Are Regional Policies Effective? An Empirical Evaluation on the Diffusion of the Effects of R&D Incentives[*]

Daniele Di Gennaro[†] Guido Pellegrini[‡]

[*] The Authors are grateful to Dr. Giovanni Cerulli for his helpful review of the text. The authors wish to thank Dr. Marta Scettri and the Umbria Regional Centre of Statistics and Evaluation of the Investment for the provision of the data and their useful collaboration. We would also like to thank the participants at the 2nd Doctoral Workshop in Economic of Innovation, Complexity and Knowledge and the XXXVI Annual Conference of AISRE for their useful suggestion. However, the views expressed in this paper are solely those of the authors.
[†] Department of Political Science, Roma Tre University, e-mail: daniele.digennaro@uniroma3.it
[‡] Department of Social Sciences and Economics, Sapienza, University of Rome, e-mail: guido.pellegrini@uniroma1.it

Are Regional Policies Effective? An Empirical Evaluation on the Diffusion of the Effects of R&D Incentives

“Evaluating Public Policies Special Issue”

Abstract

This paper provides evidence on the effectiveness of R&D incentives to private firms allocated by Region Umbria in the period between 2004 and 2009. The methodological innovation proposed in this paper is a novel spatial Difference-in-Difference estimator. Our approach compares distinct treatment effects on the basis of the localization in the main local market areas of Umbria (Perugia and Terni), controlling for the presence of technological spillovers due to geographical and economic proximity. The results show a positive and statistically significant impact of the subsidies, especially for innovative outputs and for small firms. The impact is higher for the firms located in less concentrated areas, suggesting the presence of significant local technological and economical spillovers due to the conjunct action of regional policies and spatial diffusion of the activities. Finally, this paper provides some empirical evidence in favour of the effectiveness of “place-based” innovation policies which constitutes the “core" of the recent smart specialization strategy.

Keywords: *SUTVA*; *spillovers; policy evaluation; Diff-in-Diff; regional policies*

JEL: R58; C21; O38

1 Introduction

In recent years, regional R&D policies cover an increasingly relevant role in stimulating innovation. Moreover, EU strategy aims to foster a *“smart, sustainable and inclusive growth”* in the less developed areas by means of innovation policies oriented to the identification and development of areas of specialization. The scope is to promote growth in areas characterized by comparative advantages and the formation of network externalities (Foray et al., 2011).

The strengthening of regional policies as tools to enhance innovation and growth has a twofold justification. A stream of literature highlights how "place-based" policies, supported by institutional reforms and well-informed local governments, stimulate the commitment of the stakeholders, i.e. firms, research centres, universities and local authorities, with beneficial effects on local development and, potentially, on the entire economic system (Barca 2009; OECD 2009b; Garcilazo and Oliveira Martins 2015; Kempton 2015). Crescenzi and Rodríguez-Pose (2011) propose a conceptual framework to justify "place-based" policies as a vehicle for local development and instrument of coordination among different type of policies both at national and regional level. Furthermore, "place-based" policies are usually implemented in favour of lagging areas to stimulate labour market participation and skills. This may provide a stimulus to local development and may increase the degree of connectivity between developed areas and peripheral regions in order to maximize knowledge spillovers and, in wider terms, innovation[1] (OECD 2009a). Interestingly, place-based policies may foster spillovers formation not only on the basis of geographical space. On this point, Dechezleprêtre et al (2016) demonstrate the occurrence of technological spillovers by considering sectoral distance, i.e. unaffected firms operating on the same sector of the treated ones improves their number of patents. Overall, "place-based" policies tend to emphasize the role played by public administrations; their intervention includes the provision of the incentives, the identification of the locations where regions have a comparative advantage and the recognition of the presence of investments in backward areas (Foray 2009).

In this paper we evaluate the effects of a broad range R&D regional policy in Umbria, a small region located in Central Italy. We develop a "place-based" approach by the identification of areas of specialization in order to assess the "additional" impact of public policies promoting R&D activities of the firms. Our approach focuses on the creation of spillovers due to the relative proximity of the firms, considering both the geographical and the sectoral proximity. We restrict the analysis only to the effects of regional policies, controlling for the presence of any national and EU incentives The most relevant Italian empirical literature on R&D subsidies provides contradictory indications: the positive impact of the incentives is suggested by some evaluation studies, in particular with a greater efficacy limited to the SMEs (Merito,

[1] Neumark and Simpson (2015) propose a summary on the potential benefits of place-based policies, i.e. agglomeration and network effects, equity, industrial clusters. However, they remark how literature does not provide evidences in favour of the major efficiency of place-based policies if compared with broader incentives.

Giannangeli, and Bonaccorsi 2007; Bronzini et al. 2008), while many others show no additionality (Accetturo and Blasio 2008; De Blasio, Fantino, and Pellegrini 2015; Andini and De Blasio 2014, Mariani and Mealli 2018). Sometimes additionality is attributed to a process of inter-temporal substitution that leads companies to anticipate investment in R&D (Bronzini and Blasio 2006).

Despite the wide and heterogeneous literature on empirical analyses at national scale[2], works focused on the evaluation of regional innovation policies are still scarce. Gabriele et al. (2007) and Corsino et al. (2012), analysing the case of Trentino-South Tirol, underline an increment on the stock of capital with beneficial effects on the access to new market opportunity without consequences on factor productivity and profitability. Fantino and Cannone (2014) provide evidence on the effectiveness of policies as instruments to foster short term investments, especially for the smallest firms and the ones with a low credit rating. Bronzini and Iachini (2014), examining R&D incentives in Emilia-Romagna, show positive effects of the policies limited to the investments of small enterprises. Similar results are obtained by Bronzini and Piselli (2016) which demonstrate a significant and positive impact on the number of patents of small firms. Bertramino et al. (2017), studying the case of Italian Technological Districts, underline how firms performing better, both in terms of profitability and innovativeness, are more likely to join the districts, while be part of the same do not affect positively performances.

The main innovations of this work concern two particular aspects related to the methodological approach and the dataset used. The first novelty consists in the evaluation of the global effect of the policies, by identifying the occurrence of spillover effects. Therefore, we develop a ”novel” approach that allow for differentiated interactions between the firms on the basis of their geographical localization and market concentration.

The second crucial point introduced in this work relies on the availability of Community Innovation Survey (from now, CIS) micro-data[3]. Despite the relevant amount of information

[2] For further information on evaluation studies at national scale see the surveys in David, Hall, and Toole (2000), Hall and Van Reenen (2000), Cerulli (2010) and Zúñiga-Vicente et al. (2014).

[3] The Community Innovation Survey (CIS) are carried out with two years' frequency by EU member states and number of ESS member countries. The CIS is a survey of innovation activity in enterprises. The harmonized survey is designed to provide information on the innovativeness of sectors by type of enterprises, on the different types of innovation and on various aspects of the development of an innovation, such as the objectives, the sources of information, the public funding, the innovation expenditures, etc. The CIS provides statistics broken down by type of innovators, economic activities and size classes (Eurostat).

included in the CIS and the comparability with results of studies involving other European countries, only a limited number of works utilize this data to evaluate the effects of public policies (Cefis and Evangelista 2007; Cerulli and Potì 2012; Marzucchi and Montresor 2013; Becker and Bizer 2015). The innovation introduced in this paper consists in merging the micro-data of the CIS with balance sheet data and a questionnaire administered by the Regional Public Administration of Umbria. In this way we obtain complete and detailed information on technological structure, R&D process, economic and financial situation of the firms.

The remainder of the paper is organized as follows. The second section proposes a detailed analysis of the data, including a description of the characteristics of the policies and the firms considered; the third section introduces the proposed methodological framework with a focus on the distinction between traditional and our novel approach. In the fourth section we present the results of the estimates, whereas the last section is devoted to test the validity of the common trend assumption in order to confer robustness to our results. The conclusions and the policy implications are at the end of the paper.

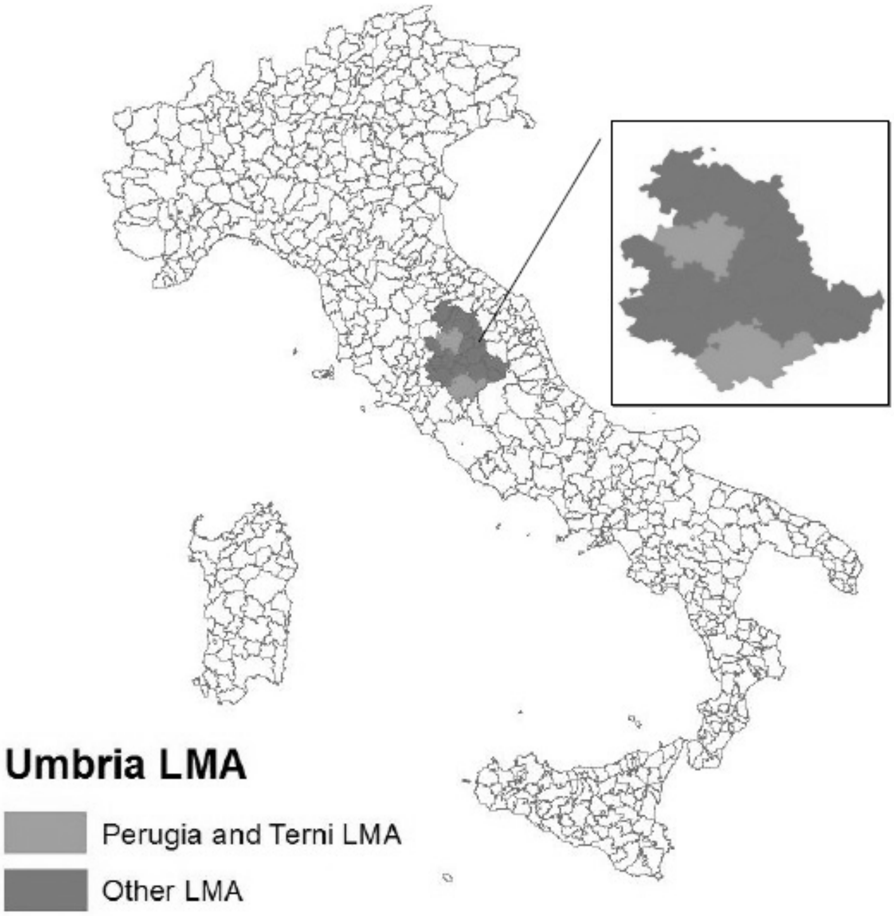
2 Data Analysis

Labour Market Areas

This paper focuses on the evaluation of place-based policies in Umbria, a small region located in Central Italy. Considering the limited geographical dimension of the region, we are not able individuate the "better-performing" areas on the basis of the traditional administrative division of the territory, like municipalities or provinces. In this sense, the identification of more developed local areas requires the preliminary determination of an alternative subdivision of regional territory to take into account the presence of relevant demographic and economic agglomeration. For this reason, the territorial grid that best suits the purposes of this study is based on the Labour Market Areas[4] (from now LMAs). Umbria Region is composed by 14 LMAs, many of which characterized by a reduced size, both geographical and economical, that does not allow to fully grasp the presence of externalities.

[4] Labour market areas (LMAs, "local labour systems" or Sistemi Locali del Lavoro) are sub-regional geographical areas where the bulk of the labour force lives and works. They respond to the need for meaningfully comparable sub-regional labour market areas for the reporting and analysis of statistics. LMAs are defined on a functional basis, the key criterion being the proportion of commuters who cross the LMA boundary on their way to work (ISTAT). An important characteristic of the LMA is that the areas are not overlapping and cover the entire region.

Figure 1: Italian Labour Market Areas



Legend: Geographical Distribution of Umbria LMA in the overall Italian context.

Figure 1 shows the limited dimension of Umbria LMAs compared to the Italian territory. While, the average size of Umbria LMA is small, it emerges clearly how the presence of two main LMAs, i.e. the areas surrounding the city of Perugia (on the North) and Terni (on the South).

Notwithstanding the limited average dimension of the LMAs, Table 1 confirms the evidence of two major areas, Perugia and Terni, where population and industrial production tend to be more agglomerated. In this sense, the localization in one of the main LMAs may cover a determinant role in the evaluation of the effectiveness of regional policies. Starting from this assumption, we want to analyse how industrial concentration influences R&D processes and the formation of technological and economical spillovers.

Table 1: Demographical and Economic Characteristics of Umbria LMAs

Denomination	Population	Employed	N. of jobs	Int. Movements	Demand	Supply	Municipals
Assisi	57640	20698	20269	14934	0.74	0.72	4
Cascia	6489	2029	1825	1635	0.9	0.81	4
Castiglione	24955	8022	7073	5132	0.73	0.64	3
Città di Castello	56075	20477	19496	16643	0.85	0.81	4
Foligno	85262	28145	26743	22145	0.83	0.79	6
Gualdo Tadino	31476	9689	8407	6824	0.81	0.7	6
Gubbio	33874	11095	10038	8883	0.88	0.8	2
Norcia	7934	2376	2426	1959	0.81	0.82	4
Perugia	243653	87072	91796	77890	0.85	0.89	9
Spoleto	45688	14713	15253	12470	0.82	0.85	6
Todi	37854	11611	10527	8278	0.79	0.71	7
Umbertide	20326	6973	7001	4980	0.71	0.71	3
Orvieto	42983	13461	12801	11166	0.87	0.83	12
Terni	178862	57036	55633	52020	0.94	0.91	18

Source: Quality Indicator of Umbria LMAs (Istat, 2011)
Note: Employed (Number of Jobs) indicates the number of occupied people living (working) in LMA; while Internal Movements represents people that lives and works in their own LMAs. Supply (demand) column represents the ratio between internal movements and Resident Employed (Number of Jobs).

Dataset

Since the 6th Framework Programme (FP6, 2000-2006) Umbria Region has developed a number of strategic actions to sustain the creation of business networks and improve their links with research centres. From 2004 the measures implemented by the Region encouraging entrepreneurial and territorial competitiveness are included in the so-called ”competitiveness package”. In order to assess the additionality of “place-based” policies on technological and economic performances of the firms, we take into account only the instruments directly provided by the Region. Regional measures can be distinct in three different packages: calls for investment in technological innovation, Law N. 598/1994; calls for integrated packages of benefits (Pacchetti Integrati di Agevolazioni, PIA); calls to promote the creation of stable networks of enterprise (Re.Sta.). Umbria, in the period between 2004 and 2009, provided over €120 million to the businesses split into 14 calls. Given the presence of more than one ranking in some calls, we have observed a total amount of 17 announcements.

Table 2: Number of funded projects per announcement

Announcement	N. projects	Overall Funds	R&D funds
RESTA 2007	15	1 457 578	432 330
RESTA RICERCA 2007	69	9 519 586	2 992 390
RESTA INNO 2007	64	4 055 532	0
RESTA INNO 2008	28	2 825 528	0
RESTA RICERCA 2008	37	3 922 551	2 520 110
RESTA MODA 2009	32	981 169	0
RESTA RICERCA 2009	43	5 960 492	3 319 415
PIA 2004	37	5 313 663	1 781 310
PIA 2006	47	6 637 302	2 038 105
PIA 2007	187	27 672 951	4 572 935
PIA RICERCA 2008	56	10 156 096	6 478 780
PIA INNO 2009	45	7 036 432	0
L. 598/94 2004	32	6 701 330	6 701 330
L. 598/94 2006	41	6 407 565	6 407 565
L. 598/94 2007	74	10 021 750	10 021 750
L. 598/94 2008	49	6 660 275	6 660 275
L. 598/94 2009	59	9 088 240	9 088 240
TOTAL	**915**	**124418039**	**63014535**

Source: Core of Statistics and Evaluation of the investment, Regione Umbria.
Note: This table resumes the overall financial commitment of the Region to the SMEs in order to improve their competitiveness, pointing out the number of funded projects for each announcements. In the last column is reported the incentives devoted directly to R\&D activities.

However, firms' involvement on public funding opportunities appears limited. Indeed, the analysis of participation rate of the firms (number of calls on which each firm has obtained funding) shows that the majority of them have participated in a single call, while few are the companies that have received funding on more than 3 calls. Regional aid for competitiveness provides support for 915 projects, of whom 476 directed to R&D activities. In this paper we consider only the incentives to R&D in defining the considered treatment variable. In this way, we isolate 253 financed firms which constitutes the factual sample.

Table 3: Summary of public policies by objective

	Aid for competitiveness	Aid for R&D activities
N. Public announcement	17	14
N. Financed Firms	575	253
N. Financed Projects	915	476
Total contributions	**124 418 039**	**63 014 535**

Source: Core of Statistics and Evaluation of the investment, Regione Umbria
Legend: Resume of policies implemented by Umbria between 2004 and 2009.

On the other hand, the counterfactual sample was identified on a list of 148 companies selected by the method of the matching pairs[5]. In this way, we obtain a final dataset composed by 401 firms. The objective of obtaining detailed information on economic and financial accounts and on the main characteristics of the production process, in particular those related to innovation and investments in R&D, requires the merging of data from different sources.

The economic and financial accounts are considered by the balance sheet data for the years between 2004 and 2011 and provided by the Infocamere archives, while information on technological processes are extracted from the questionnaire and the micro-data of the Istat annual survey (i.e. CIS) on R&D. Besides, CIS data allow to identify pairs of companies subsidized and non-supported on the basis of their propensity to innovate. The baseline year of this analysis is 2005. This choice can be motivated in a twofold way. On one hand, balance sheet data provide a limited amount of information on firms' economic data for 2004. On the other hand, the policies are mainly concentrated between 2006-2009 (90% of overall R&D funding).

Table 4 highlights the different economic structure between treated and controls. The firsts exhibit, in average, better results on the profitability indicators (ROE and ROI). On the other hand, the untreated show greater values on turnovers, mean number of employees and net assets. To check for significant discrepancies between the two samples we implement a mean comparison test, that confirms, in overall, the absence of structural differences in the baseline period. Systematic differences are found in terms of net assets and ROI; this result, by itself, does not bias the estimates of the difference-in-difference, but requires additional robustness check to evaluate if these discrepancies can affect the validity of the "common trend" assumption. Moreover, to confer additional robustness to the results obtained we provide differentiated estimates for small firms (i.e. less than 50 workers) and the ones operating in

[5]Our data set is based on the sample that is used by Istat to the Community Innovation Survey. The sample includes all the firms that are subsidized by the region and a group of not subsidized firms with comparable characteristics. All the larger firms are in the sample. The sample is defined and constructed by Region Umbria. The treated firms are all the R&D subsidized firms in Umbria in the period 2004-2007. The not treated firms are identified among firms located in Umbria in the same period that have the same economic characteristics of the treated ones. The following variables are used: number of workers, turnover, economic sectors, location, profitability. A stratification exact matching based of these characteristics was used. The variables were discretized if necessary, and for each stratum, determined by the different modalities of the selected variables, the not subsidized firms with the same characteristics were identified.

manufacturing sector. In this way, we are able to consider more homogeneous samples and introduce the possibility of intra-sectoral technological spillovers.

Table 4: Summary Statistics by Treatment-Economic Variables (2005)

	Treatment	Mean	Std. Err.	Difference in means
Turnover	0	12 996 575.00	2 740 826	4 128 271
	1	8 868 304.00	1 752 325	[3 102 912]
Employees	0	53.50	6.50	4.2
	1	49.30	5.80	[9.1]
Capital assets	0	4 576 935.00	1 338 821	1 722 595
	1	2 854 341.00	554 093	[1 255 488]
Intangible assets	0	753 746.00	470 290	464 352
	1	289 393.00	67 183	[371 326]
Net assets	0	9 471 459.00	1 746 489	3741262*
	1	5 730 197.00	897 238	[1 778 125]
ROE	0	0.28	0.35	-0.52
	1	0.81	0.38	[0.56]
Ebitda	0	949 779.00	219 093	155 031
	1	794 748.00	128 246	[237 002]
ROI	0	2.65	0.66	-2.35*
	1	5.00	0.81	[1.17]
Added Value	0	2 435 978.00	385 156	340 545
	1	2 095 433.00	303 563	[493 224]
Added Value per Employee	0	40 635.00	3 272	-14 784
	1	55 420.00	11 745	[15 413]
Turnover per Employee	0	231 696.00	46 494	-60 602
	1	292 298.00	97 795	[131 597]

Legend: "Difference in Means" reports the difference between the average of control and treatment group, while standard errors are in square bracket. The level of statistical significance of the mean comparison test is indicated with: * 0,05

While treated and control groups do not present significant differences in terms of economic performances, a further analysis on technological and R&D variables is required. Indeed, defining the state of treatment on the basis of having received, or not, R&D subsidies may induce a different propensity on innovation and R&D activities between the two groups. Table 5, by comparing treated and not treated firms, shows how, on average, receiving R&D subsidies increase technological-related expenditures. However, in this paper we take into account the different R&D structure between the two groups by considering only if a firm is involved, or not, in a specific R&D activities. In this way, we are able to control for the major expenditures on technological variables due to the treatment.

Table 5: Summary Statistics by Treatment-R&D Variables (2005)

	Treatment	Mean	Difference in Means
Personnel Cost R&D	1	462.069	239.887
	0	222.182	[0.083]
Total R&D extramuros Expenditure	1	64.966	33.875
	0	31.091	[0.398]
Total R&D intramuros Expenditure	1	611.862	283.953
	0	327.909	[0.114]
Total Current Expenditure	1	563.517	287.790
	0	275.727	[0.072]

Legend: Values are expressed in terms of Thousand of Euro. "Difference in Means" reports the difference between the average of control and treatment group, while p-values are in square bracket.

In the next section we present the ”standard” DID and our ”novel” approach that, considering the geographical localization, allows for differentiated effects on the basis of firms concentration.

3 Methods

In this paper we evaluate the additionality of regional policies by a “counterfactual” approach. The limited number of observation and the temporal discontinuity across the period 2004 and 2011 in available data[6], i.e. unbalanced panel, makes preferable an estimation procedure based on a Diff-in-Diff method[7], i.e. the impact of a policy is computed using a “double difference”, in time (pre-post treatment) and between subjects (treated and control). However, the validity of this approach requires un-testable assumptions. Indeed, the results of methodologies based on single difference are characterized by the “*selection bias*”, while if what differentiates treated and controls does not change over time, the Diff-in-Diff eliminates the selection bias and produces correct estimates of the policies effects. In other words, the un-testable assumption in DID approach is that the differences between the groups are constant over time; thus, without treatment, there would not be differences in behaviour between the groups.

[6] Temporal discontinuity on available data is attenuated by considering the years 2005 (pre-treatment) and 2010 (post-treatment).

[7] Detailed information on the difference in difference approach and its development can be found in: Ashenfelter and Card, 1984; Abadie, 2005; Bertrand, Duflo, and Mullainathan, 2004; Donald and Lang, 2007; Athey and Imbens, 2006; Puhani, 2012; Mora and Reggio 2012.

To implement the DID approach we estimate equations of the type:

$$(1) \qquad y = \beta_0 + \beta_1 T + \beta_2 P + \beta_3 T * P + \varepsilon$$

where y denotes the outcome of interest, T and P are dummy variables equal, respectively, to 1 for the treated units and for the post-treatment period. Under the SUTVA assumption we can estimate the Average Treatment Effect (ATE):

$$(2) \qquad ATE = \{E[y_i|T_i = 1, P_i = 1] - E[y_i|T_i = 1, P_i = 0]\} - \{E[y_i|T_i = 0, P_i = 1] - E[y_i|T_i = 0, P_i = 0]\}$$

The analysis focuses on a 5-years period, where P=0 refers to 2005 and P=1 to 2010. This choice is optimal since most of the instruments provided by the region has been delivered in 2007. In this way we can correctly define both pre and post treatment periods. A relevant issue related to the evaluation of the effects of R&D subsidies consists in the diffusion of technological spillovers, i.e. potential benefits which may arise also for non-treated units due to the combined action of the policies, business location and economic sector. The identification of the spillover effects, however, requires a partially relaxed version of the SUTVA (Stable Unit Treatment Value Assumption) hypothesis.

Indeed, evaluation strategies based on the SUTVA rely on the assumption that the response of a particular unit depends only on its assigned treatment, and not on the treatments received by the others, i.e. absence of interferences between units (Rubin 1974). However, there are circumstances in which invoke the validity of the SUTVA could not be plausible. For instance, considering two firms located in the same area and part of the same competitive market and assuming that only one of them receives public incentives, the benefits of the subsidized one can be shared, indirectly, even by the other (i.e. the untreated one).

Recently an increasing number of studies focuses on the cases in which the assumptions at the basis of the SUTVA are violated in order to find a methodological approach that includes the presence of interactions between units[8]. Research on drawing inference on causal effects in

[8] Manski (1993) explains how the impossibility to distinguish between endogenous and contextual interactions and the possible presence of correlated effects reveals the so-called "Reflection Problem". The author refers to endogenous effect as the contemporaneous and reciprocal influences of peers, meanwhile the contextual effect includes measures of peers unaffected by current behaviour. The identification problem arises because mean behaviour in the group is itself determined by the conduct of group members. Possible approach in order to take into account the identification problem includes the restrictions on the shape of the response function (Manski 2013), estimation of structural interaction effects by means of a spatial autoregressive model (Lee 2006), binary treatment model with "endogenous" neighbourhood effects (Cerulli 2015).

presence of interferences is not yet common, although some exceptions exist (Verbitsky and Raudenbush 2004; Sobel 2006; Rosenbaum 2007; Tchetgen and VanderWeele 2012; Hudgens and Halloran 2012; Kao et al. 2012; Sinclair, McConnell, and Green 2012; De Castris and Pellegrini 2015; Di Gennaro and Pellegrini, 2017; Giua 2017; Cerqua and Pellegrini, 2017; Fiaschi et al. 2018)[9].

However, most of the existing works are theoretical, focalized on randomized experiments or based on the combination of spatial and counterfactual models. In this paper we develop an approach similar to the one proposed by Cerqua and Pellegrini (2017). The authors propose a partially relaxed version of the SUTVA that take into account the interactions between the untreated firms; they distinguish non-recipient firms considering their exposition to the subsidized ones and evaluate the spillover effects by a comparison between the affected ones and the others. The peculiarity of our approach is to assume the validity of the SUTVA only outside "best-performing" regional LMAs, i.e. Perugia and Terni, in relation to their geographical localization[10]; while we allow the presence of interactions within the groups. As previously explained, the identification of major LMAs relies on demographic, economic and labour market concentration.

Therefore, our assumption imposes the restriction that interferences between subsidized and not subsidized firms are relevant only inside the LMA and not significant outside. In other words, we are assuming that technological spillovers due to regional policies depends from the presence of spatial agglomeration of economic activities (Andersson et al, 2016). The interferences are introduced in our empirical framework through an additional dummy variable (LMA), which represent Perugia and Terni LMA, and the interaction term with treatment and temporal variables.

[9] New advancements in the field of causal inference using the DID approach in a spatial context are: Delgado and Florax (2015), Chagas et al. (2016) and Di Gennaro and Pellegrini (2016)

[10] Rosenbaum (2007) remarks how the interference can be expressed as a function of proximity between units. Appropriate measure of proximity can be: geographical distance, nodal distance in a known social network, metrics of social or economic distance. Nevertheless, we focus only on the geographical dimension of the interferences between units, many are the studies that consider alternative measures of proximity on the identification of causal effects. Brock and Durlauf (2007), Cerulli (2015) and Arduini, Patacchini, and Rainone (2014) focus on social interferences, meanwhile Arpino, Mattei, and others (2013) model interferences as a function of firms size and geographical distances.

This framework allows to estimate two specific causal effects:

Average Treatment Effect using the Influenced Controls (ATEIC):

(3) $$ATEIC = \{E(y_i|T_i = 1, P_i = 1, LMA = 1) - E(y_i|T_i = 1, P_i = 0, LMA = 1)\} - \{E(y_i|T_i = 0, P_i = 1, LMA = 1) - E(y_i|T_i = 0, P_i = 0, LMA = 1)\}$$

Average Treatment Effect using the Uninfluenced Control (ATEUC):

(4) $$ATEUC = \{E(y_i|T_i = 1, P_i = 1, LMA = 1) - E(y_i|T_i = 1, P_i = 0, LMA = 1)\} - \{E(y_i|T_i = 0, P_i = 1, LMA = 0) - E(y_i|T_i = 0, P_i = 0, LMA = 0)\}$$

ATEIC and the ATEUC allow for diversified impacts, depending on the choice of the controls. ATEUC, considering control units in smaller regional LMAs, gives us the impact of the subsidies, while the ATEIC, calculated on Perugia and Terni non-subsidized firms, is a measure of the error in the estimation of the effects when we assume wrongly the validity of the SUTVA. This intuition is a consequence on the restriction of interferences. Indeed, assuming the relevance of interferences only inside Perugia and Terni allows to identify the spillover effects as the difference between ATEIC, i.e. the effect in presence of interferences, and ATEUC, i.e. treatment effect when interferences are not considered[11].

While control units are differentiated if they are located or not in greater regional LMAs, in estimating ATEIC and ATEUC we consider only treated firms in Perugia and Terni areas[12]. In doing so, we implicitly assume the occurrence of unidirectional technological spillovers which may arise from Perugia and Terni LMAs to other areas, and not vice versa.

4 Results

In this section we provide evidence on the effectiveness of public policies in Umbria, analysing the presence of technological spillovers due to the conjunct action of regional aid and market concentration. This operation requires the empirical evaluation of the three distinct treatment effects (ATE, ATEIC, ATEUC) presented in the previous section. Following the suggestion in

[11] However, the method we use does not allow to estimate properly the intensity of these effects. Indeed, we have not imposed restrictions on the sample of influenced and not influenced firms. In other words, we do not match directly these two groups of firms, and therefore we are not completely sure that the difference between the ATEIC and ATEUC is not marginally affected by differences in the characteristics of influenced and not influenced firms.
[12] ATE estimate considers the entire treated and control group, independently from the location or not in Perugia and Terni LMAs.

Neumark and Simpson (2015) to better understand overall effects of the policies we extend our analysis to a wider range of outcomes, i.e. policies targeted to innovation and R&D processes may have an impact not only on technological variables, but also on profitability and firm's workforce. In doing so, Table 6 shows the results for technological and economic variables[13].

The estimates demonstrate the presence of additional effects for innovation and technological processes, but scarce results on economic performances. Firstly, we assume the validity of the SUTVA, considering the effects using the ATE on all LMAs. The results indicate a major propensity to R&D process for the treated, both for internal and external research. This higher propensity is confirmed by the positive and significant impact of the policies on patents, innovation of product and production process, the development of better logistic systems and the acquisition of machinery, equipment and software. Furthermore, treated firms demonstrate a greater propensity to operate in international markets, in contra-position of a regional tendency of the controls.

The international openness of the subsidized firms highlights the improvement of their relative competitiveness in regional market, making it more dynamic and global. Instead, the limited impact on firms' performance is in line with Italian literature (Bronzini and Piselli, 2016; Corsino et al.,2012). ATEIC results, i.e. when SUTVA is not valid, are similar in size and statistical significance. The comparison between the ATEIC and ATEUC allows to identify the direction of technological and economic spillovers on the treated firms due to regional policies and market concentration (column ATEIC-ATEUC). However, given the method we have used for the estimation, we cannot exactly quantify the dimension and test its statistical significance.[14]

[13]A description of Innovation and Technological variables is in Appendix. Performance Variables are defined following the traditional definition in balance sheet and are expressed in Euro.
[14] This analysis would have required a statistical matching among treated and not treated for each LMAs, that was not possible given the limited size of the control sample.

Table 6: Results

Input Variables at Innovation and R&D				
	ATE	ATEIC	ATEUC	ATEIC-ATEUC
Employes R&D	1.43	3.48	0.05	3.43
R&D intramuros (%)	36.56***	46.62 ***	31.29 ***	15.33
R&D extramuros (%)	45.68***	48.65 ***	54.87 ***	-6.22
Machine,equipment,software(%)	20.69 ***	21.82**	13.35	8.47
Output Variables at Innovation and R&D				
	ATE	ATEIC	ATEUC	ATEIC-ATEUC
Product (%)	26.31 ***	29.87 ***	24.07 ***	5.8
Service (%)	2.59	9.58	-3.7	13.28
Production Process (%)	22.47 ***	30.68 ***	17.18	13.5
Logistic System (%)	16.16**	14.44	25.42*	-10.98
Patent (%)	25.66 ***	25.85**	28.36**	-2.51
Protection design and model (%)	8.28	9.82	13.26	-3.44
Regional Market Share (%)	-16.98 ***	-12.55	-17.1*	4.55
National Market Share (%)	5.88	1.47	6.77	-5.3
EU Market Share (%)	2.38	3.45	5.69	-2.24
Non-EU Market Share (%)	9.36 ***	8.86 ***	7.09*	1.77
Performance Variables				
	ATE	ATEIC	ATEUC	ATEIC-ATEUC
Output Value	-1660703	-3036829	-1033338	-2003491
Personnel Costs	-119255	-118806	-523622 ***	404816
Amortization	215765 ***	287742**	188119	99623
Added Value	117942	88808	-183487	272295
Ebitda	237197	207614	340135*	-132521
Ebit	81873	-3083	155234	-158317
ROI	0.34	-0.98	-1.27	0.29

Legend: *Diff-in-Diff estimates refers to the period 2005-2010. Column* ATEIC-ATEUC *is built by differencing ATEIC-ATEUC. For ATE, ATEIC and ATEUC: *** 99 %, ** 95 %, * 90 %*

This comparison evidences some interesting differences on technological processes between influenced and uninfluenced units[15]. When the difference between ATEIC and ATEUC is positive (negative) we provide evidences in favour of the occurrence of negative (positive) spillover effects on influenced firms. Results show that firm concentration plays a determinant role in the choice between internal and external research; influenced firms tend to develop external research (for instance, using the subsidized firms), while the uninfluenced units highlights a greater propensity on internal research.

[15]Remark that the differences between this two samples depend on the geographical localization of the units. With the term *"influenced"* we indicate the unsubsidized located in Perugia and Terni LMAs, while the *"uninfluenced"* are the controls in the other LMAs.

A second insight regards the differentiated output of R&D activities for influenced and not influenced. Control units in major LMAs are less involved in product and production process innovations. Conversely, uninfluenced firms show a lower attitude on improving their logistic systems. The third consideration regards the presence of a negative and significant effect on personnel costs for the controls located outside the influence areas of the treated. Recombining the results of the estimates in a unique framework, we can identify some interesting characteristics on the dissimilarities on technological process between firms located inside and outside the influence area of the treated.

Summarising, the influenced controls tend to externalize their research activity, with a small reduction on the number of employees to R&D. The lack of internal activity is reflected in a lower propensity to product and process innovation and the improvement in their logistic systems to improve the connection with other economical agents, i.e. firms, research centre and universities, involved in joint innovation activities. The unifluenced, taking into account also the less concentrated market in which they operate, improve their capital assets (i.e. positive effect on the acquisition of equipment and machinery) to implement internal R&D activities and develop independently their innovative products, with a number of firms which improves their production processes and services materials higher in comparison with the uninfluenced ones. This is confirmed by larger R&D personnel expenses, symptomatic of an higher requirement of qualified and expensive human capital. In conclusion, we can gather that the uninfluenced tend to create and develop some forms of research network in order to counteract their involvement in a less concentrated market.

Results by Group

The results presented in the previous section highlight the presence of some technological spillovers. However, the peculiarities of the regional productive structure require an in-depth analysis. RUICS (2009) indicates the lack of large firms as one of the main structural problem in the region, highlighting a reduced average size of the regional enterprises. Additional estimates limited only to the sample of small firms are therefore useful. Furthermore, following Dechezleprêtre et al (2016), which demonstrate the relevance of sectoral distance in evaluating spillover effects, we present results limited to manufacturing sector.

Small firms estimates highlight a higher additional impact of regional policies. Treated firms demonstrate a lower propensity to operate on regional market, while they are more involved in both internal and external research. The effects on economic variables are still limited, even if the impact on net assets is positive and significant. Moreover, the results provide evidence in favour of the occurrence of spillover effects. The most significant effect is related to the expenditure components. The wide ATEUC reflects the fact that small firms located outside the main LMAs invest less than the influenced controls, especially in external research activities. Interestingly, being part of joint research activities improves substantially the innovative output for influenced units, i.e. negative spillover effects on R&D output. Conversely, the estimates suggest the preference for the uninfluenced to implement internal research.

Table 7: Results by group

	Small Firms			Manufacturing		
Input Variables at innovation and R&D						
	ATEIC	ATEUC	ATEIC-ATEUC	ATEIC	ATEUC	ATEIC-ATEUC
Employees R&D	6.07	4.32	1.75	-0.21	-4.53	4.32
R&D intramuros (%)	53.38***	35.33***	18.05	39***	20.82*	18.18
R&D extramuros (%)	54.73***	59.51***	-4.78	34.6 **	52.79***	-18.19
Total research expenditures	-49.97	119.54 **	-169.51	189	-385.54	574.54
Output Variables at innovation and R&D						
	ATEIC	ATEUC	ATEIC-ATEUC	ATEIC	ATEUC	ATEIC-ATEUC
Product (%)	32.37***	33.48***	-1.11	14.37	5.28	9.09
Service (%)	-2.17	-8.42	6.25	15.84	11.29	4.55
Production Process (%)	30**	18.89 **	11.11	43.64***	16.36	27.28
Logistic System (%)	20	26.94*	-6.94	27.88*	36.97**	-9.09
Patent (%)	26.81**	30.98 **	-4.17	20.53	29.62*	-9.09
Protection design and model(%)	8.45	13.32	-4.87	7.04	7.04	0
Regional Market Share (%)	-14.72*	-22.18 **	7.46	-1.25	1.38	-2.63
National Market Share (%)	3.68	11.77	-8.09	-2.95	0.55	-3.5
EU Market Share (%)	4.7	5.31	-0.61	-3.31	-3.03	-0.28
Non-EU Market Share (%)	8.03 **	6.31*	1.72	9.51*	6.05	3.46
Performance Variables						
	ATEIC	ATEUC	ATEIC-ATEUC	ATEIC	ATEUC	ATEIC-ATEUC
Output Value	-101256	-366314	-2003491	1757665	-1193062	2950727
Personnel Costs	-78578	-53972	404816	95516	-703631**	799147
Amortization	70674*	88316**	99623	387028*	204118	182910
Added Value	-45215	-37722	272295	160838	-193869	354707
Ebitda	33363	16250	-132521	65322	509762*	-444440
Ebit	-37431	-132708	-158317	-108669	332410	-441079
ROI	-0.93	-1.6	0.29	-2.32	-1.24	-1.08

Legend: *** 99 % Significativity, ** 95 % Significativity, * 90 % Significativity.

Note: *Diff-in-Diff estimates refers to the period 2005-2010. "Small firms" includes only the enterprises with a number of employees between 10 and 49. The definition of manufacturing sector follows the ATECO 2007 classification (Nace rev.2). Column* ATEIC-ATEUC *is built by differencing ATEIC-ATEUC.*

Analysing manufacturing[16] sector, we provide weak evidence in favour of the development of spillover effects on technological process, limited to negative impacts on production process and positive effects on the development of new logistic system, i.e. output to enhance external research, and the number of firms which register at least one patent. In overall, the estimates on the manufacturing highlight how the uninfluenced controls present better technological and financial performances if compared with the influenced untreated, highlighting the occurrence of negative externalities due to the localization in a more concentrated market.

5 Robustness check

A correct implementation of the DID approach relies on the validity of the "common" trend assumption; i.e. the trend in the outcome variable for both treatment and control groups during pre-treatment period does not differ. Thus, in absence of treatment, there would not be differences in behaviour between the two groups and the deviation on temporal trend after the treatment identifies the treatment effects. This assumption plays a fundamental role in the implementation of the Difference in Difference estimators. To test the validity of the common trend assumption we evaluate if the growth rate for treated and controls outcomes follows parallel paths during the pre-treatment period.

Table 8: Robustness Check

	ATE	ATEIC	ATEUC
Equity	0.3	0.05	-0.01
Net assets	0.05	0.06	13.67
Net income	-17.78	-41.81	-45.22
Output Value	1.07	0.18	0.36
Personnel Costs	6.81	13.67	13.61
Amortization	-30.76	0.1	-12.04
Added Value	4.67	8.13	12.01
Ebitda	18.95	6.88	6.95
Ebit	16.82	35.95	36.46
ROI	3.63	7.63	6.59

Note: The reported statistics are expressed in terms of growth rate between 2004 and 2005.

[16] The definition of manufacturing are based on the Italian classification of the economic activity (ATECO 2007). ATECO 2007 recalls the European definition and guidelines indicated in the NACE rev.2; in this way the data are comparable both at EU and extra-EU level. In detail, Manufacturing corresponds to the entire Section C of the classifications.

Table 8 shows the absence of significant differences in the economic performances for all the outcome variables used in the estimation of the ATE, ATEIC and the ATEUC during pre-treatment period. The lack of systematic differences in the temporal trend between treated and controls confirms the validity of the "common trend" assumption and, by consequence, of the results presented in this paper.

6 Conclusions

Modern economic theory places a strong emphasis on the role of innovation and technical change in generating growth. In this paper we provide evidence on the effectiveness of R&D regional policies in Umbria. Starting from a "traditional" counterfactual approach, we introduce the possibility of interactions between firms, on the basis of their geographical localization and market concentration. Modelling interferences in a casual framework, rules out the validity of the SUTVA and makes impossible the identification of casual effects (Manski, 1993, 2013). To overcome this limitation, literature proposes a series of different possible approaches, including spatial model (Florax and Delgado, 2016; Chagas et al., 2016), spatial hierarchical approach (Corrado and Fingleton, 2012; Di Gennaro and Pellegrini, 2017), network (Forastiere et al, 2016) and mediation analysis (Deuchert et al., 2018). Overall, a common point of these different approaches is to impose restriction on the extension and the typology of interactions which may arise between different units to make identifiable causal effects and estimate the spillovers.

Conversely, we propose a less stringent restriction on interferences. This choice has a twofold impact on our estimates. On one hand, it allows to differentiate the effects in consideration of territorial strength and identify the occurrence of technological and economic spillovers. In other words, we partially relax the SUTVA by limiting interferences on more concentrated regional local areas and, in second instance, we compare results obtained with the estimates of the areas in which interactions are ruled out. On the other hand, without posing further restriction on the interactions between units, we cannot correctly quantify the real extension of the spillovers.

Results provide evidence in favour of the effectiveness of regional policies. The subsidies have additional and significant effects on the improvement of technological capabilities, both in terms of input and output of the R&D processes, while there are no impacts on firms' performances.

The lack of short-term effects on the economic variables can be explained, at least partially, by regional policies objectives, i.e. foster research and innovation of the firms. This produces a change in firms' behaviour which stimulate technological production and R&D process. In this way, seems reasonable to expect a longer temporal lag between the production of the innovation and economic benefits on the activities of the firms. However, the limited temporal extension of our data does not allow now to evaluate medium and long period effects[17].

Moreover, the impact is heterogeneous across firms. Indeed, we have found some empirical evidence on the different structure of the process of innovation; the uninfluenced firms acquire machine and equipment to develop internal research finalized to product and production process innovation. Conversely, the influenced ones prefer to implement external, i.e. joint, research, increasing their link with the other economic agents in the same area.

The effectiveness of public policies is not only influenced by geographical location. As expected, also firms' size is important. Small firms present a larger additional impact, both in terms of policy effectiveness and for the technological spillovers. The more evident results are found considering the development of negative spillover effects for R&D expenditures. Indeed, the uninfluenced controls tend to spend more for technological input variables, both for personnel and research costs, while estimates for the manufacturing show the presence of different technological paths compared with the previous cases. Indeed, the limited effects on product innovation are counterbalanced by the significant impact on the development of new production process and the acquisition of machinery and equipment. Besides, it is important to remark the development of negative externalities. This shows how the process innovation, in this sector, is affected by market concentration and does not necessarily imply the development of research network.

In conclusion the results seem to confirm empirically strict local links and the presence of significant local technological and economic, positive or negative, spillovers as a response of the conjunct influence of the regional policies and the geographical concentration. This concept constitutes the "core" of the smart specialization policies in Europe and our novel approach can

---

[17] This will be the object of a future analysis

be considered a powerful tool in order to provide evidence on the presence of technological and economic spillovers in the same area.

REFERENCES

Abadie, A. (2005). "Semiparametric Difference-in-Differences Estimators." *The Review of Economic Studies* 72 (1). Oxford University Press: 1–19.

Accetturo, A. and De Blasio, G. (2008). "Le Politiche Per Lo Sviluppo Locale: La Valutazione Dei Patti Territoriali." *G. de Blasio E F. Lotti (a Cura Di), La Valutazione Degli Aiuti Alle Imprese, Il Mulino, Bologna*.

Andersson, M., Klaesson, J. and Larsson, J. P. (2016). "How local are spatial density externalities? Neighbourhood effects in agglomeration economies". *Regional studies*, 50(6), 1082-1095.

Andini, M. and De Blasio, G. (2014). "Local Development That Money Cannot Buy: Italy's Contratti Di Programma." *Journal of Economic Geography*. Oxford Univ Press.

Arduini, T.; Patacchini, E. and Rainone, E. (2014). "Identification and Estimation of Outcome Response with Heterogeneous Treatment Externalities." *IZA Institute of Labor Economics.*

Arpino, B. and Mattei, A. (2013). "Assessing the Impact of Financial Aids to Firms: Causal Inference in the Presence of Interference." *MPRA Paper 51795, University Library of Munich, Germany.*

Ashenfelter, O. and Card, D. (1984). "Using the Longitudinal Structure of Earnings to Estimate the Effect of Training Programs." National Bureau of Economic Research Cambridge, Mass., USA.

Athey, S. and Imbens, G. (2006). "Identification and Inference in Nonlinear Difference-in-Differences Models." *Econometrica* 74 (2). Wiley Online Library: 431–97.

Barca, F. (2009). "An Agenda for a Reformed Cohesion Policy: The Barca Report." *Brussels: European Commission, DG Regio*.

Becker, L. and Bizer, K. (2015). “Federalism and Innovation Support for Small and Medium-Sized Enterprises: Empirical Evidence in Europe.” Center for European, Governance and Economic Development Research Discussion Papers 245, University of Goettingen, Department of Economics.

Bertamino, F., Bronzini, R., De Maggio, M. and Revelli, D. (2017). “Regional policies for innovation: the case of technology districts in Italy”. *Regional Studies*, 51(12), 1826-1839.

Bertrand, M.; Duflo, E. and Mullainathan, S. (2004). “How Much Should We Trust Differences-in-Differences Estimates.” *The Quarterly Journal of Economics, Oxford University Press, vol. 119(1), pages 249-275.*

Brock, W. and Durlauf, S. (2007). “Identification of Binary Choice Models with Social Interactions.” *Journal of Econometrics* 140 (1). Elsevier: 52–75.

Bronzini, R. and De Blasio, G. (2006). “Evaluating the Impact of Investment Incentives: The Case of Italy’s Law 488/1992.” *Journal of Urban Economics,* 60 (2), 327–49.

Bronzini, R. and Iachini, E. (2014). “Are Incentives for R&D Effective? Evidence from a Regression Discontinuity Approach.” *American Economic Journal: Economic Policy, American Economic Association, 6(4),100-134.*

Bronzini, R. and Piselli, P. (2016). “The Impact of R&D Subsidies on Firm Innovation.” *Research Policy* 45 (2). 442–57.

Bronzini, R.; De Blasio, G. ; Pellegrini, G. and Scognamiglio, A. (2008). The Effect of Investment Tax Credit: Evidence from an Atypical Programme in Italy. Vol. 661. Banca d’Italia.

Cefis, E. and Evangelista, R. (2007). “The Evaluation of Innovation Policies: A Comparative Analysis Between Italy and the Netherlands.” *L’industria* 28 (2). Società editrice il Mulino: 243–64.

Cerqua, A. and Pellegrini, G. (2017). “Industrial policy evaluation in the presence of spillovers.”, *Small Business Econonomics, vol. 49, Issue 3, 671–686*

Cerulli, G. (2010). “Modelling and Measuring the Effect of Public Subsidies on Business R&D: A Critical Review of the Econometric Literature.” *Economic Record* 86 (274). Wiley Online Library: 421–49.

Cerulli, G. (2015). “Identification and Estimation of Treatment Effects in Presence of Neighbourhood Interactions.” CERIS Working Paper 2014 (04).

Cerulli, G. and Potì, B. (2012). “Evaluating the Effect of Public Subsidies of Firm R&D Activity: An Application to Italy.*” Journal of Applied Economics, Universidad del CEMA, vol. 15, 287-320.*

Chagas, A.; Azzoni, C. and Almeida, A. (2016). “A spatial difference-in-differences analysis of the impact of sugarcane production on respiratory diseases”. *Regional Science and Urban Economics, Elsevier, vol. 59(C), pages 24-36.*

Corrado, L., & Fingleton, B. (2012). “Where is the economics in spatial econometrics?” *Journal of Regional Science*, 52(2), 210-239.

Corsino, M.; Gabriele, R. and Giunta, A. (2012). “R&D Incentives: The Effectiveness of a Place-Based Policy.” *Economics Department Working Papers-Università’Roma Tre*, no. 169.

Crescenzi, R. and Rodríguez-Pose, A. (2011). “Reconciling Top-down and Bottom-up Development Policies.” *Environment and Planning a* 43 (4). Pion: 773–80.

David, P., Hall, B. and Toole, A. (2000). “Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence.” *Research Policy* 29 (4). Elsevier: 497–529.

De Blasio, G., Fantino, D. and Pellegrini, G. (2015). “Evaluating the Impact of Innovation Incentives: Evidence from an Unexpected Shortage of Funds.” *Industrial and Corporate Change* 24 (6). Oxford Univ Press: 1285–1314.

De Castris, M. and Pellegrini, G. (2015). “Neighborhood Effects on the Propensity Score Matching.” *CREI Working Papers-Università Roma Tre*.

Dechezleprêtre, A., Einiö, E., Martin, R., Nguyen, K. T. and Van Reenen, J. (2016). “Do tax incentives for research increase firm innovation? An RD design for R&D” (No. w22405). National Bureau of Economic Research.

Delgado, M. S. and Florax, R. J. (2015). "Difference-in-differences techniques for spatial data: Local autocorrelation and spatial interaction". *Economics Letters*, 137:123–126.

Di Gennaro, D. and Pellegrini, G. (2016). "Policy Evaluation in Presence of Interferences: A Spatial Multilevel DID Model." *Working Papers 04/16, CREI Università degli Studi Roma Tre.*

Di Gennaro, D., & Pellegrini, G. (2017). "Evaluating direct and indirect treatment effects in Italian R&D expenditures." MPRA Paper, No. 76467. University Library of Munich, Germany.

Donald, S. and Lang, K. (2007). "Inference with Difference-in-Differences and Other Panel Data." *The Review of Economics and Statistics* 89 (2). MIT Press: 221–33.

Deuchert, E., Huber, M. and Schelker, M. (2018). "Direct and indirect effects based on difference-in-differences with an application to political preferences following the Vietnam draft lottery." *Journal of Business & Economic Statistics*, 1-11.

Fantino, D. and Cannone, G: (2014). "Evaluating the Efficacy of European Regional Funds for R&D." *RIV Rassegna Italiana Di Valutazione*. Franco Angeli Editore.

Fiaschi, D., Lavezzi, A. M., & Parenti, A. (2018). "Does EU cohesion policy work? Theory and evidence." *Journal of Regional Science*, 58(2), 386-423.

Forastiere, L., Airoldi, E. M., & Mealli, F. (2016). "Identification and estimation of treatment and interference effects in observational studies on networks". arXiv preprint arXiv:1609.06245.

Foray, D. (2009). "Understanding Smart Specialisation." *The Question of R&D Specialisation, JRC, European Commission, Directoral General for Research, Brussels*, 19–28.

Foray, D.; David, P. and Hall, B. (2011). "Smart Specialisation from Academic Idea to Political Instrument, the Surprising Career of a Concept and the Difficulties Involved in Its Implementation." EPFL.

Gabriele, R., Zamarian, M. and Zaninotto, E. (2007). "Gli Effetti Degli Incentivi Pubblici Agli Investimenti Industriali Sui Risultati Di Impresa: Il Caso Del Trentino." *L'industria*, no. 2. Società editrice il Mulino: 265–80.

Garcilazo, E. and Oliveira Martins, J. (2015). "The Contribution of Regions to Aggregate Growth in the OECD." *Economic Geography,* 91 (2). Taylor & Francis: 205–21.

Giua, M. (2017). “Spatial discontinuity for the impact assessment of the EU regional policy: The case of Italian objective 1 regions”. *Journal of Regional Science*, 57(1), 109-131.

Hall, B. and Van Reenen, J. (2000). “How Effective Are Fiscal Incentives for R&D? A Review of the Evidence.” *Research Policy,* 29 (4). Elsevier: 449–69.

Hudgens, M. and Halloran, M. (2012). “Toward Causal Inference with Interference.” *Journal of the American Statistical Association*. Taylor & Francis.

Kao, E.; Toulis, P.; Airoldi, E. and Rubin, D. (2012). “Causal Estimation of Peer Influence Effects.” In *Proceedings of the NIPS Workshop on Social Network and Social Media Analysis*.

Kempton, L. (2015). “Delivering smart specialization in peripheral regions: the role of Universities.” *Regional Studies, Regional Science, 2(1),* 489-496.

Lee, L. (2006). “Identification and Estimation of Spatial Econometrics Models with Group Interactions, Contextual Factors and Fixed Effects.” *Journal of Econometrics* 140: 333–74.

Manski, C. (1993). “Identification of Endogenous Social Effects: The Reflection Problem.” *The Review of Economic Studies* 60 (3). Oxford University Press: 531–42.

Manski, C. (2013). “Identification of Treatment Response with Social Interactions.” *The Econometrics Journal* 16 (1). Wiley Online Library: S1–S23.

Mariani, M. and Mealli, F. (2018). “The Effects of R&D Subsidies to Small and Medium-Sized Enterprises. Evidence from a Regional Program”. *Italian Economic Journal*, 4(2), 249-281.

Marzucchi, A. and Montresor, S. (2013). “The Multi-Dimensional Additionality of Innovation Policies. a Multi-Level Application to Italy and Spain.” SPRU Working Paper Series 2013-04, SPRU - Science Policy Research Unit, University of Sussex Business School..

Merito, M., Giannangeli, S. and 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*, no. 2. Società editrice il Mulino: 221–42.

Mora, R. and Reggio, I. (2012). “Treatment Effect Identification Using Alternative Parallel Assumptions.” UC3M Working papers. Economics 1233, Universidad Carlos III de Madrid. Departamento de Economía.

Neumark, D. and Simpson, H. (2015). Place-based policies. In Handbook of regional and urban economics (Vol. 5, pp. 1197-1287). Elsevier.

OECD. (2009a). *How Regions Grow: Trends and Analysis*. Organisation for Economic Co-operation; Development.

OECD. (2009b). *Regions Matter: Economic Recovery, Innovation and Sustainable Growth*. OECD Publishing.

Puhani, P. (2012). “The Treatment Effect, the Cross Difference, and the Interaction Term in Nonlinear ”Difference-in-Differences” Models.” *Economics Letters* 115 (1). Elsevier: 85–87.

Rosenbaum, P. (2007). “Interference Between Units in Randomized Experiments.” *Journal of the American Statistical Association, 102(477), 191-200.*

Rubin, D. (1974). “Estimating Causal Effects of Treatments in Randomized and Nonrandomized Studies.” *Journal of Educational Psychology* 66 (5). American Psychological Association: 688.

RUICS. 2009. *Il Quadro Di Valutazione Regionale Della Competitività E Dell’innovazione in Umbria*. Regione Umbria.

Sinclair, B.; McConnell, M. and Green, D. (2012). “Detecting Spillover Effects: Design and Analysis of Multilevel Experiments.” *American Journal of Political Science* 56 (4). Wiley Online Library: 1055–69.

Sobel, M. (2006). “What Do Randomized Studies of Housing Mobility Demonstrate? Causal Inference in the Face of Interference.” *Journal of the American Statistical Association* 101 (476). Taylor & Francis: 1398–1407.

Tchetgen, E. and VanderWeele, T. (2012). “On Causal Inference in the Presence of Interference.” *Statistical methods in medical research, 21(1), 55-75..*

Verbitsky, N, and Raudenbush, S. (2004). “Causal inference under interference in spatial settings: a case study evaluating community policing program in Chicago”. *Epidemiologic Methods, 1(1), 107-130.*

Zúñiga-Vicente, J.; Alonso-Borrego, C. ; Forcadell, F. and Galán, J. (2014). "Assessing the Effect of Public Subsidies on Firm R&D Investment: A Survey." *Journal of Economic Surveys* 28 (1). Wiley Online Library: 36–67.

7 APPENDIX

List of Variables

Input Variables at innovation and R&D

Employees R&D: Number of workers operating in R&D activities

R&D intramuros: Percentage of firms which implement internal R&D activities.

R&D extramuros: Percentage of firms involved in external R&D activities, i.e. joint R&D projects with other firms, research centre or universities.

Total research expenditures: Total expenses for R&D activities (both intra and extramuros, in Euro).

Machine,equipment,software: Percentage of firms which acquire machine, equipment and/or software.

Output Variables at innovation and R&D

Product: Percentage of firms which provide product innovation.

Service: Percentage of firms which provide service innovation.

Production Process: Percentage of firms which provide innovation on production process

Logistic System: Percentage of firms which provide innovation on logistic system.

Patent: Percentage of firms which register at least a patent.

Copyright: Percentage of firms which implement actions of copyright.

Regional Market Share: Share of firms' activities in regional market.

National Market Share: Share of firms' activities in national market.

EU Market Share: Share of firms' activities in EU market.

Non-EU Market Share: Share of firms' activities in Non-EU market.