54th Annual Conference of the Italian Economic Association

ISSUES IN REGIONAL ECONOMICS (CO-ORGANIZED WITH AISRE)

University of Bologna, 24-26 October 2013

Are the R&D Subsidies Effective? An Empirical Analysis of the Italian Fund for Technological Innovation

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ABSTRACT

Empirical evidence on the effects of public subsidies to R&D at firm level is mixed and contradictory. The paper presents new empirical results based on new dataset, that integrates administrative archives with a balance sheet dataset containing longitudinal information on sales, fixed assets, value added, employment. The impact of incentives is estimated using different samples by dimension, sectors and geographic area. A DID Matching estimator is applied, considering the presence of selection on observables and non observables The results suggest the presence of significant effect on employment and investment, but not on sales and productivity.

JEL classification: O38; L1; C21
Keywords: R&D; Subsidies; DID Matching.

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1 Introduction

Both academic scholars and policy makers are debating the effectiveness of incentive system that boost firms' competition enhancing innovation and research and development (R&D) efforts. In the last 10 years, the objectives of the Lisbon Strategy (the objective of increasing R&D expenditure to 3% of GDP) have accelerated the growth rate of public R&D support but the sign and the size of the effects on firms' R&D expenditure and performances is an open question. Spurred by the increasing share of public resources devoted to supporting innovation activity, a growing body of literature has investigated the effectiveness of R&D subsidies. The findings are mixed and controversial. David et al. (2000) revise the results of forty years of empirical studies and find that there is no conclusive evidence in favour of public support. The unconvincing empirical results could mainly be explained by the difficulties in isolating the impact of innovation subsidies from the confounding effects induced by other factors. In particular, participation in these programs is generally endogenous and the selection bias is pervasive. Economists and econometricians deal with the problem of inferring the effect of a policy by using different evaluation methods, depending basically on the type and quality of available data and on the policy "assignment rule'' (Blundell-Dias, 2009). Only recently an interesting literature on econometric evaluation methods for non-experimental data, also in the field of public support to private R&D, has arisen.
The paper is cast in this new stream of literature. The study analyzes the effect of public R&D subsidies on firms performance and innovative efforts in Italian industry using a counterfactual approach based on a non-experimental method. The main concern is to assess the effectiveness of public R&D support on firm's performances analyzing whether the sign and the size of the effects depend on the size of the firms and on its technological level.

The aim of the paper is to evaluate a policy instrument used to subsidize private projects on R&D, the Fund for Technological Innovation (FTI). The study compares subsidized firms with not subsidized ones using a counterfactual approach based on a MDID (Matching Difference-in Differences) estimator. The empirical analysis is carried on a new detailed and informative database including companies awarded at least one R&D grant during the years 2002-2010; for each company we have data on the size of subsidies, from the administrative archive, and balance sheet data from Bureau Van Dijk database. We estimate the impact of the subsidies on revenues, material and immaterial investment, value added, employment, labour productivity and profitability.

2 Theoretical motivation

In 1950, Schumpeter emphasized the role of innovation as driver of economic growth. His theory has been the starting point of lots of studies on the economic effects of technological innovation; most of them recognize a relative advantage of large firms over small business in the supply of innovation. Size emerges as a determinant to drive technological innovation: large firms can get cheaper credit for carrying out risky R&D projects in the financial market (Cohen and Levin, 1989); moreover the large size is a prerequisite to attract high skill workers required to achieve a successful innovation process (Corsino et al., 2011). In fact, only firms that dispose of resources with technical expertise can hold a "temporary monopoly power" linked to their innovative products. Unfortunately, the amount of financial resource devoted to R&D is often not enough to insure the undertaking of innovation products for the private units.

In this context, the role of government funding becomes essential to overcome market failures and stimulate innovation. Over the past two decades, OECD governments have contributed to the R&D expenditure with almost one third of the total expenditure. In Europe, we observe different economic policies that use grants, procurement, tax incentives and direct funding on business R&D.

The presence of market failures related with R&D activities motivates government interest to sustain R&D investment. The reason of these market failures has been deeply discussed. Firms achieve lower rate return to R&D than the social marginal return since they don't have control over the diffusion of knowledge of their technological innovation and so a positive spill over effects arise; the uncertain of research activities discourage firms, especially small ones for which high risk is a barrier to take on new innovation activities. For this reason, in general, the private amount invested in R&D is below the optimal point (Arrow, 1962). Government action can help to overcome the hurdles reducing the cost and uncertainty of private R&D, increasing knowledge of technological opportunities. If public policies are effective then public and private funding may be complementary such that the increase of public funds may boost the private ones.

However there are strong impediments to the effectiveness of public funding. First of all, asymmetric information that generates distortions in resources allocation between different fields of research. Market driving forces can allocate resources more efficiently then public operators thanks to more or superior information on the economic and social features of the project and its feasibility. The main consequence of this asymmetry is the absence of additionality for public funds. Firms can substitute private money with public support and realize the same research that they will be realized. Sometimes the funding of a private project discourage other firms in the same sector that were planning to do a similar project, this is a further case of no additionality at aggregate level.

In general, positive externalities take place when the firm undertakes an innovative project. In the case of SMEs, this effect is less intense because they have higher liquidity constraints than larger firms. In addition, SMEs are less effective in internalizing the advantage of innovation activities' (Cohen and Klepper, 1996); this can reduce the value of an R&D investment because it depends on the chance of preventing other competitors from having access to the investment's innovative results. In this context it is evident the connection between innovative results and patenting normative whose access depends on firms' market power.

Moreover, a potential crowding out effect of private spending can arise. David et al (2000) assert that also if the total amount of R&D increase, as result of the sum of public and private funds, the real amount of R&D remains low because the presence of public subsidies bring on an higher labour cost of research, given a major competition on all research inputs. Not-withstanding, Wolf and Reinthaler (2008) show a positive impact of R&D subsidies on private innovation activity also if they control for higher wages.

Empirical analysis on the effectiveness of R&D subsidies has been carried out by several scholars with dissimilar and ambiguous results as highlighted by David et al. (2000) in their review of econometric evidence. Certainly, evaluation of the impact of public funds to private sector has to tackle the complexity of identification strategy as long as public funding is endogenous with regard to innovation. This bring to a wrong estimation of the real impact of subsidies that could be over or under estimated depending on the selection of firms, healthy firms which invest anyway in R&D or unhealthy firms that use public funds to support business in the meantime in which the investment is realized, several factors can act modifying the size or the sign of the dependent variable, object of the estimation. The challenge of empirical evaluation is to detach such factors separating confounding effects from the subsidies effect.

Over the last three decades, several studies were interested on the casual effect of policies developing different methods to tackle the problem in different way that take into account the policy assignment rule and the type of available data. Beginning from the consideration that in economic policy the treatment's assignment is not randomized, a lot of non experimental methods have been developed to overcome estimation problem due to the nature of data.

As regards the additionality effects on input (i.e. innovation expenditures), David et al. (2000), developing a firm-level analysis conducted in the previous three decades, observe that policies, in about half of cases (9 of 19), do not lead to additionality for investment, while in the remaining half of the cases is exactly the opposite. In the case of the Small Business Innovation Research program (SBIR) in USA, two different studies obtained opposite conclusions. Lerner (1999), using the matching method by sector and size of firms, finds that policies increase sales and employment for the subsidized firms. On the contrary Wallsten (2000), using the method of instrumental variables, shows that incentives do not induce an increase in employment and public subsidies. The available results for other countries are different. In the case of Israel, Lach (2002) shows how the incentives generate additionality effects in investment in R&D for small business units while for large enterprises, that get more easily subsidies, do not emerge additionality effects and the total impact equals zero. Almus and Czarnitzki (2003) use a matching method to study R&D grants in Western Germany where find a positive total effect on investment. Gonzalez et al. (2005) explore the case of Spain and they estimate simultaneously the probability of obtaining a subsidy, assuming a set of observable characteristics of the enterprise as fixed (such as size, age, sector, location, capital growth), and they find a positive effect on private investment, although very small, which tends to become much more significant for smaller firms. More recently Gorg and Strobl (2007) combine matching method with Diff-in-Diffs estimators and find that in Ireland only small grants have an additional effect on investment, while the incentives of greater magnitude tend to crowd out private investment.

The empirical literature that evaluates the impact of public R&D on measures of performance is scarce and the results are not unique if we exclude expenditure on R&D. Hujer and Radic (2005) observed establishments in West Germany and Eastern Europe which have received public support for private R&D in 1997 and 1998 and they did not find effect on innovation activities, measured by the introduction of new products or services during the years 1999 and 2000. Czarnitki and Licht (2006), analyzing the data of firms in the West and East Germany with a matching method, show that in West Germany firms which benefit from public subsidies have a lower productivity than those finance themselves the expenditures in R&D. On the contrary, in East Germany public funding for R&D is a crucial component of R&D investment and thus essential to develop new products and operate in the national and international market. Czarnitki et al. (2007) focus on the impact of innovation policies and R&D collaboration in Germany and Finland. In Germany, subsidies for individual research do not show a significant impact on R&D or patent's activity, but the performance of innovation activity and R&D collaboration can be improved through additional incentives. For Finnish companies public funds are an important source for the R&D: you would have a lower expenditure in R&D and patenting activities without subsidies; firms that did not receive subsidies could significantly improve their performance if they had benefited from public funds. Hussinger (2008), using a selection method for German manufacturing firms, found a positive effect of R&D subsidies on the level of investment per employee and sales of new products, while increasing the incentives a further positive effect on the results of R&D is not guaranteed. Berube and Mohnen (2009) turn their attention to the case of Canadian businesses and in particular show how the firms that simultaneously benefit of subsidies and tax credits introduce a greater amount of new products and obtain greater success in commercializing their innovations than their counterparts who get only R&D tax benefits.

Merito, Giannangeli and Bonaccorsi (2007) evaluated the effects on firm performance of the Special Fund for Applied Research (FSRA) by adopting a non-parametric matching method combined with an auxiliary regression. The results show a temporary improvement of the innovative performance and highlight significant differences, between subsidized firms and unsubsidized ones, with regard to sales, productivity and employment. Cerulli and Potì (2008) analyzing the data from the third wave of the Community Innovation Survey (CIS) for Italy have noted that the main factors influencing the likelihood of participating in the incentive policy are experience in R&D, human capital, liquidity constraints and ownership of foreign capital. It underlines the existence of some cases of total crowding out of investment, in particular, the low-knowledge intensive services, the small firms (10 to 19 employees) and the automotive industry. Similar results confirming the lack of crowding out between private and public funds are obtained by De Blasio, Fantino and Pellegrini (2011) analysis of the Fund of Technological Innovation (FTI). Colombo, Croce and Guerini (2010) insist on additionality of investments for small businesses, consequence of the limitations faced by their liquidity constraints and a more difficult access to the credit market. Small businesses which benefit from a subsidy with an increase in the rate of investment limited to a short period, while there was an increase in cash flows that lasts through time providing support to the thesis of removal of liquidity constraints for small businesses as a result of receiving an incentive. Bronzini and Iachini (2011) have carried out the evaluation of a program of incentives for R&D in Emilia Romagna using a method of type RDD highlighting how the subsidy policy has had a positive effect on investment exclusively for small businesses. Furthermore, Carboni (2011) shows as the Italian subsidized firms have a private spending on R&D greater than that which would have occurred in the absence of the incentive.
A recent study regarding small firms by Czarnitzki and Delanote (2013) shows that the only firms that convincingly make more efficient use of subsidies than the other small young firms, both in terms of R&D expenditures and in terms of R&D employment, are independent high-tech small young firms. These results emphasize the role of these enterprises to create valuable knowledge.

3 Law 46/1982: the Fund for Technological Innovation

Among R&D subsidies to firms, law 46/1982 is one of the most relevant law to promote private investment in the field of research and innovation in Italy. The law creates two instruments to found R&D and innovation: the Fund for Research Credit and one that regards specifically the institution of a Fund for Technological Innovation (FTI).

The Fund for Technological Innovation was revised several times and it was fully reorganized in 2001. The FIT is oriented to R&D investment that, in Italy, is under the European average: it represent only 0.67% of GDP versus 1.25 of European Community. It is considered the most important policy measure in Italy. Subsidized support is available for firms that have productive units in Italy and operate in the manufacturing sectors such as industrial activities to produce goods and services, craftsmanship to produce goods, transportation activities. Moreover the fund is directed to research centre characterized by independent legal status.

The instrument operate following two ways: a direct subsidy to investment and an indirect subsidy for subsidized credit.

Since 2002, the subsidies for investment are of about 770 (€/millions) and the paid out grants are 580 (€/millions). The southern regions of Italy have got only the 14% of the grants. The subsidized credit for reduction in interest rate is of about 1.700 (€/millions) which only 11% in the Southern regions, the paid out grants are 1.240 (€/millions).

In the period 2002-2010, 2,904 projects were considered eligible by a commission of experts of the Ministry of Industry. The Fund for Technological Innovation finances, on average, the 39% of the costs of the investment; the 28% are directed to capital accumulation while the remaining share is directed to subsidized loans. Unfortunately the selection timing of subsidized firms are long (2,1 years); it depends on a non-automatic evaluation process: the commission is responsible for selecting the projects that will be subsidized and for determining the proportion of financed costs. Also the time to realize the investment is very long, on average 4,6 years, but it depends on the characteristics of the project. Considering the distribution of subsidized investments, we observe that only the 14% of the projects is located in the southern regions and they get a financial aid approximately equal to the 35% of the total value of the investment; on the contrary the northern regions which represent the 86% of the eligible investment get aids for the 28%. The 68% of the firms belongs to the manufacturing sector and they get the 70% of total subsidies which is allocated for the 47% to the large firms. This show that in Italy FTI is an important instrument not only for large enterprises but also for medium and small firms.

The specific aim of the fund is the support of innovative firms programme which intend to introduce relevant technological innovation. The innovation considers both the production of new goods as new productive processes or also to improve existing goods or processes. The programme regards the planning of product realization, the design and development, experimentation, production of industrial prototype. It excludes customer-related processes and marketing of the products. Moreover the fund grant the promotion of innovation activities and the implementation of industrial research results. It is directed to increase R&D expenditure of firms. The aims of the fund advantage large firms in Northern regions, operating in technologically advanced sectors and expert in the development of large research projects.

The selection procedure of the benefited firms is carried out by the Ministry of Industry. Firms apply demand and project and, through a procedure of enquiry, the competent office of the Ministry ascertain which firms satisfy the conditions required to get financial support.
If a project is rejected, the Ministry explains the reasons to the firm on the base of the committee judgement. There is no deadline for applications, every proposal is evaluated in chronological order of receipt.
Every firm declares that it does not have grants from other public funds for the same goal. The grant amount established for each firm is paid out in several steps, during the undertaking of the project thanks to a verification procedure that control if the firms use public funds to realize the program. The procedure makes use of a penalties when firms do not respect the programme interrupting the funding and forcing them to return the received amounts. The procedure does not consider the risk of non-additionality, that is the hypothesis in which firms would have carried out the project in any case, also in the absence of public incentives.

L. 46/82 uses a planned selection process because subsidies are assigned to projects, and so to firms, following policy's criteria. This means that treated and non treated firms are different respect to their structural and financial dimension. Only a randomized assignment of subsidies could ensure that the two groups are not different. We are conscious that the selection system produces some types of selection bias that certainly influence the average outcome of treated and non treated firms. For example, larger firms characterized by high profit and capital intensive may achieve better results also in the absence of subsidy. Moreover, the possibility of being subsidized increases if the firm has better relationship with banks, has an effective management and the project is clear and well structured. Each factor can influence firm performance. For these reasons, the evaluation strategy aims to decrease the selection bias associated with a firm's observable and non observable characteristics.
The main observable characteristics which affect selection bias are the factors considered more important to be eligible by the policy makers. For innovation project, economic sector and firm size can be relevant in the selection mechanism. EU rules assure higher incentives share to SMEs because the low size reduces the likelihood of access to credit.
In order to control for these effects, in the analysis we utilize information on firm size (measured by the number of employees).
Management ability and inclination to innovate are the major non observable characteristics.
We assume that other local factors are constant over time, and the effect can be captured by a firm fixed effect. In this set we also include other non observable variables affecting the decision to participate, such as the quality of firm management and its propensity to risk, the quality of the R&D produced by the firm and productivity effects related to the geographical location of the firms, which are only partially captured by the previous covariates. These factors are all intrinsically related to each firm, and can be considered invariant over the analyzed period of time.

4 The evaluation model

To identify the impact of L.46/82 using a matching technique we need that the control group satisfy two main conditions: (a) before the policy, the control group is very similar to the treated group (b) the control group is a very good control for the selection process.

We assume that the time dimension (the time when firm presents the project) and the space dimension (regions) are not relevant in respect to the selection problem. Under this hypothesis (which we verify below with several robustness checks) we pool projects across different regions. In this way, an overlapping area of firms with the same propensity to be subsidized (they are in both the treated group and the control group) is available and a matching estimator is a feasible instrument to determine the effects of Law 46/82.

The matching estimator assumes that selection can be explained purely in terms of observable characteristics. In this case the conditional independence assumption (CIA) holds, it means that the outcomes of non treated units are independent from the participation status conditioned to the observables. The consequence of CIA is that for each subsidized unit, observations of not subsidized unit on outcome variable with the same covariates realization constitute the correct counterfactual.

The ability of matching to reproduce an experimental framework depends on the availability of the counterfactual. Hence, the second matching assumption is that all treated units have a counterpart in the non treated population and any one constitutes a possible participant. The main advantage offered by the matching method is that it does not require any assumption on the functional form of the dependency between the outcome variable and the observed covariates. On the other hand, if there are a high number of covariates, it may be difficult to identify a non subsidized firm to match with every subsidized firm, unless the sample is huge. This obstacle is overcome with the Propensity Score Matching (Rosenbaum and Rubin, 1983). The correct use of a propensity score also requires that firms with the same propensity score must have the same distribution of observable (and non observable) characteristics independent to the treatment status.

This hypothesis is called the “balancing hypothesis” and can be tested using the approach presented in Becker and Ichino (2002).

In the case of L. 46/82, the weak unconfoundedness (CIA) hypothesis is theoretically not satisfied because we do not know the selection procedure. To implement the matching technique, we define the treatment group as the set of firms subsidized by L. 46/82 and the control group is made up of the rejected applicant firms. The outcome variable (calculated as compound annual growth rate) of interest is the performance, profitability and employment indices; the covariates refers to observed firms' characteristics such as size, activity sector and research cost.

In the previous chapter we identified another source of bias due to non observables factors; we can assume that these factors are constant over the time. A sensible estimation strategy is based on the DIFF-in-DIFFSs estimators that could be integrated in the matching procedure as suggested by (Smith Todd, 2005).

Differences between subsidized and non subsidized outcomes persist also after conditioning on observables; in our analysis different regional or time fixed effects can affect the outcomes. We can correct for this potential cause of selection bias supposing that differences across regions are considered constant over time (Bernini, Pellegrini, 2011). Under this assumption a possible strategy to correctly evaluate the impact of L. 46/82 is to combine Matching with a DID estimator (MDID).
MDID consider first-difference outcomes on a pre-program period, in order to remove selection on time-invariant unobservables, both for subsidized units and unsubsidized ones. We first select the unsubsidized firms using a matching method, and then we compare the first difference of outcomes to remove selection on observables (Smith and Todd, 2005; Blundell and Costa Dias, 2009). In this way, the MDID weakens the identifying assumption for matching (Bryson et al., 2002).

As usual, three statistical assumptions guarantee the validity of Matching and MDID estimation. The first assumption regards the Stable Unit Treatment Value Assumption (SUTVA), which requires the program not to have any effects on non participants. This assumption is credible for our analysis because the subsidized firms account less than 1% of the total manufacturing firms in the south. We can assume, on that basis, that the overall spill-over effect is negligible (Bernini and Pellegrini, 2011). Another issue for the validity of the SUTVA hypothesis relies on the fact that the time span to realize project (4.6 years) is not enough long to develop spill-over effects and however they should be negligible from an empirical point of view. As shown in De Castris and Pellegrini (2012), for the main regional development policies in the southern regions of Italy (Law 488/92 and Program Agreement), spill-overs are small and negative across areas, suggesting the presence of modest spatial crowding out where subsidized regions attract employment and firms from neighbouring areas. A second assumption, concerning the MDID, is the conditional independence of variations: in the absence of the program, average change of pre-program outcomes are identical among treated and untreated firms. The last assumption considers that the change occurred in the period before–after the treatment is the same for control firms and treated ones, regarding the observable component of the model and the non observable time trend. The assumption is rational if the treated firms have common characteristics with the non treated ones. After all, the assumption of common support requires that for each treated unit of the program there be observationally identical untreated units.
The impact of the subsidies can be estimated as the effect of the treatment on the treated firms over the common support of the covariates by means of the matching diff-in-diffs estimator (Blundell and Costa Dias, 2009):

$$\alpha_{MDID} = \Sigma_{i \in S} [(Y^{S}_{it1} - Y^{S}_{it0}) - \Sigma_{j \in NS} \omega_{ij} (Y^{NS}_{jt1} - Y^{NS}_{jt0})] \omega_i = \Sigma_{i \in S} [\Delta Y^{S}_{i} - \Sigma_{j \in NS} \omega_{ij} \Delta Y^{NS}_{j}] \omega_i$$

Let be: i the firm, Y the outcome variable, t0 and t1 the time before and after program time periods, ΔY the change of Y in the period, S and NS the subsidized and non subsidized firms, respectively,

ωij a weight indicator of the similarity between the two firms, and ω_i is the weight of the subsidized firms over the common support.
We can choose different methods of determining the weights ωij that generate different matching estimator. In the stratification matching, the common support is divided into a set of blocks, where the average treatment impact is calculated using a simple average. While if we define a neighborhood for each treated observation and constructs the counterfactual using all control observations within the neighborhood, we can assign positive weight to all observations within the neighborhood and a zero weight to the remaining observations. The weights' distribution will depend on the shape of a kernel function (we use the Epanechnikov Kernel function). Another possibility is represented by the assignment of a positive weight only for the closest units, nearest neighbour matching estimation.
We implement also kernel matching and nearest neighbour matching estimation as robustness check.

5 Data

The database of the analysis is composed by a sample of R&D projects approved by the Ministry of Industry in the years between the 2000-2010 regarding manufacturing firms and services activities. The sample considers projects that were considered eligible by a commission of experts of the Ministry of Industry (2904).
We had a 26% of drop-outs from the sample to take in account that:

- each firm can present projects in different tenders and so we dropped out 343duplicates from the database;
- a group composed by 173 firms saw their grant revoked;
- a group of 245 firms had not concluded their investment at the moment of the evaluation. We consider that the project is realized when we have a final decree of the ministry about it or if the firm has got the 90% of the subsidy.

The final sample is composed by 2143 firms (939 of which subsidized).

For each firm the archive includes the following information: name, address, tax number, amount of the planned R&D expenditure, amount of the subsidy. Only for the eligible projects, it is also available the project’s starting date and conclusion date. We link the FTI archive with the 2000-2010 firms balance sheet from AIDA database (realized by Bureau Van Dijk society) to get economic variables for each firms that describe firms before the investment and after the investment. Unfortunately, the linking procedure based on the firm identifier (tax number) can fail, the unavailability of balance-sheet data for the entire period, and standard data cleaning reduce the sample and the final number of units depends on the variable that we want analyze.

Each firm start its investment on the depending on the time of application and the time of granting and so we have different time spans. The data set contains information on the years of beginning and end of investment and we consider the time between the year before the start and the year after the end to estimate the impact of the subsidy. This choice depend on the fact that the time span is different for each project. For the evaluation we consider as pre-treatment year, the previous year of the beginning of the investment and as post-treatment year, the year after the year of ending.
For not subsidized firms we consider that the end date is equal to the sum of the start date (mean in the group of subsidized firms) and the average investment period calculated from the sample of subsidized firms.

Moreover, an important check of data regards the consistency of the control group with respect to the treated group. We evaluate the two sample comparing the main economic indicators before the start of the project. The characteristics of the firms in the two sub-set before starting investment is relevant to build up the counterfactual analysis. The table 1 shows a substantial homogeneity between the two groups. The treated group is composed by firms a little bigger, more profitable and more capital intensive. We checked also for the year after the end of investment and we found homogeneity.

Table 1 - Summary of the main covariates in the final dataset before the investment.

	Median		
	Not Subsidized	Subsidized	Total
Employment	57	62	59
Turnover	8371.4	9447.6	9101.0
Total Fixed Assets	2080.5	2648.172	2345.1
Intangible Assets	142.2	247.8	191.4
Tangible Assets	1439.5	1702.9	1538.0
ROI	8.7	5.7	6.9
Value added per capita	46.1	48.92	47.155
Labor cost per capita	28.1	28.7	28.3
Ebitda	587.3	720.269	646.1
Turnover per capita	150.2	169.9	160.4

Source: Elaboration on L.46/82 and Aida data.

6 Results

The first step to estimate the impact of the policy is the specification of the propensity score model. We adopt a Logit specification of the treatment dummy variable (T), which is equal to one if firm has received the subsidy and zero otherwise. For the identification of covariates, we consider variables on fixed assets, sales, labour cost. Size is controlled with dummies for medium or small firms. Localization is controlled with a dummy on the southern regions. The adopted specification also reflects that the selection procedure is not linearly based on the three main indicators and the interaction between the main indicators and dimension is introduced. Sector dummies capture both the productive heterogeneity of firms and potential specific sector shocks. Dummy related to the localization of the project is also considered.

The ratio labour cost and turnover per capita at time zero is used to control for pre-program firm productivity, approximating unobserved management ability.

The final specification of the Logit model for propensity score and the parameter estimates are shown in Table 2. The estimate is highly statistically significant and the coefficients have the expected signs.

Table 2 Logit Estimate: baseline model

Variables	Coefficient	Std. Error
Dummy for southern regions	0.546	0.245
Dummy for economic sector (2 digit Ateco)	-0.002	0.004
Dummy for small firm	-0.322	0.232
Dummy for medium firm	-0.558	0.258
Total Fixed Assets/Sales	0.194	0.372
Share of labour cost on sales per capita	-0.070	0.216
(Fixed Assets/Sales) * (dummy small firm)	-0.190	0.372
(Fixed Assets/Sales) * (dummy medium firm)	0.395	0.490
(Intangible assets) * (dummy variable southern regions)	7.00E-05	6.00E-05
Constant	0.146	0.237
Number of observations = 1336		
Log likelihood = -908.8		
LR $\chi^2(9)$ = 28.10		
Prob > $\chi^2(9)$ = 0.0009		
Pseudo R^2 = 0.0152		

Splitting the sample by propensity score into six blocks, we verify that the balancing hypothesis is satisfied, following the procedure proposed in Becker and Ichino (2002).

This number of blocks ensures that the mean propensity score is not different for treated and controls in each blocks. As a further check of the conditional mean independence assumption required for the application of propensity score matching, we test the mean outcome equality between subsidized and non subsidized groups at time zero, for each of the propensity score blocks. The tests are performed on the outcome variables not included in the propensity score function but used to evaluate L. 46/82 effects. Test results confirm that the mean variable differences for every outcome variable are not significantly different from zero. Hence, homogeneity of firms within blocks is assured and the matching hypotheses are satisfied.

ATT is estimated using the MDID technique, implemented by a Stratification matching estimator. The presence of some anomalous data (as signaled by the large difference between median and mean across indicators) indicates a need to trim the subsidized and the non subsidized firm samples at the 5 and 95 percentiles. We impose the common support restriction in all the estimations in order to improve the quality of the matches. The standard errors of the ATT are estimated by the bootstrap procedure (100 replications) described in Becker and Ichino (2002). The estimates of ATT for the full sample are presented in Table 3.

Table 3 Impact estimation of FTI subsidies on the full sample. Results of Stratification Matching Estimation.

Outcome variable*	ATT	S.E.	t-test	Number of Treated Unit	Number of Control Unit
Turnover	-0.011	0.008	-1.419	422	568
Value added per capita	-0.008	0.006	-1.334	355	466
Employment	0.011	0.005	1.947	357	489
Total Fixed Assets	0.022	0.010	2.159	429	579
Labor cost per capita	0.002	0.004	0.524	360	481
Intangible assets	0.001	0.026	0.022	407	526
Turnover/Employment	-0.012	0.007	-1.583	364	479
Research and advertising cost	0.087	0.052	1.680	107	125
**EBIDTA/turnover ratio	-0.239	0.297	-0.805	350	487

Notes: *The outcome variables are compound annual growth rate

** Absolute change of the variable between time t_0 and t_1.

L. 46/82 has a significant positive effects on total fixed assets, employment and Research and advertising cost of the sample of subsidized firms.

In general, the study doesn't find significant positive effects on turnover, intangible assets and productivity. This highlights the absence of additionality of the subsidy. The positive effect on employment can be regarded as the increasing demand of high skilled workers employed in R&D activities, especially to design the proposal project.

As robust check we estimated the ATT using the MDID technique, implemented by a Nearest Neighbour matching estimation and by Kernel Matching Estimation and the results in table 4 confirm the previous analysis.

Table 4. Impact estimation of FTI subsidies on the full sample. Results of Nearest Neighbour and Kernel Matching Estimation.

	Nearest Neighbour matching estimation					Kernel Matching Estimaton				
Outcome variables	ATT	S.E.	t-test	Number of Treated Unit	Number of Control Unit	ATT	S.E.	t-test	Number of Treated Unit	Number of Control Unit
Turnover	-0.012	0.009	-1.067	423	260	-0.012	0.008	-1.644	423	567
Employment	0.017	0.007	2.368	358	221	0.014	0.005	2.539	358	488
Fixed assets	0.024	0.013	1.868	430	269	0.025	0.009	2.628	438	578
Intangible assets	-0.028	0.036	0.760	408	249	0.011	0.02	0.554	408	525
Turnover/Employment	-0.017	0.009	-1.859	365	221	-0.017	0.007	-2.385	365	478
Research and advertising cost	0.05	0.073	0.685	108	73	0.086	0.051	1.699	108	124
Gross margin/Turnover	-0.597	0.377	-1.585	350	229	-0.238	0.272	-0.875	350	487
ROI	1.992	1.114	1.816	87	43	1.576	0.765	2.059	87	85

Notes: ATT estimations are given as the difference in growth rates between treated and control firms, except for ROI variable where I consider the difference in levels.

Table 5 presents the average treatment effect on the treated by firms' size. Only medium firms gain the advantage of the subsidy as shown by return on investment, while the large firms can realize their project also in the absence of the incentives.

Table 5. Impact estimation of FTI subsidies by firm dimension (stratification matching)

Small firms					
Outcome variables	ATT	S.E.	t-test	Number of Treated Unit	Number of Control Unit
Turnover	-0.014	0.01	-1.371	191	275
Employment	0.009	0.008	1.173	142	212
Total Fixed assets	0.035	0.019	1.825	196	283
Intangible assets	0.033	0.042	0.771	179	255
Turnover/Employment	-0.026	0.012	-2.257	139	206
Research and advertising cost	0.042	0.103	0.412	41	40
Gross margin/Turnover	0.272	0.475	0.573	152	235
ROI	1.972	1.528	1.291	32	21

Medium firms					
Outcome variables	ATT	S.E.	t-test	Number of Treated Unit	Number of Control Unit
Turnover	-0.018	0.01	-1.808	150	216
Employment	0.009	0.008	1.170	140	208
Fixed assets	0.033	0.015	2.167	153	216
Intangible assets	0.041	0.042	0.991	150	199
Turnover/Employment	-0.008	0.088	-0.709	146	202
Research and advertising cost	0.191	0.107	1.786	40	63
Gross margin/Turnover	-0.361	0.437	-0.826	129	185
ROI	2.363	0.883	2.676	37	48

Large firms					
Outcome variables	ATT	S.E.	t-test	Number of Treated Unit	Number of Control Unit
Turnover	-0.003	0.012	-0.253	77	75
Employment	-0.015	0.014	1.047	75	70
Fixed assets	0.006	0.016	0.389	75	79
Intangible assets	-0.001	0.029	-0.025	76	73
Turnover/Employment	0.009	0.013	0.705	74	72
Research and advertising cost	-0.054	0.104	-0.520	22	27
Gross margin/Turnover	-0.649	0.685	-0.947	66	69
ROI	1.636	2.296	0.713	19	17

Notes: ATT estimations are given as the difference in growth rates between treated and control firms, except for ROI variable which is the difference in levels.

The evaluation of the effects of FTI subsidies on manufacturing sector (table 6) shows a positive impact of subsidy on fixed assets and on research and advertising cost. This suggest that firms invest to increase capital accumulation more than they would do in absence of the incentive. Unfortunately these investment do not produce significant effects on employment and firm performance.

Table 6. Impact estimation of FTI subsidies by sector (stratification matching)

	Only manufacturing				
	ATT***	S.E.	t-test	Treated*	Control**
Turnover	-0.017	0.007	2.415	346	462
Employment	0.004	0.006	0.642	298	409
Fixed assets	0.025	0.010	2.602	349	465
Intangible assets	0.019	0.027	0.709	332	427
Turnover/Employment	-0.009	0.007	-1.234	298	407
Research and advertising cost	0.103	0.062	1.663	90	110
Gross margin/Turnover	-0.145	0.306	-0.473	286	399
ROI	1.069	0.863	1.240	63	73

Notes: ATT estimations are given as the difference in growth rates between treated and control firms, except for ROI variable which is the difference in levels.

The northern and central regions (table 7) show better results than the whole country; the impact is significant positive on employment, turnover, fixed assets and ROI. This effect depend on the different territorial distribution of innovative Italian firms.

Table 7. Impact estimation of FTI subsidies by area (stratification matching)

	Only Northern and Central Regions				
	ATT	S.E.	t-test	Treated*	Control**
Turnover	-0.014	0.007	-1.987	391	545
Employment	0.01	0.005	1.864	336	468
Fixed assets	0.024	0.009	2.545	400	551
Intangible assets	0.018	0.023	0.815	381	499
Turnover/Employment	-0.01	0.008	-1.283	342	461
Research and advertising cost	0.072	0.061	1.183	95	115
Gross margin/Turnover	-0.193	0.275	-0.704	325	462
ROI	1.792	0.838	2.138	75	79

Notes: ATT estimations are given as the difference in growth rates between Treated and Control firms, except for ROI variable which is the difference in levels.

7 Conclusions

This article provides new evidence on the impact of public R&D funds highlighting some positive effects still not came out of previous studies. It is analyzed if the participation to FTI program leads on average to higher performance at the firm level. By means of a non parametric approach, we compare the outcome of subsidized firms to a matched control group of not subsidized ones. The analysis of the effectiveness of the R&D subsidy is carried out using a counterfactual approach: treated firms are matched with control firms for each investigated aspect. The selection of control group is very careful in order to guarantee the closest (reliable) likeness to treated firms.

The information collected in our dataset covers not only administrative data but also balance sheet data for the time before the investment and for the time following the investment.

This has allowed for a deepen analysis of the casual effect of public R&D subsidies. The casual effect identified is significantly positive for employment while it is significantly negative on productivity.

In general, the study doesn't find significant positive effects on turnover, intangible assets and R&D costs. This highlights the absence of additionality of the subsidy. The positive effect on employment can be regarded as the increasing demand of high skilled workers employed in R&D activities. Moreover, subsidies negatively influence labor productivity bringing to light the creation of new job positions to get incentives.

The results change the sign and the level of the impact if we estimate by region, size and economic activity. Central and northern regions can take advantage of this kind of incentive thank to an higher concentration of advanced technological firms that gain a competitive advantage during the assignment of the subsidies and the realization of the investment's project. R&D grant have a positive and significant effect on fixed assets and return on investment (ROI) of the medium subsidized firms while large firms don't take advantage. This result highlight the lack of additionality for large firms: they can get public subsidies more easily than smaller firms and they realize investment that should be realized anyway. In the manufacturing sector, the results support the idea that an increased amount of R&D investment translate into higher levels of profitability at firm's level. They can use own resources to finance the research activities in the core areas of firms' business. In this way the firms can avoid the disclosure of the results of R&D activities and can follow its scheduling according to a more efficient time to market.

The study underline that a positive effectiveness of the R&D subsidy characterized only some areas of the country, those with an higher development level and a good technological level that is an important base to design successfully R&D project that can be subsidized. Medium firms are able to overcome entrance barriers to realize R&D activities only with financial aids.

The conclusion of the study is still ambiguous: we have some issues to deal with to achieve a more comprehensive result. First of all, to improve the propensity score estimation controlling for more covariates able to differentiate treated and non treated firms, in order to reduce the selection bias effect. In this way, it could be useful to get information about firm's previous experiences in the field of technological innovation and R&D activities. Second, R&D investment can be influenced by the neighbouring innovation firms that can set barriers to entry and to get high skill workers.

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