Regional innovation policy and the performance of small enterprises

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Abstract

Purpose of the study. *The paper aims at disentangling the role of a R&D place based policy implemented in the Italian province of Trento, during the period 2002-2007 in spurring R&D investment of private firms and in enhancing the firm performances.*

Methodology. *This paper proposes an investigation based on an original and unique database about the population of limited liabilities firm operating in Trentino. The econometric analysis is based on counterfactual models. In particular, we make use of the Conditional-Difference-in-Differences estimator*

Findings. *We find that R&D incentives positively affect investments in intangible assets and human capital, while they have no effect on firms' turnover, labor productivity and profitability.*

Research limits. Two issues are *not fully studied in the present paper: the role of micro-complementarities and the role of localized knowledge spillovers. which may well be the main advantage of a place-based policy*

Practical implications. *The results on additionality allow to shed light about the degree of success of the direct measures of public interventions (subsidies). Moreover, the findings can be used to fine tuning the industrial policies.*

Originality of the study. *The context of analysis allows us to disaggregate the different components of R&D spending of firms, namely labor force and its quality, intangibles, fixed assets. Indeed, The study is based on exhaustive information about financial R&D subsidies the population of the firms subsidized during the years 2002-2007 in Trentino matched with the population of limited liabilities firms operating in Trentino during the same time window.*

Key words: *regional innovation policy; ex post evaluation; R&D subsidies; research and development; counterfactual models*

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1. Introduction

Beyond traditional rationales pointed out in the economics literature (Lerner, 2000; Wallsten, 2000), arguments concerning economic growth, quality of human capital, and firm competitiveness have represented common justification for government intervention to engender innovation (Lundvall and Borras, 2005). As declining population in many countries and diminishing returns from investment in physical capital have neutralized two major channels of long-term growth, the role of innovation as a key enabler of economic prosperity appears unquestionable. This is particularly so in the aftermath of the recent economic downturn. What is still contended, however, is the ability of policy makers to rectify market failures, provide effective incentives to spur welfare-enhancing innovations, and avoid the introduction of additional distortions in the economic system.

Despite the relevance of this issue, a review of the empirical literature (Klette and Moen, 1999; Lerner, 2000; Wallsten, 2000; Czarnitzki *et al*., 2007; Merito *et al*., 2007; Piekkola, 2007; Hussinger, 2008; Potì and Cerulli, 2010) suggests that findings concerning the effect of R&D subsidies on the outcomes of the innovation process and the overall performance of the firm are mixed. Moreover, the number of government layers intervening in several areas of business soared over time: across European countries the role of regions in implementing and assessing innovation policies has strongly increased since the early 2000 (European Commission, 2004). Most of the recent empirical evidence deals with the effectiveness of public policy implemented at the national level, thus providing no clue on the role of place-based policy and the ability of host regions to retrieve social benefits from sponsored activities (Roper *et al*., 2004).

The goal of our paper is to contribute to the debate and provide novel evidence by analyzing the effectiveness of R&D subsidies implemented within a local design of public intervention. Specifically, our investigation evaluates the achievements of the local policy maker with respect to the following objectives: *(i)* prompt additional investments in innovative activities by private organizations; (*ii*) enhance the overall competitiveness of the business sector in the regional area.

The present study contributes to the existing literature in two ways. First, we concentrate on the increased role that regional governments play in several areas of business. A regional orientation to innovation policy may help achieve nation-wide goals insofar as it accounts for the uneven distribution of innovation processes across space (Fritsch and Stephan, 2005). Moreover, because of differences in the way regional innovation systems function a one-size-fits-all approach to innovation policy is unlikely to be efficient (Asheim and Coenen, 2005; Todtling and Trippl, 2005; Howell, 2005). In principle, regional policy makers may better select projects with high social returns but insufficient private returns since local authorities have better knowledge of potential awardees and local market conditions. This preferential stance should help them to ascertain whether submitted projects and firms applying for a grant display those attributes that are more likely to generate knowledge spillovers (Feldman and Kelley, 2006). Moreover a place-based policy should allow the host region to retain a share of the social benefit arising out from the financed projects (Roper *et al*., 2004). Nevertheless, local authorities may be more easily captured by lobbies and therefore, prone to finance R&D projects that are privately profitable and would be pursued even without R&D subsidies (Wallsten, 2000). As underlined by Lerner (2002), there is an extensive political economy literature that has emphasised this kind of distortions and the several ways these distortions can manifest themselves (Eisinger, 1988; Cohen and Noll, 1991; Lerner, 2000; Wallsten, 2000).

Second, we address a methodological concern. Government typically deploys a range of industrial policies to support business activities (e.g., subsidizing investments in tangible assets) where R&D policies represent just one measure in this broader policy set. Moreover, an R&D program can rely on multiple instruments to channel finance towards enterprises (Potì and Cerulli, 2010). To the extent that firms apply for various subsidies that, contemporaneously, affect their performance, an identification problem may arise that prevents the researcher from isolating the causal effect associated with each subsidy. Such an occurrence makes it difficult to isolate confounding factors. In these circumstances a proper evaluation of the effectiveness of R&D subsidies requires comprehensive information on measures that agencies, at different levels of government, undertake and firms, eventually, exploit.

We rely upon econometric methods commonly used to evaluate technology programs (Klette *et al*., 2000; Hussinger, 2008; Trivellato *et al*., 2009). Such methods recognize the counter factual nature of the analysis and allow the researcher to clean out most of the confounding effects associated with factors like technological opportunities, appropriability conditions, endowment of knowledge capital, other type of incentives granted to enterprises, which may eventually influence a firm's ability to benefit from innovation activities. The treatment consists of an incentive to co-finance a R&D oriented project.

Our paper explores the effectiveness of R&D subsidies in the Italian northern province of Trento in the past decade. The policy operates entirely in Trento, the administration and decision competencies are completely intra-regional and the resources spent are entirely raised in the region. The local dimension of the intervention (a firm to be eligible must be located and must implement the investment in the province of Trento) mitigates potential heterogeneity among firms (Heckman, Ichimura, Smith and Todd, 1998; Heckman, Ichimura and Tod, 1997; and Lechner, 2001).

Our investigation draws on a very detailed and informative database, profiling the population of companies awarded at least one R&D grant during the years 2002-2007. A distinguishing feature of our data set (as in Mairesse and Mohnen, 2010) is the merge of balance sheet data of limited liability companies operating in the province of Trento (around 800 firms per year) with the administrative archives, which allows us to track all the subsidies granted to firms operating in the province of Trento within the Law 4/1981 for the period 1991-2004 and within the Provincial Law 6 (PL6 henceforth) for the period 2002-2007.

The paper is organized as follows. Section 2 briefly summarizes the recent empirical literature on the effectiveness of R&D policy, based on firm-level observations, and outlines the goals of our paper; section 3 illustrates the main characteristics of the Provincial Law 6/99 implemented in the province of Trento. Estimation method and the presentation of data set are in Section 4. Section 5 presents the results of the econometric analysis, while Section 6 concludes.

2. Literature review and hypotheses

Government programs that subsidize innovative activity and R&D spending are justified on the grounds that market failures prevent firms from opportunely investing in and reaping the benefits of R&D activities, with the result that firms invest in R&D below the social optimum level. Two major rationales[1] have been emphasized in the theoretical and empirical literature that clarifies the nature of these market failures. First, profit-maximizing firms do not face sufficient incentives to make a socially optimal investment in R&D. This occurs because R&D investments are likely to generate positive spillovers, thus implying that the investing firms are unlikely to appropriate all the gains originating from their innovative effort (Nelson, 1959; Arrow, 1962). An extensive econometric literature (Griliches, 1992; Hall *et al*., 2009) has shown that the external economies associated with R&D effort are important as they engender productivity gains at both industry and firm level (Jaffe, 1986; Henderson and Cockburn, 1996). Moreover, external economies are larger in magnitude when the R&D effort is directed towards product rather than process innovation (Ornaghi, 2006). It is then conceivable that, from the social point of view, the gains from private R&D are often higher than private returns. Hence, a number of research projects would be worth undertaking even if they are privately unprofitable. A public policy that re-balances the marginal

[1] Hall (2002) addresses additional considerations in favor of policy intervention: *(i)* the existence of industries that are strategic for national security or to foster technological advances in other industries; *(ii)* the promotion of technological standards.

costs and revenues for the firm that undertakes the R&D effort, can make these projects privately profitable as well.

Second, the presence of capital market imperfections makes costly for firms to secure the financing needs to support their innovative endeavor from external sources. Hall (2002) discusses three types of factors that may make raising external capital very expensive as compared with the internal costs of capital: *(i)* information asymmetries between investors and inventors; *(ii)* moral hazard problems; *(iii)* tax considerations that can differently impinge on alternative sources of financing. Although a venture capital industry can ameliorate these problems, limits still exist that call for governments' intervention. By granting R&D awards, the latter may convey information to other potential investors and certify the quality of start-ups, thus easing the financing constraint that might have otherwise precluded the undertaking of socially valuable projects (Lerner, 2000, 2002).

Empirical studies investigating the impact of R&D policies recognize the counter factual nature of the evaluation exercise and rely upon methods that address the endogeneity of the R&D treatment (Klette *et al*., 2000; Cerulli, 2010).

Although the bulk of evidence conveys the idea that public support do not crowd out private investment in R&D activities (Almus and Czarnitzki, 2003; Hyytinen and Toivanen, 2005; Czarnitzki and Tool, 2007; Czarnitzki *et al*., 2007; Hussinger, 2008; Aerts and Schmidt, 2008), a number of other scholars point out contrasting results. Busom (2000) and Potì and Cerulli (2010) find that crowding out exists for a non negligible share (i.e., thirty and fifty per cent, respectively) of firms awarded with R&D grants, respectively in Spain and Italy. Lach (2002) presents evidence on Israeli enterprises according to which additionality only concerns small firms, whereas no significant effect emerges among large companies that are, nonetheless, the more likely to gain access to public funding. Similarly, Gorg and Strobl (2007) show that in Ireland only small R&D grants awarded to domestic firms spur additional private investment in innovative activities. On the contrary, no significant effect arises for foreign multinationals and crowding-out is observed when relatively large grants are awarded to domestic firms. Duguet (2004) and Gonzalez *et al*. (2005) do not find any significant relationship between public funding and R&D intensity in France and Spain; in the case of Spanish firms, however, subsidies induce firms to perform research activities. Finally, Wallsten (2000) provides evidence of crowding-out in a sample of US ventures which received awards from the Small Business Administration. Given the above discussion we propose the following hypothesis to test:

HP 1) R&D subsidies granted through the PL6/99 do not crowd out private investment.

Public R&D subsidies positively affect the propensity to patent of Italian firms (Potì and Cerulli, 2010), although the effect is significant only in the short run (Merito *et al*., 2007). Positive effects emerge among Finnish companies, whereas the propensity to patent and the actual number of patents per employee are not significantly higher among Western Germany firms that received R&D awards (Czarnitki *et al*., 2007). Alongside, there is scant evidence (Berubè and Mohnen, 2009; Hussinger, 2008) that R&D policy engenders positive bearings on the propensity to innovate[2] and the stream of revenues generated by newly commercialized products.

The results about the ability of subsidies to enhance firm performance are mixed too. Klette and Moen (1999) and Merito et al. (2007) find no results on firm performance as measured by different indicators, i.e. labour productivity, profitability. Wallsten (2000) finds no effect on employment level. On the contrary, Lerner (2000) e Piekkola (2007) show that subsidies are able to spur growth performance and productivity of awarded firms. Hence, we propose the following competing hypotheses:

HP 2.a) Firms that benefit from an R&D subsidies within the PL6/99 do not show higher level performance compared to other not subsidized firms operating in Trentino;

[2] It is worth underlying that Berubè and Mohnen (2009) consider a set of establishment receiving R&D tax credits as a control group, while treated firms are those receiving both tax credits and R&D grants.

HP 2.b) Firms that benefit from an R&D subsidies within the PL6/99 show higher performance level compared to other not subsidized firms operating in Trentino.

3. The Law 6/99 in the province of Trento

A distinguishing feature of the institutional setting under analysis is the impossibility for firms operating in the province of Trento to request grants and subsidies from other public institution[3] (national level and EU level). In this setting the PL6 defines the guidelines that regulates the allowance of economic incentives to firms operating in the province.

As for subsidies concerning innovative activity, the law identifies two types of commercial research worth to be financed: (i) industrial research; (ii) experimental development. Industrial research is defined as a planned activity to acquire new knowledge that is used to introduce new products, new processes and services. Activities that can improve the quality of existing products, processes and services also fall into such category. Experimental development is defined as the acquisition, recombination and utilization of existing scientific, technological and commercial knowledge in order to produce projects, products, processes new to the firm or enhanced.

PL6 aims at: (a) stimulating additional expenditures in research activities by firms operating in the region (compared to the normal research and development activity undertaken by firms); (b) stabilizing the employment rate, and enhancing the competitiveness of local firms.

All firms operating in the province of Trento can apply for a grant within the framework of the PL6. In order to apply for a grant firms must submit a project to the Province. A first-in-first-out criterion is used to assign financial resources (provided that a panel of expert gives a positive assessment of the project), some firms might get a refusal once the budget for financing R&D activities is exhausted.

Once a firm submits an application for a grant, the related research project is examined by a technical committee (evaluation procedure). If the application successfully passes the first stage of evaluation, then in the second stage is analyzed its economic viability and its financial sustainability. Only if the project gets a positive evaluation at both stages, it can be co-financed by the local government.

Projects can entail expenses referred to a period going from the date of concession to the following three years. The expenses falls in the following categories: (1) employment costs: additional high skilled workforce to be employed in the project; (2) patenting costs and contractual costs of licenses acquisition; (3) general additional costs related to the project (overhead up to 60% of costs declared at point 1); (4) part of costs related to the use of the tools and machines employed within the project.

4. Data and estimation method

4.1 Data

Administrative archives, held by the local government, are the primary source we used to gather information on firms receiving the R&D grants and on firms that received any type of grants throughout the period of analysis.

Data from the profit and loss account together with balance sheet data of limited liability companies operating in the province of Trento come from two sources: the Bureau Van Dijk's AIDA database and the Cerved Group's Pitagora database. The final collection of data comprises about eight thousand companies observed over the period 1998-2008.

[3] Few exceptions are allowed. For instance few firms (around three per year) have been allowed to get financial incentives within the national program called "Sabatini law".

To deal with the problem of unreliable employment figures we recovered data on the labor force of firms in our sample from the Archivio Statistico delle Imprese Attive (ASIA), constructed and managed by the National Statistical Office (ISTAT).

4.2 Estimation method

Our estimation exercise aim at estimating the additionality in R&D intensity due to the public intervention and the impact on firm performance as measured by profitability, labor productivity, and other indicators of competitiveness.

The estimation of the effect of a policy on an objective variable is problematic given that grants are not randomly assigned to firms. In such contexts the usual OLS regression leads to biased estimates (Heckman *et al*, 1998; Rubin, 1977).

The selection bias can arise from the local government behavior or from self-selection of more active firms. In the first case, the selection bias can be due to the implicit aim of the policy maker of maximizing the probability of success of the policy choosing the best preforming firms with respect to the R&D past activity. In the second case, more innovative firms can have higher ability of getting the grants (Aerts and Schmidt, 2008).

The standard way to solve the endogeneity problem - i.e. the subsidy receipt is correlated with the past R&D activity- and to correct for the bias is related with the opportunity to find valid instruments for the treatment which is not so easy and has the major shortcoming of arbitrary choices of functional form and of instruments (Heckman *et al*, 1998). The matching estimators are viable alternatives and have the advantage of being free from any parametric assumption related with the selection process. Such class of estimators is based on the counterfactual paradigm (Trivellato *et al*., 2009): each treated firm, a firm which received a R&D grant, is compared with its counterfactual situation - i.e. the hypothetical situation that it does not receive the grant. Under a series of assumptions - see below - the counterfactual situation is built looking at the set of non treated firms (Heckman *et al.* 1998). Nonetheless, standard matching does not solve the problem of unobserved heterogeneity. Indeed, while one can control for a series of observed covariates in order to neutralize the effect of selection, nothing can be done to correct for unobserved characteristics that can affect the selection of firms into the treatment (e.g., differential ability of entrepreneurs in capturing grants). Given the availability of a panel of data, we address this issue by employing the Conditional Difference-in-Differences (CDID) methodology that helps in solving the problem of invariant over time unobserved heterogeneity.

The identification of the treatment effect is conditioned on two assumptions: (a) unconfoundedness given a set of k predetermined variables (X): T is independent of Y(0),Y(1) conditional on X=x; (b) the probability of being included into the treatment is bigger than zero given any set of covariates (overlapping): $Prob(T=1|X=x) \in (0,1)$.

An additional assumption is the Stable Unit Treatment Value Assumption (SUTVA; Rubin, 1980), which states that the outcomes of one firm is not affected by treatment assignment of any other firms. This is a subtle assumption to make in our context because spillover effects might exist that lead us to argue in favor of its violation. Nonetheless, if the objective variable is the additional innovative activity we can make two considerations: (1) the level of investment in innovation activities in one firm does not influence the investment behavior of other firms , in the short run; (2) while there is evidence of partnerships between private firms and public institutions –university and research centers- we do not have any evidence of collaborations between private firms with respect to innovation activity. In one sense the behavior of firms seem to support more a competition like mindset rather than a coopetition one.

Under these assumptions we can identify the average treatment effect on treated firms, which is the effect for the subsample of treated firms (ATT), as follows:

$$ATT=E[ATT(x)=E[Y(1)-Y(0)|T=1,X=x]]. \quad (6)$$

ATT results from comparing the actual outcome of subsidized firms with their potential outcome in case of not receiving the R&D subsidy.

4.3 Empirical strategy

We define a firm as treated if it is awarded a grant to carry out an R&D project. The year of treatment corresponds to the period in which the firm receives a notification of allowance from the local government. From this moment through the following three years, the firms are co-financed for costs entailed in the project.

We compare a treated firm in period *t*, *t=2002,…,2008* with a set of control firms which: a) did not receive any grant in the periods *t-1, t-2, t-3*; b) did not receive an R&D grant in the whole period. A further condition we impose to include a firm either in the group of treated or in the control group is that it was a business organization active in at least one year before the notification of the grant[4]. The exact knowledge of which firm received what grant for the population of companies operating in the region allows us to neutralize the bias arising from a wrong choice of units to be included in the control group.

We also pre-filter the data (Ho *et al*., 2007): (i) we exclude from the sample those firms belonging to the three digit Ateco 2002 sectors in which no treated firm operates. (ii) we restrict the sample of potential control firms to those firms that have innovative performance above the median of the distribution of the initial sample of not subsidized firms to guarantees that the two groups of treated and control firms are comparable.

The choice of the control group is done using the propensity score technique (Rosenbaum and Rubin, 1983). The choice of the control variables is done including in the matching procedure all variables known to be related to both treatment assignment and the outcome in order to satisfy the assumption of ignorable treatment assignment as the literature suggests (Rubin and Thomas, 1996; Heckman, Ichimura and Todd, 1998; Glazerman, Levy and Myers, 2003; Caliendo and Kopeinig, 2008; Stuart 2010).

Specifically we follow the methodology proposed by Dehejia and Wahba (2002). The main advantage of the procedure is that the homogeneity within strata can be considered as an indirect test of unconfoundedness (Stuart, 2010).

We then, adopt a CDID matching estimator (Smith and Todd, 2005; Blundell and Costa Dias, 2000). Heckman *et al.* (1998) show that CDID based on a non-parametric matching provides an effective tool in controlling for selection on both observables and unobservables. In particular, it allows us to control for temporally invariant differences in outcomes between participants and nonparticipants (Smith and Todd, 2005).

Given the small number of subsidies per year we pooled the data across years, i.e. we consider the group of treated firms regardless of the calendar year in which they receive the subsidy. Accordingly, a set of time dummies is used to control for time related aggregate shocks. Furthermore, in order to make comparable monetary amounts we use production prices indices to deflate all the monetary variables.

4.4 Variables definition

The treatment indicator we employ is given by a dummy variable indicating if in the current year the firm has a co-financed R&D project within the PL6 in the time window 2002-2007.

In constructing the objective variables to evaluate the effectiveness of the public policy, we exploit the fact that expenses subsidized by the PL6 can be associated with specific items in the balance sheet and the profit and loss account. As mentioned above, the overall grant is partitioned in the following items: (i) expenses for intangible assets (i.e., costs for “genuine” R&D activities, the acquisition of licenses and patents etc.); *(ii)* expenses for tangible assets; *(iii)* expenses for

[4] This conditions let us to exclude two research centers and three business organizations from the set of awardees.

human resources. Knowing the amount of financing that subsidized firms receive for each item, and knowing that more than 50% of the overall subsidy is made available as soon as a grant is awarded, we compute[5] the net value of these items for the year of concession (t_1). Finally, using these net values we consider the following objective variables to study additionality:

- Intangibles intensity *(Inta_int)* - the ratio between net intangible assets and turnover, as a proxy for R&D capitalization.
- Capital intensity (*Capint*) - the ratio between net tangible assets and turnover
- Unit labor costs - the ratio between net labor costs and the total number of employees
- Employment dynamics.
- The performances of firms are evaluated looking at the following variables:
- Total sales per employee which is a proxy of *labor productivity*;
- Operating margin measured by the ratio: Earnings before interest and taxes over value added.
- The control variables included in our models are[6]:
- The *technological sector* (OECD, 2003): low tech, low-mid tech, high-mid tech, high tech (Low technology sector (DUtech_sech=1), low-mid technology sector (DUtech_sech=2), mid-high technology sector (DUtech_sech=3), high technology sector (DUtech_sech=4));[7]
- The firm *size*: based on number of employees and sales: micro firms (DUsizeEU=1), small firms (DUsizeEU=2), medium firms (DUsizeEU=3), large firms (DUsizeEU=4);
- Firm *age* (in years) that is meant to gauge experience effects, such as managerial skills and the ability to obtain external resources (Wallsten, 2000; Busom, 2000; Almus and Czarnitzki, 2003; Hussinger, 2008; Görg and Strobl, 2006);
- The *year* to control for aggregate time variant shocks (business cycle effects);
- The ratio between tangible fixed assets and turnover stood for firm *capital intensity*, which in turn is a proxy of both access to capital market, and embedded stock of knowledge and technological upgrade (Hyytinen and Toivanen, 2005);
- Rescaled *cashflow* to proxy the financial constraints that firms can have and it is expressed as the ratio between cash flow and total sales; also this terms enters in the final functional form also squared;
- The level of *intangible investments* measured by the increase in intangible intensity experimented by firms.

5. Results

The reliability of results of an evaluation exercise strongly depends on the procedure adopted to clean the selection bias. In our case we employ a matching methodology in which the PS score plays a key role. Consequently, we start this section by discussing the specification and the quality of PS. Then, we make some considerations about the adequacy of the unconfoundedness assumption that is needed to identify the ATT. Finally, we present estimates of the effect of R&D grants on innovative investments and the overall performance of firms.

5.1 The propensity score specification

We included in PS variables lagged one year with respect to the year of treatment that previous economic theory, empirical findings and information about institutional setting suggest us. After

[5] Net intangible assets(t_1) = intangible assets (t_1) - financed expenses classified into intangible assets for the period t_1; Net tangible assets(t_1) = tangible asset (t_1) - financed expenses classified into tangible assets for the period t_1; Net labor costs(t_1) = labor costs(t_1) – financed expenses for human resources for the period t_1.

[6] The set of control used for different models slightly differs from one model to another given the need to satisfy the balancing property.

[7] Note that we extended the OECD classification in order to take into account also services sectors present in our database.

this initial selection of covariates the final number of covariates is then based on the procedure of DW described below.

The selection into treatment - i.e. the concession of an R&D grant- is modeled through a probit regression model[8]. The final list of the control variables, following the procedure of Dehejia and Wahba (2002), is made, in order to satisfy the “balancing property”.

We estimate three different PS models given that each particular sample needs its own PS (Dehejia and Wahba, 2002). In our case the consideration of different time lags, form one year to three, change the sample of treated firms we consider for the estimation of results. Table 3 shows the number of blocks and the number of treated and control firms taken into account for the estimations referred to different time lags. This number ranges from 7, in the case of one year time lag, to 5, in the other two cases. Within these strata we performed the *t-tests* for mean equality with respect to all the control variables and the null hypothesis was never rejected in each stratum for each variable included in the controls set. Such result can be interpreted as an indirect test of unconfoundedness (Stuart, 2009): once matched the samples of treated and control firms no significant difference emerge between the two[9].

Tab. 1: samples structures and their blocks partition defined using the Dehejia and Wahba (2002) procedure

Time lags of the estimated effects	Blocks	on common support		Used obs.	Discarded Treated	Full sample
		Controls	Subsidized			
1 year lag	7	786	87	866	2	1124
2 years lag	5	495	61	551	5	879
3 years lag	6	378	39	417	5	661

Source: our elaborations

Table 4 presents the estimations of propensity score for different time lags (one, two and three years). The set of variables included in the three models is similar even if there are some differences due to the particular procedure used to satisfy the balancing property. For the same reason some terms are included with a degree higher than one (*inno_int* and *cashflow*). All the control variables are lagged one year and can be considered predetermined with respect to the treatment.

A second indirect test of unconfoundedness we can run is related with the availability of panel data and is given by the estimation of the treatment effect on a lagged objective variable -$Y_i(t\text{-}1)$- which is by definition not affected by the treatment. If treatment effect is not zero this implies that treated and control observation are not comparable, namely, the distribution treated units is not comparable to the distribution of control. If the treatment is zero it is more plausible that the assumption holds (Imbens, 2004).

8 The use of a logit specification leaves unchanged the results.

9 Recall that unconfoundedness is expressed by: $(Y(1),Y(0))\perp T|X$. Potential outcomes are independent from treatment given a set of predetermined variables. Such assumption is not directly testable given that we cannot observe the potential outcomes but only their realizations.

Tab. 2: Propensity score estimations for different time lags

	One year lag			Two years lag			Three years lag		
Dependent variables:	Coef.	Std. Err.	z	Coef.	Std. Err.	z	Coef.	Std. Err.	z
capint(t-1)	-0.021	0.085	0.250	0.078	0.122	0.640	-0.009	0.184	-0.050
intagibles(t-1)	0.000	0.000	0.430				0.000	0.000	-1.380
ts_empl(t-1)	-0.001	0.001	2.030**	-0.001	0.001	-1.410	-0.002	0.001	-1.400
ts(t-1)	0.000	0.000	2.850	0.000	0.000	2.290**	0.000	0.000	2.490**
inno_int(t-1)	1.089	0.479	2.280**	1.004	0.962	1.040	2.125	1.485	1.430
$inno\_int(t-1)^2$	-0.351	0.213	-1.650*	-0.361	0.854	-0.420	-1.075	1.413	-0.760
cashflow(t-1)	0.074	0.504	0.150	4.653	2.568	1.810*	0.963	1.062	0.910
$cashflow(t-1)^2$	-0.261	0.564	-0.460	-14.969	9.124	-1.640	0.305	0.993	0.310
Dinno_int(t-1)	0.242	0.322	0.750	0.663	0.802	0.830			
age	0.005	0.004	1.110	-0.003	0.005	-0.480	-0.006	0.007	-0.810
constant	-2.485	0.267	9.320***	-3.097	0.412	7.520***	-3.393	0.505	6.710***

Source: our elaborations

Notes Included dummies technological sector, year, size class (EU definition). Probit specification.

Table 5 shows the results of the test where the intangibles intensity is the objective variable and the one, two and three years lags are considered. In all the estimations the lagged changes in intangibles intensity are not statistically different for subsidized and not subsidized firms as confirmed by the small differences between the two groups and the significance level of *t-tests*.

Tab. 3: Imbens (2004) indirect tests of unconfoundedness for different time lags

	Treated	Controls	Difference	S.E.	T-stat
1 year lag	0.00127	-0.00357	0.00485	0.04492	0.11
2 years lag	-0.00333	-0.00779	0.00446	0.02619	0.17
3 years lag	-0.02106	-0.01844	-0.00262	0.05851	-0.04

Source: our elaborations

The analysis of the quality of the matching procedure is checked using the Imbens (2004) methodology which prescribes that the performances of PS before and after matching are informative to evaluate the adequacy of the matching related with the use of a particular form of the PS. Hence, in order to conduct the test, we estimate the propensity score models as specified by the Dehejia and Wahba (2002) procedure before and after the matching. Then, we evaluate their performances on the full sample (before) and on the restricted subsample of treated and matched control firms given by the particular matching estimator we chose (after the matching) in terms of ability[10]: of explaining the variability of the sample (pseudo R-squared) and the significance of control variables (Chi-test). A good PS specification implies that before the matching: (a) the pseudo R-squared should be higher than in the case of after matching estimation and (b) the Chi-test is significant before matching and not significant after estimation. Table 6 shows the results of such tests for the different time lags analyzed. In all the estimations the pseudo R-squared decreases a lot passing from unmatched to matched sample and the tests that all control variables are jointly not different from zero are all significant before matching, but lose significance after matching. In all our models the control variables are not capable to explain the differences between the treated firms and their matched control firms.

[10] The restricted sample is chosen using the nearest neighbor matching estimator.

Tab. 4: Tests of performance of the propensity score specification for different time lags

	1 year lag		2 years lag		3 years lag	
	before	after	before	after	before	after
LR chi2	133.52	8.14	109.42	19.98	80.58	10.64
Prob > chi2	0	0.9909	0	0.4593	0	0.9091
Pseudo R2	0.2314	0.0415	0.2626	0.0156	0.2719	0.1229

Source: our elaborations

5.2 *The effect of R&D subsidies*

Table 5 reports the estimates of the conditional difference-in-differences estimations of average treatment effect on treated for the intangible intensity on the firms that were awarded at least one R&D grant during the period under scrutiny. In order to fully explore the time dimension of input (HP 1) and output effectiveness (HP 2.a and HP 2.b) we evaluate how firms receiving a R&D grant fared with respect to non-granted ones at one, two and three periods after obtaining the financing.

Estimations for one and two years lags reveal a significant positive difference between treated and control firms. In particular, one year lag difference is around 0.19 significant at 10% while two years lags estimation even if is smaller in magnitude -0.06- is significant at1%. After three years the difference seems to vanish. Results are confirmed if we look at intangible assets of firms (in this case the significance levels are, respectively 5% and 10%). Based on the results we cannot reject HP1. Indeed, they can be interpreted as the evidence against the hypothesis of full crowding out of private R&D investments coherently with a large body of literature (Aerts and Czarnitzki, 2004, 2006; Almus and Czarnitzki, 2003; Aerts and Schimdt, 2008; Czarnitzki, 2001; Czarnitzki and Fier, 2002; Duguet, 2004; Fier, 2002; Gonzalez and Pazo, 2006; Gonzalez *et al*., 2005; Gorg and Strobl, 2007; Hussinger, 2008; Loof and Heshmati, 2005).

Tab. 5: CDID estimations of average treatment effect on treated on intangibles intensity, intangibles assets and number of employees

	intangible intensity				
	Treated	Controls	Difference	S.E.	T-stat
1 year lag	0.1663	-0.0241	0.1903	0.1120	1.7
2 years lag	0.0429	-0.0188	0.0617	0.0224	2.76
3 years lag	-0.0394	-0.0097	-0.0296	0.0362	-0.82
	Intangible assets				
	Treated	Controls	Difference	S.E.	T-stat
1 year lag	138.9614	-69.6648	208.6262	92.8397	2.25
2 years lag	197.3980	-143.2814	340.6794	206.3584	1.65
3 years lag	-12.4971	19.1850	-31.6821	143.3959	-0.22
	Employment				
	Treated	Controls	Difference	S.E.	T-stat
1 year lag	1.6503	2.6809	-1.0305	1.5323	-0.67
2 years lag	3.0001	2.7404	0.2597	3.1497	0.08
3 years lag	6.4491	4.3531	2.0960	3.4062	0.62

Source: our elaborations

To test HPs 2 we interpret the results shown in Table 6, which refer to the performance differences of awarded firms in terms of labor productivity - sales per employee – and a measure of profitability - operating margin. The only significant effect on performance side is found for total sales per employee after three years from grant concession. These results are in line with the literature. Hence, HP 2.a cannot be rejected, while HP 2.b is rejected.

5.3 Robustness checks

To support the evidence, namely full crowding-out hypothesis can be rejected and weak effect on labor productivity, we provide some extra robustness checks. First, we repeat the exercises using a different weighting scheme, i.e. a different matching algorithm. Table 7 shows CDID estimations using nearest neighbor estimator with one and three neighbors. Results are in line with the previous ones: significant effects on intangibles intensity emerge after one and two years. Their magnitude and their significance is comparable with previous ones. A second check is related with the restriction of sample to medium-high and high technology firm: One can expect that with such restriction the results are clearer. Our estimations show that, again, results are in line with the previous ones. Note that we do not estimate the three years lags model given the small sample size.

Tab. 6: CDID estimations of average treatment effect on treated on Labor productivity, and operating margin

	Labor Productivity				
	Treated	Controls	Difference	S.E.	T-stat
1 year lag	5.5053	-1.0639	6.5692	7.8505	0.84
2 years lag	18.5505	7.4751	11.0755	13.7827	0.8
3 years lag	25.3687	-10.9638	36.3325	17.3949	2.09
	Operating margin				
	Treated	Controls	Difference	S.E.	T-stat
1 year lag	0.1695	-1.1555	1.3249	1.0152	1.31
2 years lag	0.2416	-0.0970	0.3386	0.5121	0.66
3 years lag	0.7420	-0.6916	1.4336	1.0529	1.36

Source: our elaborations

Tab. 7: Robusteness checks: CDID estimations of average treatment effect on treated on intangibles intensity

	nearest neighbor (3 matches)				
	Treated	Controls	Difference	S.E.	T-stat
1 year lag	0.1528	-0.0161	0.1688	0.1029	1.64
2 years lag	0.0416	-0.0288	0.0704	0.0232	3.04
3 years lag	-0.0066	-0.0503	0.0437	0.0406	1.08
	nearest neighbor (1 match)				
	Treated	Controls	Difference	S.E.	T-stat
1 year lag	0.1528	-0.0248	0.1776	0.1034	1.72
2 years lag	0.0416	-0.0073	0.0489	0.0212	2.31
3 years lag	-0.0066	-0.0510	0.0443	0.0683	0.65
	Sample reduced to medium-high and high technology firms				
	Treated	Controls	Difference	S.E.	T-stat
1 year lag	0.2669	-0.0251	0.2920	0.1801	1.62
2 years lag	0.0716	-0.0321	0.1037	0.0413	2.51

Source: our elaborations

5.4 Discussion

A comparison of our results with prior evidence at the national level (Merito *et al.*, 2007) corroborates the idea that R&D policy may be expected to leverage the innovative effort of firms that are awarded a grant. Hence, public support does not seem to crowd out private investment in knowledge accumulation. Nonetheless, while companies appear ready to adopt new knowledge and technologies, they seem less able to exploit efficiently and to profit from the investment done.

In more details, the results of our analysis suggest that the R&D grant had a positive and significant effect on the input side of the innovation process. One year after receiving the financial support, the group of treated firms recorded a significantly higher variation of intangible assets. The differential appears stable over time and tends to last even three years after the assignment of the R&D grant: This result is quite robust even if the number of treated firms on which we can assess the causal effect significantly shrink when we carry out our investigation on a longer span of time. From a managerial point of view, this results would imply a stronger commitment of small and medium sized enterprises in the competition for public incentives tailored to specific objectives. This type of incentives represent a powerful channel for the accumulation of intangible assets. The latter, in turn, is mandatory for small ventures to enter in and profit from strategic relationships with larger partners which can deploy the complementary resources to serve the downstream markets.

As for the effect of the policy intervention on the competitiveness of the firm we observe a positive and significant effect of the R&D grant on the labor productivity of treated firms three years after financing is awarded. Hence, a higher degree of innovative effort seems to translate in higher efficiency scores at the firm level. Given the poor macroeconomic outlook at the national and international level, this finding provides useful insights for managers who are redefying their corporate strategy. In particular, the higher productivity leveraged through the award of public grant can, in the short run, increase the chances of survival for small companies. In the medium and long term it can provide a basis for differentiating the offer, either by entering new foreign markets, or by tailoring the current offer to the changed tastes of the customers. Overall, this would recommend a dynamic approach to the formulation of the corporate strategy that should opportunely balance the chances of survival with the potential future profits.

Furthermore, irrespective of the time horizon we focus on, there does not appear any statistically significant impact of the policy on profitability. This piece of evidence opens the door to management interventions on at least two grounds. First, there is a question of micro-complementarities between investments in intangible assets, skilled labor force and firms' reorganization that managers need to address. In other words, intangible asset might need an adequate level of human capital and firms' reorganization, for example the presence of an R&D function inside the firm, in order to have an impact on profits. Secondly, there might be a problem of lack of innovativeness in the offerings that small firms bring to the market. Such a problem can stem from the inability of small organization relying heavily on a close innovation approach to recognize, seize and exploit value creating opportunities. As a consequence, managers should be more concerned with widening the boundaries of their innovation search, for example through fruitful collaborations, and less with the sheer amount of resources that they can allocate to innovative activities.

6. Conclusions

This paper empirically investigates whether public R&D project funding in the province of Trento by the PL6, from 2001 to 2008, foster private firms R&D investment (intangible assets investments) and improve firms' performance (labour productivity and operating margin). In order to accomplish these aims, we propose to test two hypothesis using a high quality dataset built on purpose which combines information from firms' balance-sheet data with the administrative archives. The latter gather information on the specific projects that subsidized firms carried out.

Furthermore, these data are enriched with quali-quantitative data coming from face to face interviews to entrepreneurs and policy makers, undertaken in the period ranging from November 2009 to December 2010.

The investigation of the effectiveness of the PL6 is carried out using counterfactual methods: treated firms (the population amounted to 89) were matched with around 335 control firms each year. The latter were carefully selected, against predetermined variables, in order to guarantee the closest similarity with treated firms.

This paper contributed to the existing literature on the effects of incentives for firms' R&D investment and firms' performance in several ways. It takes into account the effectiveness of R&D place-based intervention, a topic that has received so far little scrutiny, despite the increasing regionalization of innovation policy. Moreover, confining our ex post R&D policy evaluation to the province of Trento guarantees a much closer similarity among treated and non-treated firms than one can find comparing nationwide firms. Thus alleviating firms' heterogeneity that could undermine the robustness of counterfactual methods. By choosing the firms, which only received R&D subsidies (and none of other incentives), we have been able to "isolate" the treatment, thus mitigating the effect of one relevant confounding factor, often raised as a cumbersome problem in the recent applied literature.

Unlike most of the current empirical studies, in our evaluation exercise, we take into consideration several variables, both input and output ones, thus enlarging the number of outcome variables that might be influenced by R&D subsidies.

In terms of our results, we find that: *i)* R&D grant had a positive, significant effect on the input side of the innovation process. One year after receiving the financial support, the group of treated firms record significantly higher level of intangible assets than the control group. The differential lasts two years after the assignment of the R&D grant; *ii)* as for the effect of the policy intervention on the competitiveness of the firm, we observe a positive and significant effect of the R&D grant on the labor productivity after three years; *iii)* there is not any statistically significant impact of the policy on both measures of profitability.

While providing a partial positive assessment of the effectiveness of the PL6, we are aware that there other issues needing to be addressed in order for the law to fully express its potential. Among these, the question of microcomplementarities deserves further research. It seems quite relevant, as our exercise shows, that awarded firms are not able to render fully productive the R&D investments fostered by the PL6. To this end, we intend to make better use of the data concerned with the internal organization of the firm and the human capital employed.

Another issue concerns the presence of localized spillovers, which may well be main advantage of a place-based policy. Existing research, based on ex post evaluation, sheds some light upon the likely determinants for the host region to accrue the potential benefits of R&D (Roper, 2004). They are the nature of R&D project itself and the innovation system of the region. Both are worthwhile further investigation in order to provide a thorough assessment of PL6 effectiveness.

Bibliografia

AERTS K., SCHMIDT T. (2008), "Two for the price of one? Additionality effects of R&D subsidies: A comparison between Flanders and Germany", *Research Policy*, vol. 37, n. 5, pp. 806-822.

ALMUS M., CZARNITZKI D. (2003), "The effects of public R&D subsidies on firms innovation activities: The case of Eastern Germany", *Journal of Business and Economic Statistics*, vol. 21, n. 2, pp. 226-236.

ANTONELLI C., CRESPI F. (2012), "Matthew effects and R&D subsidies: Knowledge cumulability in high-tech and low tech industries", *Giornale degli Economisti e Annali di Economia*, vol. 71, n. 1 (October 2012), pp. 5-31.

ARROW K.J. (1962), "The economic implications of learning by doing", *The Review of Economic Studies*, vol. 29, n. 3, pp. 155-173.

ASHEIM B.T., COENEN L. (2005), "Knowledge bases and regional innovation systems: Comparing Nordic clusters", *Research Policy*, vol. 34, n. 8, pp. 1173-1190.

BÉRUBÉ C., MOHNEN P. (2009), "Are firms that receive R&D subsidies more innovative?", *Canadian Journal of Economics (Revue Canadienne d'économique)*, vol. 42, n. 1, pp. 206-225.

BLUNDELL M., COSTA DIAS M. (2000), "Evaluation methods for non-experimental data", *Fiscal Studies*, vol. 21, n. 4, pp. 427-468.

BRONZINI R., IACHINI E. (2011), "Are incentives for R&D effective? Evidence from a regression discontinuity approach", *Working papers*, n. 791, Banca d'Italia, Rome.

BUSOM I. (2000), "An empirical evaluation of the effects of R&D subsidies", *Economics of Innovation and New Technology*, vol. 9, n. 2, pp. 111-148.

CALIENDO M., KOPEINIG S. (2008), "Some practical guidance for the implementation of propensity score matching", *Journal of Economic Surveys*, vol. 22, n. 1, pp. 31-72

CERULLI G. (2010), "Modelling and measuring the effect of public subsidies on business R&D: A critical review of the econometric literature", *Economic Record*, vol. 86, n. 274, pp. 421-449.

COHEN L.L.R., NOLL R.G. (1991), *The technology pork barrel*, Brookings Institution, Washington D.C.

COOKE P., URANGA M.G., ETXEBARRIA G. (1997), "Regional innovation systems: Institutional and organisational dimensions", *Research Policy*, vol. 26, n. 4-5, pp. 475-491.

CZARNITZKI D., EBERSBERGER B., FIER A. (2007), "The relationship between R&D collaboration, subsidies and R&D performance: empirical evidence from Finland and Germany", *Journal of Applied Econometrics*, vol. 22, n. 7, pp. 1347-1366.

CZARNITZKI D., TOOLE A.A. (2007), "Business R&D and the interplay of R&D subsidies and product market uncertainty", *Review of Industrial Organization*, vol. 31, n. 3, pp. 169-181.

DAVID P.A., HALL B.H., TOOLE A.A. (2000), "Is public R&D a complement or substitute for private R&D? A review of the econometric evidence", *Research Policy*, vol. 29, n. 4-5, pp. 497-529.

DEHEJIA R., WAHBA S. (2002), "Propensity score-matching methods for nonexperimental causal studies", *The Review of Economics and Statistics*, vol. 84, n. 1, pp. 151-161.

DUGUET E. (2004), "Are R&D subsidies a substitute or a complement to privately funded R&D?", *Revue d'Economie Politique*, vol. 114, n. 2, pp. 245-274.

EISINGER P.K. (1988), The rise of the entrepreneurial state: state and local economic development policy in the United States, Univ. of Wisconsin Press.

EUROPEAN COMMISSION (2004), *Innovation Policy in Europe 2004*, DG Enterprise and Industry, Bruxelles.

EUROSTAT (2009), *Eurostat regional yearbook 2009*.

FELDMAN M.P., KELLEY M.R. (2006), "The *ex ante* assessment of knowledge spillovers: Government R&D policy, economic incentives and private firm behavior", *Research Policy*, vol. 35, n. 10, pp. 1509-1521.

FRITSCH M., STEPHAN A. (2005), "Regionalization of innovation policy. Introduction to the special issue", *Research Policy*, vol. 34, n. 8, pp. 1123-1127.

GARCÍA-QUEVEDO J. (2004), "Do public subsidies complement business R&D? A meta-analysis of the econometric evidence". *Kyklos*, vol. 57, n. 1, pp. 87-102.

GLAZERMAN S., LEVY D.M., MYERS D. (2003), "Nonexperimental Versus Experimental Estimates of Earnings Impacts", *The Annals of the American Academy of Political and Social Science September,* vol. 589, n. 1, pp. 63-93.

GONZÁLEZ X., JAUMANDREU J., PAZÓ C. (2005), "Barriers to innovation and subsidy effectiveness", *The RAND Journal of Economics*, vol. 36, n. 4, pp. 930-950.

GÖRG H., STROBL E. (2007), "The Effect of R&D Subsidies on Private R&D", *Economica*, vol. 74, n. 294, pp. 215-234.

GRILICHES Z. (1992), "The search for R&D spillovers", *The Scandinavian Journal of Economics*, vol. 94, pp. S29-S47.

HALL B.H. (2002), "The financing of research and development", *Oxford Review of Economic Policy*, vol. 18, n.1, pp. 35-51.

HALL B.H., MAIRESSE J., MOHNEN P. (2009), "Measuring the returns to R&D", *NBER Working Paper* No. 15622.

HECKMAN J., ICHIMURA H., TODD P. (1997), "Matching as an econometric evaluation estimator: Evidence from evaluating a job training program", *Review of Economic Studies*, vol. 64, n. 4, pp. 605-654.

HECKMAN J., ICHIMURA H., TODD P. (1998), "Matching as an econometric evaluation estimator", *Review of Economic Studies*, vol. 65, n. 2, pp. 261-294.

HENDERSON R., COCKBURN I. (1996), "Scale, scope, and spillovers: The determinants of research productivity in drug discovery", *The RAND Journal of Economics*, vol. 27, n. 1, pp. 32-59.

HO D.E., IMAI K., KING G., STUART E.A. (2007), "Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference", *Political Analysis*, vol.15, n. 3, pp. 199-236.

HOWELLS J. (2005), "Innovation and regional economic development: A matter of perspective? ", *Research Policy*, vol. 34, n. 8, pp. 1220-1234.

HUSSINGER K. (2008), "R&D and subsidies at the firm level: an application of parametric and semi-parametric two-step selection models", *Journal of Applied Econometrics*, vol. 23, n. 6, pp. 729-747.

HYYTINEN A., TOIVANEN O. (2005), "Do financial constraints hold back innovation and growth?: Evidence on the role of public policy", *Research Policy*, vol. 34, n. 9, pp. 1385-1403.

KLETTE T.J., MOEN J. (1999), "From growth theory to technology policy - coordination problems in theory and practice", *Nordic Journal of Political Economy*, vol.25, n. 1, pp. 53-74.

KLETTE T.J., MOEN J., GRILICHES Z. (2000), "Do subsidies to commercial R&D reduce market failures? Microeconometric Evaluation Studies", *Research Policy*, vol.29, n. 4, pp. 471-495.

JAFFE A.B. (1986), “Technological opportunity and spillovers of R&D: evidence from firms' patents, profits and market value”, *American Economic Review*, vol. 76, n. 5, pp. 984-999.

IMBENS G. (2004), “Nonparametric estimation of average treatment effects under exogeneity: a review”, *Review of Economics and Statistics*, vol. 86, n. 1, pp. 4-29.

LACH S. (2002), “Do R&D subsidies stimulate or displace private R&D? Evidence from Israel, “ *Journal of Industrial Economics*, vol. 50, n. 4, pp. 369-390.

LECHNER M. (2001), “Identification and estimation of causal effects of multiple treatments under the conditional independence assumption”, in Lechner and Pfeiffer (eds), *Econometric evaluations of active labor market policies in Europe*, Heidelberg, Physica

LERNER J. (2000), “The government as venture capitalist: the long-run impact of the SBIR program”, *Journal of Private Equity*, vol. 3, n. 2 pp. 55-78.

LERNER J. (2002), “When bureaucrats meet entrepreneurs: The design of effective ‘public venture capital’ programmes”, *The Economic Journal*, vol. 112, n. 477, pp. F73-F84.

LUNDVALL B.A., BORRAS S. (2005), “Science, technology and innovation policy”, in Fagerberg, G., Mowery, D.C. and Nelson, R.R. (eds), *The Oxford Handbook of Innovation*, pp. 599-631, Oxford University Press, Oxford.

MAIRESSE J., MOHNEN P. (2010), “Using innovation surveys for econometric analysis”, *NBER Working paper*, n. 15857.

MERITO M., GIANNANGELI S., BONACCORSI A. (2007), “Gli incentivi per la ricerca e lo sviluppo industriale stimolano la produttività della ricerca e la crescita delle imprese? Evidenza sul caso italiano”, *L'Industria*, vol. 27, n. 2, pp. 221-241.

MET (2009), *Rapporto MET 2009: Imprese e politiche in Italia*, Monitoraggio Economia e Territorio, Roma.

NELSON R.R. (1959), “The simple economics of basic science research”, *Journal of Political Economy*, vol. 67, pp. 297-306.

OECD (2003), *Science, Technology and Industry Scoreboard*, OECD, Paris.

OECD (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, (third ed,), OECD, Paris.

ORNAGHI C. (2006), “Spillovers in product and process innovation: Evidence from manufacturing firms”, *International Journal of Industrial Organization*, vol. 24, n. 2, pp. 349-380

PEDROTTI L., TUNDIS E., ZANINOTTO E. (2008), *Crescita economica e produttività: misure e applicazioni*. Edizioni 31, Trento.

PIEKKOLA H. (2007), “Public funding of R&D and growth: firm-level evidence from Finland”, *Economics of Innovation and New Technology*, vol. 16, n. 3, pp. 195-210.

POTÌ B., CERULLI G. (2010), “La valutazione *ex-post* di uno strumento di politica della ricerca industriale: modello analitico, processo di realizzazione, eterogeneità degli effetti”, *L'Industria*, vol. 31, n. 2, pp. 307-333.

ROPER S., HEWITT-DUNDAS N., LOVE J.H. (2004), “An ex ante evaluation framework for the regional benefits of publicly supported R&D projects”, *Research Policy*, vol. 33, n. 3, pp. 487-509.

ROSENBAUM P., RUBIN D.B. (1983), “The central role of the propensity score in observational studies for causal effects”, *Biometrika*, vol. 70, n. 1, pp. 41-55.

RUBIN D.B. (1973), “The use of matched sampling and regression adjustment to remove bias in observational studies”, *Biometrics*, vol. 29, n. 1, pp. 185-203.

RUBIN D.B. (1977), “Assignment to treatment group on the basis of covariate”, *Journal of Educational Statistics*, vol. 2, n. 1, pp. 1-26.

RUBIN D.B., THOMAS N. (1996), “Matching Using Estimated Propensity Scores: Relating Theory to Practice”, *Biometrics*, vol. 2, n. 3, pp. 249-264.

SMITH J.A., TODD P.E. (2005), “Does matching overcome LaLonde's critique of nonexperimental estimators?”, *Journal of Econometrics*, vol. 125, n. 1-2, March-April 2005, pp. 305-353

STUART E.A. (2010), “Matching Methods for Causal Inference: A Review and a Look Forward, statistical science”, vol. 25, n. 1, pp. 1-21.

TÖDTLING F., TRIPPL M. (2005), “One size fits all?: Towards a differentiated regional innovation policy approach”, *Research Policy*, vol. 34, n. 8, pp. 1203-1219.

TRIVELLATO U., MARTINI A., RETTORE E. (2009), “Valutare gli effetti delle politiche attive del lavoro: la logica controfattuale”, in M. Cantalupi and M. Demurtas (eds), *Politiche di attivazione e ‘performance’ dei servizi per l'impiego. Esperienze e percorsi di implementazione in Italia e in Europa*, il Mulino, Bologna, pp. 291-323.

WALLSTEN S.J. (2000), “The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation research program”, *The Rand Journal of Economics*, vol. 31, n. 1, pp. 82-100.