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A propensity score matching evaluation

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Regional innovation policy and innovative behaviours. A propensity score matching evaluation*

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Abstract

The paper aims at evaluating the additionality of innovation policy in terms of innovative behaviours at the regional level.Innovation behaviours are distinguished, depending on their occurrence within and across the firms and the regional boundaries.The policy role with respect to them is evaluated for a sample of firms in the Italian region of Emilia-Romagna, by making use of an original, survey-based dataset, to which a Propensity Score Matching approach is applied. Funded firms are more likely to upgrade their competencies, when compared to similar non subsidised companies. On the other hand, their innovation cooperation with other business partners is not significantly affected by the policy, both within and outside the region, unless in the interaction with particular partners. All in all, the investigated innovation policy in the ER region seems to show more of what could be termed 'cognitive capacity additionality', rather than 'network additionality'.

Keywords: Innovation Cooperation, Regional Innovation Systems, Behavioural Additionality

JEL Classification: O32; O38; R11; R58

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1 Introduction

Innovation is a complex process, which involves systems of actors and interactions, within and across different industries and territories (Edquist, 2005). At the local level, this has inspired the notion of Regional System of Innovation (RIS) (e.g. Cooke et al., 1997), which has revealed extremely helpful in drawing policy implications to spur regional growth and competitiveness (e.g. Howells, 1999; Asheim, 2009).

Using a system perspective, the spectrum of policy interventions extends beyond the remedies to standard market failures in innovation, such as those created by the public good nature of the underlying knowledge and by its imperfect appropriability (Nelson, 1959; Arrow, 1962). A different kind of failures require policies to address cases of missing system components – e.g. the lack of skilled workforce at the company level – misspecified system connections – e.g. weak science and technology links – and misplaced system boundaries – e.g. redundancy of regional and national innovative efforts (Metcalfe, 1995). This is also and above all true at the regional level, at which these system failures in innovation are exacerbated in case of predominance of small and medium enterprises (SMEs) and when these latter are characterized by traditional specialization patterns, informal cooperation relationships, and inward-looking (i.e. mainly local) strategy of interactions with scientific organisations (e.g. Uyarra, 2010).

Following the system perspective, the target of regional innovation policies is not simply that of increasing the amount of resources local firms invest in innovation, and/or their innovative outputs. R&D grants and tax incentives are instead also conceived in order to enhance innovation opportunities, capabilities and interactions (Metcalfe, 1995, p.56): in brief, "innovative behaviours". Accordingly, the evaluation of regional innovation policies needs to consider an important dimension, which has been called "behavioural additionality" (OECD, 2006).

In spite of its relevance, in the literature this kind of evaluation still hesitates to take off. In particular, given the difficulties to deal with some challenging issues. On the one hand, when innovative behaviours are considered, the policy outcome becomes hard to identify, as these behaviours are not one-shot like, but rather evolve over time once established (as has been shown, for example, with respect to R&D cooperation (Lhuillery and Pfister, 2009)). On the other hand, what innovation policy actually "adds"" to the innovative behaviours, which the regional firms would have however established searching for their competitive advantages, is hard to disentangle. Non-standard econometric techniques are required, which have been so far mainly applied to assess the policy boost to the firms' innovative inputs (e.g. R&D expenditure) and outputs (e.g. patents) (Buisseret et al., 1995; Davenport et al., 1998).

As a contribute to fill in this gap, in this paper we investigate the extent

to which a regional subsidy to firms' R&D expenditures is able to add a number of innovative behaviours, within and outside the company and the regional boundaries. The underlying rationale is that, by qualifying for and receiving a financial contribution to their internal R&D efforts, the targeted firms are expected, not only to increase their innovative inputs and outputs, but also to change the way they engage in the innovation process at the regional level. In particular, the subsidy could be expected to alleviate the costs that firms have to undertake in order to increase their internal human capital and organisational competences – through more or less dedicated training programs – as well as to contribute to those costs which they face to acquire external knowledge, through regional and extra-regional business cooperation agreements.

The policy evaluation is carried out with respect to the Emilia-Romagna region, in Italy.[1] By making use of an original, firm-level dataset, containing information on both pre-policy characteristics and post-policy behaviours and performances, a set of propensity score matching techniques is used. The reminder of the paper is organised as follows. Section 2 briefly discusses the behavioural implication of innovation policy at the regional level. Section 3 presents the empirical application and discusses its main results. Section 5 concludes.

2 The behavioural impact of regional innovation policy

The policy role in affecting firms' innovative behaviours is particularly important at the regional level. This emerges clearly, for example, from regional scoreboard analysis (such as the European Regional Scoreboard), in which regions are often found to lag behind the leading ones, not only in their innovative output (e.g. the number of regional product and/or process innovators) and in their innovative inputs/enablers (e.g. the level of regional tertiary education), but also and above all in the *innovative activities* of their firms, such as in the cooperation they entertain with other business and research organisations (Hollanders et al., 2009).

In regional studies, this issue has been mainly addressed by documenting the insufficient capacity of local small and medium-sized enterprises (SMEs) to conduct in-house R&D, and by recommending public intervention

[1] In order to maintain the focus, the analysis of the input and the output additionality of the policy will be not addressed. To be sure, as the investigated policy scheme has been devised with the "direct" scope to increase the regional firms' cooperation with research organisations (e.g. universities and research institutes), the additionality of this last behaviour has also been left out in order to have a homogeneous focus on what we could call the "indirect" behavioural effects of the policy. The effects of the same policy in terms of cooperation with research organisations are investigated in Marzucchi et al. (2012)

to remedy this input-gap and thus supporting regional convergence (e.g. Rodriguez-Pose, 2001; Piergiovanni et al., 1997; Acs and Audretsch, 1990). Relatively less and recent attention has instead received the gap that regions might have in innovation because of their firms' constraints in acquiring and eventually upgrading those competencies which are necessary to turn their innovative inputs into outputs (Asheim et al., 2007). In this last respect, the policy recommendation becomes that of making of the region a "learning region" (Rutten and Boekema, 2007). On the one hand, innovation policies are expected to make regional firms more internally 'receptive', and help them develop those competencies which are necessary to master internally the technology which is relevant to their market needs and to integrate it within their broader corporate strategies (Morgan, 1997). On the other hand, regional firms should be also supported in becoming more externally 'receptive', and develop those capabilities through which they can absorb the external knowledge they miss and integrate it with the internal one (e.g. Uyarra, 2010).

Following this last perspective, a number of different regional policy schemes have been devised to foster innovative behaviours of regional firms (see, for example, the seminal evidence provided by Morgan (1997)). First of all, in terms of "internal receptivity" education and training at the company level have become a key leverage of public policy for inducing innovation and regional development, especially within the EU (Markusen, 2008). The rationale for these policies is quite established and has found new recent micro-foundation and empirical support (e.g. Ballot and Taymaz, 2001; Bronzini and Piselli, 2009). In brief, investing in human capital, affects regional growth and economic development both through "direct channels" – i.e. by making knowledge grow and stimulating both the introduction and the adoption of technological and organisational changes – and "indirect channels – e.g. by facilitating new start-ups and higher firm survival rates (Mathur, 1999)

In terms of "external receptivity", innovation policy schemes with a focus on innovation cooperation are diffusing at the regional level too (e.g. Hassink, 2002, 2005). Also in this case the supporting arguments are diverse. As far as the interaction with business partners is concerned, the case has been made for cooperation policy to helps firms overcome those contractual (e.g. partners rivalry) and competence-based (e.g. cognitive mis-matches) problems that market relationships in the field of technology pose to them, even when they are embedded in the same local, institutional set-up (Fischer and Varga, 2002). As for the enterprise-research cooperation, the specific policy role is that of helping firms solving those problems (in particular, of uncertainty and asymmetric information) which hamper the development of the knowledge fabric of the region (Fritsch and Schwirten, 1999).

In addition to these specific policy interventions, innovative behaviours by regional firms can also be induced by a more general kind of public funding

to their own R&D investments. This is the basic idea which underlies the so-called "behavioural additionality" of an innovation policy, according to which the policy could lead to a "change in a company's way of undertaking R&D" (Buisseret et al., 1995, p. 590, additional emphasis).[2] More in general, as a result of the R&D-projects they are financed for, subsidized firms are involved in a process of organisational learning which spurs them to adopt a number of behavioural changes (Clarysse et al., 2009; Antonioli and Marzucchi, 2012).

The changes that a R&D subsidy can bring to the pre-policy behaviours of the firms have been found to be of different kind, and have received different classifications.[3] As we said above, out of all these, two behaviours are particularly important to evaluate in a context of regional development. The first one refers to the possibility that, by carrying out publicly funded R&D activities, regional firms are allowed and/or required to undertake investments in order to upgrade or acquire new competencies, capabilities and organisational routines for the sake of innovation (e.g. Magro et al., 2010; Marino and Parrotta, 2010). In so doing, the R&D policy could help regional firms overcome the costs of investing and exploiting the intangible assets represented by their workforce and by their organisational capital (Florida et al., 2008). Accordingly, the evaluation of this first case of behavioural additionality becomes important for the policy makers to assess their capacity to close the gap their regions often have in the construction of their internal knowledge base (Asheim and Coenen, 2005).

The second behavioural effect which deserves attention at the regional level concerns the additional innovation cooperation that the R&D subsidy could stimulate with the business partners of the treated firms, both within and outside the regional boundaries (e.g. Hall and Maffioli, 2008; Afcha Chávez, 2011). On the one hand, the policy could help local firms to face the costs of undertaking virtuous innovation cooperation within the region (e.g. Fier et al., 2006; Busom and Fernández-Ribas, 2008). Indeed, knowledge flows in the business relationships at the regional level are often unilateral consultancy ones, with little interactive nature, so that they hardly serve for more than incremental innovations. The same occurs also because the degree of interaction with local knowledge organisations (e.g. universities) is often relatively weak and occasional (Asheim and Isaksen, 2002). On the other hand, the benefit of a R&D subsidy could stimulate regional firms

[2] This is an extension of the more standard ideas of "input" and "output" additionality of a policy. In brief, the former refers to the additional resources targeted firms can be induced to invest in innovation with respect to non-targeted ones. The latter, to the additional outcomes the former could be led to have with respect to the former (e.g. Georghiou and Clarysse, 2006)

[3] Falk (2007), for example, has distinguished, among the others, the ideas of scope additionality, cognitive capacity additionality, acceleration additionality, challenge additionality, network additionality, follow-up additionality, and management additionality.

to embrace extra-regional business cooperation. Indeed, that could help local firms to support the "liability of foreignness" they have to discount in cooperating (and competing) across the national boundaries (Zaheer, 1995), and the socio-cultural and techno-economic gap which often separate business partners of different regions, even in the same national environment (e.g. Evangelista et al., 2002). Given the role that innovation cooperation has in inserting local firms into global value chains (e.g. Humphrey and Schmitz, 2002), evaluating this last bit of behavioural additionality appears particularly important for devising policies which are able to unlock regional economies from path dependency, and turn RIS into Open RIS (Belussi et al., 2010).

3 The behavioural additionality of the PRRIITT: Emilia-Romagna (Italy)

As an empirical application of the arguments we have developed in the previous section, in the following we evaluate the behavioural additionality of an innovation-policy scheme, called *PRRIITT* (*Programma Regionale per la Ricerca Industriale, l'Innovazione e il Trasferimento Tecnologico* (Regional Program for Industrial Research, Innovation and Technology Transfer)), which constitutes the core of the policy-space of one of the most innovative European region: Emilia-Romagna (ER), in Italy.

The ER region has quite idiosyncratic techno-economic features[4], which have made of it a model of local development (known as the "Emilian model" (Brusco, 1982)) that other European and non-European countries have been targeting as a benchmark (e.g. Molina-Morales, 2001; Humphrey, 1995). Furthermore, within an only moderately innovative country, ER is along with Lombardy the only region which displays the features of a medium-high innovative region, at the EU27 level.[5]

Innovation policy has always been a key-element of the innovation system of this region (Bianchi and Giordani, 1993), which shows some conflicting characteristics. In spite of their structural features, ER companies perform relatively well in Europe in terms of innovative activities. On the other hand, they suffer from the absence of relatively strong innovative enablers (e.g. population with tertiary education, participation in life-long learning, public R&D expenditures and broadband access) (Hollanders et al., 2009). ER firms are also characterised by wide networking, both within and outside the

[4]In brief: a high density of SMEs, with a pervasive co-location in specialised local production systems, with diffuse social capital (i.e. industrial districts); a deep rooted unionism, especially strong in the most industrialised provinces (e.g. Reggio Emilia); an articulated institutional set-up of business and research organisations.

[5]This is what emerges from the Regional Innovation Scoreboard (*http://www.proinno-europe.eu/page/regional-innovation-scoreboard*), both in 2004 and in 2006.

region, especially in knowledge-intensive sectors (e.g. Belussi et al., 2010). However, the linkages they have, both in the business realm and in the science-industry link, are quite loosely structured and make of the relative RIS an "informal learning system" when compared with other Italian ones (Evangelista et al., 2002).

Launched for the first time in 2003, the PRRIITT is a pivotal instrument of innovation policy in the region. Indeed, it has been conceived in order to exploit the strengths given by the regional firms dynamism and to mitigate the weaknesses of the institutional set-up in which they are embedded.[6]

Within it, particularly important is the Measure 3.1.A, devised in order to sustain industrial research and pre-competitive development through more dedicated objectives than a general R&D subsidy. In addition to the direct support to R&D activities, the subsidy was conceived to spur, among the others, the reinforcement of the collaboration among the components of the RIS.

In the first two calls of this measure (in February and September 2004), on which the current application focuses, regional funds were allocated on the basis of the assessment of firms' innovation projects, carried out by an independent committee of experts. The committee evaluated each project along several dimensions (each of those having a different potential score): technical-scientific aspects (45 points); economic-financial aspects (20 points); managerial aspects (20 points); regional impact (15 points). The threshold to get funded was then fixed to 75. The eligible firms were then subsidised by grants covering up to 50% of the total cost of the industrial research activities and up to 25% (35% for SMEs) of the total cost of the precompetitive development activities. The overall number of projects subsidised through the two calls was 529, for a total of 557 recipient firms. The total cost of the projects proposed by the beneficiaries was about 236 million Euros and the public funding about 96 million, covering around the 40% of the total projects' cost, with an average regional contribution of 175,000 Euros per-project.

3.1 The dataset

The dataset of the present empirical application has been obtained starting from a recent *ad-hoc* survey of the PRRIITT itself, carried out by a research-group of the University of Ferrara (Italy) (Antonioli et al., 2011). The survey, which has been accomplished as part of the PRRIITT evaluation, includes detailed information on structural and organisational characteristics of a random sample of PRRIITT recipient firms, and on their innovation strategies. The sample comprehends 555 manufacturing firms, with at least 20 employees, located in the Emilia-Romagna region. It is stratified by size,

[6] For an extended illustration of the history of this instrument, see Marzocchi (2009).

province (geographic location at NUTS 3 level) and sector. The information collected mainly refers to the period 2006-2008.

This first data source has been integrated with balance-sheets data extracted from the AIDA-BureauVanDijk database, in order to have relevant information (e.g. intramural R&D and advertising) for the pre-policy period (year 2003).

The merge of the two datasets results in a working sample of 408 firms: 99 subsidised, and 309 non-subsidised with the PRRIITT Measure 3.1 A.

Table 3A shows that the sample of the treated firms (99 firms) has a distribution by size (SMEs and large firms) and sector (Pavitt/OECD taxonomy) similar to that of all the manufacturing firms (with more than 20 employees) that received the regional R&D subsidy. All in all, it can been deemed to be representative and thus reliable in the econometric test we are going to carry out.

3.2 Innovative behaviours and controls

The available dataset enables us to employ a number of variables, which account for the impact of the PRRIITT on both the internal and external receptivity of the funded firms. As far as the former is concerned, three variables are obtained about the firms' behaviour in acquiring and upgrading their skills and organisational competences: (i) a dummy indicating whether the workers' competencies have been improved or upgraded ($COMPUP$); (ii) a dummy capturing whether undifferentiated training programs have been implemented ($TRAIN$); (iii) a dummy indicating whether the firm has implemented training programmes to improve technical/specialised competencies ($TECHTRAIN$). While the latter two refer to an explicit use of the R&D subsidy in pursuing an investment in human capital, the former considers the possibility that the policy improves the firm's competencies also through other non deliberated actions, such as learning-by-doing and learning-by-interacting.

As far as the external-receptivity effect of the policy is concerned, the dataset enables us to distinguish, still through a set of dummies, whether the funded firms engaged in innovation cooperation with different kinds of business partners – namely suppliers ($COOPSUP$), customers ($COOPCUS$), competitors ($COOPCOM$), and firms of the same group ($COOPG$) – both within (subscript, REG) and outside (subscript, $EXTRA$) the region. Given the importance that the identity of the partners has been found to have in determining the success (or failures) of R&D cooperation (e.g. Mora-Valentin et al., 2004; Lhuillery and Pfister, 2009), their distinction in evaluating the effect of the policy appears more than opportune. As much important is also to retain the distinction between those interactions through which local firms possibly try to exploit and/or update the regional knowledge base, and those through which they might try to overcome the local path-dependence

from it (ter Wal and Boschma, 2007).

Table 4A presents the main descriptive statistics of the outcome variables.

As we will see, to solve an otherwise insurmountable selection bias in the econometric estimation of the policy effect, we will compare the innovative behaviours of funded firms with those of non subsidised companies that have the same (or significantly similar) "propensity" of being supported by the policy. In order to do so, a number of proper controls need to be identified in the dataset, accounting for those features of the firms in the sample which might have affected the participation in the R&D subsidy scheme.

In order to serve for our econometric strategy, all these variables, except for the time-invariant ones, are considered at a time (2003), which is beforehand the policy (administrated in 2004), thus attenuating endogeneity problems in the estimates. What is more, many of these covariates (i.e. those created upon balance sheets data) are of a continuous nature, thus enhancing the quality of the estimates.

First of all, the innovative profile of the firms is proxied by their expenditure (per capita) in intramural R&D and advertising, $RDADV_{2003}$.[7] The underlying rationale is that the innovation story of the firm is expected to affect its decision to apply for public subsidies, and to make further steps along the innovation path.

Second, the financial condition of the firm is proxied by its cash-flow per capita ($CASHFLOW_{2003}$) and its short-term debt index ($FINCONST_{2003}$). While the former accounts for the firms' availability of financial resources to invest in innovation – without recurring to external sources – the latter should signal the presence of eventual financial constraints.[8]

Furthermore, two sets of dummies are introduced in order to control for the technological nature (á la Pavitt) of the firms' sector ($PAVITT1$-$PAVITT5$) and for their size in terms of employment ($lnEMP_{2003}$). Size and sector are indeed considered to be relevant determinants of firms' innovation activities, as a large amount of literature has shown (e.g. Malerba, 2002; Cohen, 2010), and thus likely to influence the probability to participate in a R&D policy scheme. Finally, to account for the intra-RIS heterogeneity of the innovation processes (e.g. Todtling and Trippl, 2005) and the consequent different ability/willingness to access to the public funding, we include a set of dummies capturing firms' location in terms of NUTS-3 level province.[9]

Tables 5A presents the main descriptive statistics of the covariates we

[7] Unfortunately, disaggregated data for the two kinds of expenditure were not available. On the other hand, recent studies are emerging on their complementarity nature in the current open-innovation and demand-led paradigm (e.g. Perks et al., 2009).

[8] The short-term debt is here considered to be probably more relevant than the long-term one, given the contingent nature of the decision to plan a R&D project and thus apply for a subsidy.

[9] One of the dummies ($GEO1$) captures firms based outside the regional borders, but having at least a production unit in the region.

have built up.

3.3 The Propensity Score Matching

As has been widely shown by the econometric literature on the impact of a R&D policy support (e.g Fier et al., 2006; Czarnitzki and Licht, 2006; Aerts and Schmidt, 2008; Busom and Fernández-Ribas, 2008), the choice of the econometric strategy for its evaluation is determined by the fact that the policy is in general non-exogeneous.[10] Given the problems this entails in using a OLS model, a viable alternative is that of getting an estimate of the *Average Treatment* on the *Treated* (ATT) for the policy, by making use of a *Propensity Score Matching* (PSM) technique (Rosenbaum and Rubin, 1983).

Denoting the policy outcome in the presence and absence of the policy-treatment with Y_1 and Y_0, respectively, and with D the treatment status ($D = 1$: treated; $D = 0$: untreated), the ATT can be defined as:

$$ATT = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1) \tag{1}$$

In Eq.1, $E(Y_1|D = 1)$ can be estimated with a simple mean of the outcome in the group of funded firms, but $E(Y_0|D = 1)$ is by definition non-observable. In order to overcome this problem, $E(Y_0|D = 1)$ needs to be substituted by referring to a suitable "counter-factual" of non-treated firms. More precisely, in order to control for the selection bias on observables, the difference in the outcome of the two groups need to be exclusively due to the policy intervention. One way to get this is by choosing the non-treated firms in such a way that they match the treated ones in terms of their propensity score, $Pr(D = 1|X)$ (or $P(X)$). In other words, non-treated firms are so to have the same probability of being funded than the treated ones, given the set of pre-treatment characteristics, X, which are supposed to affect both the treatment and the outcome. In so doing, the PSM estimate of ATT is given by:

$$ATT_{PSM} = E_{P(X)|D=1}\left\{E\left[Y_1|D = 1, P(X)\right] - E[Y_0|D = 0, P(X)]\right\} \tag{2}$$

where $P(X)$ is estimated with a standard probit model.

In estimating Eq(2), different matching procedures will be used,[11] which differ in the way non-treated firms are selected and weighted, and in their capacity to trade bias reduction with efficiency in the estimates (Caliendo

[10] One just need to think about its very common "picking the winner" strategy (Cerulli, 2010).

[11] In particular, the 5 nearest-neighbours, the caliper and the kernel, for which see Becker and Ichino (2002); Cameron and Trivedi (2009); Smith and Todd (2005); Caliendo and Kopeinig (2008).

and Kopeinig, 2008; Smith and Todd, 2005). A comparison of the results obtained with different algorithms provides information on the stability and, indirectly, on the reliability of the evidence. For all the implemented matching procedures, the so-called common support condition $(P(D = 1)|X < 1)$ is imposed.[12] Furthermore, the quality of the matching is checked by controlling that beneficiaries and controls are correctly aligned with respect to the vector of covariates X.[13]

4 Results

As an introduction to our *PSM* analysis, let us consider the reliability of the policy propensity-predictors we have identified (Table 1). As expected, the probability of receiving the investigated subsidy increases significantly with the intensity of R&D (and advertising) expenditures of the firms ($RDADV_{2003}$). Apparently, a previous experience of innovative investments, and the effect that it has on their absorptive capacity (Franco et al., 2011), provides the firms of the region with an advantage also in terms of funding. On the one hand, firms with a significant history of engagement in R&D are more willing and able to apply (successfully) for the subsidy. On the other hand, previous experiences in formal innovation activities seem to increase firms' capacity to identify and exploit innovation opportunities lying outside their boundaries (i.e. in this case the presence of a R&D subsidy). A significant positive effect on the probability of getting the policy is also played by the financial conditions of the firms: indeed, the sign on their financial constraints, $FINCONST_{2003}$, is negative. In other words, the firms' financial soundness could be deemed by the policy makers as a collateral for an efficient use of the subsidy. Another aspect that affects the probability of receiving the funding is the sector firms' belong to. Finally, also the sector in which the firms operate is an important determinant for the participation in the subsidy scheme. As expected, firms operating in more dynamic and technology-intensive sectors are more able/willing to participate in the subsidy scheme. In addition to scale-intensive firms ($PAVITT4$), science-based companies ($PAVITT3$) and firms operating in the propulsive districtual-core of the region characterised by specialised-suppliers sectors ($PAVITT5$) outperform other industries, in terms of capacity to get funded. All in all, the regional policy in this RIS seems to follow a "picking the winner" strategy (Cerulli, 2010). A result which makes the use of a *PSM*

[12] This guarantees the presence of suitable counterfactual firms for each treated (Smith and Todd, 2005; Caliendo and Kopeinig, 2008). Following Caliendo and Kopeinig (2008), we also impose the common support condition with a "minima and maxima" comparison. In addition, a 1% "trim" is applied to the 5 nearest-neighbours matching.

[13] Drawing on Caliendo and Kopeinig (2008), we employ a set of tests (Pseudo-R2 test, LR test on joint significance and a regression based t-Test on differences in the covariates means). These largely support the quality of the matching.

Covariates	Coeff.	S.E.
$lnEMP_{2003}$	0.119	0.083
GEO1	3.420***	1.146
GEO2	1.755*	1.053
GEO3	0.789	1.155
GEO5	1.839*	1.057
GEO6	2.639**	1.096
GEO7	1.531	1.077
GEO8	2.184**	1.083
GEO9	1.849*	1.064
GEO10	1.187	1.122
PAVITT1	0.148	0.29
PAVITT3	1.361***	0.326
PAVITT4	0.575**	0.279
PAVITT5	0.726***	0.255
$FINCONST_{2003}$	-0.881*	0.525
$CASHFLOW_{2003}$	-0.005	0.005
$RDADV_{2003}$	0.162***	0.043
cons	-2.671**	1.219
$N = 408$		
Pseudo $R^2 = 0.217$		
Prob$\geq \chi^2$ 0.000		
***, **, *: 1%, 5%, 10% significance		
VIF test excludes multicollinearity (all VIF values lower than 10)		

Table 1: Probit estimation of the propensity score

methodology actually necessary.

Coming to the behavioural additionality of the investigated scheme, a first interesting result refers to the effects that it exerts within the boundaries of the firm, in terms of acquisition and/or upgrading of the workers' competencies (Table 2). Indeed, funded firms are more likely (from +16.6% to +20.0%) to report an upgrading in their competencies, when compared to similar non subsidised companies. Hence, carrying out funded R&D activities generates a relevant learning process; a result that is consistent with the finding of Autio et al. (2008). On the other hand, this learning process does not seem to pass through complementary training schemes. In fact, taking into account both general training programmes and programmes targeted to technical competencies, the effect of the policy is found to be generally not significant. A possible interpretation for that, which of course would deserve further investigation, is that the R&D subsidy enables the targeted firms to make their organisational processes (possibly within and outside the R&D department) more efficient in terms of learning-by-doing for their employees.

Unlike the innovative behaviours within the corporate boundaries, those which are carried out across them through innovation cooperation with other business players do not generally appear to be significantly affected by the investigated policy scheme (Table 2). First of all, interactions with *regional*

	5NN		Caliper		Kernel		5NN Trim	
	ATT	S.E.	ATT	S.E.	ATT	S.E.	ATT	S.E.
Acquisition and upgrading of competencies								
$COMPUP$	0.198***	0.072	0.166**	0.073	0.181***	0.067	0.200***	0.076
$TRAIN$	0.026	0.055	0.026	0.061	0.052	0.047	0.025	0.059
$TECHTRAIN$	0.085	0.071	0.072	0.076	0.103*	0.062	0.082	0.081
Innovation cooperation with business partners								
Intra-RIS								
$COOPCUS_{REG}$	-0.096	0.067	-0.056	0.067	-0.054	0.059	-0.105	0.071
$COOPSUP_{REG}$	-0.109	0.072	-0.089	0.07	-0.058	0.058	-0.112*	0.063
$COOPCOM_{REG}$	-0.109**	0.048	-0.089 *	0.048	-0.074 *	0.045	-0.101*	0.057
$COOPGP_{REG}$	0.000	0.056	0.022	0.052	0.037	0.048	-0.006	0.055
Extra-RIS								
$COOPCUS_{EXTRA}$	-0.028	0.077	-0.069	0.077	-0.067	0.071	-0.04	0.081
$COOPSUP_{EXTRA}$	0.072	0.088	0.073	0.083	0.092	0.071	0.069	0.082
$COOPCOM_{EXTRA}$	0.043	0.05	0.043	0.043	0.041	0.043	0.063	0.047
$COOPGP_{EXTRA}$	0.096*	0.056	0.098 *	0.057	0.099**	0.048	0.103*	0.054
N treated on support	92		92		92		95	
N treated total	99		99		99		99	
N non treated	309		309		309		309	
Methods:								
5 nearest neighbours (5NN)								
5 nearest neigbhours with a 0.05 caliper (Caliper)								
Epanechnikov kernel matching (Kernel)								
5 nearest neighbours with 1% trim (5NN Trim)								
Standard errors estimated with a 200-replication bootstrap procedure								
***, **, *: 1%, 5%, 10% significance								

Table 2: Behavioural additionality of the regional R&D subsidy

clients, suppliers and firms in the same group are generally not significantly influenced by it. Second, the policy does not appear to induce additional interactions with business partners *across the region*.

Given the problems that the region has been found to suffer in terms of 'innovative enablers' (Hollanders et al., 2009), these last results could be thought to be a sign of inefficiency of the investigated policy. However, in their interpretation one can not exclude that the firms of this RIS could be less affected by interactive problems than what the literature generally suggests, and thus make an alternative use of the scheme. In particular, the informal character these relationships have been found to have in ER (Evangelista et al., 2002), within the notable social-milieu of the region (Brusco, 1982), can help attenuating the rivalry problems and the cognitive mis-match which often hamper their innovative outcomes (e.g. Lhuillery and Pfister, 2009).

The R&D subsidy seems able to add innovation cooperation in some special circumstances (Table 2). This is the case, for example, of its impact on extra-regional cooperation, which appears significant when the interactions occur with companies belonging to the same group of the treated ones (from +9.6% to +10.3%). As a tentative explanation for this result, a certain organisational proximity – such as the one guaranteed by information filters and communication channels shared within the group – appears necessary for the policy to spur regional firms to interact across the border, that is in absence of geographical proximity.

In the case of other interactions, however, the R&D subsidy seems to even crowd out innovation cooperation within the region. This is the case of the interaction with the firm's competitors, which the subsidy significantly reduces (from -7.4% to -10.9%). With respect to this result, two tentative and related explanations could be advanced. On the one hand, one might think about the possible effect of the subsidy on the trade-off between knowledge protection and sharing (e.g. Olander et al., 2009). More specifically, it could be argued that when, due to the subsidy, firms invest in innovation activities they also reduce the risk of knowledge leakages that could benefit their competitors. In so doing, they adopt a strategy of knowledge protection which results in a decreased propensity to cooperate. This seems to be consistent with the fact that also SMEs (the main beneficiaries of the investigated policy, see Table 3) and not only large firms generally find secrecy of greater value than a patenting strategy in securing the appropriability of the innovative results (Arundel, 2001). On the other hand, it can not be excluded that the engagement in the publicly funded R&D activities has triggered the "Non-Invented-Here" syndrome (Katz and Allen, 1982), which in this case is sharpened by the similarity of the potential partners (Wastyn and Hussinger, 2011).

All in all, (the investigated) innovation policy in the ER region seems to show more of what could be termed 'cognitive capacity additionality',

rather than 'network additionality' (Falk, 2007). More precisely, the latter appears to be a conditional one, for whose working the nature of the business partners need to be carefully evaluated. In this respect, while the policy appears to help firms in strengthening their innovative activities by enabling them internal learning effect, it seems to require a further tailoring effort to allow firms to benefit from innovation cooperation.

5 Conclusions

Once looked at from a system perspective, as both academic scholars and policy makers suggest, innovation turns out to be a process in which innovative behaviours, in particularly at the company level, are as much important as the innovative inputs firms invest in and the innovative outputs they obtain. Following this perspective, the array of failures innovation policy is asked to address extends over incentive problems and appropriability issues. Indeed, firms might also behave in such a way to suffer from institutional and cognitive failures, innovation policy should try to solve by devising new policy instruments and/or approaches. What is more, the need emerges to evaluate the extent to which these policies actually "add" innovative behaviours to those which firms would have however undertaken, or not undertaken at all. In brief, the evaluation of what is called "behavioural additionality" of the policy becomes crucial.

This is even the more so in regional contexts, where the benefits of agglomeration economies are counterbalanced by the disadvantages of several kind of diseconomies. In particular, because of the obstacles that their structural features (mainly, small-medium company size, mid-low tech specialization, informal relationships) pose to those internal organisational processes and external innovation cooperation, which are crucial for innovative learning to occur.

The present paper has investigated the extent to which a public R&D subsidy administrated to regional firms can induce additional behaviours in terms of competences acquisition/upgrading and innovation cooperation.

The Italian region of Emilia-Romagna (ER) has been investigated for that, by using a unique dataset, containing info on both pre-policy characteristics and post-policy behaviours for a representative sample of treated firms.

At the outset, the empirical application has confirmed that innovation policy can actually follow a "picking the winner" strategy, especially in a region like ER with an outstanding innovation record at the European level. In particular, intensive R&D activities, sound financial conditions and engagement in dynamic and technology-intensive sectors appear to be considered by the policy makers as leverages for make success-breeds-success in innovation.

Looking at innovative behaviours internal to the firms, it seems that a

R&D subsidy could help firms in getting an additional advantage in terms of skills and competencies, although this is not one for which additional investments are carried out. This additionality actually looks a true behavioural, rather than an input additionality. The policy implication of this first bit of evaluation is therefore quite straightforward. The financial support to R&D can actually make firms more active learning organisations, allowing them to be more efficient in terms of competencies acquisition and/or upgrading. On the other hand, formal training programs are apparently 'incremented' by policy of a different nature. Indeed, we may argue that because of the dynamic correlation in the course of time between training and innovation activities (e.g. Acemoglu, 1997; Bauernschuster et al., 2008)), the policy makers should complement the policy implemented to sustain innovation with instruments that directly aim to spur the diffusion and adoption of training programs.

As far as external innovative behaviours are concerned, the investigated policy scheme seem to have very limited impact in stimulating innovation cooperation by the firms in the business realm. The only additional impact here is represented by the capacity that the administration of the policy has to induce local firms to interact across the boundaries in the business realm. This additionality is however conditional, as it works providing the loss of geographical proximity is counter-balanced by the presence of organisational proximity, which is guaranteed by the firms belonging to the same business group. To be sure, another significant impact the policy has is in crowding-out the cooperation with the rivals. With this respect, the policy might have affected the trade-off between knowledge protection and sharing: in carrying out publicly funded R&D activities firms are induced to avoid the risk of knowledge leakages that might benefit their competitors.

All in all, the most direct policy implication might seem that the ER region has been unable, although with an horizontal policy such as an R&D subsidy, to stimulate those interactive behaviours it has been found to be in need as a regional system. However, the possibility that the typical informal, business relationships of the RIS make rivalry and knowledge mis-match problems in cooperation less severe, and then make the recipient firms move the subsidy towards other non-relational kind of behaviours, cannot be dismissed either.

Of course, the results here presented might be sensible to the characteristics of the context and of the policy considered in the paper, as, in particular, the fact that SMEs were the main beneficiaries of the intervention, and the low average public support. However, in spite of its idiosyncratic techno-economic characteristics (Brusco, 1982; Hollanders et al., 2009), ER has been found to be a good approximation of the theoretical RIS conceptualisation (e.g. Evangelista et al., 2002) and a benchmark of an industrial-district based of model for other countries (e.g. Molina-Morales, 2001; Humphrey, 1995). For this reason, the results of the present study can have some general value

in regional and innovation policy studies.

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A Data appendix

Recipient population distribution	SMEs (< 250 employees) %	Large (= 250 employees) %	*Total* %	*Total* (*a.v.*)
Sector				
PAVITT1 (Labour Intensive)	8.55	0.43	8.97	*21*
PAVITT2 (Resource Intensive)	9.83	2.56	12.39	*29*
PAVITT3 (Science Based)	11.11	1.28	12.39	*29*
PAVITT4 (Scale Intensive)	14.96	4.7	19.66	*46*
PAVITT5 (Specialised Suppliers)	39.74	6.84	46.58	*109*
Total	84.19	15.81		
Total (a.v.)	*197*	*37*		*234*
Recipient sample distribution	**SMEs %**	**Large %**	***Total* %**	***Total* (*a.v.*)**
Sector				
PAVITT1 (Labour Intensive)	9.09	1.01	11.11	*11*
PAVITT2 (Resource Intensive)	7.07	2.02	9.09	*9*
PAVITT3 (Science Based)	15.16	1.01	16.16	*16*
PAVITT4 (Scale Intensive)	14.15	7.07	21.21	*21*
PAVITT5 (Specialised Suppliers)	34.34	8.08	42.42	*42*
Total	80.81	19.19		
Total (a.v.)	*80*	*19*		*99*

Table 3: Sample representativeness

	Overall mean 408 obs	Mean subs. 99 obs	Mean non subs. 309 obs	Min.	Max.
Acquisition and upgrading of competencies					
$COMPUP$	0.740	0.869	0.699	0	1
$TRAIN$	0.819	0.879	0.799	0	1
$TECHTRAIN$	0.718	0.818	0.686	0	1
Innovation cooperation with business partners					
Intra-RIS					
$COOPCUS_{REG}$	0.172	0.162	0.175	0	1
$COOPSUP_{REG}$	0.184	0.152	0.194	0	1
$COOPCOM_{REG}$	0.074	0.04	0.084	0	1
$COOPGP_{REG}$	0.100	0.131	0.091	0	1
Extra-RIS					
$COOPCUS_{EXTRA}$	0.275	0.263	0.278	0	1
$COOPSUP_{EXTRA}$	0.331	0.364	0.32	0	1
$COOPCOM_{EXTRA}$	0.076	0.121	0.061	0	1
$COOPGP_{EXTRA}$	0.113	0.172	0.094	0	1

Table 4: Outcome variables

Variables	*Description*	*Overall mean (408 obs)*	*Min*	*Max*	*Mean subsidised (99 obs)*	*Min*	*Max*	*Mean not subs. (309 obs)*	*Min*	*Max*
Time invariant survey data										
Geographical location (10 dummies)	GEO1: Extra-Region GEO2: Bologna GEO3: Forli' Cesena GEO4: Ferrara GEO5: Modena GEO6: Piacenza GEO7: Parma GEO8: Ravenna GEO9: Reggio Emilia GEO10: Rimini		0	1		0	1		0	1
Sector (5 dummies)	PAVITT1: labour intensive PAVITT2: resource intensive PAVITT3: science based PAVITT4: scale intensive PAVITT5: specialised suppliers		0	1		0	1		0	1
Balance sheets data										
$lnEMP_{2003}$	Log number employees in 2003	4.218	0.693	7.961	4.516	2.639	7.754	4.122	0.693	7.961
$FINCONST_{2003}$	Short-term debt in 2003	0.871	0.32	1	0.838	0.33	1	0.882	0.32	1
$CASHFLOW_{2003}$	Cash-flow p.c. in year 2003 (,000 Euros)	0.792	-1.105	185.222	0.183	-0.475	1.555	0.987	-1.105	185.222
$RDADV_{2003}$	Expend. p.c. in R&D and ADV in 2003 (,000 Euros)	0.007	0	0.405	0.016	0	0.326	0.003	0	0.405

Table 5: Covariates variables