**Does public financial support stimulate private innovation expenditure and innovation?[[1]](#footnote-2)**

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Abstract

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1. **Introduction**

The need for public support to innovation and particularly, public financial support, rest on the assumption that innovation is a non-rival good (i.e. that can be used by multiple firms) and cannot be fully protected because its output is basically knowledge (i.e. how to produce new or improved goods or services) and most of it tacit knowledge (i.e. not codified). Therefore firms cannot appropriate fully the return to innovation investment. In other words, we have a problem of positive externalities of innovation. This generates a gap between the social return of innovation and the private return of innovation, having as a consequence that the firm will underinvest with respect to the social optimum.

As pointed out by Hall and Lerner (2010) there is some evidence that points out that imitations are not free, and that they can cost between 50% and 75%of the original R&D investment. This can mitigate the above mentioned externality problem, but in any case the problem still persist since the returns are not fully appropriated by the original investor. Moreover, this available evidence is for manufacturing; we can think that the problem is more important for service innovations where innovations rely less on codified knowledge (that can be more easily protected) and presumably where the costs of imitating are smaller.

The argument for public financial support goes beyond the externality problem mentioned above. Even when this problem could be solved with intellectual property protection, there are other characteristics of the innovation investment that justifies public financial support. In particular, innovation investment is highly uncertain and the asymmetric information that exists between the innovator and the investor could be greater than in other type of investment, leading to more important moral hazard and adverse selection problems.[[2]](#footnote-3)Therefore credit constraints and high cost of credit is likely to affect the level of innovation investment and consequently of innovation. The intangibility characteristic of services and the non-technological and more ad-hoc characteristic of many innovations in services make these problems even worse in services.

These theoretical considerations have stimulated public intervention in different countries with the objective of increasing innovation investment, innovation and productivity. These interventions generated the need for evaluation of their impacts.

So far, most of the available empirical literature has focused on public financial support policies to research and development (R&D) activities and their impact on R&D expenditure. As pointed out by Hall and Lerner (2010) the focus on R&D instead of the broader concept of innovation investment is largely due to reasons of data availability and measurement. In addition, most of the available evidence does not distinguish between manufacturing and services, and in fact most of these papers are for the manufacturing sector only. The potential positive effects of public support to the service sector could be even more important for services than for the manufacturing, not only because the above mentioned arguments, but also because the service sector represents nowadays more than 70% of the GDP in advanced economies, and more than 60% in less developed economies, and therefore this sector is key for the aggregate productivity of countries. Therefore there is the need to understand better this sector. Finally, most of the studies available are for OECD or European countries, and we are lacking evidence for less developed economies.

Our paper aims to help fill some of these gaps, through an impact evaluation of public financial support on innovation using quasi-experimental methods and innovation survey data from Uruguay, that allow us to distinguish between manufacturing and service sector.

This paper contributes to the literature in three ways. First, it presents an impact evaluation of public financial support to innovation on innovation expenditure. Therefore the analysis is extended beyond the R&D context. Second, we analyze the possible heterogeneity of impacts on services and manufacturing. Finally, the evaluation is for a middle income developing Latin American country. There is no much evidence for developing countries so far.

Our findings show the absence of a crowding out effect, either full or partial, between public and private innovation expenditure, though the presence of subsidies hardly stimulates private innovation spending of firms engaged in innovation activities in any case. We found a larger effect on the manufacturing than in the service sector. While there is no crowding effect in neither of the two sectors, in the manufacturing sector we found that public financial support stimulates innovation expenditure.

The paper is organized as follows. Next section discusses available evidence on public financial support and innovation in developing countries. Section 3 describes the empirical strategy and data. Section 4 presents the main results. Finally, section 5 reports some conclusions.

1. **Public financial support and innovation: the available evidence**

Assessing on the implications of innovation policy imposes the issue of dealing with endogeneity in program participation. Thus, being that subsidies are not assigned randomly, impact evaluation of such policy measures calls for the use of special techniques that allow correcting for possible selection biases. To account for this, empirical studies on this matter have implemented different strategies such as the use of instrumental variables, censored variable models, two-step selection models, difference in differences estimators and matching methods[[3]](#footnote-4).

Available evidence focuses its attention mostly on developed countries, being R&D expenditure the most commonly used outcome variable. David et al. (2000) carry out an extensive survey of this literature, finding substitution effects between public and private R&D in one-third of the studies analyzed. More recent studies have focused on matching methodologies to evaluate the crowding out effects. Along these lines, different studies have found that public financial support stimulates privately financed R&D, so that the crowding out hypothesis is rejected. Examples are Almus and Czarnitzki (2003) who use data from a survey of innovating German manufacturing firms; Duguet (2004) who uses a pool of French R&D-performing firms; and Gonzalez and Paso (2008) who use a sample of Spanish firms to evaluate the effect of subsidies. As for the service sector, Czarnitzki and Fier (2002) found that financial support stimulated private expenditure on innovative activities by studying a panel of German service firms. However, there are no studies that we know of that allow direct comparison of the impact that a certain policy imposes on the service and manufacturing sectors.

As for evidence regarding the policy impact on innovation output (rather than R&D and innovation efforts which are *inputs* for innovation), Aerts and Czarnitzki (2004) found no significant effects of public support for innovation on patent applications from a survey of Flemish firms; while Czarnitzki and Hussinger (2004) found that the impact was positive on this variable for a set of German manufacturing firms and Czarnitzki et al. (2011) found a positive impact on the number of new products introduced by manufacturing Canadian firms. Evidence on the impact on firm performance is scarcer: Czarnitzki et al. (2011) found that the impact was not significant on firms’ profitability, while Wallsten found no significant impact on employment for American high-tech small firms. This may owe to the fact that such policy effects often do not arise until after several years since policy implementation, so that they may not be observed throughout the short periods of analysis. On a different note, Lokshin and Mohnen (2013) found that fiscal incentives had a positive impact on wages of R&D workers throughout Dutch firms.

The available evidence of the effects of public financial support on innovation is scarce in emerging and developing countries. Few examples can be found in Hall and Maffioli (2008), Lopez and Tan (2010), or Crespi et al (2012).

Hall and Maffioli (2008) synthesized the results of a series of evaluations of Technology Development Funds (TDFs) in Argentina, Brazil, Chile and Panama. The authors evaluated TDF recipients with data from innovation and industrial surveys. They found that Technology Development Funds (TDFs) do not crowd out R&D from private sources and that TDFs have a positive impact on the intensity of R&D. Also, although low-cost credit had a more positive effect than matching grants on R&D projects—suggesting that different types of financing impact firms differently—matching grants were more effective for new innovators. The authors also found that participating in a TDF results in a more proactive attitude toward innovation strategy for firms. Although Argentina and Brazil were not included in this part of the study, using a firm’s willingness to engage with external financing and knowledge sources as proxies for innovation strategy shifts, the authors found that TDFs have a positive effect on innovation. Conversely, participation in a TDF did not positively affect patent grants or new product sales, which were used as measures of innovative output, although the authors note that the time frame may have been too short to observe the full effects of TDF participation in this regard. Evidence concerning the potential impacts on firm performance was not uniform, such that TDF participation was found to positively impact firm growth but not firm productivity. The authors argue that this can be due to the short time period in which the evaluations were conducted, and that additional impact evaluations based on longer panel data are needed to shed some light on long-run effects.

López-Acevedo and Tan (2010) provided an evaluation of SME credit programs in Mexico, Chile, Colombia and Peru. The authors found positive gains in labor productivity, sales and employment in Chile, and higher value added, sales, export and employment in Mexico. In Colombia, the results suggest positive effects on exports, investment in R&D and TFP. Finally, in Peru the findings show significant positive effects in sales and profits. Confirming the findings of Hall and Maffioli, López-Acevedo and Tan note that some of the estimated impacts on firm’s performance do not materialize until after several years.

Crespi et al (2012) evaluate the effects of financial incentives for R&D (matching grants and contingent loans), given by Colciencias in Colombia, on firm’s beneficiaries economic performance. With a dataset that allows the authors to look at long term effects, the authors find significant impact on firm performance of public funding from Colciencias. More precisely, the authors found that introduction of new products and labor productivity increased around 12% and 15% respectively, with these effects becoming more significant between three to five years after the firms started being treated.

1. **Empirical strategy and data**
	1. **Empirical strategy**

The objective of this paper is to estimate the impact of public financial support on some firm’s outcome variables (innovation investment, innovation, productivity). As it is well known the main problem to perform such evaluation is that we cannot observe what would happen with (treated) firm’s outcomes variables in case they wouldn’t get public financial support, i.e. the counterfactual. Therefore, we have to find a suitable “proxy” for the counterfactual. Of course, the firms that didn’t get public financial support are clear candidates to form a comparison group (or control group). The problem here is that it is possible that these firms didn’t get the public financial support because they have some characteristics that also affect the outcome variables. For example, it could me more difficult for small firms to get public financial support, and we know that the size of firms affect innovation. Therefore if we compare the innovation performance of the firms that got support with that of the firms that didn’t get support, we will find that the supported firms innovate more, but this could be simply because they are bigger, and not as a consequence of the public financial support program.

Luckily, under some assumptions we can circumvent this problem. The strategy followed here was to use propensity score matching methods.[[4]](#footnote-5) In what follows we will explain briefly the rationale behind it and make explicit some methodological decisions taken here.

One of the parameters of interest in this paper is:

$τ\_{ATT}=E\left[Y\left(1\right)|D=1\right]-E\left[Y\left(0\right)|D=1\right]$,

where $τ\_{ATT}$ is the average treatment effect on the treated, $E\left[Y\left(1\right)|D=1\right]$ is the mean value of the outcome variable $Y(1)$ (for example innovation investment) given that the firms received public financial support, and $E\left[Y\left(0\right)|D=1\right]$ is the counterfactual, i.e. the expected value of outcome variables, $Y\left(0\right)$, for the firms in the treatment group in case they haven’t received public financial support (of course this can never be observed). D=1 means that the firm belongs to the treatment group.

What we can observe is $E\left[Y\left(0\right)|D=0\right]$, the mean of the innovation investment for firms that do not belong to the treatment group ($D=0)$ and did not receive treatment. But of course is $E\left[Y\left(0\right)|D=0\right]$ must not need to be equal to $E\left[Y\left(0\right)|D=1\right]$ and therefore can introduce a bias in our estimation in case it is used as a proxy of $E\left[Y\left(0\right)|D=1\right]$. Note that,

$τ\_{ATT}=E\left[Y\left(1\right)|D=1\right]-E\left[Y\left(0\right)|D=1\right]-E\left[Y\left(0\right)|D=0\right]+E\left[Y\left(0\right)|D=0\right]$,

and therefore

$E\left[Y\left(1\right)|D=1\right]-E\left[Y\left(0\right)|D=0\right]=τ\_{ATT}+bias$,

Where $bias≡E\left[Y\left(0\right)|D=1\right]-E\left[Y\left(0\right)|D=0\right]$. As said before, if firms with some especial characteristics tend to be selected in the treatment group and these characteristics affect outcomes, then we will have a bias. On the contrary if the assignment to both groups is completely random we should not be concerned with the existence of this bias. Because normally this condition does not hold for innovation survey data we have to do something else.

Under the assumption that the differences between the treated and the control group comes from observable characteristics (e.g. firms’ size, capital and knowledge intensity, etc.), that were not affected by the treatment, we can proceed to find firms that are similar on these characteristics in both groups and compare them.

Instead of finding similar firms in all the X relevant characteristics, we can use the Xs to estimate the probability of being selected for treatment P(D=1$|$ X)=P(X )(using a probit or logit model in the case of binary treatment) and use this probability for finding similar firms in both groups (treated and control groups).

The PSM estimator for average treatment effect on the treated is:

$$τ\_{ATT}^{PSM}=E\left[Y\left(1\right)|D=1,P(X)\right]-E\left[Y\left(0\right)|D=0,P(X)\right].$$

Under the assumption of conditional (on the propensity score, $P(X)$) independence (CIA) of outcome variables with respect to treatment, this estimator is unbiased.

An additional important condition to be able to use PSM, besides CIA, is that we must have enough treated and control firms on the common support. More formally we need: $0<P\left(X\right)<1$. This condition ensures that firms with the same values of X have a positive probability of being both participants and non-participants, and we avoid predicting perfectly if a firm belongs to control or treatment group.

The matching algorithm used in this work is the Nearest Neighbor (NN) with replacement. We use oversampling, taking advantage of the big number of potential controls in our sample. In particular for each treated firm we find the 5 nearest neighbors (matching partners) and compare them with the treated firm.

Our vector of variables X is composed of six variables: firm size (proxy by the number of employees at the beginning of the period), exporter status (current period), foreign owned (if foreign capital is greater than 10% of firm’s capital in the current period), patent (if the firm obtained a patent in the period, we use this variable as proxy for the innovation performance of the firm in the past), capital intensity (defined as K/L at the beginning of the period, where K is capital and L the number of employees) and firm’s age. We can argue reasonably that these variables are not affected by the treatment.

* 1. **Data**

We apply the above methodology to evaluate the effect of financial support granted to Uruguayan service and manufacturing firms during the period 2004-2009. For this purpose we make use of two waves of Innovation Surveys (IS): 2004-2006 and 2007-2009.

The IS data is collected in parallel with the Economic Activity Survey (EAS); same sample and statistical framework. All the firms with more than 49 workers are of mandatory inclusion. Units with 20 to 49 employees and with fewer than 19 workers are selected using simple random sampling within each economic sector at the ISIC 2-digit level up to 2005. Since then, random strata are defined for units with fewer than 50 workers within each economic sector at the ISIC 4-digit level.

Both surveys have been matched with the annual Economic Activity Surveys (EAS). We matched both SIS with the 2004 and 2007 EAS because we needed information on the size of the firm at the beginning of the period, and capital (fixed assets). In order to avoid endogeneity problems associated to the size and capital, we use these variables at the beginning of the period of the survey. All the other variables used in the empirical exercise come from the SIS. When matching with the EAS some firms are lost because of sampling problems, hence when using data collected form the EAS, the size of the sample are reduced.

For the service sector, the final number of included firms in the IS is 1868; 885from the first survey, and 983 from the second one. When using size from beginning of the period, and the capital per worker the sample is reduced to 1093, 776 for the 2004-2007 survey, and 317 firms for the last survey available. For the manufacturing sector, the final number of included firms is 1727; 816 for 2004-2006 survey, and 911 for the last one. When using variables from the EAS the sample is reduced to 1,209; 757 for the survey 2004-2006, and 454 for the last survey.

The main variable of the study is treatment variable, defined as a firm to be financially supported. We consider a firm to be financially supported if it has received some financial support from any the government[[5]](#footnote-6) in the period of reference. We evaluate the effect of financial support on the innovation expenditure (IE) effort, i.e. expenditure over sales. Total innovation expenditure comprises investment in design, installation of machinery, industrial engineering, embodied and disembodied technology, marketing, and training. We are able to distinguish between total and private firms’ innovation investment. Moreover, we analyze the effect on productivity, defined as the logarithm of sales over total employment. We believe the effects of financial support on productivity to be realized on a longer term, so we expect to find no contemporaneous effect on productivity.

Table 1 bellow reports the number of firms in each sector, divided in KIBS and traditional services, or High and Low-tech manufacturing sectors. The manufacturing sector as a whole tends to invest more in innovation activities than the service sector. The High-Tech sectors tend to be the most innovators, followed by the KIBS sectors. The third column of the table reflects the manufacturing bias of innovation policies. While almost 5% of the manufacturing sample has received public financial support in the period 2004-2009, only 2.2% did in the service sector.

**Table 1. Firms with innovation activities and financial support. Period 2004-2009.**

|  |  |  |  |
| --- | --- | --- | --- |
|   |   | **% with** | **% with**  |
|   | **Obs** | **Inn activities** | **financial support** |
| **Services** | 1093 | 44.8 | 2.2 |
| Kibs | 343 | 49.9 | 2.0 |
| Traditional | 750 | 42.5 | 2.3 |
| **Manufacturing** | 1209 | 48.6 | 4.7 |
| Hightech | 281 | 60.5 | 6.0 |
| Lowtech | 928 | 45.0 | 4.3 |

In table 2 we report the innovation effort (IE/sales) for firms with and without financial support. On average firms from the manufacturing sector invest more in innovation activities than in the service sector. One fact to highlight is that the private effort of firms with financial support is notably higher than the effort of firms without financial support and innovation activities in the manufacturing sector. On average, the difference is 1.75 percentage points, being even higher in the High-tech sector (3,4pp). On the contrary, in the service sector the private effect of those that received financial support is lower than those firms that undertook innovation activities without financial support; on average, 1.15 percentage points lower. This raw data can lead to us to the conclusion that a crowding out effect could exist in the service sector, while not in the manufacturing sector. Our empirical strategy will try to disentangle if this an effect derived from the fact that public financial support tend to be directed to firms that tend to invest more in the manufacturing sector, while to firms that show a poor performance in innovation in the service sector. This will be done by comparing firms with similar probability of obtaining financial support.

**Table 2. Innovation effort in firms with and without financial support (in %). Averages for period 2004-2009.**

|  |  |
| --- | --- |
|  | **Innovation effort**  |
|   | With financial support | Without financial support |
|  | Total | Private | All firms | Firms with IE>0 |
| **Services** | 4.18 | 2.35 | 1.53 | 3.51 |
| Kibs | 4.22 | 3.08 | 1.85 | 3.79 |
| Traditional | 4.16 | 2.05 | 1.39 | 3.37 |
| **Manufacturing** | 7.99 | 5.41 | 1.69 | 3.65 |
| Hightech | 7.56 | 6.24 | 1.68 | 2.88 |
| Lowtech | 8.18 | 5.05 | 1.69 | 3.97 |

Finally, table 3 presents the mean of control and treatment group of selected controls to be added in the econometric strategy by sector. Firms tend to be larger and more exporters in the treatment group, than in the control group. At the same time, in the treatment group firms tend to have obtained more patents than in the control group, while with respect to age and foreign owned status there are no clear differences.

**Table 3. Mean comparison of financially supported firms, non-supported firms on selected controls**

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Services** | Kibs | Traditional |
|   | With | Without | With | Without | With | Without |
| Size (log employees) t-1 | 4.87 | 3.87 | 4.73 | 3.93 | 4.93 | 3.84 |
| Exporter dummy | 29.2% | 14.3% | 28.6% | 13.4% | 29.4% | 14.7% |
| Foreign owned | 12.5% | 12.5% | 28.6% | 15.8% | 5.9% | 11.1% |
| Age (years) | 29.39 | 22.13 | 13.86 | 17.90 | 36.19 | 24.07 |
| Obtained patent | 4.2% | 1.7% | 0.0% | 2.1% | 5.9% | 1.5% |
|   | **Manufacturing** | Hightech | Lowtech |
|   | With | Without | With | Without | With | Without |
| Size (log employees) t-1 | 4.38 | 3.88 | 4.22 | 3.64 | 4.45 | 3.95 |
| Exporter dummy | 66.7% | 45.9% | 82.4% | 48.1% | 60.0% | 45.3% |
| Foreign owned | 12.3% | 14.3% | 11.8% | 21.2% | 12.5% | 12.3% |
| Age (years) | 33.91 | 63.53 | 36.24 | 54.41 | 32.93 | 66.24 |
| Obtained patent | 3.5% | 2.9% | 0.0% | 3.9% | 5.0% | 2.6% |

1. **Results**

We will present results for the complete sample of firms, that is, manufacturing and service sector firms together. The main idea of the strategy, in order to reduce endogeneity issues, is to match observations, according to their pre-treatment behavior. For this reason, we choose to work with the size of the firms at the beginning of the period of reference of the IS(t-1), and capital per worker at t-1. This implies that we need to use data from EAS from the beginning of period, with the consequent reduction in the number of firms in treatment group. The treatment group is composed by 24 firms in the service sector, and 57 in the manufacturing sector. Since the number of firms is much reduced we choose to present results for the whole sample.

In the next section, we present results diving the sample n manufacturing and service sector, assuming that if the firm is not present in the EAS sample, this firm did not change quintile of size thought the period. This imputation procedure leaves us with 39 firms in the service sector and 72 firms in the manufacturing sector which received financial support during the period of reference.

We employ two different groups of observations to select the controls for the average treatment effects on the treated estimator: first of all,the full sample which includes observations with and without innovation expenditures; and in second place we restrict the sample to observations with innovation activities. In the first case, we take into account the potential effect of financial support on the inducement to undertake innovation activities. In the second case,we evaluate the stimulus of financial support on the effort considering that all supported firms would have performed innovation activities in the absence of support.

* 1. **Complete sample results**

In the first stage we investigate factors that influence the probability of receiving public financial support.The dependent variable takes the value one if the firm has got public funding, and zero in the other case. Table 4 displays marginal effects afterProbit estimation results. The first column takes all firms as the possible control group, while in the second column the sample is restricted to only firms that reported positive innovation expenditure.

The vector of explanatory variables includes firm characteristics that may influence the probability of getting public funds. We included the size of the firm, measured as the logarithm of the number of employees, age (proxy for experience), a dummy variable for exporter status and foreign owned (when more than 10% is foreign owned), and capital intensity (measured as fixed assets per worker). We also, include a dummy indicating if the firm has obtained patents in the period of reference. This variable tries to measure the persistence in innovation, since obtaining a patent is a long process; the obtained patent is probably consequence of past innovations. Finally, we included 33 sectorial dummies divided by 2-digit sector.

**Table 4. Estimation of the propensity score**

|  |  |  |
| --- | --- | --- |
|   | (1) | (2) |
|   | All firms | Only innovative firms |
|   |   |   |
| Sizet-1 | 0.0147\*\*\* | 0.0174\*\* |
|   | (0.00326) | (0.00755) |
| Foreign owned | -0.0142\* | -0.0337\* |
|   | (0.00793) | (0.0178) |
| Exporter dummy | 0.0210\*\* | 0.0264 |
|   | (0.0106) | (0.0195) |
| Age | 7.28e-05 | 8.94e-05 |
|   | (0.000172) | (0.000366) |
| Patent | 0.0122 | -0.00753 |
|   | (0.0266) | (0.0370) |
| K\_Lt-1 | -0.000476 | -0.00388 |
|   | (0.00259) | (0.00619) |
|   |   |   |
| Industry dummies | yes | yes |
|   |   |   |
| Observations | 1,942 | 997 |
| Log like | -301.2 | -258.0 |
| Standard errors in parentheses |
| \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |

Results show that the most important determinant that influences the probability of receiving public funds is size. The larger the size of the firm, the larger the probability of receiving public funds. On the contrary, being foreign owned decreases the probability of receiving public funds for innovation, while being an exporter increases the probability but only when including non-innovators firms in the control group.

According to our empirical strategy the matching is done using the calculated propensity score. Hence, some important assumptions need to be validated. The first is to check thecommon support or overlap condition. With this purpose we can perform a visual analysis of the density distribution of the propensity score in both groups.

**Figure 1. Propensity score of treated and potencial controls considering all firma (left panel) and only observations with positive innovation expenditure (right panel)**



Figure 1 shows the calculated propensity score by treated and untreated group. Observations in the control group are more left skewed than the treatment group. But a comparison of the minima and maxima of propensity scored leads to the conclusion that significant overlap is achieved. When taken into account firms with positive innovation expenditure there some firms that are off common support. We restrict the estimation to the region of common support of the propensity scores.

**Table 6. Mean comparison of supported firms, non-supported firms on selected controls**



Finally, since we do not condition on all covariates but on the propensity score, it has to be checked if the matching procedure is able to balance the distribution of the relevant variables in both the control and treatment group.

Table 6 shows that the group of treated appears different from the groups of potential controls in some relevant variables, but the similarity between treated and controls after the matching provides sensible results; the differences have been significantly reduced and not statistically significant.

Table 7 reports the results for the average treatment effect of the treated, considering as performing variables the investment expenditure effect, private effort and the log productivity. Results show that financial support has a stimulating effect on both private and total investment expenditure. Financial support firms invest 2.5% more of their sales in innovation than non-supported firms. This result indicates that not only no crowding-out effect exists, but invest more from their budget.

**Table 7.Effects from financial support**

|  |  |  |  |
| --- | --- | --- | --- |
|   | (1) | (2) | (3) |
| Dep variable | IE effort | Private effort | Productivity |
|   |   |   |   |
| ATT | 4.911\*\*\* | 2.524\*\* | -0.00952 |
|   | (1.409) | (1.092) | (0.141) |
|   |   |   |   |
| Treated group | 81 | 81 | 81 |
| Off support | 0 | 0 | 0 |
| Potential control group | 1861 | 1861 | 1861 |
| Bootstrapped standard errors in parentheses. 100 replications |
| \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |   |   |

Table 8 presents the results when only taken into account firms with positive investment expenditure. Results show that financial support has no stimulating effect on both private and total investment expenditure. The difference of private effort between treated and control firm is negative but not statistically significantly. This result indicates that no crowding-out effect exists, i.e., firms add the amount of subsidies to their private budget, not substituting private investment by public funds.

**Table 8.Effects from financial support. Firm with positive IE.**

|  |  |  |
| --- | --- | --- |
|   | (1) | (2) |
|   | IE effort | Private effort |
|   |   |   |
| ATT | 1.384 | -0.329 |
|   | (1.314) | (1.172) |
|   |   |   |
| Treated group | 79 | 79 |
| Off support | 5 | 5 |
| Potential control group | 1861 | 1861 |
| Bootstrapped standard errors in parentheses. 100 replications |
| \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |   |

Table 9 presents the potential effect of the financial support on non-supported firms (average treatment effect on the untreated). In this case, we restrict the analysis to observations with positive innovation expenditure, as it is not possible to identify which of the non-performers will be induced to undertake innovation activities.

**Table 9. Effects from financial support on non-supported firms**

|  |  |  |
| --- | --- | --- |
|   | (1) | (2) |
| Dep variable | IE effort | Private effort |
|   |   |   |
| ATU | 2.172\*\* | -0.0661 |
|   | (1.073) | (0.836) |
|   |   |   |
| Treated group | 75 | 75 |
| Potential control group | 892 | 892 |
| Bootstrapped standard errors in parentheses. 100 replications |
| \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |   |

The table shows that the effect on private effort is not significant; that is, the non-supported firms would not have increased their private investment effort if they had received financial support. On the other side, the effect on total innovation expenditure effort shows a positive and significant difference. This can be interpreted as if the non-supported firms were supported, they would probably receive, on average, larger financial support than those obtained by the supported firms. In any case, these results should be viewed with caution since the number of treated from which to select the “similar” and matched observations for the controls is certainly very scarce.

To summarize, the results lead to the conclusion that there is no crowding-out effect of private funds by public funds, and that public financing in Uruguay seems to induce some increase in private technological effort. But public funds do not significantlystimulate private expenditures of firms that wouldcarry out innovation activities in the absence of subsidies. In what follows, we will distinguish between service and manufacturing sectors.

* 1. **Services and Manufacturing sectors results**

Because, the heterogeneity existing between the service and manufacturing sectors, and the different impact financial support could have in both sectors, in this section, we present results for the manufacturing and service sector, separately.

We follow an imputation procedure as follows: if the firm has missing data on size at the beginning of the period of the IS (i.e., is not present in the EAS sample), we impute the same quintile of size as in the end of period of IS. Hence, now instead of including size as a determinant for the probit, we include the quintile of size. This imputation procedure leaves us with 39 firms in the service sector and 72 firms in the manufacturing sector which received financial support during the period of reference.

**Table 10. Estimation of the propensity score**

|  |  |  |
| --- | --- | --- |
|  | **Services** | **Manufacturing** |
|   | (1) | (2) | (3) | (4) |
| Control group | All | IE>0 | ALL | IE>0 |
| Quintile size1 | -0.0236\*\*\* | -0.0494\*\*\* | -0.0397\*\* | -0.0160 |
|   | (0.00543) | (0.0137) | (0.0170) | (0.0397) |
| Quintile size2 | -0.0146\*\*\* | -0.0353\*\* | -0.0129 | 0.0215 |
|   | (0.00536) | (0.0167) | (0.0194) | (0.0406) |
| Quintile size3 | -0.00780 | -0.0138 | -0.00939 | 0.00935 |
|   | (0.00570) | (0.0200) | (0.0196) | (0.0375) |
| Quintile size4 | -0.0105\*\* | -0.0291\* | 0.0207 | 0.0545 |
|   | (0.00533) | (0.0174) | (0.0239) | (0.0405) |
| Foreign owned | -0.00636 | -0.0263 | -0.0327\*\* | -0.0601\*\*\* |
|   | (0.00672) | (0.0179) | (0.0134) | (0.0226) |
| Exporter dummy | 0.0164 | 0.0206 | 0.0294\* | 0.0391 |
|   | (0.0118) | (0.0243) | (0.0154) | (0.0248) |
| Age | 7.95e-05 | 8.57e-05 | 0.000312 | 0.000512 |
|   | (0.000129) | (0.000368) | (0.000309) | (0.000519) |
| Patent | 0.0265 | 0.0264 | -0.00768 | -0.0409 |
|   | (0.0371) | (0.0581) | (0.0359) | (0.0417) |
|   |   |   |   |   |
| Industry dummies | Yes | yes | yes | yes |
|   |   |   |   |   |
| Observations | 1,758 | 684 | 1,156 | 698 |
| Log like | -169.1 | -136.8 | -253.8 | -217.5 |
| Standard errors in parentheses |   |   |
| \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |   |   |

In table 10 the marginal effects of the probability of being receiving public financial support are reported. Size is still a very important determinant in the service sector, while less so in the manufacturing sector. When restricting the sample to firms that show positive innovation expenditure, the quintiles become statistically insignificant. In the manufacturing sector, being foreign owned affects negatively the probability of being financially supported, while being an exporter seems to have mildly positive effects on the probability.

In tables A.1 and A.2 and figures A.1 and A.2 in the appendix we report the balance test for the covariates for treatment and control groups, and the estimated propensity score to check for common support. For results are satisfactory, showing that after matching the mean of the covariates in the control and treatment group cannot be rejected to be equal in the sample. Also, the analysis of the estimated propensity scores leads to the conclusion that significant overlap is achieved.

Table 11 shows the effects of financial support over the financially supported firms in the service and manufacturing sector. Results show that financial support has a stimulating effect on both private and total investment expenditure, in the manufacturing sector. Financially supported firms invest 2.1% more of their sales in innovation than non-supported firms. This result indicates that not only no crowding-out effect exists, but invest more from their budget. On the contrary, in the service sector the mean of private effort financially support is positive but not significantly significant different from the non-financially supported firms, while the total investment is higher in the treated firms. This also signals that there is no crowding out effect; instead firms add the amount of support to their private budget, not substituting private investment by public funds.

**Table 11. Financial support effects on supported firms**

|  |  |  |  |
| --- | --- | --- | --- |
|   | (1) | (2) | (3) |
| Dep variable | IE effort | Private effort | Productivity |
|   |   |   |   |
| **Service sector** | **3.072\*\*** | **0.430** | **0.368\*\*** |
|  | **(1.501)** | **(1.088)** | **(0.175)** |
|   |   |   |   |
| Treated group | 38 | 38 | 38 |
| Off support | 1 | 1 | 1 |
| Potential control group | 1,758 | 1,758 | 1,775 |
|   |   |   |   |
| **Manufacturing sector** | **4.554\*\*\*** | **2.102\*** | **0.0839** |
|  | **(1.689)** | **(1.121)** | **(0.134)** |
|   |   |   |   |
| Treated group | 72 | 72 | 72 |
| Off support | 0 | 0 | 0 |
| Potential control group | 1,156 | 1,156 | 1,156 |
| Bootstrapped standard errors in parentheses. 100 replications |
| \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |   |   |

When restricting the sample to firms with positive innovation expenditure (table 12), in the service sector the mean difference in private effort between treated and control is negative but not statistically significant. This means that there is no crowding-out effects of public financial support. Also isthere no stimulating effect, neither in the total or private effort, in the service sector. In the manufacturing sector, while there is no stimulating effect (the mean difference is positive but not significant) in the private effort, there is no crowding out effect. Instead, the mean difference in total effort between treatment and control is positive and significant. This means that firms in the manufacturing sector do not cut their private budget because of receiving public funds.

**Table 12. Financial support effects on supported firms if IE>0**

|  |  |  |
| --- | --- | --- |
|   | (1) | (2) |
|   | IE effort | Private effort |
|   |   |   |
| **Service sector** | **2.234** | **-0.646** |
|  | **(2.026)** | **(1.563)** |
|   |   |   |
| Treated group | 38 | 38 |
| Off support | 0 | 0 |
| Potential control group | 684 | 684 |
|   |   |   |
| **Manufacturing sector** | **3.928\*** | **1.424** |
|  | **(2.011)** | **(1.247)** |
|   |   |   |
| Treated group | 69 | 69 |
| Off support | 2 | 2 |
| Potential control group | 698 | 698 |
| Bootstrapped standard errors in parentheses. 100 replications |
| \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |

Table 13 reports the effects of financial support on unsupported firms. The table shows that the effect on private effort is not significant in the service and manufacturing sector. This suggests that the non-supported firms would not have increased their private investment effort if they had received financial support. On the other side, the effect on total innovation expenditure effort shows a positive and significant increment in the manufacturing sector, while not significant in the service sector. While in the manufacturing sector if the non-supported firms were supported, they would probably receive, on average, larger financial support than those obtained by the supported firms; this is not the case in the service sector.

To summarize, when analyzing the differential impact of financial support in the service and manufacturing sector, the results lead to the conclusion that there is no crowding-out effect of private funds by public funds in any of the two sectors. The larger effect on innovation of public financial support was found in the manufacturing sector. While public financing funds seems to induce some increase in private technological effort in the manufacturing sector, this is not present in service sector firms. In any case, there is no inducement effect on firms that would carry innovation activities in any case.

**Table 13.Effects from financial support on non-supported firms**

|  |  |  |
| --- | --- | --- |
|   | (1) | (2) |
| Dep variable | IE effort | Private effort |
|   |   |   |
| **Service sector** | 3.597 | -0.271 |
|  | (2.888) | (1.567) |
|   |   |   |
| Treated group | 23 | 23 |
| Control group | 376 | 376 |
|   |   |   |
| **Manufacturing sector** | 2.536\* | 0.662 |
|  | (1.343) | (1.211) |
|   |   |   |
| Treated group | 52 | 52 |
| Potential control group | 445 | 445 |
| Bootstrapped standard errors in parentheses. 100 replications |
| \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 |   |   |

1. **Conclusions**

This paper evaluates the impact of public financial support on innovation using quasi-experimental methods and innovation survey data from Uruguay for manufacturing and service sector.

This paper contributes to the literature in three ways. First, it presents an impact evaluation of public financial support to innovation on innovation expenditure. Therefore the analysis is extended beyond the R&D context. Second, we analyze the possible heterogeneity of impacts on services and manufacturing. Finally, the evaluation is for a middle income developing Latin American country, where the empirical evidence is scarce.

Results lead to the conclusion that there is no crowding-out effect of private funds by public funds, and that public financing in Uruguay seems to induce some increase in private technological effort. But public funds do not significantly stimulate private expenditures of firms that would carry out innovation activities in the absence of subsidies.

When analyzing the differential impact of financial support in the service and manufacturing sector, the results lead to the conclusion that there is no crowding-out effect of private funds by public funds in any of the two sectors. The larger effect on innovation of public financial support was found in the manufacturing sector. While public financing funds seems to induce some increase in private technological effort in the manufacturing sector, is not present in service sector firms. In any case, there is no inducement effect on firms that would carry innovation activities.

This results call for a re-thinking in terms of public innovation policy. On one hand, there is evidence of the bias towards manufacturing firms in terms of public financial support. Results show that funds to this sector has positive inducement of innovation activities, but leads the service sector to be secondary and relegated. This result raises the question of how this public funds are targeted to the service sector. More research is needed in the area of different instrument of support for innovation, like fiscal incentives, or technical support.

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**Appendix A**

**Table A.1. Summary of the available evidence**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Author(s)** | **Country** | **Policy measure** | **Outcome variable(s) and impact** | **Data source** | **Method** |
| Aerts and Czarnitzki (2004) | Belgium (Flanders) | Financial support | R&D expenditure (net of subsidy):+Patent applications:n.s. | Innovation survey (CIS3: 1998-2000) linked to other data resources on patents and financial statements.*Unit of analysis:* manufacturing, computer services, R&D services and business-related services firms. | Non-parametric matching |
| Almus and Czarnitzki (2003) | Germany (Eastern) | All public R&D schemes | R&D expenditure (net of subsidy):+ | Innovation panel (1995, 97, 99).*Unit of analysis:* manufacturing firms. | Non-parametric matching |
| Avellar | Brazil | Fiscal incentives | R&D expenditure (net of subsidy):+Expenditure on innovative activities (net of subsidy):+ | Innovation survey (2006-08).*Unit of analysis:* all firms. | Non-parametric matching |
| Financial support | R&D expenditure (net of subsidy):+Expenditure on innovative activities (net of subsidy):+ |
| Bloom, Griffith and Van Reenen (2002) | Australia, Canada, France, Germany, Italy, Spain, United Kingdom and USA | Fiscal incentives | R&D expenditure:+ | Panel with tax information from national sources and R&D expenditure at the country level from OECD database (1979-1997). *Unit of analysis:* national manufacturing sectors. | Instrumental variables with fixed effects |
| Busom (2000) | Spain | Financial support | R&D expenditure (net of subsidy):+R&D personnel:+ | Innovation survey (1988)*Unit of analysis:* all firms. | Heckman’s selection model  |
| Crespi, Maffioli and Melendez (2011) | Colombia | Financial support and promotion of research alliances | Product innnovation:+Labor productivity:+ | Industrial, innovation and administrative panel (1995-2007).*Unit of analysis:* manufacturing firms. | Fixed effects |
| Czarnitzki (2002) | Germany | Financial support | R&D expenditure:+ | Innovation panel (1994, 96, 98), database with credit information from a credit rating agency and patenting activity from the national patent office.*Unit of analysis:* manufacturing SME’s. | Tobit model |
| Czarnitzki and Fier (2002) | Germany | Financial support | Expenditure on innovative activities (net of subsidy):+ | Innovation panel (1997, 99)*Unit of analysis:* service firms. | Non-parametric matching |
| Czarnitzki, Hanel and Rosa (2011) | Canada | Fiscal incentives | Number of new products:+Sales of new products:+Profitability:n.s.Domestic market share:n.s.International market share:n.s.Allowed keeping up with competitors:n.s. | Innovation survey (1999).*Unit of analysis:* manufacturing firms. | Non-parametric matching |
| Czarnitzki and Hussinger (2004) | Germany | Financial support | R&D expenditure (net of subsidy):+Patent applications:+ | Innovation panel, public information on R&D funding, database with credit information from a credit rating agency and patenting activity from the national patent office.*Unit of analysis:* manufacturing firms. | Non-parametric matching to estimate the policy effect on R&D expenditure and probit model to estimate the effect of R&D on patent application. |
| Duguet (2004) | France | Financial support | R&D expenditure (net of subsidy):+ | R&D surveys and fiscal information on firms (1985-97).*Unit of analysis:* all firms. | Non-parametric matching |
| González, Jaumandreu and Pazó (2005) | Spain | Financial support | Decision to invest on R&D:+R&D expenditure(net of subsidy):+ | Entrepreneurial panel (1990-1999).*Unit of analysis:* manufacturing firms. | Tobit model  |
| González and Pazó (2008) | Spain | Financial support | R&D expenditure (net of subsidy):+ | Entrepreneurial panel (1990-1999). *Unit of analysis:* manufacturing firms. | Non-parametric matching |
| Gorg and Strobl (2007) | Ireland | Financial support | R&D expenditure (net of subsidy):n.s. | Entrepreneurial panel and public database on R&D grants (1999-2002). *Unit of analysis:* manufacturing firms. | Difference in differences with non-parametric matching. |
| Hall (1993) | USA | Fiscal incentives | R&D expenditure (net of subsidy):+ | Entrepreneurial panel (1980-91). *Unit of analysis:* manufacturing firms. | Instrumental variables. |
| Hall and Maffioli (2008) | Argentina (1994-2001) | Financial support | R&D expenditure (net of subsidy):+ | Innovation panel (1995-2001).*Unit of analysis:* all firms. | Instrumental variables with fixed effects. |
| Argentina (2001-04) | R&D expenditure:+Sales of new products:n.s.Sales growth:n.s.Employment growth:n.s.Exports growth:n.s.Productivity growth:n.s. | Innovation panel (2002-04).*Unit of analysis:* all firms. | Difference in differences with non-parametric matching. |
| Brazil (1996-2003) | R&D expenditure (net of subsidy):+ | Innovation panel (1997-2003).*Unit of analysis:* all firms. | Differences with non-parametric matching. |
| Patents:n.s.Employment growth:+Sales growth:+Productivity growth:n.s. | Difference in differences with non-parametric matching. |
| Brazil (1999-2003) | R&D expenditure (net of subsidy):+ | Innovation panel (1999-2003).*Unit of analysis:* all firms. | Differences with non-parametric matching. |
| Patents:+Employment growth:n.s.Sales growth:n.s.Productivity growth:n.s. | Difference in differences with non-parametric matching. |
| Chile (1998-2002) | R&D expenditure:n.s.Patents:n.s.New products:n.s.Sales growth:n.s.Employment growth:n.s.Exports growth:n.s.Productivity growth:n.s. | Innovation panel (1999-2001).*Unit of analysis:* all firms. | Difference in differences with non-parametric matching. |
| Product innovation:n.s.Process innovation:n.s.Financial access:n.s.Training and organization activities:n.s.Use of external knowledge:+ | Differences with non-parametric matching. |
| Panama (2000-03) | R&D expenditure:+Sales growth:n.s.Productivity growth:+Exports growth:n.s.Sales of new products:+ | Innovation panel (2001-03).*Unit of analysis:* all firms. | Fixed effects with non-parametric matching. |
| Product innovation:+Process innovation:+Financial access:+Training and organization activities:n.s.Use of external knowledge:+ | Differences with non-parametric matching. |
| Hujer and Radic (2005) | Germany | All public R&D schemes | New products:+New or improved products:n.s. | Entrepreneurial panel (1999-2000). *Unit of analysis:* all firms. | Probit model |
| New products:+New or improved products:+ | Non-parametric matching |
| New products:n.s.New or improved products:- | Simultaneous two-equation probit model |
| New products:n.s.New or improved products:n.s. | Difference in differences |
| Hussinger (2003) | Germany | Financial support | R&D expenditure (net of subsidy):+ | Innovation panel, public information on R&D funding and patent application, and database with credit information from a credit rating agency.*Unit of analysis:* manufacturing firms. | Heckman’s selection model and semi-parametric two-step selection models |
| Klette and Moen (2012) | Norway | Financial support | R&D expenditure:+ | Innovation panel (1982-1995).*Unit of analysis:* high-tech firms. | Fixed effects regression |
| Lach (2002) | Israel | Financial support | R&D expenditure (net of subsidy) :n.s. | Innovation panel (1990-95).*Unit of analysis:* manufacturing firms. | Difference in differences |
| Lokshin and Mohnen (2013) | Netherlands | Fiscal incentives | Wages of R&D workers:+ | Innovation panel and census data on production (1997-2004).*Unit of analysis:* all firms. | Instrumental variables |
| Loof and Heshmati (2005) | Sweden | Financial support | R&D expenditure (net of subsidy):+ | Innovation survey (CIS3: 1998-2000).*Unit of analysis:* all firms. | Non-parametric matching |
| Lopez-Acevedo and Tan (2010) | Mexico | Different programs supporting innovation in SME’s | Sales:+Employment:+Wages:n.s. | Industrial panel linked to program participation information (1994-2005)*Unit of analysis:* SME’s | Fixed effects with non-parametric matching |
| Chile | Product or process innovation:+Probability of investing in R&D:+Implementation of quality control systems:+Provision of training for employees:+Sales:-Labor:+Productivity:- | Innovation and entrepreneurial panel (1992-2006)*Unit of analysis:* SME’s | Difference in differences with non-parametric matching. |
| Colombia | Sales:+Employment:+Wages:+Exports:n.s. | Innovation and entrepreneurial panel linked to administrative tax information (1992-2006)*Unit of analysis:* SME’s | Fixed effects with non-parametric matching |
| Peru | Profits:+Sales:+ | Industrial panel linked to program participation information (1994-2005)*Unit of analysis:* SME’s | Fixed effects with non-parametric matching |
| Ozcelik and Taymaz (2008) | Turkey | Financial support | R&D expenditure (net of subsidy):+ | Innovation panel, entrepreneurial panel and database with information on R&D support (1993-2001).*Unit of analysis:* all firms.  | Random effects Tobit, fixed effects regression and dynamic models. |
| Paff (2004) | USA (California) | Fiscal incentives | R&D expenditure:n.s. | 10K filings (1994-99)*Unit of analysis:* software and pharmaceutical firms.  | Regression model |
| Suetens (2002) | Belgium (Flanders) | Financial support | R&D personnel:n.s. | Innovation panel and annual national accounts database (1992-99)*Unit of analysis:* all firms. | Instrumental variables with fixed effects |
| Wallsten (2000) | USA | Financial support | R&D expenditure (net of subsidy):n.s.Employment:n.s. | Financial reports (1990-92).*Unit of analysis:* small high-tech firms. | Instrumental variables |

Note: n.s.=not significant effect at the 5% level, + = positive effect found.

**Table A.1. Mean comparison of supported firms, non-supported firms on selected controls in the service sector**



**Table A.2. Mean comparison of supported firms, non-supported firms on selected controls in the manufacturing sector**



**Figure A.1. Propensity score of treated and potencial controls considering all firms (left panel) and only observations with positive innovation expenditure (right panel). Service sector**



**Figure A.2. Propensity score of treated and potencial controls considering all firms (left panel) and only observations with positive innovation expenditure (right panel). Manufacturing sector**



1. The financial support of the Inter-American Development Bank is gratefully acknowledged. We thank the comments and suggestions by Gustavo Crespi, and Maren Vairo for excellent research assistance. The usual disclaimer applies. [↑](#footnote-ref-2)
2. Given that the innovator has more information about the project than the investor, it can use this advantage to increase his profit in detriment of the investor. [↑](#footnote-ref-3)
3. For a summary of the overall evidence, see table A.1 in the appendix. [↑](#footnote-ref-4)
4. See Caliendo and Kipeinig (2008) for a very intuitive presentation of these methods. [↑](#footnote-ref-5)
5. The survey includes information regarding financial support received from the Public Sector (not including public firms). [↑](#footnote-ref-6)