Journal of Applied Economic Sciences
Volume XXI, Special Issue 1(91), 2026

Public Subsidies and Firm Innovation in Latin America: A Non-Parametric Assessment of Policy Effectiveness

Oliviero A. CARBONI
https://orcid.org/0000-0002-2818-816X
Department of Economics and Business (DiSEA)
University of Sassari and CRENoS, Italy
ocarboni@uniss.it

Article's history
Received 23rd of November, 2025; *Revised* 13th of February, 2025; *Accepted* 1st of March, 2026; *Available online*: 15th of March, 2026. *Published* as article in the Volume XXI, Special Issue, 1(91), 2026.

Suggested citation
Carboni, O. (2026). Public Subsidies and Firm Innovation in Latin America: A Non-Parametric Assessment of Policy Effectiveness. *Journal of Applied Economic Sciences*, Volume XXI, Special Issue, 1(91), 115 – 136. https://doi.org/10.57017/jaes.v21.si.1(91).06

Abstract
This study examines the impact of public grants on firms' innovation expenditures using a large sample of Latin American firms. The methodology is based on the non-parametric matching procedure. The results indicate that public incentives have a positive and statistically significant effect on firms' innovation spending. However, public grants do not boost additional net innovation spending. This may reflect the general structural weakness in Latin America's technological system, where complex relationships involving complementarities and synergies, typically found in the technological field, are not entirely fulfilled. Moreover, companies that utilize government funds tend to finance innovation by using their own financial resources more than non-granted companies. Although the data do not allow for identifying potential substitution effects, the analysis suggests that, without the grants, these firms would have been possibly less committed to innovation. This finding supports the idea of partial positive effects of public support on firms' innovative activities.

Keywords: public support, R&D policy, innovation expenditure, applied econometrics, firm behaviour, structural weakness Latin America.

JEL Classification: O31; O38; L21; O54; C14.

Introduction

The idea that innovation and research can favour economic growth has been a primary concern in economic literature and policy arguments in recent decades. Several scholars have provided empirical and theoretical evidence that R&D and innovation efforts are crucial for firms' competitiveness and long-term economic prosperity. At the same time, firms' technological advances spill over to the rest of the system, facilitating the creation of further knowledge. For instance, the recognition of technology as a pivotal element for efficiency and production has strongly characterized the EU policy and objectives since the beginning of the 1990s through the Structural Funds and the Lisbon Strategy.

The understanding of the role of innovation and R&D in shaping competitiveness becomes particularly relevant in times of global competition and challenging economic recovery, such as after the 2008 crisis. R&D can generate positive outcomes for firms, providing technological capabilities that enhance their engagement in international markets. It may provide technological competitive skills that favour commitment to international business (Harris & Li, 2009; Aw et al., 2011). Available evidence suggests that a considerable share of productivity gain depends on R&D (Coccia, 2009).

From this perspective, government financial support schemes may offer a crucial tool to incentivize the commitment to uncertain technological programs, particularly in the light of the existence of financial restraints in technology production areas. It is widely recognized that market imperfections hinder firms' ability to obtain resources from financial institutions, resulting in underinvestment in technology and, consequently, adverse effects on economic growth. The rationale underlying public policy is to mitigate market failures resulting from asymmetric information, moral hazard, and imperfect appropriability, which typically characterise the entire process of technology creation. This is particularly the case for most developing countries, where financial systems are typically not equipped to support companies in their financial needs fully (Quartey et al., 2017). The shortage of technological knowledge necessary to evaluate the goodness of firms strongly limits the financial flows to research projects. In most cases, companies' own endowments and savings represent the only viable solution.

Although the acknowledged importance of innovation in economic systems, relatively limited empirical studies are available regarding the relationship between research activities and government instruments in Latin American countries. This study contributes to the empirical evidence on the effects of public financing on technology investment by analysing a large set of firms operating in seven South American countries: Colombia, Argentina, Ecuador, Paraguay, Uruguay, Peru, Chile, and Panama.

The Latin American context assumes a special significance and serves as a litmus test for examining the relationship between grant-technology spending. National and private spending on R&D is remarkably modest, and, although there is consistent regional heterogeneity, countries generally exhibit low productivity and an unsound technology advance (Zuniga & Crespi, 2013; Grazzi & Pietrobelli, 2016). Indeed, technology dynamics are crucial to avoid the "middle-income technology trap" (Andreoni & Tregenna, 2020). A crucial challenge for Latin American economies is to activate domestic innovation activities progressively, and the commitment of public support may be determinant.

From the methodological point of view, this analysis employs a non-parametric matching procedure. The primary objective of this method is to investigate whether subsidised companies would have allocated the same volume of resources on innovation spending had they not received the subsidy. This is achieved by comparing the outcomes of firms selected for the R&D government financial schemes with the outcomes of those that were not participants, but which are considered "twin" according to certain appropriate characteristics (covariates). The propensity score methodology is then used to compute the likelihood of obtaining the grant and to identify the best twin observations for any individual beneficiary company. According to the propensity score estimation, beneficiary firms are then matched with their non-beneficiary counterparts. The eventual R&D average amount difference in the two groups can be attributed to the public financial support.

The analysis suggests that the potential of public subsidies is not entirely exploited and that they only exert a partial beneficial effect on innovation spending. Given the pivotal role technology plays in economic efficiency and performance, this raises special concerns in the Latin American context. Here, the whole technological structure appears to be rather fragile, and the manifold relationships, encompassing complementarities and synergies commonly involved in this field, are far from being fully realized. While government financial assistance is generally a substantial and effective tool in encouraging companies to engage in risky research projects, it might not be sufficient alone, without a proper technological environment and proper private and market return perspectives.

Interestingly, firms that use government financial assistance attain a higher total amount of innovation disbursement by utilizing their own financial assets, compared to non-subsidised ones. Although the analysis does not allow for identifying eventual substitution effects, it is likely to indicate that, had these firms not received the grant, they would have invested less in innovation activities. Hence, although partial, beneficial outcomes of public support on research activity emerge from this sample of Latin American firms.

The results of this study also provide some relevant policy insights and may draw guidance in designing and shaping future technological trajectories. Moreover, the economic development of less technologically advanced countries inevitably depends on strengthening capabilities and enhancing human skills.

The work is framed in five sections. Section 1 provides a brief overview of the existing literature. Section 2 illustrates the Latin American context. Section 3 describes the data and the variables used. Section 4 presents the estimation framework. Section 5 outlines the matching procedure. Section 6 contains the results followed by some concluding remarks.

1. Research Background

The commitment of public policy to enhancing innovative performance has attracted the attention of various scholars within the literature on research and development, as well as innovation management (Huergo et al., 2016; Carvalho, 2017; Szczygielski et al., 2017). The adoption of government financial support to incentivize private innovation projects has become a common practice in many countries, whether they are developed or developing (Wei & Liu, 2015), and a considerable amount of public revenue is devoted to assisting private companies in their innovative plans. A key concept underlying this practice is that the production of technology does not occur in isolation; it encompasses several aspects, including the institutional context, to be fully accomplished (Caraca et al., 2009).

In broad terms, public financial assistance is intended to incentivize firms to commit to innovation by reducing marginal costs and the hazard commonly associated with technological projects. Especially in this field, financial restraints deriving from capital market imperfections and asymmetric information (Hyytinen & Toivanen, 2005; Czarnitzki, 2006) are among the causes of under-investment, and scholars and policy makers largely acknowledge the appropriateness of granting private technological actions. There might emerge divergencies between private and social returns on investment in innovation. Incomplete appropriability of research output and externalities, which arise from the public good aspect of research, are strongly responsible for this situation (Nelson, 1959; Arrow, 1962).

Financially constrained firms are likely to abandon potentially profitable technological designs also due to moral hazard issues, which raise the overall cost of borrowing and make marginal projects less appealing (Hall, 2002). Strong technical asymmetric information issues between lenders and borrowers hamper the likelihood of receiving loans from the financial system. The hazards of technological ventures and their implicit microeconomic characteristics compel organizations to fund innovation expenditures with internal financing (Mairesse et al. 1999). This is particularly the case for small research-oriented companies, which are, in fact, the most financially vulnerable (Hall, 2002). All this makes investment in technology projects riskier than in more traditional assets. Hence, one robust argument at the base of public intervention is concerned with the exigence to overcome market failures.

Numerous empirical studies have drawn attention to the role that public financing plays in supporting the innovation process (Torregrosa-Hetland et al., 2019). Evidence that public assistance supports companies in industries that heavily depend on outdoor credits is found in Hyytinen & Toivanen (2005). Obtaining an award for public financing also provides a good indication of the quality of the companies; this, in turn, is an effective leverage to obtain further financing and mitigate the detrimental effects of the financial system failures. According to Meuleman & De Maeseneire (2012), who investigated Belgian companies, access to the government research schemes resulted in easier access to long-duration debt. Employing a sample of firms in Spain, Huergo et al. (2016) suggested that obtaining government funding may encourage firms to engage in technological activity through external credit.

According to Funk (2002), basic research is a source of sound global spillovers, providing a strong justification for governments' technological policies. Investigating the outcomes of government grants on corporate R&D expenditures in China, Dai & Cheng (2015) found that beneficial indirect effects are expected to spill over to other companies in the system. Carboni (2013) provided evidence that government financial assistance has a positive impact on companies' outdoor research collaboration strategies. Cin et al. (2017) provided strong evidence that public subsidies have a positive impact on both R&D spending and the value-added productivity of Korean manufacturing SMEs. This mostly suggests that the policy has been effective in driving technological progress and supporting economic growth (Criscuolo et al., 2022).

Innovation expenditure rises only if financial aid encourages companies to commit to technological projects that would result unrentable without public assistance (Tokila et al., 2008; Zúñiga-Vicente et al., 2014). This latter is likely to exert a favourable influence on the budgetary assets at hand of the firms, which may improve, producing a beneficial response to investment. If not, government aid only stimulates internal displacement of assets, substituting own with public financing. Minor or inexistent effects on firms' innovation investment are then expected. This is likely to be particularly true for large organizations that would have committed to technological projects also without receiving public support. According to Wallesten (2000), if investment in research displays short-term diminishing returns and the company has already reached the desired amount of R&D using internal financial assets, grants are likely to prompt the company to reduce internal resources by the entire amount of the aid received. The final bulk of R&D spending will not vary.

In fact, government financial support may adversely impact the research and innovation endeavour of firms, particularly in the presence of rent seekers. Receiving grant assistance may decrease or entirely eliminate their private spending in technological activities, thereby increasing their dependence on the public sector. Additionally, government support can have

a detrimental effect on the innovative performance of companies, as they may divert public funds to non-technology-related expenditures (Catozzella & Vivarelli, 2016). This is particularly the case when it not possible to detect the financial preferences that companies have, public programs may attract and grant organizations that already attained their proper amount of innovation spending but search for additional economical resources to be diverted to other forms of investment giving rise to partial or complete crowding out effect (David et al, 2000; Klette et al, 2000; Chudnovsky et al. (2006).

Employing data on Vietnamese SMEs, Doan et al. (2021) found that public financial grants, used alone or in conjunction with technical assistance, are neither able to support firms in improving efficiency nor to reduce the cost of SMEs' innovation activities. There is still no clear agreement on which public policy instruments are most effective in fostering technological activities. Examining R&D policies across 45 countries, Carvalho (2017) observed that governments often fall short in providing adequate support, frequently making promises of innovation outcomes that exceed their actual capacity to deliver.

Similarly, the literature remains divided on the role and effectiveness of R&D investment in enhancing competitiveness (Carvalho, 2017), particularly in contexts of fiscal austerity (Cano-Kollmann et al., 2017) or during periods of crisis (Antonioli & Montresor, 2019). In these situations, policymakers face the challenge of identifying the most efficient allocation of scarce resources to sustain a virtuous cycle of innovation that boosts firms' innovative performance (Greco et al., 2017), while also shaping an institutional environment supportive of R&D investment (Montmartin & Massard, 2015; Criscuolo et al., 2022). Moreover, although public assistance is widely acknowledged as a key driver of innovation, the existing literature has yet to establish a direct and consistent link between state intervention and firms' strategic innovation decisions (Santos, 2019).

2. The Latin American Context

The debate about the most appropriate strategy to stimulate private spending in innovation has generated a substantial theoretical and empirical literature on the justification for public financial support and its efficacy. However, many of the empirical studies have focused on advanced countries, while relatively little evidence is available for Latin American countries. One key justification for this analysis is the significant dependence of research and development projects on government financial support, as well as the technological activities of private firms (De Negri et al., 2018).

Starting from the early 1990s, many LACs have viewed the implementation of substantial government support schemes to improve firms' technology growth and competitiveness. The rationale was that these countries failed to modernize and enhance their innovative activities and efficiency because the market did not provide the appropriate incentives. R&D intensity in the region lags behind the levels achieved in the United States, the European Union, and China (OECD, 2018).

The question of why LAC economies, and particularly LAC firms, underinvest in R&D has been extensively examined in the literature. Recent studies reject the view that low returns to such investments drive low levels of R&D expenditure and limited private sector participation in innovation. On the contrary, empirical evidence shows that rates of return to R&D are higher in developing economies - especially in LAC and Asia - than in advanced countries (Benavente et al., 2006). Since these returns surpass those of physical capital, LAC economies should invest at least twice as much as they currently do.

The relatively low level of private innovation spending therefore appears to be linked to other factors, including short planning horizons induced by macroeconomic volatility, financial constraints, weak intellectual property rights, poor quality of research institutions, limited government support, and a rentier mentality shaped by the long-standing reliance on natural resource exploitation (Lederman & Maloney, 2003; De Ferranti et al., 2003). Moreover, a notable feature of LACs' economies is the small number of firms committed to research projects and the content of innovation actions, which are mainly oriented toward the acquisition of hardware machinery rather than focusing on research plans (Crespi et al. 2014).

Given such a scenario, many LACs began to establish diverse forms of state support and foster the relationship between companies and the National System of Innovation. Research and technology attained priority importance in the agenda of multilateral organisations such as the Inter-American Development Bank (IDB) and the World Bank. Technology programmes were typically shaped on a demand-driven basis, relying on participating firms' own project proposals and implementation (Hall & Maffioli, 2008). Government schemes were initiated in Chile, and subsequently, other countries followed, including Argentina, Colombia, Mexico, Panama, Peru, Paraguay, and Uruguay (Benavente et al., 2007). Particularly, given the strategic importance of technology for economic advancement in the region, the IDB was particularly concerned with the potential effects of the base research funding, generally managed through universities, and research funds supporting firms' technological projects.

Employing data from Argentina, Chile, Colombia, Costa Rica, Panama, and Uruguay, Crespi & Zuniga (2012) found evidence of substantial heterogeneity among countries in terms of the effects of innovation on the productive system, primarily due to differences in the regulatory contexts. Chudnovsky et al. (2006) and Raffo et al. (2008) found beneficial effects of innovation and productivity in LACs. A similar conclusion is reached by De Negri et al. (2007) in their econometric analysis of Brazilian companies. Beneficial outcomes from R&D intensity to productivity in Brazil are also documented in Cavalcante et al. (2015).

Applying a difference-in-differences procedure on a sample of Chilean manufacturing companies, Benavente (2004) detects valuable effects of the FONTEC innovation program on research spending. Sanguinetti (2005) reached a similar conclusion by analysing the Argentinean FONTAR (Fondo Tecnológico Argentino) program, which showed positive effects on firms' research spending but no significant impact on total innovation expenditures. Investigating the FONTEC program in Chile, Benavente et al. (2007) supply evidence of partial crowding-out, meaning that the recipient firms increased their total R&D spending, but not only did it not boost additional private investment in technology commitment, but average firm expenditure on innovation increased less than the full amount of the average grant.

3. Data and Variable Description

The data used in this work come from the Harmonized Latin American Innovation Surveys (LAIS) collected by the Inter-American Development Bank (IDB). The dataset harmonizes 30 national innovation surveys (NIS) conducted between 2007 and 2017, covering 10 Latin American countries: Argentina, Chile, Colombia, Ecuador, El Salvador, the Dominican Republic, Panama, Paraguay, Peru, and Uruguay. The information refers to approximately 119000 firm-level observations and includes 687 variables that can be grouped into the following macro-categories: general firm characteristics; inputs and expenditures on innovation; innovation outputs; obstacles to innovation; sources of information and

cooperation; sources of financing; protection of innovation; and workforce composition (Crespi et al, 2022).

In the following, the variables that are considered in this work will be briefly described (Table A1 - Appendix). The variable under observation is the total amount of expenditures on innovation ($INNO_{SPEND}$). The treatment variable is a binary indicator indicating whether the firm received public financial support (PUB_{GRANT}). The analysis includes a set of control variables that may influence a firm's decision to apply for grants (and engage in innovation). The inclusion of these controls is crucial for isolating the effect of the primary regressors and accounting for potential confounding factors. The variables considered are reported and described below.

Product innovation ($INNO_{PROD}$) refers to new or significantly improved goods or services that differ from existing market offerings, aiming to achieve technological and market gains, as well as enhance quality and variety (Teece, 2007a). It often requires firms to scan technologies, markets, and consumer needs continuously, and has been shown to influence organizational change through its interaction with firm capabilities (Carboni & Medda, 2021).

Process innovation ($INNO_{PROC}$) involves the development of new or substantially improved production methods designed to increase efficiency and competitiveness, often through targeted investments in equipment (OECD & Eurostat, 2018). It is closely tied to production objectives, requiring deep knowledge of production cycles and dynamic capabilities (Reichstein & Salter, 2006; Teece, 2007b). While product innovation is consistently linked to positive performance outcomes, evidence on the effects of process innovation is more mixed (Morris, 2018).

Organizational innovation (INN_{ORG}) refers to change in structures, routines, and management systems, including teamwork, supply chains, and quality practices (Damanpour, 1987). Such improvements are crucial for enhancing the effectiveness of product and process innovations and maintaining competitiveness in rapidly evolving environments. A common view in the literature is that organizational innovation is a prerequisite for successful product and process innovation, as well as for the absorption of external technologies. It plays a central role in resource and information sharing, decision-making, and in shaping the mechanisms underlying complex innovation dynamics (Vather & Vadi, 2024; Carboni & Russu, 2024).

Firm size, measured by the number of employees (EMPL), may be a key determinant of investment in innovation. Larger firms benefit from better organization, easier access to financial markets, greater specialization, and the ability to spread fixed costs. This increases both the likelihood and scale of innovative activity. Perez-Alaniz et al. (2022) provide evidence that firm size moderates the impact of firms' internal financial resources on scientific research, development, and innovation.

An export dummy (EXPORT) is included among the regressors, as firms competing in international markets are often more innovative and, consequently, more inclined to apply for subsidies (Carboni & Medda, 2024).

Two further controls are introduced to account for the internal capability of firms: the number of R&D employees in the research division ($R\&D_{EMPL}$) and the share of workers holding a university degree (UNI_{DEGREE}). These variables serve as proxies for a firm's technical competence and absorptive capacity, as they capture both the scale of research efforts and the quality of human capital available. The rationale is that the creation of value and the success of innovation processes depend heavily on internal skills and the knowledge base of the workforce. As highlighted in the literature, firms with stronger human capital endowments

are better positioned to exploit technological opportunities, adapt to dynamic environments, and generate competitive advantages (Atzeni & Carboni, 2004, 2006; Dimakopoulou et al., 2023; Fiorentin et al., 2023).

The model also incorporates a variable measuring the level of internal financing (FIN_{OWN}). The sources of investment financing can vary substantially across firms. Highly innovative firms, for instance, may be reluctant to disclose details of their R&D projects to external investors, while the inherent uncertainty surrounding research outcomes often limits access to external capital. As highlighted by Hall (2002), financing innovation externally tends to be more expensive than other types of investment. Even when internal funds, such as cash flow, are insufficient, raising new equity can be costly and undesirable. Bond et al. (2005) further show that, although cash flow does not significantly affect the amount of R&D expenditure, it does influence the likelihood that high-tech firms in the UK engage in R&D activities at all.

An indicator of financial constraints is also considered (FIN_{CONSTR}). Financial constraints act as a proxy for credit market efficiency. Given the risky and sunk-cost nature of R&D, liquidity shortages may severely limit firms' ability to invest in research. Consistent with this view, Borisova & Brown (2013) find evidence of financing frictions among small and young high-tech firms. Such constraints are, in general, good at explaining under-investment.

The model also includes a binary variable (GROUP), which equals one if the firm belongs to a business group. Group membership can ease financial constraints for both innovative and traditional firms. A considerable body of research has investigated the determinants of innovation expenditure, highlighting factors such as firm size, internal financing capacity, external competition, and group affiliation (Hall et al., 2010). Schiantarelli & Sembenelli (2000) show that firms in medium and large groups are less sensitive to cash-flow availability, benefiting from greater stability and easier access to resources. Additionally, group-affiliated firms may internalize externalities, particularly those arising from technological activities.

An indicator reflecting the shortage of professional capabilities is also considered. Obstacles in recruiting the necessary human capital ($OBST_{HK}$) represent a significant barrier to firms' innovation activity. The availability of skilled personnel is a crucial determinant. Shortages in this area tend to discourage investment, as highlighted by the literature on the role of human capital in fostering technological progress (Atzeni & Carboni, 2004, 2006).

Finally, industry dummies are included to capture sectoral heterogeneity (INDUSTRY). Cross-sectional differences in technological opportunities, appropriability conditions, competencies, and fixed costs may all influence firms' innovative behaviour. For similar reasons, country dummies (COUNTRY) are also included in the model.

4. Research Methodology and Econometric Framework

When investigating the effects of public policy, the issue arises in assessing the efficacy of government-supporting schemes and determining whether they can replace firms' own financing. Given the relatively lower cost of public subsidies compared to capital markets, companies may be tempted to participate in public schemes even if they possess private budgetary resources (Blanes & Busom, 2004). However, although such an asset replacement may realise, obtaining the grant implies that some firms participating in the selection process are ultimately not granted, hence determining the aggregate net result deriving from public intervention becomes a challenging task (Hujer & Radic, 2005).

Despite the significant body of studies aimed at assessing the impact of public assistance, there is a lack of agreement, and the empirical findings are quite controversial. Compelling methodological aspects that still require investigation are at the base of such heterogeneous results. Garcia-Quevedo (2004) suggests that conclusions may vary depending on the level of analysis, and there is a weak micro indication of crowding out effects.

One common methodological issue in many empirical studies is that estimations could be affected by selection problems. Grants awarded organizations may have been selected by government officers because they are considered objectively more plausible for conducting successful research ventures. Officers are inclined to "pick the winners" and back appealing research proposals (Antonelli & Crespi, 2013). Commonly, the driving principles for awarding government grants are based on firms' expected revenues. Hence, it is likely that the amount of existing investment may increase the probability that a firm will be selected, and consequently, that government financing becomes endogenous, making estimates unreliable.

The econometric applications aiming at policy evaluation supply different recipes of analysis: (i) regressions with controls, (ii) fixed effects or difference-in-difference models, (iii) sample selection models, (iv) instrumental variable estimators, and (v) non-parametric matching of treated and untreated firms (Heckman, 2007). Following this branch of research, this paper presents new empirical evidence on the potential effects of public grants on firms' innovative investment.

Evaluating the effects of government subsidies requires estimating the counterfactual scenario, that is, what would have happened in the absence of the incentive program. Since beneficiary and non-beneficiary firms cannot be regarded as random samples, the main difficulty lies in identifying a credible control group. Matching methods are commonly employed to address this issue (Heckman et al., 1998; Heckman & Navarro-Lozano, 2004), as they approximate a randomized ex post experiment when experimental data are unavailable. Smith & Todd (2005) provide a comprehensive assessment of different matching estimators, showing that, with sufficiently high-quality data, matching represents a reliable approach. This technique enables a comparison between the outcomes of participating firms and those of a suitably defined group of non-participants, with the evaluation typically based on the average treatment effect on the treated (ATT). The ATT measures the extent to which a firm receiving the subsidy (D=1) benefits compared to the hypothetical outcome it would have experienced without the subsidy (D=0), conditional on a set of observed characteristics (X):

$$E\,(Y_1 - Y_0 \mid X,\ D = 1) \qquad (1)$$

To evaluate the impact of subsidies, the counterfactual benefit is defined as the difference between the potential outcomes with and without treatment ($\Delta = Y_1 - Y_0$). However, since for each firm only one of these outcomes is observed, the missing counterfactual must be inferred from the data. This inference relies on the conditional independence assumption, which states that, given observable characteristics X, the potential outcomes (Y_1, Y_0) are independent of the participation decision D (Rosenbaum & Rubin, 1983). In other words, conditional on X, the expected outcome of treated firms without the subsidy equals the expected outcome of untreated firms with similar characteristics.

To operationalize this, the propensity score, defined as the conditional probability of receiving the subsidy given X is estimated, thereby reducing the multidimensional matching problem to a scalar index. Based on this score, each treated firm is matched with a comparable untreated firm ("nearest neighbour"), with additional criteria sometimes applied to improve

matching quality. Firms outside the acceptable range of similarity are excluded. The average difference in outcomes between treated firms and their matched counterparts is then interpreted as the causal effect of the subsidy. Finally, the identification assumption requires that all the observations of comparable individuals who chose not to participate are included in the analysis (Abadie & Imbens, 2002).

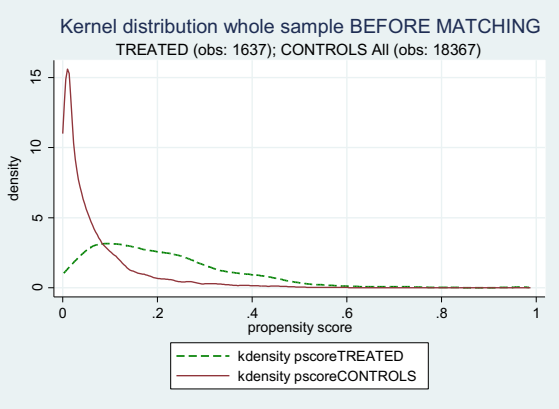
$$c < Pr(D = 1 \mid X = x) < 1 \text{ for some } c > 0 \quad (2)$$

The issue arises from the fact that some firms did not apply for public support, while others applied but were denied it. Including the latter in the matching process undermines the assumption of ex post random selection, as the control group would then be biased by the presence of lower-quality firms that were rejected from the program. The probit model is then used to estimate a one-dimensional propensity score for each firm, which serves to identify counterfactuals for the subsidized units and to separate the sample into participants in the public program and a potential control group of non-subsidized firms. The probit model is expressed as:

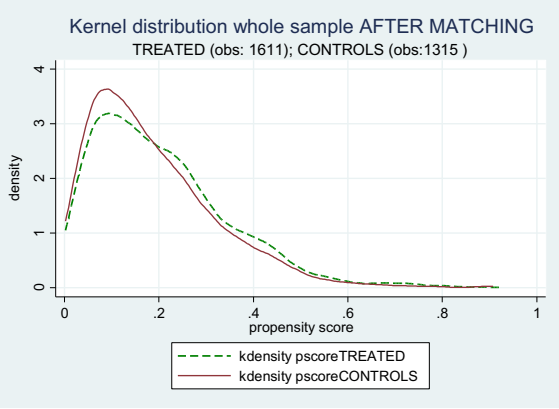
$$PUB_{GRANT} = INNO_{PRODU}, INNO_{PROCE}, INNO_{ORGA}, EMPL, EXPORT, R\&D_{EMPL}, UNI_{DEGREE}, FIN_{OWN}, FIN_{CONSTR}, OBST_{HK}, COOP, INDUSTRY, COUNTRY. \quad (3)$$

Figure 1 illustrates the kernel density distribution of the estimated propensity scores for treated and control observations before and after the matching procedure. In the unmatched sample, the distributions differ considerably, indicating an imbalance in the probability of receiving investment incentives between the treated and control groups. Such divergence suggests potential selection bias in the original sample. After applying the matching procedure, the distributions of propensity scores for the treated and control groups become substantially closer, indicating improved comparability between the two groups. The increased overlap of the distributions confirms that the matching process enhances the common support condition and improves the balancing properties of the covariates. Consequently, the matched sample provides a more appropriate counterfactual framework for estimating the causal impact of investment incentives on investment spending.

Figure 1. Kernel Distribution



Estimated Propensity Score - whole sample – Outcome variable: Investment spending. Treatment variable: Incentives to investment (0,1)



Estimated Propensity Score - matching sample – Outcome variable: Investment spending.Treatment variable: Incentives to investment (0,1)

Source: Authors' own calculations based on the study dataset.

5. The Matching Procedure

This section addresses the issue of potential selectivity bias by first estimating the probability of a firm receiving public funding, conditional on a set of observable characteristics. This estimates the likelihood of obtaining public subsidies using data from firms engaged in innovative investment activities during the period 2007-2017. The dependent variable is a binary indicator capturing whether firms received public support for investment in innovation activities, while the covariates correspond to those outlined in the previous section. The use of the propensity score aims to capture the factors that public agencies are likely to consider when allocating subsidies.

For each treated firm, a control firm is selected. This latter eventually exhibits a comparable probability of receiving the treatment, based on observed characteristics. After excluding non-matching firms and retaining only those that are potential matches, the estimation shows that the nearest neighbour distributions of subsidized firms and controls are sufficiently balanced with respect to the matching variables. Finally, 1,611 granted firms and 1,315 control observations are identified for the analysis. The Average Treatment Effect on the Treated (ATT) is then obtained by averaging the unit-level treatment effects, where each treated firm is matched with the non-treated firm in the control group that has the closest propensity score (measured using the Mahalanobis distance). Nearest neighbour matching is performed with replacement, allowing the same control firm to serve, eventually, as a counterfactual for multiple treated firms.

Table 1 reports the probability of receiving investment incentives using a dataset of 20,004 observations. Participation in public schemes is captured through a binary dependent variable. The propensity score method is employed to approximate the selection criteria that public authorities may use when awarding grants to firms.

Table 1: Probit Estimate

Determinants of receipt of public grants - firms before matching. Dependent: Public incentives to investment		
Variable	Coef.	Std. Err.
$INNO_{PRODU}$	0.21***	0.03
$INNO_{PROCE}$	0.06*	0.03
$INNO_{ORGA}$	0.06*	0.03
EMPL	0.0001***	0.000
EXPORT	0.33***	0.03
$R\&D_{EMPL}$	0.003***	0.000
UNI_{DEGREE}	0.006***	0.000
FIN_{OWN}	-0.01***	0.000
FIN_{CONSTR}	0.16***	0.03
$OBST_{HK}$	0.04	0.03
COOP	0.35***	0.04
Cons	-2.71***	0.20
# obs:	20,004	
Industry dummies	Yes	
Test on joint significance on industry dummies	$\chi2 = 113.80$, prob > $\chi2=0.000$	

Countries dummies	Yes
Test on joint significance of countries dummies	$\chi2 = 518.71$, prob > $\chi2=0.000$
Log likelihood:	- 4497.699
Pseudo R2	0.2061
Prob > $\chi2$	0.0000

Note: *** Significant at 1%; ** Significant at 5%; * Significant at 10%. The common support option has been selected [.0021353, .98491114].

It emerges that this probability is positively associated with product, process, and organizational innovation, export orientation, R&D intensity ($R\&D_{EMPL}$), the presence of university graduates (UNI_{DEGREE}), financial constraints (FIN_{CONSTR}), and cooperation (COOP). Firm size (EMPL) has a positive, albeit very small, marginal effect. By contrast, the availability of own financial resources (FIN_{OWN}) is negatively correlated with the likelihood of obtaining grants, which is consistent with the idea that public support is targeted toward more financially constrained firms.

The chi-squared test of joint significance confirms that systematic cross-country and cross-industry differences shape the probability of engaging in innovation. This is in line with previous evidence highlighting how institutional and sectoral environments critically influence firms' innovative behaviour (Hall et al., 2010). The probit model is subsequently employed to estimate a one-dimensional propensity score for each firm in the sample. This score is then used to construct counterfactuals for the subsidized firms, effectively dividing the sample into participants in public programmes and a potential control group of non-subsidized firms. According to the estimated propensity score, each treated firm is matched with the non-recipient firm displaying the closest probability of receiving a subsidy. Given the specified matching assumptions, the treated and control groups differ only in terms of receiving the grants. This framework enables the evaluation of the impact of public support by comparing expenditure levels between subsidized firms and their matched counterparts. Under these assumptions, the estimated difference in innovation expenditure can be interpreted as the causal effect of grant allocation.

6. The Matching Results

As outlined above, firms are classified as subsidized if they received innovation grants during the period 2007–2017. Specifically, 1,611 firms benefiting from innovation incentives are matched with 1,315 non-subsidized counterparts, which have the same probability of receiving the grant. The estimation results reported in Table 2 indicate that public incentives have a positive and statistically significant effect on firms' innovation spending. No matching firms were found for El Salvador, so, it is excluded from the evaluation procedure. Firms receiving incentives spend on average US$ 286000 more on innovation than comparable non-treated firms, with the effect being significant at the 1% level. When normalized by firm size, the results remain robust: incentivized firms exhibit an increase of US$ 1,607 in innovation spending per employee, again statistically significant at the 1% level. These findings suggest that public incentives are effective in stimulating both the overall volume and the intensity of innovation expenditures.

By contrast, the effects on net innovation spending are not statistically significant, although the estimated coefficient is positive (US$ 595,000). Similarly, the impact on net innovation spending per employee is negative (–US$ 4,308) but it is not statistically significant. These results imply that, while incentives appear to increase gross innovation expenditures, their effect on net spending is less clear. A possible explanation is that incentives may partly substitute for expenditures that firms would have undertaken in any case, thereby limiting their incremental impact on net investment.

Table 2: Average Treatment Effect (ATT) of Incentives on Innovation Spending. (*)

Outcome variable: Innovation spending (US$ period average). Treatment variable: Public Incentives			
Matched treated: 1,611 Matched controls: 1,315	ATT	Std. error	t-Value (°)
	286,000	76,683	3.729
Outcome variable: Innovation spending per employee (US$ period average). Treatment variable: Public Incentives			
Matched treated: 1,611 Matched controls: 1,315	ATT	Std. error	t-Value (°)
	1,607	443	3.626
Outcome variable: Net innovation spending (US$ period average) Treatment variable: Public Incentives			
Matched treated: 1,611 Matched controls: 1,315	ATT	Std. error	t-Value (°)
	595,000	716,000	0.832
Outcome variable: Net investment per employee (US$ period average) Treatment variable: Public Incentives			
Matched treated: 1,611 Matched controls: 1,315	ATT	Std. error	t-Value (°)
	-4308	3,909	-1.102

Note: (*) Estimation with the Nearest Neighbour Matching method (random draw version). (°) Takes account of repeated use of control observations in the control group.

Based on these results, it might be worthwhile to examine whether grants influence firms' financial access to investment financing (Meuleman & De Maeseneire, 2012). Table 3 reports the average effect of grants on firms' own finance for investment. The findings indicate that subsidized firms employ more internal financial assets compared to their non-subsidized counterparts (ATT = 3.18, t = 2.12). These results are consistent with the overall matching estimates, showing that grants not only enhance total innovation investment but also exert complementary effects on own resource use. This suggests to a modest crowding-in of own resources alongside public support, consistent with incentives that ease liquidity pressure and improve cash-flow planning. Interestingly, the effect on bank financing is negative and highly significant (ATT = –23.89, t = –17.59), suggesting that granted firms relied less on bank credit to finance their innovation activities. This may indicate that grants substitute for bank borrowing in the average financing mix within this sample.

Hence, grants appear not to help firms alleviate their credit constraints. It may also be an indication that, in the Latin American countries considered, self-financing in innovation represents the only viable option for firms, and public grants may help them support their internal finance commitment. This appears to be a potential weakness of the support system.

Several theoretical contributions discuss the impact of financial constraints on firms. Information asymmetries, for example, lead to credit rationing and financing limitations (Fazzari et al., 1988; Bond & Meghir, 1994), suggesting that credit markets may not operate efficiently. The literature on capital market imperfections and the financing of high-tech projects emphasizes the difficulty investors face in distinguishing between high-quality and poor projects.

Consequently, banks and other lenders often show reluctance to finance technological investment, which must therefore rely predominantly on internal resources, a mechanism described by the 'financing gap' hypothesis. From a policy standpoint, these considerations support the social desirability of public programs aimed at reducing firms' investment costs. Empirical evidence by Hyytinen & Toivanen (2005) further indicates that government support mitigates underinvestment problems in industries that are highly dependent on external finance.

Table 3: Average Treatment Effect (ATT) of Public Incentives on Financing. (*)

Outcome variable: Own financing (%) Treatment variable: Public Incentives			
Matched treated: 1,611 Matched controls: 1,315	ATT	Std. error	t-Value (°)
	3.18	1.50	2.12
Outcome variable: Bank financing (%) Treatment variable: Public Incentives			
Matched treated: 1,568 Matched controls: 1,283	ATT	Std. error	t-Value (°)
	-23.89	1.36	-17.59

Note: (*) Estimation with the Nearest Neighbour Matching method (random draw version). (°) Takes account of repeated use of control observations in the control group.

To obtain a more comprehensive picture, the potential impact of the innovation grant on sales and export performance is also analysed. The ATT estimate amounts to US$5.31 million, yet the effect is not statistically significant (t=0.403), as depicted in Table 4. While the coefficient is positive, the large standard error indicates the absence of a robust relationship between subsidies and sales. This finding is in line with the expectation that public support primarily affects firms' investment capacity rather than generating immediate increases in turnover. As argued by David et al. (2000), the benefits of public intervention often manifest with a time lag, since new investments require an adjustment period before translating into higher productivity and, subsequently, greater sales.

With respect to export the ATT is US$12.2 million, again positive but statistically insignificant (t = 1.409). Export-related outcomes are particularly complicated to be estimated with precision due to their skewed distribution: a relatively small share of firms accounts for the bulk of export activity (Bernard et al., 2007). This distributional feature can weaken the statistical power of average treatment effects. Moreover, incentives may exert differential impacts on the extensive margin (probability of exporting) versus the intensive margin (export volume among existing exporters), as emphasized by Melitz (2003) and supported by subsequent empirical work (Wagner, 2007).

To sum up, the results indicate significant effects of grants on investment, but an insignificant impact on sales and exports is consistent with previous studies. Public support generally proves more effective in promoting input accumulation, such as capital deepening and R&D, than in producing immediate improvements in market-based outcomes. For example, Cerqua & Pellegrini (2014), analysing Italian firms, report significant effects of subsidies on investment and firm survival but limited evidence for sales and exports. Similarly, Görg & Strobl (2007) find that while subsidies enhance productivity and survival, their effects on export performance tend to emerge only in the medium to long term.

Table 4: Average Treatment Effect (ATT) of Public Incentives on Sales And Export. (*)

Outcome variable: Sales (US$ period average) Treatment variable: Public Incentives			
Matched treated: 1,610 Matched controls: 1,314	ATT	Std. error	t-Value (°)
	5,310,000	13,200,000	0.403
Outcome variable: Export (US$ period average) Treatment variable: Public Incentives			
Matched treated: 1,611 Matched controls: 1,023	ATT	Std. error	t-Value (°)
	12,200,000	8,670,000	1.409

Note: (*) Estimation with the Nearest Neighbour Matching method (random draw version). (°) Takes account of repeated use of control observations in the control group.

Conclusion

This research contributes to the empirical literature by assessing the economic effects of public funding on firms across seven Latin American countries. This regional focus is particularly relevant, as Latin America's structural and institutional features provide a distinctive setting for examining the interaction between public support and firms' research and development activities. From this standpoint, public funding programs can serve as an essential instrument for encouraging firms to undertake uncertain innovative initiatives, especially given the financial constraints that often hinder investment in technology-intensive sectors.

Methodologically, this study adopts a non-parametric matching approach. The core idea of this method is to assess whether subsidized firms would have spent a different number of resources in technological activity had they not received financial support. The results of this analysis suggest that public incentives are effective in stimulating both the overall volume and the intensity of innovation expenditures. However, it emerges that subsidies have no net effect in boosting additional net innovative investment, raising concerns about the full efficiency of government aid. It is worth highlighting that firms using public support show a total larger innovation investment level, coincidentally employing higher internal financing compared to non-subsidised ones. This suggests that subsidised firms would have been less innovation-concerned without the financial assistance, indicating partial benefits of public grants. The results also indicate that relying solely on government financial aid offers limited benefits in terms of enhancing firms' commitment to innovation spending. Unfortunately, the structure of the data does not permit the establishment of potential substitution effects.

The results also suggest that while public incentives exert a partial positive effect on firms' innovation engagement, their influence on sales and export performance is less evident and statistically inconclusive. This outcome highlights the need for a longer-term evaluation horizon, as the commercial returns of investment projects often materialize with delays.

From the policy perspective, it is crucial to recognize that the amount of innovation efforts alone is not the sole determinant of a firm's growth. The institutional context plays a significant role in shaping production skills, fostering a commitment to new and advanced projects, and influencing the likelihood of success. Hence, the government policy agenda should consider the structural diversity in Latin American countries, characterized by a significant presence of micro and small firms, alongside a limited number of large and internationally competitive organizations.

Moreover, the absence of robust short-run effects on sales and exports suggests that subsidy programs alone may be insufficient to foster international competitiveness unless they are complemented by policies that directly target firms' access to foreign markets, marketing capabilities, and innovation adoption. In this sense, public support should be designed not only to stimulate capital accumulation but also to facilitate the commercialization of outcomes, particularly in international markets. Such an integrated approach ensures that subsidies contribute not only to investment expansion but also to sustained improvements in firms' growth and export capacity. The issue is especially meaningful in the Latin American context, where improving competitiveness requires firms to pursue technological advancement in a consistent and sustained manner. Incentivising firms to commit to technological process while increasingly committing to their own innovation activities becomes of paramount importance to incentivize economic and productivity performance. This is especially valuable considering that, since wages have grown excessively to compete with labour-intensive production, Latin American Countries need to shift from factor-driven to productivity-guided growth (Paus, 2020).

Credit Authorship Contribution Statement:

Oliviero A. Carboni was solely responsible for the conceptualization and design of the study, data curation, formal analysis, methodology development, software implementation, investigation, and interpretation of the results. The author also prepared the original draft of the manuscript, conducted the writing, review and editing process, and approved the final version of the manuscript for publication.

Acknowledgments/Funding

We wish to thank the University of Sassari '*Fondo di Ateneo per la Ricerca*', the Disea '*Fondo Dipartimento di Eccellenza*', the '*Progetto APEGADRUS*', and the '*Fondazione di Sardegna*' for financial support. All the usual disclaimers apply.

Conflict of Interest Statement

The author declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement

The data that support the findings of this study are taken from *The Harmonized Latin American Innovation Surveys Database* (LAIS), an extensive regional innovation policy (Crespi et al., 2022). Data are openly available at: https://data.iadb.org/dataset/harmonized-latin-american-innovation-surveys-database-lais-firm-level-micro.

Ethical Approval Statement

This study was conducted in accordance with recognized standards of academic research ethics. The analysis relies exclusively on secondary data obtained from the Harmonized Latin American

Innovation Surveys (LAIS) database provided by the Inter-American Development Bank. The dataset contains anonymized firm-level information and does not include personal or identifiable data. Consequently, no human participants were directly involved in the research and formal ethical approval was not required. All data were used solely for academic purposes and in compliance with principles of transparency, responsible data use, and proper source citation.

References

Abadie, A., Imbens, & G. W. (2002). Simple and bias-corrected matching estimators for average treatment effects. *Technical Working Paper* No. 283, National Bureau of Economic Research. https://www.nber.org/papers/t0283

Andreoni, A., & Tregenna, F. (2020). Escaping the middle-income technology trap: A comparative analysis of industrial policies in China, Brazil and South Africa. *Structural Change and Economic Dynamics*, 54, 324–340. https://doi.org/10.1016/j.strueco.2020.05.008

Antonelli, C., & Crespi, F. (2013). The Matthew effect in R&D public subsidies: The Italian evidence. *Technological Forecasting and Social Change*, 80, 1523–1534. https://doi.org/10.1016/j.techfore.2013.03.006

Antonioli, D., & Montresor, S. (2021). Innovation persistence in times of crisis: An analysis of Italian firms. *Small Business Economics*, 56(4), 1739–1764. https://doi.org/10.1007/s11187-019-00304-8

Arrow, K. J. (1962). Economic Welfare and the Allocation of Resources for Invention. In The Rate and Direction of Inventive Activity: Economic and Social Factors (pp. 609-626). Princeton, NJ: Princeton University Press. https://doi.org/10.1515/9781400879762-024

Atzeni, G. E., & Carboni, O. A. (2004). ICT productivity and human capital: The Italian North–South duality. *International Review of Economics and Business*, 51, 265–284. https://iris.uniss.it/handle/11388/78945

Atzeni, G. E., & Carboni, O. A. (2006). The effects of subsidies on investment: An empirical evaluation on ICT in Italy. *Revue de l'OFCE*, 97(5), 279–302. https://doi.org/10.3917/reof.073.0279

Aw, B. Y., Roberts, M. J., & Xu, D. Y. (2011). R&D investments, exporting, and productivity dynamics. *American Economic Review*, 101(4), 1312–1344. https://doi.org/10.1257/aer.101.4.1312

Benavente, J. M. (2004). The impact of public financing and research groups on innovative activities in Chilean industry. *Mimeo*.

Benavente, J. M., Crespi, G., & Maffioli, A. (2007). Public support to firm-level innovation: An evaluation of the FONTEC program. Inter-American Development Bank, Washington DC. https://www.semanticscholar.org/paper/Public-Support-to-Firm-Level-Innovation%3A-An-of-the-Program-Benavente/83a9c0785d3bcaf799ec6d0b0dacefac609a4250?p2df

Benavente, J. M., De Gregorio, J., & Nuñez, M. (2005). Rates of return and industrial R&D in Chile. In: *Proceedings of the World Bank Conference on R&D and Innovation in the Development Process*. World Bank, Washington DC. https://crei.cat/wp-content/uploads/2016/08/benavente.pdf

Bernard, A. B., Jensen, J. B., Redding, S. J., & Schott, P. K. (2007). Firms in international trade. *Journal of Economic Perspectives*, 21(3), 105–130. https://doi.org/10.1257/jep.21.3.105

Blanes, J. V., & Busom, I. (2004). Who participates in R&D subsidy programs? The case of Spanish manufacturing firms. *Research Policy*, 33, 1459–1476. https://doi.org/10.1016/j.respol.2004.07.006

Bond, S., Harhoff, D., & Van Reenen, J. (2005). Investment, R&D and financial constraints in Britain and Germany. *Annals of Economics and Statistics*, 79–80, 433–460. https://doi.org/10.2307/20079108

Borisova, G., & Brown, J. R. (2013). R&D sensitivity to asset sale proceeds: New evidence on financing constraints and intangible investment. *Journal of Banking and Finance*, 37(1), 159–173. https://doi.org/10.1016/j.jbankfin.2012.08.024

Cano-Kollmann, M., Hamilton, R., & Mudambi, R. (2017). Public support for innovation and the openness of firms' innovation activities. *Industrial and Corporate Change*, 26(3). 421–442. https://doi.org/10.1093/icc/dtw025

Caraca, J., Lundvall, B. A., & Mendonça, S. (2009). The changing role of science in the innovation process: From Queen to Cinderella. *Technological Forecasting and Social Change*, 76(6), 861–867. https://doi.org/10.1016/j.techfore.2008.08.009

Carboni, O. A. (2013). Heterogeneity in R&D collaboration: An empirical investigation. *Structural Change and Economic Dynamics*, 25, 48–59. https://doi.org/10.1016/j.strueco.2012.09.003

Carboni, O. A., & Medda, G. (2021). Forms of extramural research acquisition and product innovation: Data from econometric estimations. *Data in Brief*, 39, 107567. https://doi.org/10.1016/j.dib.2021.107567

Carboni, O.A., & Medda, G. (2024). Endogenous innovation and export performance in firms. *Journal of Applied Economic Sciences*, 19(1), 48–62. https://doi.org/10.57017/jaes.v19.1(83).03

Carboni, O. A., & Russu, P. (2024). Complementarities in R&D and innovation decisions: An enquiry on an extensive sample of Latin American companies. *International Journal of Innovation and Technology Management*, 21(7). https://doi.org/10.1142/S0219877024500412

Carvalho, A. (2017). Wishful thinking about R&D policy targets: What governments promise and what they actually deliver. *Science and Public Policy*, 45(3). 373–391. https://doi.org/10.1093/scipol/scx056

Catozzella, A., & Vivarelli, M. (2016). The possible adverse impact of innovation subsidies: Some evidence from Italy. *International Entrepreneurship and Management Journal*, 12(2). 351–368. https://doi.org/10.1007/s11365-014-0342-1

Cavalcante, L. R., Jacinto, P. A., & De Negri, F. (2015). P&D, Inovação e produtividade na indústria brasileira. In: De Negri, F., & Cavalcante, L.R. (Eds.), *Produtividade do Brasil: Desempenho e Determinantes*, Volume 2, 43–68. https://portalantigo.ipea.gov.br/agencia/images/stories/PDFs/livros/livros/prod_brasil_2015_cap-02.pdf

Cerqua, A., & Pellegrini, G. (2014). Do subsidies to private capital boost firms' growth? A multiple regression discontinuity design approach. *Journal of Public Economics*, 109, 114–126. https://doi.org/10.1016/j.jpubeco.2013.11.005

Chudnovsky, D., López, A., Rossi, M., & Ubfal, D. (2006). Evaluating a program of public funding of private innovation activities: An econometric study of FONTAR in Argentina. *OVE Working Papers*, No. 1606, Inter-American Development Bank. http://dx.doi.org/10.18235/0011131

Cin, B. C., Kim, Y. J., & Vonortas, N. S. (2017). The impact of public R&D subsidy on small firm productivity: Evidence from Korean SMEs. *Small Business Economics*, 48, 345–360. https://doi.org/10.1007/s11187-016-9786-1

Crespi, G., & Zúñiga, P. (2012). Innovation and productivity: Evidence from six Latin American countries. *World Development*, 40, 273–290. https://doi.org/10.1016/j.worlddev.2011.07.010

Crespi, G., Fernandez-Arias, E., & Stein, E. (2014). Rethinking productive development: Sound policies and institutions for economic transformation. *Inter-American Development Bank/Palgrave Macmillan*. https://doi.org/10.1057/9781137393999

Criscuolo, C., Gonne, N., Kitazawa, K., & Lalanne, G. (2022). Are industrial policy instruments effective? A review of the evidence in OECD countries. *OECD Science, Technology and Industry Policy Papers*, No. 128. OECD Publishing, Paris. https://doi.org/10.1787/57b3dae2-en

Czarnitzki, D. (2006). Research and development in small and medium-sized enterprises: The role of financial constraints and public funding. *Scottish Journal of Political Economy*, 53, 335–357. https://doi.org/10.1111/j.1467-9485.2006.00383.x

Dai, X., & Cheng, L. (2015). The effect of public subsidies on corporate R&D investment: An application of the generalized propensity score. *Technological Forecasting and Social Change*, 90, 410–419. https://doi.org/10.1016/j.techfore.2014.04.014

Damanpour, F. (1987). The adoption of technological, administrative and ancillary innovations: Impact of organizational factors. *Journal of Management*, 13, 675–688. https://doi.org/10.1177/014920638701300408

David, P. A., Hall, B. H., & Toole, A. A. (2000). Is public R&D a complement or substitute for private R&D? *Research Policy*, 29, 497–529. https://doi.org/10.1016/S0048-7333(99)00087-6

De Negri, F., Rauen, A. T., & Squeff, F. H. S. (2018). Ciência, inovação e produtividade: Por uma nova geração de políticas públicas. In: De Negri, J.A., Araújo, B.C., & Bacelette, R. (Eds.), *Desafios da Nação: Artigos de Apoio*, IPEA, Brasília, 702. https://web.bndes.gov.br/bib/jspui/handle/1408/28567

De Negri, J. A., Esteves, L., & Freitas, F. (2007). Knowledge production and firm growth in Brazil. *Working Papers*, No. 0057. http://www.economiaetecnologia.ufpr.br/textos_discussao/texto_para_discussao_ano_2007_texto_05.pdf

Dimakopoulou, A. G., Chatzistamoulou, N., Kounetas, K., & Tsekouras, K. (2023). Environmental innovation and R&D collaborations: Firm decisions in the innovation efficiency context. *Journal of Technology Transfer*, 48, 1176–1205. https://doi.org/10.1007/s10961-022-09954-9

Doan, A. T., Khan, A., Holmes, S., & Tran, T. (2021). SMEs' efficiency in a transitional economy: Do innovation and public support schemes matter? *Journal of the Asia Pacific Economy*, 28(3), 1029–1060. https://doi.org/10.1080/13547860.2021.1940693

Fazzari, S. M., Hubbard, R. G., & Petersen, B. C. (1988). Financing constraints and corporate investment. *Brookings Papers on Economic Activity*, 1, 141–195. https://doi.org/10.2307/2534426

Fiorentin, F., Suárez, D., & Yoguel, G. (2023). Who benefits from innovation policy? The role of firms' capabilities in accessing public innovation funding. *Innovation and Development*, 13(1), 91–108. https://doi.org/10.1080/2157930X.2022.2047095

Funk, M. (2002). Basic research and international spillovers. *International Review of Applied Economics*, 16(2), 217–226. https://doi.org/10.1080/02692170210136156

Garcia-Quevedo, J. (2004). Do public subsidies complement business R&D? *Kyklos*, 57, 87–102. https://doi.org/10.1111/j.0023-5962.2004.00241.x

Görg, H., & Strobl, E. (2007). The effect of R&D subsidies on private R&D. *Economica*, 74, 215–234. https://doi.org/10.1111/j.1468-0335.2006.00547.x

Grazzi, M., & Pietrobelli, C. (2016). Firm innovation and productivity in Latin America and the Caribbean. *IADB / Palgrave Macmillan*. https://doi.org/10.1057/978-1-349-58151-1

Greco, M., Grimaldi, M., & Cricelli, L. (2017). Hitting the nail on the head: Exploring the relationship between public subsidies and open innovation efficiency. *Technological Forecasting and Social Change*, 118, 213–225. https://doi.org/10.1016/j.techfore.2017.02.022

Hall, B. H. (2002). The financing of research and development. *Oxford Review of Economic Policy*, 18, 35–51. https://doi.org/10.1093/oxrep/18.1.35

Hall, B. H., & Maffioli, A. (2008). Evaluating the impact of technology development funds in emerging economies. *European Journal of Development Research*, 20(2), 172–198. https://doi.org/10.1080/09578810802060775

Hall, B. H., Mairesse, J., & Mohnen, P. (2010). Measuring the returns to R&D. In: Hall, B.H., & Rosenberg, N. (Eds.), *Handbook of the Economics of Innovation*, Volume 2, 1033–1082. https://eml.berkeley.edu/~bhhall/papers/HallMairesseMohnen09_rndsurvey_HEI.pdf

Harris, R., & Li, Q. C. (2009). Exporting, R&D, and absorptive capacity in UK establishments. *Oxford Economic Papers*, 61(1), 74–103. https://doi.org/10.1093/oep/gpn011

Heckman, J. J., & Navarro-Lozano, S. (2004). Using matching, instrumental variables, and control functions to estimate economic choice models. *Review of Economics and Statistics*, 86, 30–57. https://doi.org/10.1162/003465304323023741

Heckman, J. J., Ichimura, H., & Todd, P. (1998). Matching as an econometric evaluation estimator. *Review of Economic Studies*, 65, 261–294. https://doi.org/10.1111/1467-937X.00044

Huergo, E., Trenado, M., & Ubierna, A. (2016). The impact of public support on firm propensity to engage in R&D. *Technological Forecasting and Social Change*, 113, 206–219. https://doi.org/10.1016/j.techfore.2016.08.002

Hujer, R., & Radic, D. (2005). Evaluating the impacts of subsidies on innovation activities in Germany. *Scottish Journal of Political Economy*, 52(4), 565–586. https://doi.org/10.1111/j.0036-9292.2005.00361.x

Hyytinen, A., & Toivanen, O. (2005). Do financial constraints hold back innovation and growth? *Research Policy*, 34, 1385–1403. https://doi.org/10.1016/j.respol.2005.08.003

Klette, T., Møen, J., & Griliches, Z. (2000). Do subsidies to commercial R&D reduce market failures? *Research Policy*, 29, 471–495. https://doi.org/10.1016/S0048-7333(99)00086-5

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), 1695–1725. https://doi.org/10.1111/1468-0262.00467

Meuleman, M., & De Maeseneire, W. (2012). Do R&D subsidies affect SMEs' access to external financing? *Research Policy*, 41, 580–591. https://doi.org/10.1016/j.respol.2012.01.001

Montmartin, B., & Massard, N. (2015). Is financial support for private R&D always justified? *Journal of Economic Surveys*, 23(3), 479–505. https://doi.org/10.1111/joes.12085

Perez-Alaniz, M., Lenihan, H., Doran, J., & Hewitt-Dundas, N. (2022). Financial resources for research and innovation in small and larger firms. *Industry and Innovation*, 30(2), 189–232. https://doi.org/10.1080/13662716.2022.2036597

Quartey, P., Turkson, E., Abor, J., & Iddrisu, A. (2017). Financing the growth of SMEs in Africa. *Review of Development Finance*, 7. https://doi.org/10.1016/j.rdf.2017.03.001

Raffo, J., Lhuillery, S., & Miotti, L. (2008). Northern and Southern innovatively. *European Journal of Development Research*, 20, 219–239. https://doi.org/10.1080/09578810802060777

Reichstein, T., & Salter, A. (2006). Investigating the sources of process innovation. *Industrial and Corporate Change*, 15(4), 653–682. https://doi.org/10.1093/icc/dtl014

Rosenbaum, P., & Rubin, D. (1983). Central role of the propensity score in observational studies. *Biometrika*, 70, 41–55. https://doi.org/10.1093/biomet/70.1.41

Santos, A. (2019). Do selected firms show higher performance? *Structural Change and Economic Dynamics*, 50, 39–50. https://doi.org/10.1016/j.strueco.2019.04.003

Schiantarelli, F., & Sembenelli, A. (2000). Form of ownership and financial constraints. *Empirica*, 27(2), 175–192. https://doi.org/10.1023/A:1026524101450

Smith, J.A., & Todd, P. E. (2005). Does matching overcome LaLonde's critique? *Journal of Econometrics*, 125, 305–353. https://doi.org/10.1016/j.jeconom.2004.04.011

Szczygielski, K., Grabowski, W., Pamukcu, M. T., & Tandogan, V. S. (2017). Does government support for private innovation matter? *Research Policy*, 46(1), 219–237. https://doi.org/10.1016/j.respol.2016.11.005

Tokila, A., Haapanen, M., & Ritsilä, J. (2008). Evaluation of investment subsidies. *International Review of Applied Economics*, 22(5), 585–600. https://doi.org/10.1080/02692170802287352

Torregrosa-Hetland, S., Pelkonen, A., Oksanen, J., & Kander, A. (2019). The prevalence of publicly stimulated innovations. *Research Policy*, 48(6), 1373–1374. https://doi.org/10.1016/j.respol.2019.01.009

Vather, P., & Vadi, M. (2024). The relationship of technological and organizational innovation with firm performance. *Technological Forecasting and Social Change*, 206, 123516. https://doi.org/10.1016/j.techfore.2024.123516

Wagner, J. (2007). Exports and productivity. *The World Economy*, 30(1), 60–82. https://doi.org/10.1111/j.1467-9701.2007.00872.x

Wei, J., & Liu, Y. (2015). Government support and firm innovation performance. *Chinese Management Studies*, 9(1), 38–55. https://doi.org/10.1108/CMS-08-2014-0168

Zúñiga-Vicente, J. A., Alonso-Borrego, C., Forcadell, F. J., & Galán, J. I. (2014). Assessing the effect of public subsidies on firm R&D investment. *Journal of Economic Surveys*, 28(1), 36–67. https://doi.org/10.1111/joes.12028

Zuniga, P., & Crespi, G. (2013). Innovation strategies and employment in Latin American firms. *Structural Change and Economic Dynamics*, 24, 1–17. https://doi.org/10.1016/j.strueco.2012.12.001

APPENDIX

Table 1A. Variable Description

	Treatment variable
PUBGRANT	Dummy=1 if the company has received public financial support for innovation
Regressors:	
$INNO_{PRODU}$	Dummy=1 if the company has reported product innovation
$INNO_{PROCE}$	Dummy=1 if the company has reported process innovation
$INNO_{ORGA}$	Dummy=1 if the company has reported organizational innovation
EMPL	Number of employees (period average)
EXPORT	Dummy=1 if the company has exported
RD_{EMPL}	Percentage of R&D employees
UNI_{DEGREE}	Percentage of employees with a university degree
FIN_{OWN}	Percentage of internal finance for innovation activities
FIN_{CONSTR}	Dummy=1 if the company declared financial constraints in innovation spending
$OBST_{HK}$	Dummy=1 if the lack of qualified human capital in the firm is an important obstacle to innovation
COOP	Dummy=1 if the firm has cooperated in research programs
Observation variable:	
INNOVATION SPENDING (US$ period average)	Includes: In-house R&D; External R&D; Hardware & software; ICT; Machines and equipment; Training; Technology Transfer; Consultancies; Knowledge acquisition, consultancies, and technical assistance; Engineering and design; Market research; Other technological activities.