Research cooperation within and across regional boundaries. Does innovation policy add something?◆

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Abstract

The paper aims to show how policy makers can stimulate firms' cooperation with research organizations in innovation. We argue that the administration of an R&D subsidy can be effective. Furthermore, this should be more so for extra-regional than intra-regional cooperation. The firms' propensity to extend cooperation across the region is assumed to increase with the amount of support. However, the support must overcome a threshold, for firms to cover the fixed costs of distant interactions. These research hypotheses are tested with respect to a sample of firms in an Italian region. Propensity score matching is applied to identify the impact of the subsidy receipt. A generalised propensity score technique is employed to investigate the effect of an increasing amount of support. All the hypotheses are not rejected. Firms' cooperation is policy sensible, but the size of the support is crucial for its effects.

Keywords : Industry-Research Cooperation, Regional Innovation Systems, Behavioural Additionality
JEL Classification : O32; O38; R11; R58

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1. Introduction

Innovation cooperation is a core issue in both the research and the policy agenda. In the last decade, it has been one of the pillars of the system approach to innovation policy, at both the national and regional level (Edquist, 2000). More recently, it has stimulated the debate on the so-called "open innovation" mode (Chesbrough *et al.*, 2006) and the policy-shift from "knowledge stocks" to "knowledge flows" (European-Commission, 2010).

Cooperating with research organisations (ROs) (universities and research institutes) is important for industrial innovation. Through cooperation, firms are able to access new knowledge from the world of science and to share the costs and risks of their research projects.[1]

The role of firms' cooperation with ROs has been widely recognised also at the regional level. Within the regional boundaries, it contributes to shaping the 'knowledge-base' and the technological profile of the Regional Innovation System (RIS) (Cooke *et al.*, 1997; Asheim and Coenen, 2005). Across the boundaries, innovation cooperation allows regions to open up, enter into broader (possibly global) innovation networks, and upgrade their competencies (Kratke and Brandt, 2009).

In spite of its relevance, the results obtained by regional studies on the cooperation between firms and ROs still hesitate translating into science and technology policies to foster it (Hassink, 2002; Todtling and Trippl, 2005). Different reasons are responsible for that. On the one hand, the analysis of those barriers which hamper this interaction, and which require a policy intervention, is recent and mainly focused on the national level (Mora-Valentin *et al.*, 2004; Bruneel *et al.*, 2010). On the other hand, the outcome of the policies which address these barriers is hard to identify. Industry-research cooperation is not "one-shot" like, but rather evolves over time and often becomes very unstable (Lhuillery and Pfister, 2009). Furthermore, what innovation policy actually "adds" to the cooperative behaviours that firms would have however established, searching for a competitive advantage, is hard to disentangle. Non-standard econometric techniques are required. However, these have been mainly applied to assess the policy impact on firms' innovation inputs (e.g. R&D expenditure) and outputs (e.g. patents) (Georghiou, 2004).

We try to fill this gap and investigate whether, and to which extent, the networking activities of a RIS are affected by regional innovation policy. More precisely, we look at a regional subsidy to R&D, which includes cooperation between firms and ROs among the activities eligible for public funding.

We translate our arguments into research hypotheses and test them in the empirical study of

[1] Innovation cooperation among firms (for example, in R&D) also plays important functions (Kamien *et al.*, 1992; Pisano, 1990) and has been attracting a lot of empirical attention (e.g. Hagedoorn, 1993; Hagedoorn and Van Kranenburg, 2003).

an Italian region (Emilia-Romagna (ER)). Cooperation with ROs is dealt with as an element of the "behavioural additionality" of innovation policy (Antonioli and Marzucchi, 2012). We use an original, firm-level dataset, which contains information on the funding of the policy, pre-policy characteristics and post-policy behaviours and performances. A set of propensity score matching techniques is first applied. The effect that an increase in the amount of subsidy has on the geographical extent of the firms' cooperation with ROs is then investigated, by applying the generalised propensity score technique (Hirano and Imbens, 2004). This is an important value added with respect to the extant literature.

The reminder of the paper is organised as follows. Section 2 reviews the relevant literature and puts forward our research hypotheses. Section 3 presents the empirical application and Section 4 discusses its results. Section 5 concludes.

2. Background literature and hypotheses

The link between science and technology, and its role for firms' innovation has been investigated since long (Allen, 1977; Tushman and Katz, 1980). Several empirical studies have shown that many innovations have their roots in the cooperation between firms and ROs (e.g. Mansfield, 1991, 1995; Mansfield and Lee, 1996; Cockburn and Henderson, 2001). Firstly, ROs can provide firms with complementary knowledge and with other intangible assets (e.g. human capital), which are necessary for their innovations, but not easily contracted through market-based transactions (Sinha and Cusumano, 1991). Secondly, by establishing partnerships with ROs, firms can share the risks and costs of their R&D projects and try to benefit from economies of scale (Hagedoorn, 1993; Tether, 2002).

The firms' cooperation with ROs is also important at the regional level. Along with inter-firm networks (in particular, R&D partnerships) and other institutional linkages (for example, those with local banks), firms' interactions with ROs give rise to location-specific innovation patterns, of which RISs are one of the most celebrated example (Cooke *et al.*, 1997). In the RIS framework, industry-research interactions represent the "knowledge fabric" of the system, where scientific knowledge is developed, before being accessed and transformed into new products and processes by the technology sub-system (Fritsch, 2001). Following the learning-regions perspective (Florida, 1995; Hassink and Klaerding, 2012), these interactions generate the "analytical knowledge base" (that is, a *know-why* kind of knowledge) that activate the Science and Technology Innovation (STI) mode (Asheim, 2012). Firms' cooperation with ROs thus contributes to define the "knowledge-base" of the region. It makes arise a variety of RIS (learning regions), with different innovation potential (Asheim and Coenen, 2005, 2006) and different specialization patterns (Wintjes and Hollanders, 2011).[2]

Although beneficial in terms of innovation outcomes, the cooperation between firms and ROs is hampered by several barriers. These barriers create the need of a policy support (Busom and Fernandez-Ribas, 2008), also and above at the regional level (e.g. Hassink, 2002). Irrespectively from the location of the ROs, regional firms could find costly to establish and manage relationships with them, because they have different incentives and objectives (Carayol, 2003). Their approaches to intellectual property are often conflicting and result in divergent quality and evaluations of their respective patents (Valentin and Jensen, 2007). Their stocks of knowledge capital can be quite unbalanced, hampering the firms' absorption of the ROs' knowledge (Hall *et al.*, 2003). These barriers, and their implicit and explicit costs, can be exacerbated in those regional contexts (e.g. "peripheral" and "old industrial regions") whose industrial structure is dominated by SMEs characterised by a low-tech specialisation pattern (Fritsch and Schwirten, 1999).

The public support to firms' innovation - such as, for example, an R&D subsidy - can be used by the recipient firms also to restore the incentives to cooperate with ROs and to reduce the costs of managing the relative partnerships (Vilasuso and Frascatore, 2000). In other words, the policy can increase the extent and/or the number of these collaborations. The empirical evidence is consistent with this expectation. The government support appears generally significant among the determinants of science-technology relationships (e.g. Mohnen and Hoareau, 2003; Capron and Cincera, 2003). In other words, the policy can be expected to generate what has been called "behavioural-additionality" (e.g. Antonioli and Marzucchi, 2012). Not only is the public intervention able to increase, with respect to the pre-policy scenario, firms' innovation investments ("input-additionality") and results ("output-additionality"). It can also lead to a "change in a company's *way of* undertaking R&D" (Buisseret *et al.*, 1995, p.590, additional emphasis). In the case of regional firms, this behavioural-additionality is particularly important. An R&D subsidy, which includes cooperation with ROs among the activities eligible for public funding, can make the knowledge-base of the RIS "thicker" and increase its innovation potential. The following hypothesis is thus worthwhile testing:

HP1: The receipt of an R&D subsidy increases firms' cooperation with ROs.

Innovation cooperation with ROs is particularly important when they are located across the regional boundaries. This kind of interaction enables regional firms to access an external (possibly international) pool of resources and capabilities for innovation, which could complement the local ones (Asheim and Coenen, 2006). Furthermore, it enhances knowledge generation and circulation in the region, and increases the diversity of the ideas within the local

[2] In the learning region, the STI mode combines with the Doing-Using-Interacting (DUI) mode, which generates the "synthetic" (that is, *know-how)* and the "symbolic" (that is, *know-who)* knowledge-base of it (Asheim, 2012).

knowledge base (Bathelt *et al.*, 2004, Gertler and Levitte, 2005; Boschma and Ter Wal, 2007). Last, but not least, it attenuates the risk that the RIS gets locked in its current knowledge-base, which could become obsolete for the sake of innovation (Hassink, 2005; Giuliani, 2005). In synthesis, the RIS can turn into an ORIS (Open Regional Innovation System) (Belussi *et al.* 2010).

However, extra-regional cooperation is also more costly than the regional one, as it occurs with less "geographical proximity" between the partners. *Coeteris paribus*, the costs of travelling are higher, the time for making cooperation work is longer, and the relative communication is harder (Katz, 1994; Fritsch and Schwirten, 1999). This is consistent with those studies, which find that geographical proximity facilitates interaction between science and technology (e.g. Arundel and Geuna, 2004; Mora-Valentin *et al.*, 2004; Levy *et al.*, 2009). Innovation cooperation can be successful in absence of it, but the lack of geographical proximity needs to be compensated by the presence of organizational proximity and/or social proximity (Knoben *et al.*, 2012; Breschi and Lissoni, 2009; D'Este *et al.*, 2012). However, these latter forms of proximity need to be built up and/or maintained through dedicated coordination mechanisms, which could be very costly for regional firms. Different regions can be separated by socio-cultural and techno-economic gaps within the same country (e.g. Evangelista *et al.*, 2002). Furthermore, in cooperating across the national boundaries they might have to discount some "liability of foreigness" (Zaheer, 1995, Tallman and Phene, 2007).

This argument has an important implication for the policy impact on innovation cooperation. The extent to which a policy support to R&D can cover the firms' costs for cooperating is higher for regional than for extra-regional cooperation. In other words, the simple receipt of the subsidy could not be enough to overcome (also) the costs of distant cooperation. Accordingly, *coeteris paribus,* the policy will more likely enhance regional cooperation than extra-regional one. Following the behavioural-additionality perspective, the simple receipt of an R&D subsidy (disregarding the amount of support) can be expected to make funded firms more prone to interact with regional ROs than with extra-regional ROs, when compared with "non-treated" firms. We thus put forward the following hypothesis:

HP2: The receipt of an R&D subsidy increases firms' cooperation more with regional than with extra-regional ROs.

It should be noted that HP2 does not amount to stating that regional innovation policy is ineffective in stimulating extra-regional cooperation with ROs. It rather entails that this stimulus requires a substantial and qualified policy action. Investigating the circumstances under which the policy funding enhances firms' interaction with extra-regional ROs is particularly important. As we said, when firms are able to collaborate with research excellence centres located beyond the regional borders, they can renew their knowledge base and that of the region in which they operate.

The evolutionary-cognitive perspective which underpins the notion of RIS (Uyarra, 2010; Boschma and Frenken, 2006) would predict that regional firms should search for innovative knowledge by 'exploring' new sources of it, by selecting out those ones which are already 'exploited' and/or exploitable. Regional firms could bring in new ideas by deliberately creating "holes" in their local knowledge base and using cooperation to overcome the constraints of local search (Rosenkopf and Almeida, 2003). In management studies, "boundary-spanning exploration" - with respect to both the organizational and technological boundaries of the firm - has been shown to be crucial for obtaining new knowledge, with the greatest innovation impact (Rosenkopf and Nerkar, 2001). Similarly, in regional studies, spanning the boundaries of the region has also appeared important for firms to pursue innovation and competitiveness (Grotz and Braun, 1997). Firms that look for cutting-edge knowledge and diverse research partners have appeared to cooperate with ROs irrespectively from their geographical proximity (Belussi *et al.*, 2010; D'Este and Iammarino, 2010; Laursen *et al.*, 2011). In synthesis, the real adding-value cooperation can be claimed to be that for which firms are willing to face the additional costs that an increasingly distant cooperation entails.[3]

On the basis of the previous argument, the policy role in fostering extra-regional cooperation crucially depends on the extent to which the amount of the public subsidy can cover its costs. In principle, we can expect that, the higher the amount of the R&D subsidy is, the higher the degree of coverage, and the higher the propensity of cooperating extra-regionally will be.

However, an important specification should be added. Establishing a distant cooperation with (and/or switching from a local to) an extra-regional partner, requires regional firms to face important, up-front fixed costs. Local firms need to adopt more complex (e.g. multi-language) organizational search routines for identifying more geographically distant partners (Knoben and Oerlemans, 2012). They are asked to manage the eventual manifold 'institutionalisation' (e.g. different sources of contractual rules and regulating procedures, in different geographical contexts) of the cooperative relationship (Bonaccorsi and Piccaluga, 1994). Last, but not least, they need to build-up a more powerful absorptive capacity (mainly, through R&D and human capital investments) for accessing and assimilating the knowledge of more cognitively distant and/or still unexplored sources (Nooteboom, 2000).

[3] It should be noted that we are not claiming that distant cooperation is better than close one for regional innovativeness, as much as we did not claim the reverse in presenting HP2. We rather claim that the two kinds of cooperation are both useful, but for different purposes and with respect to different partners (Broström, 2010; Ponds *et al.*, 2007). The recent hypothesis that a geographical variety of knowledge-links could be the strategy to reach a higher innovative performance appears particularly interesting (Knoben and Oerlemans, 2012) and is on our future research agenda.

All the previous activities imply fixed costs that firms need to offset for cooperating successfully across the regional boundaries.[4] The need to overcome these costs can create indivisibility in the 'production' of extra-regional cooperation. Regional firms could thus find this cooperation inconvenient, unless it overcomes a minimum efficient scale in terms of number or/and size of innovative projects. The policy implication of this argument is quite straightforward. Suppose that policy-makers want to stimulate regional firms to cooperate more extra-regionally, and for this they think to increase the amount of the R&D subsidy. Unless this amount would allow them to reach the minimum scale to cover the fixed costs, this attempt will not work. For example, a small scale subsidy, or a series of them, which just partially contribute to the fixed costs of extra-regional cooperation, would not affect the decision of the recipient firms to cooperate across the region.

Combining this last argument with the previous one about the size of the subsidy, leads us to the following hypothesis:

HP3: The firms' propensity to extend cooperation with ROs beyond the regional borders increases by increasing the amount of R&D subsidy, providing that this latter overcomes a minimum threshold.

The actual specification of this minimum threshold is of course an empirical issue, specific to both the regional context and the structural features of the regional firms. However, this is out of the paper's scope. Our concern for testing this hypothesis is simply that the additionality of the regional subsidy with respect to an extra-regional cooperative behaviour does not appear significant for any (increasing) level of the subsidy, but only above a certain one.

Let us now turn to the hypothesis testing.

3. Empirical application

The empirical application through which the previous hypotheses are tested refers to the North-East Italy region (NUTS2-level) of Emilia-Romagna (ER).

The region has a population of nearly 4.5 million people and accounts for about 9% of the national GDP.[5] The characteristics of its production structure – a high density of SMEs, co-located in specialised production systems, with pervasive social capital (that is, in *industrial districts*) - are quite well-known in regional studies (Brusco, 1982). The region also has a remarkable record in firms' innovative efforts and outcomes (Antonioli *et al.*, 2011; Hollanders

[4] As Brostrom (2010) puts it, the capacity that certain firms can have to offset these costs, and to fine-tune close and distant cooperation along the R&D cycle, would explain the apparent contradictory results which have been found about the non-bounding role of geographical distance for the success of university-industry interaction.

[5] Our own elaborations drawing on: "Istat - GeoDemo Statistics"; "Istat - Regional Economic Accounts"; "Eurostat - Regional Statistics Database".

et al., 2009). On the other hand, some key-innovation enablers are weakly present[6]. Furthermore, the constitutive linkages of the RIS, both in the business realm and in the science-industry link, turn out to be quite informal and have characterised it as an "informal learning system" (Evangelista *et al.*, 2002).

Innovation policy has an important role in this RIS (Bianchi and Giordani, 1993). A remarkable example is represented by the ``Regional Programme for Industrial Research, Innovation and Technology Transfer" (PRRIITT), launched for the first time in 2003 (Marzocchi, 2009). Its aim is that of mitigating the weaknesses of the RIS, while exploiting its specific strengths.

The present application makes use of this policy scheme. In particular, we focus on the first two calls (February and September 2004) of the ``Measure 3.1 A" within it. This measure was devised to sustain industrial research and precompetitive development with a focus on more detailed objectives than a general R&D subsidy. One of these objectives was the reinforcement of cooperative activities among the components of the RIS, namely between firms and research organisations. Accordingly, this application reveals particularly suitable for testing our hypotheses.[7]

3.2. Data

The test for our hypotheses relies on a unique dataset. Firstly, by focusing on a single region, we have been able to obtain from its policy makers detailed information on the amount and characteristics of the investigated policy scheme. This information has been then integrated with other two firm-level data sources. The first one is an original survey, with a similar structure of the Eurostat Community Innovation Survey (CIS), carried out in 2009 by Antonioli *et al.* (2011) on 555 ER manufacturing firms (with at least 20 employees). The second source is the AIDA database, by BureauVanDijk, which we used to extract firms' balance-sheets data.

The survey contains detailed information on structural and organisational characteristics of the surveyed firms, and on their innovation strategies and outcomes. The random sample of 555 firms is stratified by size, province (geographic location at NUTS 3 level) and sector. The reference years are 2006-2008, after the administration of the policy, while some of the data that we will use are (supposed) time-invariant. On the other hand, balance-sheets data (for example, intramural R&D and advertising expenditures) refer to the year 2003, before the

[6] In the last two European Regional Scoreboards (see Hollanders *et al.*, 2009), these were: population with tertiary education, participation in life-long learning, public R&D expenditures, and broadband access.

[7] It is worth stressing that cooperation with ROs (regional and extra-regional) was included among the activities eligible for funding - with higher percentages of public support than other types of expenditures. However, it was neither a requirement, nor an explicit criterion for the allocation of the policy incentives.

policy.

After the merging and cleaning procedures, we were left with a sample of 408 firms: 99 subsidised, and 309 non-subsidised with the PRIITT Measure 3.1A. The 99 firms show 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 (Table B1).[8]

3.3. Econometric strategy

The strategy we use to test the first two hypotheses (HP1-HP2) is established in the empirical literature on the impact of R&D subsidies (e.g. Czarnitzki and Licht, 2006; Busom and Fernandez-Ribas, 2008; Fernandez-Ribas and Shapira, 2009).

Given the non-exogeneity of the policy support[9], and the related problems of an OLS model, the estimation of its impact can make use of a *Propensity Score Matching (PSM)* approach (Rosenbaum and Rubin, 1983). In brief, the *PSM* tries to get an estimate of the *Average Treatment effect* on the *Treated (ATT)* of the policy, defined as:

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

Y_1 and Y_0 denote the value of a certain outcome variable (Y) in the presence and absence of the treatment (policy, in this case), respectively. D denotes the status of the treatment: $D = 1$, administrated (treated); $D = 0$, non-administrated (non-treated).

($Y_0|D = 1$) is by definition non-observable. Therefore, it needs to be substituted by referring to a suitable "counter-factual" of firms that did not receive the policy support. In order to control for the selection-bias (on observables), and be sure that the difference in the outcome of the two groups is exclusively due to the policy, treated firms are matched with non-treated ones on the basis of the propensity score, $Pr(D = 1|X)$ (or $P(X)$). This latter represents the probability of being treated, given a set of pre-treatment characteristics, X, which are supposed to affect both the treatment and the outcome. The *PSM* estimate of *ATT* is thus given by:

[8] Regional funds were allocated on the basis of the assessment that an independent committee of experts made of the submitted innovation projects. 529 projects, proposed by 557 firms, were subsidised through the two calls. The average regional contribution was of 175,000 Euros per-project and the total cost of the subsidised projects was about 236 million Euros. The public funding covered about the 40% of the total cost, with an overall public expenditure of 96 million Euros.

[9] One just needs to think about the "picking the winner" or "aiding the poor" strategy that policy makers often follow (Cerulli, 2010).

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

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

PSM is implemented by using a set of standard procedures, assumptions and quality tests. In brief, a set of matching procedures are used, which allow us to assess the stability and, indirectly, the reliability of the evidence. These procedures differ in the selection and weighting of the non-treated firms to be used as matches, as well as in the capacity to trade between efficiency and bias reduction (Becker and Ichino, 2002; Cameron and Trivedi, 2009; Smith and Todd, 2005; Caliendo and Kopeinig, 2008). The common support condition is imposed to all the matching procedures, to guarantee the presence of suitable counterfactual firms for each treated.[10] Finally, the quality of the matching is tested by controlling that the beneficiaries and the matched controls are correctly aligned with respect to the vector of the covariates X.[11]

The test of HP3 makes use of an original "continuous treatment" approach: the *Generalised Propensity Score* method (*GPS*) (Hirano and Imbens, 2004; Bia and Mattei, 2008). In particular, the *GPS* is here used to estimate, for a set of subsidy levels, the effect of an additional amount of public support. In technical terms, given the treatment, T, and a set of covariates, X, which explain its administration, the Generalised Propensity Score, R, is defined as (Hirano and Imbens, 2004):

$$R = r(T, X) \qquad (3)$$

where the propensity function $r(t, x)$ is the conditional density of the *actual* treatment, t, given the *observed* covariates, x.

Like the propensity score, also the *GPS* has a balancing property.[12] Hirano and Imbens (2004) have demonstrated that, when this balancing propriety is associated with a suitable unconfoundedness assumption, the treatment is unconfounded given the *GPS*. Hence, the *GPS* can be used to eliminate the bias in the estimation of the treatment effect, which is due to differences in the covariates.

Following Hirano and Imbens (2004) and Bia and Mattei (2008), we follow a three-step estimation strategy which is illustrated in Appendix A. Two specific elements of it are however worthwhile clarifying at this stage. First of all, our HP3 refers to the effect that an extra amount

[10] In addition to the "minima and maxima" comparison, the 5 nearest-neighbours matching is implemented by imposing the common support condition also with a 1% "trimming" procedure (see Caliendo and Kopeinig, 2008).

[11] Three tests have been carried out (Caliendo and Kopeinig, 2008): a joint significance and a pseudo-R^2 test for the *PSM* probit, and a regression-based t-test on the differences in the covariates means. The results of these tests, available upon request, largely support the quality of the matching procedures.

[12] Within strata with the same value of $r(t,x)$, the probability that $T = t$ does not depend on X.

of subsidy has on a set of cooperation decisions which have a discretely increasing geographical distance: no-cooperation, cooperation with a regional partner, and cooperation with an extra-regional partner. Therefore, step-two of the *GPS* strategy is estimated with an ordered probit model. Secondly, the choice of the variation of the treatment, for analysing the incremental effects of the policy, inevitably suffers from *ad-hocness*. This problem is attenuated by choosing the variation according to the characteristics of the investigated context. As the average regional contribution was equal to 175,000 Euros, Δt has been heuristically looked for among a set of options and chosen at 20,000 Euros.[13] Looking at the minimum and maximum amount of subsidy granted to the firms, the treatment levels to which such a Δt has been applied spans from 60,000 to 250,000 Euros.

3.4. Variables

We build up two sets of variables. Firstly, we need a set of suitable covariates, *X*, to be included in the estimation of the propensity score and of the *GPS*. Sector-specific and firm-specific effects in innovation are first controlled for by considering, respectively, a set of dummies (*PAVITT1 — PAVITT5)* for the Pavitt/OECD sectors, and (the natural logarithm of) the firms' number of employees ($lnEMP_{2003}$). Furthermore, provincial (NUTS 3-level) dummies (*GEO1 — GE010*) are considered to account for the geographical heterogeneity of the ER region.

In addition to these time-invariant controls, the dataset allowed us to consider two pre-policy features (that is, in 2003), which could affect the policy administration (in 2004): the firms' innovativeness and their financial situation. The first one is proxied by per-capita expenditures in intramural R&D and advertising ($RDADV_{2003}$).[14] Our expectation is that firms with higher R&D intensity are more willing to apply for and use the subsidy to make further steps along their innovation path. The financial situation of the firm is proxied by its cash-flow per capita ($CASHFLOW_{2003}$) - accounting for the firm's internal financial resources to invest in innovation - and its short-term debt index ($FINCONST_{2003}$) - signalling the presence of eventual financial constraints.[15] Our expectation is that smaller (larger) financial resources (barriers) will make firms more prone to apply for the subsidy.

We should note that, apart from the sectoral and geographical dummies, all the considered covariates are continuous variables. This fact enhances the quality of the estimates.

[13] This is approximately the cost of an extra temporary contract for a junior researcher in a typical department of a regional university/institute. As a robustness check, we carried out our analysis with different values of Δt, namely 1.00 Euro, 1,000 Euros, and 40,000 Euros.

[14] Unfortunately, disaggregated data for the two kinds of expenditures were not available. However, recent studies are emerging on their complementary in the current open-innovation and demand-led paradigm (e.g. Perks e*t al.*, 2009).

[15] The short-term debt is here considered to be 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.

Furthermore, nearly all of them are used in the specification of both the propensity score and the *GPS*. Only few of them had to be dropped to respect the balancing propriety of the latter: the provincial dummies (*GEO1* — *GEO10*) and the expenditure in R&D and advertising in year 2003 ($RDADV_{2003}$).

The second set of variables that we need refers to the outcome of the policy in terms of innovation cooperation. At the outset, we distinguish ROs between universities and research institutes. This is consistent with the literature (e.g. Todtling *et al.*, 2009), in which the specific type of partner can have a role in determining the cooperative-additionality of the policy. More precisely, in the test for HP1 and HP2 we consider whether, in the aftermath of the policy (period 2006-2008), firms had cooperation agreements in place with: regional universities ($COOPUNI_{REG}$) and research institutes ($COOPRESINS_{REG}$); extra-regional universities ($COOPUNI_{EXTRA}$) and research institutes ($COOPRESINS_{EXTRA}$).

Finally, HP3 is tested with respect to two ordinal variables ($COOPUNI_{ORD}$ and $COOPRESINS_{ORD}$) which, in the post-policy period (2006-2008), account for the geographical range of the firms' interaction with ROs. Each of these variables takes value 0, in case of no cooperation, 1, in case of regional cooperation, 2, in case of extra-regional cooperation with at least one university or research institute, respectively.

Tables B2 and B3 present the main descriptive statistics of the covariates and of the outcome variables we have built up.

4. Results

Before looking at the *PSM* estimates for the first two hypotheses, let us consider the underlying probit estimation (Table 1).

[Insert Table 1 around here]

As expected, the R&D support has a higher probability of being searched/received by firms which already have an internal research (and advertising) experience ($RDADV_{2003}$).[16] Furthermore, firms operating in more dynamic and technology-intensive sectors are more likely to be subsidized. In addition to scale-intensive firms (*PAVITT4*), science-based companies (*PAVITT3*) and firms operating in the propulsive district core of the ER region, characterized by specialized suppliers sectors (*PAVITT5*), have a higher probability of receiving the subsidy.

[16] R&D could equally increase the willingness and the capacity of firms to apply for the policy. Unfortunately, we cannot distinguish whether previous engagement in R&D increases awareness of the need to innovate, and thus the interest/propensity to submit projects, rather than the capacity to present more promising and well-planned proposals.

Finally, a sound, rather than a weak, financial condition increases the firms' probability of being funded (*$FINCONST_{2003}$* is significantly negative). The fact that financial soundness helps firms to show/make a more efficient use of the subsidy is a tentative explanation for this result.

In synthesis, the investigated regional policy seems to help the innovative firms of ER to breed their success in innovation (Antonioli *et al.*, 2012): in brief, a "picking the winner" kind of policy (Cerulli, 2010).

Table 2 shows that the *ATT* of the policy on the firms' cooperation with ROs is positive and significant. Funded firms are actually more likely to cooperate with ROs than non-funded ones, irrespectively from the nature of the research partner and from its location. The result is extremely robust across all the matching procedures employed. HP1 is thus largely supported.

The relationship between local firms and ROs actually appear affected by costly barriers (e.g. incentive conflicts and resource asymmetries), which the policy is able to attenuate. Within the region, the *ATT* of the policy is higher with respect to universities (from +37.4% to +40.2%, depending on the procedure) than research institutes (from +32.8% to +33.5%), while the opposite is true across the regional boundaries (from +13.0% to +19.8%, and from +19.3% to +22.6%, respectively). This is another interesting result. The simple fact of receiving a subsidy of a certain amount spurs firms to search for a more basic kind of knowledge, within the region, and a more applied one, outside of it.

In synthesis, the policy actually seems to have added something to the cooperative behaviour of regional firms. Given the weaknesses the investigated RIS has been found to suffer in terms of "innovation enablers" (Hollanders *et al.*, 2009), and the lack of those formal, explicit relationships (Evangelista *et al.*, 2002), which are typical of the science-technology link, this result suggests an "illuminated" action by the policy-makers of the region.

[Insert Table 2 around here]

The comparison between the *ATT* of the policy within and across the region largely supports also HP2. With respect to non-funded ones, funded firms are actually more likely to cooperate with regional (from +37.4% to +40.2%, depending on the marching procedure) than with extra-regional universities (from +13.0% to +19.8%). The same holds true in the case of regional and extra-regional research institutes (from +32.8% to +33.5%, and from +19.3% to +22.6%, respectively). This result is also extremely robust and interesting for its implications. On the one hand, it confirms the theoretical hypothesis that geographical-proximity could favour cooperation with ROs (Abramovsky and Simpson, 2011; Ponds *et al.*, 2007). Closer cooperation is actually easier to be activated than distant one by the contribution of the public policy. On the other hand, it remains true that the policy has some additionality in terms of extra-regional cooperation too. Given the role that this kind of relationship plays in opening-up the RIS, by allowing the regional firms to renew the local knowledge base (e.g. Hassink, 2005), this is another very welcomed result of the policy in this RIS.

Let us now consider the test of HP3, which makes use of the *GPS*.[17] HP3 turns out to be generally supported. First of all, an increase of the R&D subsidy significantly affects the likelihood that firms widen the geographical extent of their cooperation with ROs, providing the subsidy overcomes a minimum threshold. By considering an increase of 20,000 (40,000) Euros, this threshold is: 200,000 (180,000) Euros, with respect to research institutes (Table 3) and 180,000 (160,000) Euros, with respect to universities (Table 4). This result is quite interesting. It supports the argument that research collaborations are affected by up-front, fixed costs, which could actually create indivisibility problems. In other words, these are costs which can not be compensated by cumulating moderated policy interventions over time, but only with a public funding above what can be considered a minimum efficient scale. Although the difference is not large, the minimum scale for cooperating extra-region appears higher with respect to research institutes than universities. Those collaborative projects which entail a more direct application of the results to the business realm (e.g., the exploitation of a certain patent, rather than its obtainment) thus seem to have comparatively higher fixed costs.

Apart from the presence of a minimum efficient scale of public funding, the results are different depending on the nature of the partner. Overall, however, they still support our HP3. In the case of research institutes (Table 3),[18] above the minimum threshold, the increase of the policy support actually increases the likelihood that the funded firms extend the geographical range of this collaboration across the region ($Y = 2$). With Δt = 20,000, the range of the treatment effects spans from +6.4% to +14%, along the considered levels of treatment. The policy could actually help regional firms in using boundary-spanning alliances to overcome the local search for research institutes, by covering the increasing costs of this spanning. To be sure, rather than diminished (if not even 'overcome' (Rosenkopf and Almeida, 2003)), the local search is left unaltered by the increase in the policy intervention (that is, the outcome $Y = 1$ is not significantly affected by it).[19] In other words, rather than using the policy support for shifting from a local to a global (or simply external) cooperative pattern with research institutes, regional firms appear more inclined to keep the former and possibly make it '*glocal*'.

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[17] The maximum likelihood estimation of the *GPS* is reported in the Appendix (Table B). In what follows, we report and comment the results obtained with Δt values of 20,000 Euros and 40,000 Euros only. Further comments on the robustness of the test will be added at the end of this section.

[18] See also the treatment effect functions in Figure B1.

[19] Although with a different threshold value (i.e. 180,000 rather than 200,000 Euros), and with a different range of the treatment effects for $Y = 2$ - that is from +9.7% to +30.1% - the results we have obtained for the interaction with research institutes are confirmed for Δt = 40,000 Euros.

[Insert Table 3 around here]

Adding an extra amount of treatment above the threshold enhances the firms' propensity to cooperate also with an extra-regional university ($Y = 2$): in a measure which, for an increase of 20,000 Euros, spans from +5.6% to + 20.4% along the considered treatment levels (Table 4).[20] The policy thus appears to have a potential role in allowing regional firms to bear the costs of the boundary-spanning exploration of excellent university centres. However, differently from what emerged for the collaboration with research institutes, the increasing attitude to cooperate with extra-regional academic partners is this time associated to a decreasing propensity to collaborate with a regional university ($Y = 1$). Above the threshold (of 180,000 Euros), an extra amount of subsidy (of 20,000 Euros) induces firms to cooperate less with regional academic partners: from -2.4% to -15.9%.[21]

This result suggests a sort of substitution effect, between an "inward-looking" and an "outward-looking" cooperation strategy in the case of universities. Its possible explanation can be found in the kind of knowledge which the two types of interactions are likely to generate. Unlike that with research institutes, the cooperation with academic partners is generally carried out within the institutional grids of internationally codified scientific fields, and with a peer-review system which is also geographically more homogeneous. Therefore, in the cooperation with local universities, regional firms could find access to an analytical kind of knowledge which is not too dissimilar - at least in terms of 'breath" - from that available outside the regional borders. Accordingly, once the public support allows firms to deal with its higher cost, the cooperation with extra-regional universities substitutes that with regional ones. As we said, the former is likely to offer knowledge that, while similar in breath to the latter, could be newer and more advanced for the sake of innovation.

[Insert Table 4 around here]

In concluding, we should note that the obtained results are largely robust across the Δt values that we have selected.[22] In order to have a further robustness check, we have re-run the

[20] See also the treatment effect functions reported in Figure B2.

[21] Also these results are robust with respect to the selected Δ of the treatment (i.e. 40,000 Euros), although with a different threshold (160,000 Euros), and different ranges in the effect for $Y = 2$ (from +7% to +39.1%) and for $Y = 1$ (from -8.6% to -32.8%).

[22] The evidence emerging from the estimates which employ Δt values of 1.00 Euro and 1,000 Euros has not been illustrated for the sake of parsimony. These additional amounts of subsidy can be considered quite small, when compared to the cost of establishing and managing cooperation with a research organisation. Accordingly, we could expect that they are not able to have economically meaningful impacts. The results, still available upon request,

previous analysis by employing a different type of "treatment". Instead of the actual amount of the subsidy, we have used the intensity of the subsidy: that is, the ratio between the subsidy and the total amount of the funded project. However, the results show that this is neither particularly meaningful, nor a viable way to proceed in the context of our empirical application. Given the design of the considered policy intervention, which supported the different types of firms' expenditures in fixed percentages, the ratio between the subsidy and the total amount of the project turns out to be extremely concentrated (for example, 65% of the observations have a subsidy intensity ratio between 35%-45%). This quite low variability made the estimation of the *GPS* (i.e. the first step of the procedure described in Appendix A) not feasible.

Finally, our evidence can also be considered robust to the potentially concurring effects of other policy interventions, which might have benefited the funded firms in our sample. In the absence of proper data, we cannot control econometrically for this potential bias. However, some qualitative evidence suggests that this distortion is not a major concern for our empirical application. In the course of informal interviews, the representatives of the regional policy-makers confirmed that the large majority of SMEs funded by the subsidy (see Table B1) did not apply for other R&D funding schemes. In the same occasion, they also reported that other firms, not necessarily SMEs, resorted to regional funding, because they were unable to access other subsidy schemes (for example, because the relative calls for applications were already closed).

5. Conclusions

Increasing industry-research cooperation is an important objective to be pursued by the policy makers. Within the region, it helps to strengthen the knowledge-base, which becomes available to the local firms for innovating. Across the regional boundaries, it allows firms to tap into different knowledge sources for then proposing novel business solutions in the region. A simple instrument like an R&D subsidy appears quite effective in both respects.

This is the first important result of the paper. The significant and robust cooperative-additionality revealed by the investigated policy-scheme, suggests us that innovation cooperation is actually affected by costly barriers. Therefore, the policy maker can have an important role in addressing this failure in the functioning of the RIS.

A second insight emerging from our analysis is that the simple receipt of an R&D subsidy

confirm this expectation. Even if they are consistent with those presented, in terms of (thresholds of) significance, the treatment effects are indeed very low in terms of magnitude.

induces local firms to increase their cooperation with ROs more within the region, than across its boundaries. This suggests that, although its lack can be overcome by relying on other kind of proximities, the geographical proximity between the cooperating partners affects the priority that the local firms attach to their cooperative projects. Apparently, the simple provision of a subsidy to innovation is not able to affect this strategic choice in cooperating.

Our evidence has shown that the amount of subsidy, rather than its simple receipt, can have play role in that. In particular, a substantial policy intervention (that is, above a minimum threshold) appears necessary to allow firm to overcome the presence of indivisible fixed costs in extra-regional cooperation. Providing it goes beyond a minimum threshold, an additional amount of subsidy increases the firms' propensity to engage in more costly extra-regional cooperation, through which firms can access cutting-edge and unique research capabilities.

The possibility that extra-regional cooperation occurs at the expenses of the intra-regional one is another important issue. Our application shows that the nature of the partner, and of the knowledge which is generated by interacting with it, is a relevant aspect for the eventual shift from an inward (local) to an outward (global) cooperative strategy. As we said, this occurs for the firms' cooperation with universities, but not with research institutes. These results have some important policy implications. First, investigating which is the minimum scale for extra-regional cooperation to be effective for the local firms, and devise a consistent contribution, becomes an important task for the regional policy-makers. Second, an accurate screening of the ROs (in particular, research institutes rather than universities) through which extra-regional cooperation is expected to provide its gains becomes another important policy task. With respect to some partners (universities, in our case), the policy could have the side effect of making them less pivotal for the development of regional innovations.

These results are not free of limitations. In particular, they are sensible to the characteristics of the context and of the policy that we have considered. The fact that SMEs were the main beneficiaries of the intervention, and the low level of the average public support, are just two examples. On the other hand, the results of the present study also have a general value. In regional studies, despite its idiosyncratic techno-economic characteristics (Brusco, 1982; Hollanders *et al.*, 2009), ER has been found to be a good approximation of the RIS conceptualisation (e.g. Evangelista *et al.*, 2002) and a benchmark of an industrial-district based model for other countries (see, for example, Humphrey, 1995). For this reason, although with inevitable specifications, what emerged from the ER policy-area by applying the original methodology which we have put forward could be expected to hold in other different regional contexts.

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Tables and Figures

Table 1: Probit estimation of the propensity score

	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	0.290
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>χ2	0.000	

***, **, * indicate a significance level of 1%, 5%, 10%, respectively.
A VIF test excludes the presence of multicollinearity among the covariates (all the VIF values are lower than 10).

Table 2: Effect of the subsidy receipt on the firms' cooperation with ROs

	5NN		Caliper		Kernel		5NN Trim	
	ATT	S.E.	ATT	S.E.	ATT	S.E.	ATT	S.E.
Cooperation with Research Organisations (ROs)								
Intra-RIS								
$COOPUNI_{REG}$	0.374 ***	0.082	0.393 ***	0.082	0.402 ***	0.072	0.381 ***	0.077
$COOPRESINS_{REG}$	0.335 ***	0.073	0.335 ***	0.076	0.330 ***	0.075	0.328 ***	0.075
Extra-RIS								
$COOPUNI_{EXTRA}$	0.189 ***	0.060	0.130 *	0.071	0.138 **	0.065	0.198 ***	0.069
$COOPRESINS_{EXTRA}$	0.193 ***	0.074	0.218 ***	0.075	0.226 ***	0.075	0.202 ***	0.077
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.
***, **, * indicate a significance level of 1%, 5%, 10% significance, respectively.

Table 3: Effect of the subsidy amount on the cooperation with research institutes

(Δt =20000)	Y=0		Y=1		Y=2	
Treatment Level	Treat. Eff.	SE	Treat. Eff.	SE	Treat. Eff.	SE
60000	0.141*	0.078	-0.003	0.064	-0.138	0.108
80000	0.128	0.087	-0.040	0.045	-0.088	0.070
100000	0.096	0.068	-0.034	0.034	-0.062	0.045
120000	0.059	0.047	-0.012	0.017	-0.047	0.037
140000	0.026	0.029	0.002	0.008	-0.028	0.032
160000	0.000	0.017	0.000	0.008	0.000	0.023
180000	-0.022	0.016	-0.010	0.009	0.032	0.020
200000	-0.042*	0.023	-0.022	0.015	0.064**	0.031
220000	-0.061**	0.030	-0.032	0.023	0.094**	0.044
240000	-0.076**	0.037	-0.048	0.036	0.124**	0.057
250000	-0.080**	0.039	-0.060	0.043	0.140**	0.063
(Δt =40000)	Y=0		Y=1		Y=2	
Treatment Level	Treat. Eff.	SE	Treat. Eff.	SE	Treat. Eff.	SE
60000	0.271	0.180	-0.050	0.089	-0.220	0.173
80000	0.226	0.161	-0.090	0.088	-0.136	0.103
100000	0.160	0.118	-0.065	0.065	-0.095	0.069
120000	0.090	0.080	-0.021	0.033	-0.069	0.059
140000	0.026	0.046	0.002	0.011	-0.028	0.050
160000	-0.022	0.028	-0.009	0.014	0.031	0.040
180000	-0.060*	0.034	-0.037	0.029	0.097*	0.056
200000	-0.093**	0.046	-0.068	0.049	0.161*	0.083
220000	-0.122**	0.058	-0.097	0.066	0.220**	0.106
240000	-0.140**	0.067	-0.136	0.083	0.275**	0.123
250000	-0.140**	0.069	-0.161*	0.089	0.301**	0.128

Standard errors are estimated with a 200-replication bootstrap procedure.
***, **, * indicate a significance level of 1%, 5%, 10%, respectively.
Critical values of the two sided t-test (df = 100): 10%, 1.660; 5%, 1.984; 1%, 2.626.

Table 4: Effect of the subsidy amount on the cooperation with universities

(Δ*t* =20000)	Y=0		Y=1		Y=2	
Treatment Level	Treat. Eff.	SE	Treat. Eff.	SE	Treat. Eff.	SE
60000	0.131*	0.070	0.029	0.118	-0.160	0.121
80000	0.137	0.087	-0.049	0.070	-0.088	0.074
100000	0.104	0.076	-0.049	0.054	-0.055	0.041
120000	0.059	0.051	-0.020	0.028	-0.039	0.033
140000	0.018	0.028	-0.001	0.009	-0.018	0.028
160000	-0.011	0.014	-0.004	0.008	0.015	0.019
180000	-0.032**	0.013	-0.024*	0.013	0.056***	0.018
200000	-0.048**	0.019	-0.052**	0.026	0.100***	0.033
220000	-0.056**	0.024	-0.088**	0.039	0.144***	0.050
240000	-0.053**	0.026	-0.134**	0.053	0.187***	0.062
250000	-0.045*	0.024	-0.159***	0.057	0.204***	0.064
(Δ*t* =40000)	Y=0		Y=1		Y=2	
Treatment Level	Treat. Eff.	SE	Treat. Eff.	SE	Treat. Eff.	SE
60000	0.273*	0.142	-0.031	0.156	-0.242	0.194
80000	0.250	0.160	-0.121	0.102	-0.129	0.104
100000	0.172	0.129	-0.093	0.090	-0.080	0.060
120000	0.082	0.083	-0.030	0.046	-0.052	0.051
140000	0.005	0.042	0.000	0.014	-0.005	0.044
160000	-0.045*	0.024	-0.024	0.019	0.070**	0.034
180000	-0.075**	0.032	-0.086**	0.041	0.160***	0.054
200000	-0.091**	0.039	-0.159**	0.068	0.250***	0.085
220000	-0.094**	0.042	-0.235***	0.088	0.328***	0.106
240000	-0.077*	0.041	-0.305***	0.097	0.383***	0.108
250000	-0.063	0.038	-0.328***	0.093	0.391***	0.102

Standard errors are estimated with a 200-replication bootstrap procedure.
***, **, * indicate a significance level of 1%, 5%, 10%, respectively.
Critical values of the two sided t-test (*df* = 100): 10%, 1.660; 5%, 1.984; 1%, 2.626.

Appendix A – Econometric appendix

Three-step estimation strategy for *GPS*

In step one, the conditional distribution of the treatment, T_i, given the covariates, X_i, is estimated, by assuming it - or a suitable transformation of it $g(T_i)$ - normally distributed:

$$g(T_i) \mid X_i \approx N\{h(\gamma, X_i), \sigma^2\} \qquad (4)$$

where h (γ , X_i) is a function of the covariates, which depends on a vector of parameters, γ, and $g(T_i)$ is a logaritmic transformation of the treatment, T.

Estimating the parameters γ and σ^2 by maximum likelihood, the *GPS* for each firm, *i,* can be obtained as:

$$\hat{R}_i = \frac{1}{\sqrt{2\pi\hat{\sigma}^2}} \exp\left\{ -\frac{1}{2\hat{\sigma}^2} \left[g(T_i) - h(\hat{\gamma}, X_i) \right]^2 \right\} \qquad (5)$$

With the estimated *GPS*, the normality of $g(T_i)$ and the fulfillment of the assumption on the balancing property can be finally tested.

In step two, in order to "maximise" the joint significance and the goodness of its fit, the conditional expectation of the outcome Yi, given T_i and R_i, is modelled and estimated as follows (the estimated *GPS*, $\hat{R}_i$, is used):

$$E(Y_i \mid T_i, R_i) = \alpha_0 + \alpha_1 T_i + \alpha_2 T_i^2 + \alpha_3 R_i \qquad (6)$$

The last step of the procedure consists of estimating the treatment effect of an additional amount of subsidy, getting the standard errors through a bootstrapping procedure. Given the parameters estimated in the previous stage, the average potential outcome at level t of treatment is given by:

$$E[\widehat{Y(t)}] = \frac{1}{N} \sum_i^N [\widehat{a}_0 + \widehat{a}_1 t + \widehat{a}_2 t^2 + \widehat{a}_3 \widehat{r}(t, X_i) \qquad (7)$$

The treatment effect for each relevant level of the treatment, t, is calculated as the difference between Eq(7), at level $t + \Delta t$, and Eq(7) at t.

Appendix B – Data appendix

Table B1: Sample representativeness

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	4.70	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 B2: Covariates variables

Variables	*Description*	*Mean (408 obs.)*	*Min*	*Max*	*Mean Subsidised (99 obs.)*	*Min*	*Max*	*Mean Not Subsid. (309 obs.)*	*Min*	*Max*
Time invariant survey data										
Geographical location (10 dummies)	*GEO1*: Extra-region *GEO2*: Bologna *GEO3*: Forlì 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 of employees in year 2003	4.218	0.693	7.961	4.516	2.639	7.754	4.122	0.693	7.961
$FINCONST_{2003}$	Short-term debt index in year 2003	0.871	0.320	1	0.838	0.330	1	0.882	0.320	1
$CASHFLOW_{2003}$	Cash flow per capita in year 2003 (thousands of Euros)	0.792	-1.105	185.222	0.183	-0.475	1.555	0.987	-1.105	185.222
$RDADV_{2003}$	Expenditures per capita in research and advertisement in year 2003 (thousands of Euros)	0.007	0	0.405	0.016	0	0.326	0.003	0	0.405

Table B3: Outcome variables

	Overall mean (408 obs)	Mean subsidised (99 obs)	Mean non subsidised (309 obs)	Min.	Max.
Cooperation with Research Organisations (ROs)					
Intra-RIS					
$COOPUNI_{REG}$	0.370	0.717	0.259	0	1
$COOPRESINS_{REG}$	0.311	0.566	0.229	0	1
Extra-RIS					
$COOPUNI_{EXTRA}$	0.145	0.343	0.081	0	1
$COOPRESINST_{EXTRA}$	0.199	0.394	0.136	0	1
Geographical range of the cooperation with Research Organisations (ROs)					
$COOPRESINS_{ORD}$	0.654	1.192	0.482	0	2
$COOPUNI_{ORD}$	0.596	1.212	0.398	0	2

Table B4: Maximum likelihood estimation of the generalised propensity score

	Coeff.	S.E.
$lnEMP_{2003}$	0.057 *	0.030
PAVITT1	0.203	0.133
PAVITT3	0.210 *	0.126
PAVITT4	0.073	0.120
PAVITT5	0.206 *	0.111
$FINCONST_{2003}$	-0.525 ***	0.182
$CASHFLOW_{2003}$	0.000	0.003
_cons	12.100 ***	0.221
N	99	
Pseudo R^2	0.293	
Prob>$\chi 2$	0.009	

***, **, * indicate a significance level of 1%, 5%, 10%, respectively.
Critical values of the two sided t-test (*df* = 100): 10%, 1.660; 5%, 1.984; 1%, 2.626.
A VIF test excludes the presence of multicollinearity among the covariates (all the VIF values are lower than 10).

Figure B1: Treatment effect on the cooperation with research institutes.
(Left: No cooperation; $Y = 0$; Centre: Cooperation with regional partner; $Y = 1$, Right: Cooperation with extra-regional partner, $Y = 2$. Top: Δt = 20,000; Bottom: Δt = 40,000. Confidence bounds at 95% level).

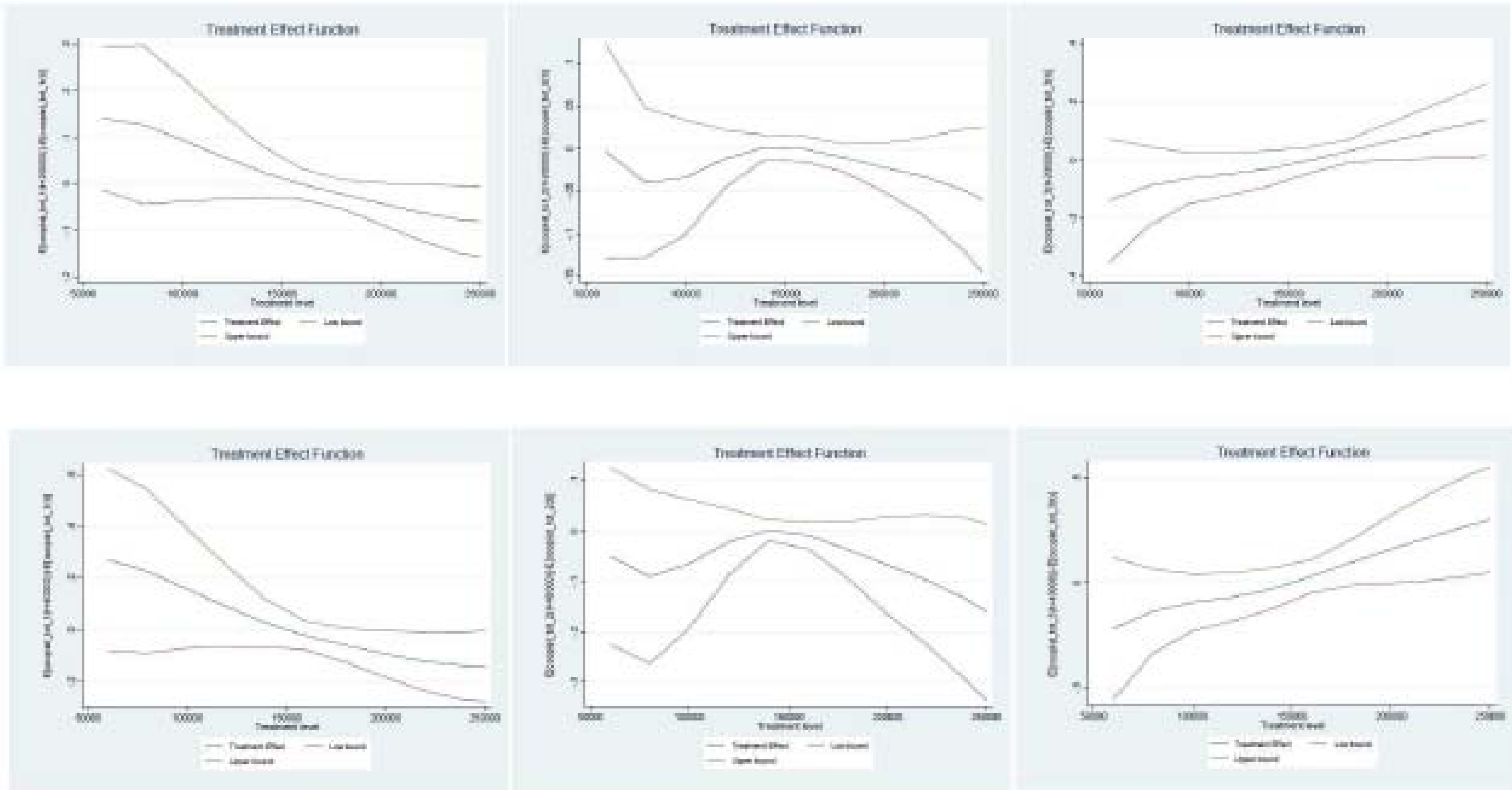

Figure B2: Treatment effect on the cooperation with universities
(Left: No cooperation; $Y = 0$; Centre: Cooperation with regional partner; $Y = 1$, Right: Cooperation with extra-regional partner, $Y = 2$. Top: $\Delta t = 20{,}000$; Bottom: $\Delta t = 40{,}000$. Confidence bounds at 95% level).