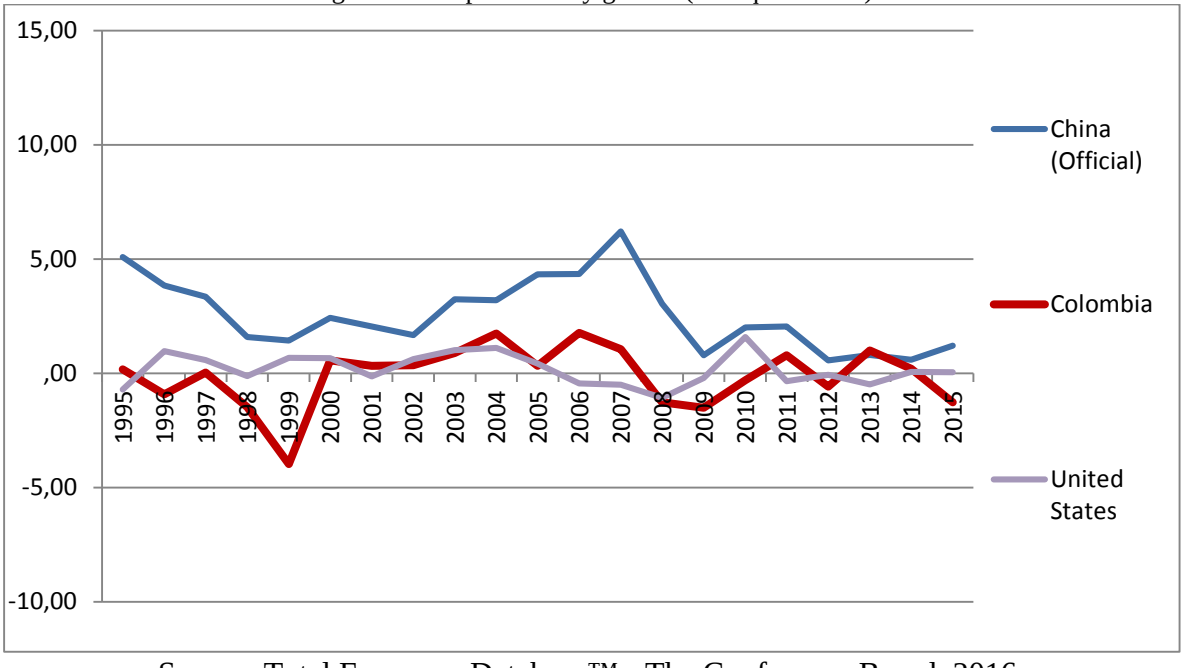
Figure 1: TFP with respect to US TFP



Source: Daude and Fernández-Arias, BID, 2013

Colombia, as other Latin American countries, has suffered from low growth of total factor productivity in the last decades. See Figure 2.

Figure 2. TFP productivity growth (Tornqvist Index)



Source: Total Economy Database™ - The Conference Board, 2016.

Though it is not possible to identify causality in these associations and neither is it easy to estimate the determinants of TFP growth, due to severe endogeneity problems, recent empirical literature on the determinants of growth suggests that different types of innovation are often behind TFP growth.[2] In this paper we adopt a broad definition of innovation including counts of changes in the technology of production and commercialization (process innovation), and counts of new or significantly improved products and services for local and for international markets.

2. Policy interventions to promote innovation activities

There is a broad literature discussing the rationale for policy interventions to promote innovation. It is frequently related to the identification of market failures leading to suboptimal levels of innovation activities and output, were they left exclusively to the interplay of market forces. Early literature emphasized the imperfect appropriability of net benefits due to high spillovers and positive externalities.[3] These create a significant wedge between social and private returns, and lead to suboptimal levels of innovation.

There is, however, another market failure deserving policy intervention. Innovation faces higher information asymmetries, uncertainty and risk than other economic activities. Thus, even if the innovator expects net positive private returns, she faces higher difficulties in financing her activities, compared to similar firms doing business as usual or even to entrepreneurs pretending to initiate new businesses with already proven and well-known technologies and products.[4] In other words, innovation activities are more affected by financial market failures than other economic activities. This consideration adds to the appropriability market failure in rendering levels of innovation activities well below the social optimum, since many innovation activities with expected positive net private returns may never be undertaken merely for financial reasons. Interventions designed to overcome financial constraints should consequently complement policies intended to mitigate appropriability problems.

Policy interventions to promote innovation activities can be considered a subset of Productive Development Policies (PDP's). A recent book on the subject by IADB[5] proposes three sets of questions to discuss the adequacy of particular PDP's:

(1) ¿Why is the market not producing the desired result?

As discussed above, in the case of innovation, imperfect appropriability and inadequate access to finance are market failures that justify policy interventions.

[2]Other factors explaining changes in TFP, which are not related to innovation activities, are changes in the structure of production related to variations in the structure of domestic demand or trade flows; increases in average sector productivity occurring when more productive firms grow at the expense of less productive firms, or learning by doing processes that improve the mastering of technologies already being used.

[3]Arrow, K (1962); Hall, B (2002); Gelabert et al (2009)

[4]Akerlof (1970), Stiglitz & Dasgupta (1971), Hall and Lerner (2009)

[5] Crespi et al (eds.) (2014).

(2) ¿Are the policy instruments designed to attack the causes of the market failures? As there are two distinct market failures behind suboptimal levels of innovation, the optimal choice of policy interventions requires two types of distinct instruments: (a) Those geared to solve or mitigate the 'imperfect appropriability failure', such as Intellectual property rights (IPR's), subsidies and tax incentives favoring innovation; (b) Those geared to solve or mitigate the failure in 'suboptimal access to finance'. Directed or subsidized credit, guarantee funds, venture capital and private equity funds, 'angel investors', and 'firm incubators' are interventions geared towards solving this market failure, though they are often not specific for innovation activities.

(3) ¿To what extent do the policy instruments present opportunities for abuse and rent-seeking? ¿Is the institutional set up and procedures adequate in order to effectively limit such opportunities? Government failures[6] in innovation policies may arise from information asymmetries[7], lobbying by interest groups [8] and short term politicians and bureaucrats objectives[9]. Some policy instruments are more prone than others to abuse and rent-seeking.

We should ask a fourth question about the efficiency of specific policies: ¿How costly and complex is the administration of the policy instrument? As explained below, there is often a trade-off between the cost of administration and the capacity to control abuse.

A complementary criterion often used to evaluate the effectiveness and efficiency of policy instruments asks for the identification of 'type I' and 'type II' errors. Type I errors, in our case, refer to types of innovations or innovators that are not covered by a particular policy intervention. Type II errors are related to the degree to which benefits are received by non-innovative activities or by firms that do not innovate. Policy instruments offering more opportunities for abuse or rent seeking are likely to lead to more Type II errors. Policy instruments with too many Type I errors are usually ineffective (low social benefits), while policy instruments with too many Type II errors are likely to be inefficient (high costs in relation to the social benefits).

There is often a trade-off between Type I and Type II errors. Defining innovations in a narrow sense would lead to many Type I errors, while defining it in a broader sense may lead to many Type II errors. Also, some instruments are more likely to incur in Type I errors, while others are more likely to incur in Type II errors. IPR's, for example, leave out many types of innovations and more innovators than, for example, tax incentives, while incentives are more likely to benefit non-innovative activities, as it is more difficult to control abuses.

Finally, a measure of ineffectiveness of particular policy instruments is the degree to which they crowd-out or crowd-in private investment in innovation. A well-designed intervention ends up crowding-in private investment in innovation: eg, the beneficiary ends

[6]For an earlier discussion see Nelson (1980).
[7]Grossman (1991), Stiglitz and Wallsten (2000)
[8]Tollison (1997)
[9]Peltzman (1976), Olson (1982), Mitchell and Munger (1991), Magee (1997) and Link (1977)

up investing more private resources in innovation that what she would have done in the absence of the intervention. This occurs, for example, when the public intervention lifts a constraint (e.g., lack of appropriability or a financial constraint) that was limiting the amount invested in innovation, in such a way that more private resources flow now to innovation activities. Public financing may also act as a signal to mobilize external private resources, when these are being limited by the high information asymmetries surrounding innovation activities.

Table 1 below apply these criteria to particular policy instruments to promote innovation. Thus, IPR's mitigate imperfect appropriability issues at the expense of reducing positive spillovers and externalities, as imitators pay a higher cost for using the innovation. In addition, they are effective for some type of innovations (those that can be protected by 'patents', 'trademarks' or 'authors rights'), but are ineffective for 'basic' innovations (scientific or technological breakthroughs) as well as for innovators that the first to introduce an existing product or technology to a country, or to export them from a country from which they are not being exported, or that apply an existing patent to a new use, or that make useful adaptations to new or existing technologies or products. Also, they normally leave out SME's and individual innovators subject to financial constraints. Thus, they have many Type I errors. Finally, they are usually costly to administer.

Table 1
Characteristics of policy instruments to promote innovation

INSTRUMENT	TYPE I ERRORS	TYPE II ERRORS	CROWDING IN	ADMIN. COSTS	EFFECTIVENESS	EFFICIENCY
IPR	HIGH	VERY LOW	HIGH	VERY HIGH	HIGH	HIGH R&D LOW Spillovers
TAX CREDIT	LOW	HIGH	LOW	LOW	LOW	LOW
TAX EXEMP.	LOW	HIGH	VERY LOW	LOW	VERY LOW	VERY LOW
SUBSIDIES **Matching grant**	MEDIUM	MEDIUM	MEDIUM HIGH	HIGH	HIGH	HIGH
CREDIT LINES AND SUBSIDIES	MEDIUM	HIGH	MEDIUM LOW	MEDIUM	LOW	MEDIUM
GUARANTEE FUNDS	MEDIUM	LOW	HIGH	HIGH	MEDIUM HIGH	MEDIUM HIGH
VENTURE AND PRIVATE EQUITY	MEDIUM	VERY LOW	HIGH	VERY HIGH	VERY HIGH	VERY HIGH

Tax incentives or subsidies have several theoretical advantages over IPR's: 1) They do not reduce the social benefits of innovations. 2) They are less restrictive in the type of innovations benefiting from them, and they reach out (especially tax incentives) to a broader array of innovators; thus, they are less likely to incur in Type I errors. However, they are subject to other limitations: 1) Tax exemptions are not effective when innovation activities produce positive net social benefits, but are not privately profitable. Well designed tax credits could, in principle, render innovations privately profitable for firms already in operation, but not for new or starting firms that have no profits against which to use tax deductions or credits. 2) Even when effective, they are not proportional to net social benefits of the innovation activity. 3) They tend to be inefficient, as it is normally very difficult to avoid benefitting activities or investments that are not really innovation-related (Type II errors) or that do not need the tax incentive, because they would be carried on anyway. On the positive side, tax incentives have a relatively low administrative cost as compared to IPR's, subsidies or special credit arrangements.

Subsidies can be better oriented towards activities that have larger (expected) social benefits in excess of private benefits, but they are more difficult and costly to administer. If the definition of innovation in tax incentives is too broad, it will be difficult to enforce and will

benefit many activities that are not really innovative (Type II errors); if too narrow it will not benefit many innovation activities (Type I errors).

On the other hand, there is a wide literature about promoting financial access for firms and activities that are affected by financial market failures. That literature normally considers the following policy instruments geared towards mitigating or compensating for particular financial market failures:

1. Credit subsidies or directed credit, including specialized credit agencies and special credit lines
3. Guarantee funds
4. Credit information bureaus
6. Regulations facilitating the use of collateral and financial products such as leasing and factoring
7. Venture capital, private equity funds, angel investors and firm incubators.

All of these policy instruments are normally not specific for innovation activities, though there may be lines of credit or subsidy schemes specifically geared towards innovation activities. The literature discusses, both theoretically and empirically, the effectiveness and efficiency of these Government interventions. We will not review it here in detail, as it is not specifically oriented towards innovation activities. However, some general conclusions, relevant for the financing of innovation activities, are mentioned below. [10]

More efficient interventions are usually directly targeted to the source of the market failure: e.g., mitigating information asymmetries through credit bureaus and specialized agencies; or solving problems associated with lack of collateral through guarantee funds, as innovators are normally more affected by lack of collateral because their main assets are intangible. Ensuring access, e.g. through special credit lines or specialized agencies, is normally more efficient than subsidizing interest costs. Second-tier public lines of credit, operating through commercial banks, maybe more efficient than direct public loans, as commercial Banks may have better information on clients, better risk analysis capacity and are less prone to abuse and lobbying. However, they usually have less information about the quality of innovation projects. Second-tier public lines of credit and guarantee funds might be efficient complements, as the first instrument reduces the need for commercial banks to tie their own liquid assets to highly uncertain activities such as innovation, while guarantee funds mitigate problems associated with lack of tangible collateral by innovators.

As in the case of tax incentives and subsidies, the definition of innovations that can benefit from public credit or equity is key to the effectiveness and efficiency of these instruments. Further, as in the case of subsidies, the criteria and process of selection of beneficiaries will largely determine how effective and efficient they are. Usually, there is also a trade-off between administrative costs and effectiveness.

[10]See, for example, World Bank (Finance for All); and Melendez and Perry (2010).

The previous discussion illustrates that the effectiveness and efficiency of any policy instrument, designed either to mitigate imperfect appropriability or financial markets failure, depends on the specific design and implementation of the instrument. It emphasizes that trade-offs (for instance between Type I and Type II errors, or between control of abuses and administrative costs) are unavoidable. Any policy instrument – depending on its specific design – may end up crowding in or crowding out private resources allocated to innovation activities, thereby increasing or not overall innovation efforts and outcomes by private firms.

Only empirical testing may indicate whether a specific program or policy crowds in or out private resources for innovation, and whether it is effective or efficient in terms of enhancing innovation outcomes. The purpose of this paper is, consequently, to estimate the effect of public funding –both subsidies and credit- on innovation activities, both on the level of private resources dedicated to innovation and on innovation outcomes (products and services new or improved for domestic and international markets, and new or improved processes) for the Colombian manufacturing industry.

3. Empirical studies about the impact of innovation policy

Studies about the impact of public policies of innovation have a long tradition. Two approaches have dominated policy analysis and discussion (Zambrano, Salazar, Forero-Pineda 2004): a systemic analysis (Freeman, 1995; Carlsson et al., 2002; Lundvall (2005); Acs et al. (2016)), and an impact evaluation of specific policy programs approach. In the former, the analysis of relationships among people, organizations and institutions is key to the innovation process. In the latter, marginal effects of a specific policy instrument on the innovative behavior of the firm or group of firms is analyzed. These two approaches are indeed complementary. The first leads to comparative analysis of eco-systems of innovation (See for instance Wonglimpiyarat, 2011), while the second allows comparing the relative efficacy of specific instruments or programs. Acknowledging the momentousness of the first approach, this paper remains within the second approach.

The empirical literature evaluating the impact of specific public policies of innovation deals with the main theoretical issues discussed in the previous section. The two instruments mainly evaluated are tax credits and Government loans. Crowding-in and crowding-out issues are a focus of attention in this literature. The ability of Government funds to leverage own resources and commercial loan financing of innovation (Main, 2013) and additionality are sometimes dealt with, as well as the side effects of subsidies to innovation on employment (Afcha 2016), productivity, absorption capacity and technology transfer (Griffith et al., 2001).

The availability of innovation related data, and the worldwide standardization of innovation surveys has opened a wide range of options for the evaluation of innovation policy instruments (Mairesse and Mohnen, 2010). In the past two decades, methodologies have evolved rapidly. In 2000, the survey by Hall and Van Reenen (2000) classified the methodologies of these studies in (a) Event and case studies, (b) Natural experiments: R&D demand equation with a shift parameter for the credit, and (c) Quasi-experiments with price elasticity estimations. In the past 10 years, Propensity Score Matching (PSM) has been introduced, and has become the main methodology for the evaluation of tax subsidies,

Government loans and other instruments. Nonetheless, some studies using less advanced methodologies are still being produced.

In Latin America, public policies promoting innovation have been analyzed in several studies during the past decade. Studies of Government support to innovation in firms have been done for Argentina, Chile, Brazil, Colombia and México, among other Latin American countries. Many of these studies have focused on the impact of innovation on productivity, and only marginally deal with the impact of public support of innovation.

Among those directly focusing on public programs that support innovation, in 2007, Benavente, Crespi and Maffioli used propensity score matching to evaluate the FONTEC program in Chile. They concluded stressing the need for high quality selection procedures, availability of funding resources through time, and an innovation ecosystem going beyond financing, and sound institutions. In 2011, Crespi, Maffioli and Meléndez evaluated the Colciencias program in Colombia. In 2015, Aboal and Garda evaluated public support of innovation in Uruguay, using propensity score matching. They found no crowding out effect on private investment. On the contrary, public financial support increases private innovation expenditures in R&D. In their study of various Mexican programs of Government support of SMEs, Lopez-Acevedo and Tinajero-Bravo find that the Technological Innovation Program is associated with higher value, sales, exports and employment, though the direct impact on innovation performance is not analyzed.

A few comparative studies of innovation in Latin American countries deal directly or indirectly with the effectiveness and consequences of public support of innovation. Crespi and Zuniga (2011) study innovation in six Latin American countries and cite work arguing that no crowding-out is observed. Hall and Maffioli (2008) analyze technology development funds in Argentina, Brazil, Chile and Panama; they conclude that Government funds do not crowd-out private investment and that they have a positive effect on R&D intensity. Lopez-Acevedo and Tan (2010) extended their analysis of government loans to SMEs to compare Chile, Colombia, Mexico and Peru. Parra (2011) reviews fiscal incentives applied in Argentina, Colombia, México, Brasil, Uruguay and Chile. She observes the small number and amount of these incentives, and casts doubt upon the effectiveness of the methodologies used to evaluate the success of these instruments.

The focus of our research goes beyond this literature in several respects. First, we make a distinction between the firm's own resources and financing by private banks. The distinction is important because it reveals a pecking order in the firm strategy to gather funds for innovation activities. Second, we analyze separately the effects of Government support on different types of innovation. Specifically, we find that these effects are not the same on invention-based innovative products than on imitation-based innovative products. We also analyze the effects on process innovation. This analysis may guide Governments towards defining more specific targets of the innovation process, where public support is more effective. Third, we deal with the issue of whether the selection criteria of Government agencies are sufficiently capable of detecting the most innovative projects and firms.

6. Methodology and Data

We apply propensity score matching techniques (PSM) to evaluate the effects of public financial support on innovation performance of manufacturing firms in 2011-2012.

For this purpose, we explore a database of 9,173 industrial firms of ten or more employees from the Survey of Development and Technological Innovation (EDIT). Complementary data is drawn from the Annual Manufacturing Survey (EAM). The objective of the EDIT survey, which is designed following the Frascati manual, is to describe the dynamics of technological development of manufacturing firms in Colombia; the magnitudes of innovation activities, technological development, financial resources, use of public policy instruments, internal and external networks for research and development activities, and occupational profiles of employees.

The variables used in our empirical analysis were:

EAM variables: Production, Labor productivity, Fixed Assets (Capital), Employed personnel, hours worked, energy consumption, total factor productivity in revenues and market size.

EDIT variables: counts of product and process innovations, R&D expenditures, financial resources (public, commercial and own resources), internal and external sources of ideas for innovation, patents, IPR protection through other means.

In the EDIT Survey, public financial resources refer both to public subsidies (non-reimbursable matching grants) and public credits for scientific, technological and innovation activities. Specifically, it considers 6 types of matching-fund subsidies:

1. FOMIPYME-INNpulsa MSMEs.
2. COLCIENCIAS: CIA-CDT-firm-University.
3. SENA: Innovation and Technological Development.
4. COLCIENCIAS: Contingent: Financing line for intangibles (patents and certificates of plant breeders).
5. Ministry of Agriculture and Rural Development: Programs for Research, Technological Development and Innovation by productive chains.
6. Regional or local funds for science and technology;

And two special credit lines geared towards innovation-related activities:

1. BANCOLDEX: Support program for productivity and competitiveness (aProgresar).
2. BANCOLDEX-COLCIENCIAS. Incentives for Innovation. Credit for business projects productivity, innovation and technological development.

Data does not derive from a random, natural or controlled, experiment. For that reason, econometric techniques such as discontinuity regression design cannot be used. Therefore, we used propensity score matching (PSM), to avoid potential selection bias.

We define the treatment as participating in a subsidized or credit public program. The identification strategy requires that, given a set of observable covariates that are not determined by the treatment, potential results in innovation in the treatment and control groups are independent of treatment assignment. This requires that all those variables that simultaneously affect assignment to treatment and potential outcomes in innovation, are included in estimations.

The objective of matching is to find a 'clone' for each treated firm in the untreated control group with similar observed characteristics (apart from treatment and innovation performance) and with a high probability of having been selected for participation. The idea of this technique is to make the distribution of other observable characteristics of the firms selected as a control group as close as possible to those in the treatment group.

The PSM estimation process follows six steps (Bernal & Peña, 2011):

1. Estimate the probability of participation in the program, for firms in the treatment and control samples. For this, the estimating firm variables used are size, age, innovation objectives, capital composition, contractual networks and aggregate value growth.
2. Predict the probability of participation of firms in the two groups (treatment and control samples).
3. Restrict the sample to a 'common support' subsample sharing a similar predicted probability of participating in the program.
4. Select a matching algorithm: for each treated firm search a non-treated firm or group of non-treated firms with a similar probability of participation.
5. Check that observables are indeed similar for the treated and non-treated firms included in the 'common support' group.
6. Estimate the average impact of the program on treated firms (ATT) by comparing the sample average of the outcome variable in the treatment group (those participating in the program) with the sample average of the outcome variable in the control group (the 'common support' subsample).

Financial resources allocated to innovation activities (alternatively public, commercial and own resources) is the treatment variable in our analysis, and the treatment group are those firms that actually received public or commercial financial support to their innovation activities.

We first evaluated the effect of public financial support on different indicators of innovation. The count of total innovations includes product, process, marketing and organizational innovations. Then, we analyzed the effect of public financial support of R&D on three types of product innovations: (a) new to the firm (but not to the domestic or international markets); (b) new to national markets (but not new to the international market), and (c) new to international markets. Observe that (a) and (b) are innovations based on imitation and (c) are innovations based on invention. Table 1 shows descriptive statistics for these categories of innovation and for independent or control variables.

We observe that there are few firms receiving public financial support; for this reason, it is not possible to estimate differential impacts of individual programs (though we will attempt latter on to estimate separately the effect of two groups of interventions: those that offer non-reimbursable funds (subsidies) and those that are credit lines.

Afterwards we evaluate the effect of allocation of own resources and external commercial financing to innovation activities, following a similar process.

Finally, we estimate if these three forms of financing innovations are complements or substitutes; that is, if public funding appears to crowd in or out the allocation of own

resources or private commercial funding to innovation activities, and if the use of external private funds appears to crowd in or out the allocation of own internal resources.

As Table 1 indicates, the mean, standard deviation and maximum value of reported innovations in new (or significantly improved) products or services for international markets have all reasonably low values. Reported innovations in goods and services new to the firm show unexpectedly high values, suggesting a potential problem of outliers that may need to be corrected in the estimation. Reported innovations in products or services new to the national market suggest a milder problem of outliers.

Table 1: Descriptive Statistics.

Variable	Mean	Std. Dev.	Min.	Max.	Firms	Firms with a value >0
Products new to the firm	0.318	7.8283	0	725	9137	701
Products new to the domestic market	0.0686	1.5781	0	134	9137	183
Products new to international markets	0.0024	0.0782	0	5	9137	13
Products significantly improved for the firm	0.263	5.124	0	338	9137	532
Products significantly improved for the domestic market	0.069	2.172	0	180	9137	147
Products significantly improved for the Int. market	0.0012	0.037	0	2	9137	10
Process Innovations	0.229	1.467	0	80	9137	1129
Public Financial Support	0.008	0.091	0	1	9137	76
Employed personnel	77.88	206.61	0	4768	8921	8915
Foreign ownership	3.777	17.70	0	100	8627	421
Count of Total Innovation	1.129	14.69	0	1182	9137	1980

Source: DANE: EDIT-EAM 2012.

5 Results

As mentioned, the main objective of the paper is to analyze the impact of different sources of financing innovation activities on innovation outcomes. To apply the PSM technique we first investigate factors determining the probability of receiving public financial support. In this first stage estimation, the dependent variable takes the value 1 if the firm received public funding and 0 if it did not. Table 2 displays a frequency table and table 3 the marginal effects after probit estimation.

Table 2A: Number of firms by sources of funding of innovation activities and year

Year	Yes/No	Own Resources	Commercial Loans	Public Support
	No	5173	6805	7602
2008	Yes	2510	878	81
	No	5890	7794	8565
2010	Yes	2753	849	78
	No	7255	8630	9061
2012	Yes	1882	507	76

Source: DANE, EDIT-EAM 2008, 2010, 2012.

Table 2B: Frequency of sources of funding of innovation activities.

Variable	Freq	Cum	Min.	Max.	Total of firms
Government funds (0)	9061	99.17	0	0	9137
Government funds (1)	76	0.83	1	1	9137
Own Resources (0)	7255	79.4	0	0	9137
Own Resources (1)	1882	20.6	1	1	9137
Commercial loans (0)	8630	94.45	0	0	9137
Commercial loans (1)	507	5.55	1	1	9137

Source: DANE, EDIT-EAM 2008, 2010, 2012.

The vector of explanatory variables includes firm characteristics that may influence the probability of getting public funds. Firm size -measured as the number of employees-, Patents, other means of IPR protection and several internal and external sources of ideas for innovation show a statistically significant effect on the probability of obtaining public financial support. Other variables that were included but did not show statistically significant effects were: labor productivity, foreign ownership, age and other sources for innovation.

Table 3: Estimation of Probability of Receiving Government Loan.

VARIABLES	Govt Loans (probit)	Govt Loans (Dprobit)
Number of employees	0.000396***	1.57e-05***
	(0.000102)	(4.42e-06)
Patents	0.0545***	0.00217***
	(0.0202)	(0.000825)
Other means of IPR protection	0.519***	0.0333**
	(0.144)	(0.0135)
Interdisciplinary groups as sources of ideas	0.377***	0.0207**
	(0.135)	(0.00971)
Industry guilds or associations as sources of ideas	-1.046***	-0.0184***
	(0.234)	(0.00300)
Technology Development Centers as sources of ideas	0.587***	0.0420*
	(0.212)	(0.0239)
Research Centers as sources of ideas	-1.040***	-0.0160***
	(0.361)	(0.00269)
IEBT[11] as sources of ideas	0.803*	0.0729
	(0.412)	(0.0657)
Universities as sources of ideas	0.456***	0.0270**
	(0.149)	(0.0123)
Consultants and experts as sources of ideas	0.411***	0.0217***
	(0.118)	(0.00778)
Public agencies as sources of ideas	0.328*	0.0177
	(0.180)	(0.0127)
Constant	-2.364***	
	(0.0834)	
Observations	2639	2639
Robust standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
R squared	0.1962	0.1962

Results show that the most important determinants of the probability of receiving public funds are size (number of employees), patents and other means of intellectual property protection. These variables significantly increase the probability of receiving public funds. Surprisingly, some sources of ideas for innovations, such as industry guilds or associations, and research centers decrease the probability of receiving public funds for innovation.

In a second step, matching was done using the estimated propensity scores. Some important assumptions needed to be validated. The first requirement was to check the

[11] Business incubator for technological bases.

'common support' or overlap condition. For this purpose, we performed a visual analysis of the density distribution of the propensity scores in the two groups.

Figure 3 shows the propensity scores estimated for the treated and control groups. Observations are more left-skewed in the control group than in the treatment group, but a comparison of the minimum and maximum propensity scores leads to the conclusion that there is a significant overlap. When only firms with positive innovation expenditures are considered, some firms are found to be off common support. We restricted the estimation to the propensity score region of common support.

Finally, since we did not condition on all covariates but only on the propensity score, it was necessary to check whether the matching procedure was balancing the distribution of the relevant variables in both the control and the treatment groups.

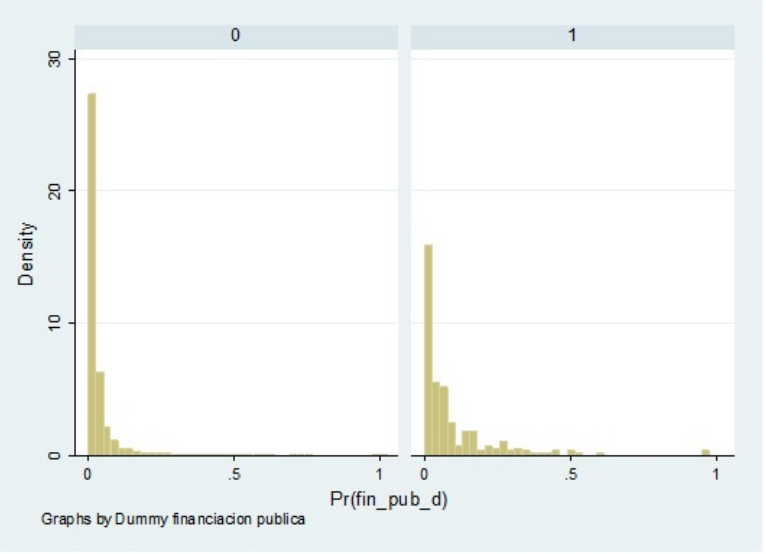
Tables 4 and 5 report the results for the average treatment effects (ATT) on the following performance variables:

1. Product innovation index (PII) (See Appendix)
2. Count of product innovation (CPI)
3. Count of process innovation (CMI)
4. Count of total innovation (CTI)
5. New/Improved Goods and services for the firm (N/I-PF)
6. New/Improved Goods and services for the national market (N/I-PN)
7. New/Improved Goods and services for the international market (N/I-PI)

The results of Propensity score matching obtained by the bootstrapping method show that public financial support has a statistically positive effect on the Count of Process Innovations and on Goods and services new for the international market. This is the main result of the analysis.

It should be recalled that this sample includes all potential firms in the control group (i.e. it includes firms that may have zero innovation expenditures). Hence, this result can be interpreted as public financial support having significant inducement effects on two types of innovation activities: process innovations and new products for the international markets. These results are robust to the use of alternative methodologies of estimation (See Appendix).

Figure 3: Probability of receiving Government funding (non-treated vs treated).



Source: Authors based on EDIT-EAM

Table 4: Propensity Score Matching. Bootstrapping method: Innovation Outputs

VARIABLES	CPI	CMI	CTI	NPF
ATT Govt Loans and Subsidies	22.07	1.722**	24.71	11.92
	(14.75)	(0.852)	(15.84)	(9.415)
Observations	2639	2639	2639	2639

Count of product innovations (CPI) ; Count of process innovation (CMI) ;Count of total innovation (CTI) ; Products new to the firm (NPF)

Source: Authors based on EDIT-EAM

Table 5: Propensity Score Matching. Bootstrapping method: Second Set of Innovation Outputs

VARIABLES	NPN	NPI.	IPF	IPN	IPI
ATT Govt Loans and subsidies	2.861 (1.981)	0.139** (0.0694)	5.958 (5.188)	1.153 (0.747)	0.0417 (0.0351)
Observations	2639	2639	2639	2639	2639
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1					

Products new to the national market (NPN); Products new to the international market (NPI); Products improved for the firm (IPF); Products improved for the national market (IPN); Products improved for the international market (IPI).

Source: Authors based on EDIT-EAM

We then explored whether allocation of own resources and private external financing had impacts similar to those of public funding for innovation activities. The First Stage equations (PSM scores) are estimated independently for each source of resources.

Table 6: Probability of using Government, own and commercial loan resources

Regression results	(1)	(2)	(3)
VARIABLES	Gov Loans	Own Resources	Commercial Loans
Other means of IPR protection	0.519***		0.274***
	(0.144)		(0.103)
Foreign Social Capital			-0.00596***
			(0.00166)
Number of employees	0.000396***	0.000479***	0.000234***
	(0.000102)	(0.000150)	(9.00e-05)
Patents	0.0545***		-0.0540*
	(0.0202)		(0.0317)
Interdisciplinary groups as sources of ideas	0.377***	-0.226**	
	(0.135)	(0.108)	
Industry guilds or associations as sources of ideas	-1.046***	0.220*	
	(0.234)	(0.130)	
Technology Development Centers as sources of ideas	0.587***		
	(0.212)		
Research Centers as sources of ideas	-1.040***		
	(0.361)		
Incubators as sources of ideas	0.803*		
	(0.412)		
Universities as sources of ideas	0.456***	0.205*	-0.254**
	(0.149)	(0.119)	(0.107)
Consultants and experts as sources of ideas	0.411***	0.438***	0.236***
	(0.118)	(0.0858)	(0.0770)
Public agencies as sources of ideas	0.328*	0.352***	
	(0.180)	(0.136)	
Internal R & D department as a source of ideas		0.373***	0.182**
		(0.0822)	(0.0742)
Production department as a source of ideas		0.346***	0.303***
		(0.0593)	(0.0684)
Sales and marketing department as a source of ideas		0.149**	
		(0.0581)	
headquarter as a source of ideas		0.308**	-0.362**
		(0.157)	(0.164)
Suppliers as a source of ideas		0.188***	
		(0.0613)	
Chamber of Commerce as sources of idea		-0.258**	
		(0.118)	
Another department as sources of idea			-0.146**
			(0.0732)
Training Centers or SENA Technoparks as sources of ideas			0.364*
			(0.193)
Constant	-2.364***	-0.0484	-1.161***
	(0.0834)	(0.0502)	(0.0590)
Observations	2639	2639	2639

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The number of employees, and sources of funding such as Universities, consultants and experts have a positive and significant effect on the probability of the three types of funding. Patents have a positive effect on the probability of receving public funding, but a negative effect on the probability of receiving commercial loans. Interdisciplinary groups as sources of ideas have a positive effect on the probability of receiving government funds but their effect on the probable allocation of own resources is negative. Also, industry guilds or associations have negative effects on the probability of receiving public resources, but positive effects on the probable allocation of own resources; and parent establishment as a source of ideas has a positive effect on the probable allocation of own resources but negative on the probability of receiving commercial loans for innovation activities.

Table 7: Propensity Score Matching. Bootstrapping method: Innovation Outputs and Type of financing

VARIABLES	CMI	CTI	NPF
ATT Govt loans and subsidies	1.722**	24.71	11.92
	(0.890)	(15.84)	(9.415)
ATT Own Resources	0.514***	3.149***	0.952**
	(0.0871)	(0.814)	(0.814)
ATT Commercial loans	0.398	2.484	2.088
	(0.259)	(2.760)	(1.479)
Observations	2639	2639	2639

Count of product innovation (CPI); Count of process innovation (CMI); Count of total innovations (CTI); Products new to the firm (NPF).

Source: Authors based on EDIT-EAM

Table 8: Propensity Score Matching. Bootstrapping method: Innovation Outputs

VARIABLES	NPN	NPI.	IPF	IPN	IPI
ATT Govt loans	2.861	0.139*	5.958	1.153	0.0417
	(1.981)	(0.0738)	(5.188)	(0.747)	(0.0351)
ATT Own Resources	0.240***	0.00775**	0.737**	0.00609***	0.0382***
	(0.0812)	(0.01317)	(0.301)	(0.00205)	(0.00457)
ATT Commercial loans	0.306	0.0160	-0.0320	-0.422	0.00200
	(0.294)	(0.0146)	(0.997)	(0.440)	(0.00654)
Observations	2639	2639	2639	2639	2639
Standard errors in parentheses					
*** p<0.01, ** p<0.05, * p<0.1					

Products new to the national market (NPN); Products new to the international market (NPI); Products improved for the firm (IPF); Products improved for the national market (IPN); Products improved for the international market (IPI).

Source: Authors based on EDIT-EAM

Tables 7 and 8 show significant impacts of funding from own resources on all categories of innovation, and no significant impact of private external financial sources (commercial loans or banking system). At the same time, the coefficient for public funding is much larger than that of own resources in the cases of products new to the international market and process innovations.

We observed earlier that more firms use own resources than any other source to finance innovation. Now we find that internal resources have significant positive impacts on every type of innovation outcomes by the firm. This might be explained by financial pecking order (Myers and Machluf, 1984), whereby when firms decide to innovate they prefer first to finance investments with retained earnings, as there is a lower risk involved in this type of financing innovation. When they access external private resources, they may reduce their allocation of own resources (see below), and hence the use of such funds may not have an impact on innovation outcomes.

The lack of impact of commercial financing for innovation activities might also be explained by observing that banks either do not have a structure capable of evaluating innovation projects or decide on the basis of collateral from entrepreneurs or generators of innovations.

Finally, we observe that, when eliminating outliers, results are robust though the impact is lower than with the original database.

Table 9: Propensity Score Matching. Bootstrapping method: Innovation outputs and source of financing, excluding outliers.

VARIABLES	CMI	NPF
ATT Govt loans and subsidies	2.410**	2.720
ATT Own Resources	0.630***	0.670***
ATT Commercial loans	0.370*	0.630*

Count of process innovation (CMI); Products new to the firm (NPF)
Source: Authors based on EDIT-EAM

Table 10: Propensity Score Matching. Bootstrapping method : Innovation outputs and source of financing, excluding outliers.

VARIABLES	NPN	NPI.	IPF	IPN	IPI
ATT Govt loans	1.060*	0.140**	0.490	0.700	0.040
ATT Own Resources	0.230***	0.118**	0.313**	0.180***	0.015***
ATT Commercial loans	-0.010	0.0150	-0.120	-0.100	0.001
Standard errors in parentheses					
*** p<0.01, ** p<0.05, * p<0.1					

Products new to the national market (NPN); Products new to the international market (NPI); Products improved for the firm (IPF); Products improved for the national market (IPN); Products improved for the international market (IPI).

Source: Authors based on EDIT-EAM

Crowding in or crowding out

We then explored whether public funding appears to crowd-in or out the allocation of own resources and private external financing. For this purpose, we included in the PSM estimation of allocation of own resources and private external sources a dummy variable indicating whether the firm has received public funding. We then included a dummy variable indicating whether the firm has received private external resources in the PSM estimation of the probability of receiving public funding and the allocation of own resources to innovation activities.

Table 11: Complementarity or Substitutability in sources of funds for innovation activities

VARIABLES	Govt Loans and Subsidies (Probit)	Govt Loans and Subsidies (DProbit)	Commercial Loans (Probit)	Commercial Loans (DProbit)	Own Resources (Probit)	Own Resources (DProbit)
Own Resources	0.298*	0.00988**	-0.238***	-0.0650***		
	(0.158)	(0.00458)	(0.0657)	(0.0186)		
Commercial Loans	-0.182	-0.00605			-0.281***	-0.0965***
	(0.135)	(0.00413)			(0.0701)	(0.0251)
Govt Loans and Subsidies			-0.263	-0.0610*	0.349	0.101*
			(0.179)	(0.0361)	(0.214)	(0.0538)
Constant	-2.559***		-2.364***		-0.0194	
	(0.148)		(0.0834)		(0.0512)	
Include variables in each propensity	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2639	2639	2639	2639	2639	2639
R squared	0.2046	0.2046	0.0409	0.0409	0.0990	0.0990

Robust standard errors in parentheses *** p<0.01, ** p<0.05, *p<0.1

Source: Authors based on EDIT-EAM

The results are shown in Table 11. We find that public funding is associated with a higher probability of allocating own resources to finance innovation activities, while it is associated with a lower probability of using private external sources. Conversely, the first two columns of Table 8 suggest that firms that allocate own resources to finance innovation activities have a higher probability of obtaining public funding. This is not the case for firms using private external resources. Though we cannot assert causality, these results suggest that there is complementarity in the use of public and own resources in financing innovation activities, while there is substitution between either of these sources and private external sources in financing innovation activities.

A summary interpretation of these results is that, first, allocating own resources to financing innovation activities has positive effects on all forms of innovation. Public funding appears to be complementary to the allocation of own resources and increases significantly the likelihood of developing new processes and products new for international markets. Private external funding does not appear to have any additionality (in terms of outcomes) and it tends to be a substitute for both public funding and the allocation of own resources to innovation activities.

Public subsidies versus loans

The results of the first stage of the regressions of subsidies and credits show some variables that are significant and common to both financing systems. These are the number of employees, strategic protection and interdisciplinary groups.

The number of employees, patents and other means of IP protection affect positively and significantly the probability of receiving subsidies. It is important to note that the variables related to organizations or associations of scientific character and public institutions are key determinants of the probability of receiving subsidies. For instance, sources of ideas like universities, consultants or experts, interdisciplinary groups and public institutions, increase this probability; but sources of ideas related to other companies and associations negatively affect the probability of receiving Government subsidies.

The number of employees and IP protection through utility models, copyright and other instruments different from patents increase the probability of receiving commercial loans. Sources of ideas for innovation such as interdisciplinary groups, suppliers and technology parks are main determinants of the probability of receiving commercial loans.

Separating the estimations of subsidies from those of Government loans, we observe that results are similar to those of aggregate public funding. The ATT is higher for loans than for subsidies, which might indicate that overcoming financial market failures is particularly important for some innovation activities (process innovations and products new for the international market). When removing outliers, results keep their significance, but coefficients decrease except for product innovations for the international market[12].

[12] To enquire about robustness, two panel PSM explorations were performed with three surveys. With pooled panel, the ATT of public financing is still significant for processes but not for products new to the international market. With sequential panel, the effects of public support were clear both for products new to the international market and for processes for 2011-2012, but not for the previous surveys. The explanation of these differences is that there were abrupt changes in the innovation ecosystem, and the results for the last of these observations substantially differ from those for 2007-2008 and 2009-2010.

Table 12: Propensity Score Matching. Bootstrapping method: Different innovation outputs with Government subsidies and loans

VARIABLES	CMI	CTI	NPF
ATT Govt loans	4.143 (4.042)	1.923 (3.797)	-0.923 (1.830)
ATT Govt subsidies	2.000** (0.980)	2.593 (1.705)	2.541 (1.876)
Observations	2040-2639	2035-2633	2039-2638

Count of product innovations (CPI); Count of process innovations (CMI); Count of total innovations (CTI); Products new to the firm (NPF).

Source: Authors based on EDIT-EAM

Table 13: Propensity Score Matching. Bootstrapping method: Different innovation outputs with Government subsidies and loans

VARIABLES	NPN	NPI.	IPF	IPN	IPI
ATT Govt loans	-0.692 (0.611)	0.429* (0.251)	0.231 (5.188)	5.000 (4.065)	0.214 (0.162)
ATT Govt subsidies	1.377* (1.704)	0.145* (0.0806)	-0.917 (0.872)	1.210 (0.939)	0.0645 (0.0423)
Observations Standard errors in parentheses	2039-2638	2040-2639	2037-2635	2040-2638	2040-2639
*** p<0.01, ** p<0.05, * p<0.1					

Products new for the national market (NPN); Products new for the international market (NPI); Products improved for the firm (IPF); Products improved for the national market (IPN); Products improved for the international market (IPI).

Source: Authors based on EDIT-EAM

5. Conclusion

This paper evaluates the impact of government financing on innovation results, using quasi-experimental methods and the Innovation and Manufacturing Surveys data. It contributes to the literature in two ways. First, it presents an evaluation of the impact of government funding on different innovation categories and on other sources of funding for innovation (own resources and commercial lending); as well as the impact of these other sources of financing on different types of innovation. Second, the evaluation is for a developing Latin American country where empirical evidence is scarce.

On the basis of the results, we conclude that while the allocation of own resources to finance innovation induces some improvements over a wide variety of innovation results, the use of public funds has a significant and much higher impact on process innovations and on products new to the international market, than on imitation of products. In contrast, we found no significant effects of loans from commercial banks on innovation.

We further found that public funding has a direct effect on process innovations and on products new to the international market and an indirect effect, since it attracts the own resources of the firm, and these have an additional positive effect on all types of innovation. Public support appears to crowd-out the use of commercial loans for innovation, which however has no significant effects on innovation outputs.

These results have some limitations. First, they are derived from cross-section analysis, and therefore are subject to endogeneity issues. Panel analysis was attempted, but abrupt changes in the innovation ecosystem are observed when comparing the results with those of previous surveys. Second, the instruments of Government intervention are various but the survey captures very few observations for each of them, so that an analysis for each of these instruments is not possible.

Plausible interpretations of these results are the following. Firms may follow a pecking order, preferably allocating own resources to finance innovations. When these resources are not sufficient (because required funds are large for the firm's cash generating capacity), firms look for external resources. Public funding is preferred when innovation investments are particularly large and risky (as is normally the case when developing new processes or new products for the international market). Also, public agencies may prefer to finance these innovation activities because they are likely to generate larger externalities. Public agencies require significant allocations of own resources of the firm to the innovation investments they finance. As a consequence of these two plausible hypotheses, public funding becomes critical both for process innovation and for the development of products new to the international market, and tends to crowd in own resources allocated to finance such activities. Subsequent research should try to verify these hypotheses.

Appendix

Table 14: ATT, estimated with 10 nearest neighbors

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
IPI	Unmatched	0.053	0.003	0.051	0.008	6.21
	ATT	0.055	0.008	0.047	0.033	1.39
IPN	Unmatched	1.373	0.207	1.166	0.472	2.47
	ATT	1.319	0.452	0.867	0.922	0.94
IPF	Unmatched	8.213	0.694	7.519	1.104	6.81
	ATT	8.194	1.490	6.704	5.218	1.28
NPI	Unmatched	0.147	0.004	0.142	0.017	8.47
	ATT	0.139	0.002	0.136	0.067	2.04
NPN	Unmatched	3.227	0.150	3.076	0.338	9.1
	ATT	3.222	0.411	2.811	1.935	1.45
NPF	Unmatched	13.813	0.726	13.087	1.684	7.77
	ATT	13.069	1.161	11.908	10.103	1.18
CTI	Unmatched	32.200	3.068	29.131	3.130	9.31
	ATT	30.444	5.380	25.063	17.246	1.45
CMI	Unmatched	3.533	0.710	2.823	0.305	9.25
	ATT	2.597	0.989	1.608	0.861	1.87
CPI	Unmatched	26.827	1.785	25.041	2.833	8.84
	ATT	26	3.526	22.474	15.925	1.41

Products new for the firm (NPF); Products new for the national market (NPN); Products new for the international market (NPI); Products improved for the firm (IPF); Products improved for the national market (IPN); Products improved for the international market (IPI); Count of product innovations (CPI); Count of process innovations (CMI); Count of total innovations (CTI).

Source: Authors based on EDIT-EAM

Table 15: ATT, estimated with 40 nearest neighbors

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
IPI	Unmatched	0.053	0.003	0.051	0.008	6.21
	ATT	0.055	0.005	0.050	0.034	1.49
IPN	Unmatched	1.373	0.207	1.166	0.472	2.47
	ATT	1.319	0.252	1.067	0.816	1.31
IPF	Unmatched	8.213	0.694	7.519	1.104	6.81
	ATT	8.194	1.077	7.117	5.203	1.37
NPI	Unmatched	0.147	0.004	0.142	0.017	8.47
	ATT	0.139	0.004	0.135	0.066	2.03
NPN	Unmatched	3.227	0.150	3.076	0.338	9.1
	ATT	3.222	0.355	2.867	1.932	1.48
NPF	Unmatched	13.813	0.726	13.087	1.684	7.77
	ATT	13.069	1.242	11.827	10.103	1.17
CTI	Unmatched	32.200	3.068	29.131	3.130	9.31
	ATT	30.444	4.697	25.746	17.208	1.5
CMI	Unmatched	3.533	0.710	2.823	0.305	9.25
	ATT	2.597	0.873	1.724	0.840	2.05
CPI	Unmatched	26.827	1.785	25.041	2.833	8.84
	ATT	26	2.936	23.064	15.900	1.45

Products new for the firm (NPF); Products new for the national market (NPN); Products new for the international market (NPI); Products improved for the firm (IPF); Products improved for the national market (IPN); Products improved for the international market (IPI); Count of product innovations (CPI); Count of process innovations (CMI); Count of total innovations (CTI).

Source: Authors based on EDIT-EAM

Table 16: ATT, estimated with 100 nearest neighbors

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
IPI	Unmatched	0.053	0.003	0.051	0.008	6.21
	ATT	0.055	0.008	0.048	0.034	1.42
IPN	Unmatched	1.373	0.207	1.166	0.472	2.47
	ATT	1.319	0.201	1.118	0.795	1.41
IPF	Unmatched	8.213	0.694	7.519	1.104	6.81
	ATT	8.194	1.201	6.993	5.206	1.34
NPI	Unmatched	0.147	0.004	0.142	0.017	8.47
	ATT	0.139	0.005	0.134	0.066	2.02
NPN	Unmatched	3.227	0.150	3.076	0.338	9.1
	ATT	3.222	0.353	2.869	1.932	1.49
NPF	Unmatched	13.813	0.726	13.087	1.684	7.77
	ATT	13.069	1.175	11.894	10.103	1.18
CTI	Unmatched	32.2	3.068	29.131	3.130	9.31
	ATT	30.444	4.761	25.683	17.201	1.49
CMI	Unmatched	3.533	0.710	2.823	0.305	9.25
	ATT	2.597	0.911	1.686	0.835	2.02
CPI	Unmatched	26.827	1.785	25.041	2.833	8.84
	ATT	26	2.944	23.056	15.897	1.45

Products new for the firm (NPF); Products new for the national market (NPN); Products new for the international market (NPI); Products improved for the firm (IPF); Products improved for the national market (IPN); Products improved for the international market (IPI); Count of product innovations (CPI); Count of process innovations (CMI); Count of total innovations (CTI).

Source: Authors based on EDIT-EAM

Table 17: ATT, estimated with Kernel methodology

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
IPI	Unmatched	0.053	0.003	0.051	0.008	6.21
	ATT	0.055	0.014	0.042	0.037	1.12
IPN	Unmatched	1.373	0.207	1.166	0.472	2.47
	ATT	1.319	0.167	1.153	0.780	1.48
IPF	Unmatched	8.213	0.694	7.519	1.104	6.81
	ATT	8.194	2.236	5.958	5.280	1.13
NPI	Unmatched	0.147	0.004	0.142	0.017	8.47
	ATT	0.139	0	0.139	0.066	2.09
NPN	Unmatched	3.227	0.150	3.076	0.338	9.1
	ATT	3.222	0.361	2.861	1.936	1.48
NPF	Unmatched	13.813	0.726	13.087	1.684	7.77
	ATT	13.069	1.153	11.917	10.110	1.18
CTI	Unmatched	32.2	3.068	29.132	3.130	9.31
	ATT	30.444	5.736	24.708	17.233	1.43
CMI	Unmatched	3.533	0.710	2.823	0.305	9.25
	ATT	2.597	0.875	1.722	0.842	2.05
CPI	Unmatched	26.827	1.785	25.041	2.833	8.84
	ATT	26	3.930	22.069	15.928	1.39

Products new for the firm (NPF); Products new for the national market (NPN); Products new for the international market (NPI); Products improved for the firm (IPF); Products improved for the national market (IPN); Products improved for the international market (IPI); Count of product innovations (CPI); Count of process innovations (CMI); Count of total innovations (CTI).

Source: Authors based on EDIT-EAM

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