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Evaluating the Impact of a Mix of Subsidies on Firms' Innovation Effort and Performance

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Abstract

Innovation subsidies are one of the most-used policy tools to promote firms' innovation. At each level, regional, national and supranational, governments have designed and implemented innovation-subsidy programs. But, while scholars have extensively studied the impact of subsidies on firms' innovation, the existence of complementary effects between grants from different funding sources has not been sufficiently analysed. To address this gap in the literature, we apply a novel variant of a non-parametric matching estimator to panel data, considering each type of funding as a heterogeneous treatment, distinguishing and simultaneously analysing the effect of these treatments on firms' innovation effort and performance. In terms of the innovation effort, getting funds from different sources results in the highest impact. If funding from only one source is received, regional grants show a bigger additional effect. In terms of innovation performance, funding from both sources does not show a complementary effect, and only national or European innovation subsidies produce an additional effect.

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Keywords: Subsidies; innovation; PSM-DID; policy mix; treatment effects

Jel codes: O31, O38

1 Introduction

In the tradition of innovation literature, public support of research, development and innovation activities has been justified by the existence of "market failures" (Hall, 2002; Hall & Lerner, 2010). This concept goes back to Nelson (1959) and Arrow (1962), who state that firms do not invest at the socially desired R&D level due to market imperfections. These imperfections are produced by conflicts related to appropriability regimes, the uncertainty of R&D projects and the limited rationality of the agents. As Stiglitz and Weiss (1981) pointed out, the uncertainty about project success and the limited rationality of the capital market produce financing constraints for firm R&D investment (Bond et al., 2005). As a result, governments have implemented different programmes to promote firms' private R&D in order to benefit society. Among all the policy tools developed to promote innovation, subsidies are one of the most important (Becker, 2015; Georghiou et al., 2017).

Scholars who have evaluated the impact of innovation subsidies on firm's R&D have described the two main effects as *additional* and *crowding-out* effects (Hall & Lerner, 2010). The additional effect is produced when the innovation subsidy triggers additional firm-financed R&D spending beyond the subsidy or when a higher level of R&D output is obtained than the counterfactual state of *not having received a subsidy*. The crowding-out effect occurs when firm-financed R&D expenditures decrease by the full amount of the subsidy or when subsidised firms' R&D output becomes smaller than in the counterfactual case. After more than a quarter of a century (David et al., 2000; Zúñiga-Vicente et al., 2014), scholars have rejected the existence of a full crowding-out effect of private R&D investment but have discovered no evidence of substantial additional effect on firm's innovation outcomes (Dimos & Pugh, 2016). To reach these conclusions, empirical studies have developed robust techniques to control for potential endogeneity, non-linear effects and firm heterogeneity. However, there are still methodological blind spots such as time effects and complementarity among different funding sources (Zúñiga-Vicente et al., 2014).

Specifically, those studies that have considered complementarity effects among different funding sources have been few and far between. Only a few studies have analysed the impact of national and European subsidies on firms' innovation (Czarnitzki & Lopes-Bento, 2014; Huergo & Moreno, 2017; Radicic & Pugh, 2017). Although these studies are highly relevant for the literature, and strongly built, they suffer from a significant limitation: the regional innovation subsidies have not been considered. This is a problem when analysing firms from countries with a multilevel governance design, where regional, national and European institutions strongly cooperate (Georghiou et al., 2017). Considering interactions among these three institutional levels is a more realistic approach to evaluating the existence of positive "policy-mix" among innovation subsidies from different sources. However, the studies that have taken this approach are even fewer and also suffer some limitations regarding methodology (González-Blanco et al., 2019; Mulligan et al., 2019).

Therefore, this study attempts to shed light on the interaction between the regional, national and European innovation subsidies and their effect on firms' innovation. We use a novel non-parametric matching estimator for panel data, combining propensity score matching (PSM) with a Difference in Difference (DiD) estimator (Dettmann et al., 2020). Relying on a sample of 12,810 innovative Spanish firms during the period 2008 – 2016, and controlling for several characteristics of the firms: the technological level, the industry, the location, and the time of treatment, this study investigates (i) whether regional, national and European funding agencies follow different criteria to give an innovation subsidy, (ii) what individual effects each funding scheme produced, (iii) what effect produces the combination of innovation subsidies on firm's innovation and, (iv) whether the combination of different subsidies produces a more significant effect on firm's innovation than individual ones do.

Our analyses show the following results: first, there are two main funding schemes. regional and national or European ones. Second, all the individual subsidies increase a firm's innovation effort. However, only national or European subsidies increase firm's innovative performance. Third, combining the two funding schemes positively impacts firms' innovation effort but has not a significative effect on firms' performance. Fourth, the combination of different types of innovation subsidies has a complementary effect on innovation efforts more significantly than individual effects. These conclusions provide policymakers with valuable information about restructuring the "policy mix" to enhance public funds' efficiency. In addition, it also provides firm managers with a better understanding of the most potential benefits that they can expect when receiving funds from different sources and what programmes are more aligned with their goals.

The paper is organised as follows. In Section 2, we review extant literature and develop our main hypotheses. Section 3 describes our research strategy, our methodological procedure and the data used, and Section 4 presents the empirical findings. We discuss these findings in Section 5. Finally, Section 6 concludes the paper by examining the implications and our contribution to research on innovation policy.

2 Literature Background

In this section, we tackle a literature review of the funding sources of the innovation subsidies, their impact on firms' innovation, and the existence of complementary effects between them. Based on this review, we develop our main hypotheses.

2.1 Different Types of Funding Sources for Innovation Subsidies

For more than a quarter of century, there has existed a great deal of evidence on the impact of subsidies on a firm's innovation (David et al., 2000; Dimos & Pugh, 2016). However, most studies only consider one programme in their analyses. This approach generates blind spots, especially in developed countries with a multilevel design and where institutions have the autonomy to develop their own public policies (Flanagan et al., 2011; Georghiou et al., 2017). Furthermore, in decentralised systems, each funding institution can pursue the same or different objectives in their policies to promote innovation

(Bressers & O'Toole, 1998). This fact makes it difficult for researchers to accurately compare the impact of innovation subsidies if they do not consider the possibility of simultaneously receiving funding from more than one source (Blanes & Busom, 2004; Czarnitzki & Lopes-Bento, 2014; Huergo & Moreno, 2017).

Huergo & Moreno (2017) also show that national and European agencies are highly related to each other. Their study found that Spanish national and European programmes are positively linked and tend to have similar criteria in their selection phase. Similar results were found in Germany (Czarnitzki & Lopes-Bento, 2014) and a sample of European countries (Radicic & Pugh, 2017). Like Blanes & Busom (2004) pointed out, this similarity between national and supranational agencies is due to both agencies supporting innovation based on scientific knowledge, and the receiptof support from the one agency is read as a sign of a "desirable" project by the other.

On the other hand, Blanes & Busom (2004) show that neither national nor European subsidies are related to regional subsidies. They suggest that regional innovation subsidies focus on promoting incremental innovation and helping firms take the first step. This analysis is supported by González-Blanco et al. (2019) and Mulligan et al. (2019). Their study shows that while national and European agencies considered filing patents, cooperation with scientific institutions and previous R&D activities positively. Regional agencies tend not to consider only the firm's size and the export intensity.

This could lead us to think that in multilevel-governance systems there is a dual funding scheme. Local or regional funding agencies are focussed on promoting innovation orientated to develop incremental innovation. While national and European programmes are highly aligned and positively linked because they pursue the same innovative goals. This way, they could align national and European programmes promoting innovation based on advance scientific knowledge (Flanagan et al., 2011; Mulligan et al., 2019). Taking the above arguments together, we suggest the following hypothesis:

H1: Regional innovation subsidies and national-European ones are two different funding schemes.

2.2 Innovation Subsidies Impact on Firm's Innovation

Since the seminal works of Nelson (1959) and Arrow (1962), innovation subsidies and their impact on promoting firm innovation have received a lot of attention from scholars. After a long debate, academics have reached a consensus about its positive impact on different types of firm's indicators: for example, internal or total R&D expenses, and the existence of more nuance results on others like product innovation, patent generation and sales growth (David et al., 2000; Dimos & Pugh, 2016; Zúñiga-Vicente et al., 2014).

Firms' innovation indicators can be classified into two groups: *innovation effort*, and *performance*. Innovation effort groups those indicators related to knowledge production or acquisition as their point of departure. For instance, such results may be achieved through R&D internal investment or expenditure (Beneito, 2006). Innovation performance groups those indicators which reflect the successful result of the combination of innovative inputs. It allows for the identification of innovations for the company or the market and accounts for the economic impact of these innovations, e.g., through the impact on sales (Zúñiga-Vicente et al., 2014).

Specifically, there is a long tradition in innovation literature of analysing the impact of innovation subsidies on firms' innovation efforts. For example, Czarnitzki and Hussinger (2004) analyse a cross-sectional sample of German firms using instrumental variables (IV). Their results show that those firms who received a national innovation subsidy add new projects to their R&D portfolio and increase their innovative expenses. Recent works like Czarnitzki & Lopes-Bento (2013) found similar results for a sample of Flemish, as did Mateut (2018) in a sample of firms across Eastern Europe and Central Asian countries. These studies pointed out that it has an additional effect on firms' R&D efforts: innovation subsidy triggers additional firm-financed R&D spending beyond the amount of the subsidy.

Regarding innovation performance, the empirical evidence is less abundant, and there are more nuanced results. Some studies like Czarnitzki et al. (2007) analyse a sample of German and Finnish firms on patent activity using PSM. Their result shows that in Germany, innovation subsidies do not exhibit a significant impact on filing more patents. However, in the Finnish case, the same study shows that those firms who-receive a grant showed higher impact on patenting activity. Similar results were found by Hewitt-Dundas & Roper (2010) using an IV approach on a sample of Irish and Northern Irish firms. Their results show additional effects on improved and new products in both samples.

The existence of a clear effect on R&D efforts and the nuanced impacts on performance could be caused by implicit measuring difficulties. For example, a minimum period of maturation is required during a firm's R&D project to show the impact of innovation subsidies on innovation performance. The lack of data can produce biased results. Thanks to the effort made by governments and funding agencies to recollect panel data, recent studies have started to take into account this time dimension. Vanino et al. (2019) is one of the recent studies which take this approach to analyse the UK Research Councils (UKRCs) innovation subsidy program. This study positively affects participating firms' employment and turnover growth in the short and medium-term. In addition, others like Dettmann et al. (2018) found similar results combining a PSM and DiD approach in a sample of German firms; grants positively influence employment development; regardless of the year of treatment.

Taking this literature together, it is reasonable to expect a potential positive relationship between innovation subsidies and firm innovation effort and performance if the time dimension is considered. The positive effect produced by innovation subsidies does not impact the firm's innovation in the receiptyear. Therefore, it requires some time to increase innovation effort and impact innovation outcomes (Zúñiga-Vicente et al., 2014). Since the analysis of the combination of innovation subsidies from different sources relies on cross-sectional data, we believe that a panel data analysis would show that individual innovation subsidies positively affect both innovation measurements. In light of the above arguments, we suggest the following hypotheses:

H2a: Individual innovation subsidies have a positive impact on firms' innovation effort

H2b: Individual innovation subsidies have a positive impact on firms' innovation performance

2.3 Complementarity Effects on Firm's Innovation

When governments implement innovation policies they want to address as many innovation goals as possible. However, the rational implementation of innovation subsidies programmes requires that governments apply specific criteria for inclusion and exclusion based on the most likely obtained result (Flanagan et al., 2011; Magro & Wilson, 2013; Vitola, 2015). This rationalisation of the innovation programmes and the multilevel design of the public administrations opens the door to "interactions" among the innovation policies from different institutional levels (Borrás & Edquist, 2013; Cunningham et al., 2013; Georghiou et al., 2017). However, the studies which have analysed this topic are few and far between. Most of these studies have focused their analysis on the interaction between national and EU programmes and have neglected regional support.

For example, the study by Garcia & Mohnen (2010) analyses the interaction between innovation subsidies from the national government and the EU on a sample of Austrian firms. Using the asymptotic least square method, these authors find that the combination of European and national support does not reveal a complementary effect on firms' innovation input. Others like Czarnitzki & Lopes-Bento (2014) analyse national and European subsidies in a sample of German manufacturing firms, using cross-sectional data and an approach based on PSM. They found that getting funds from both sources has a slight effect on performance and a complementary effect on innovation effort. Similar results were found by Radicic & Pugh (2017) using a sample of European firms and a PSM approach. These authors found positive and complementary effects for innovation inputs from national and EU programmes. But they discovered no evidence of additionality from national programmes on output and cannot reject the crowding out effect from EU programmes.

As mentioned before, only a few studies have deployed a complete analysis of the public innovation subsidies "policy mix", analysing the regional, national, and European funding sources together. One of them is González-Blanco et al. (2019)'s study which analyses a cross-sectional sample of Spanish firms using an adoption approach. Their results show that there are indications of substitution between the regional and national agencies, while national and European agencies exhibit indications of complementarity. They show that the implementation of the principle of subsidiarity between the Spanish national and regional agencies seems to work correctly. In contrast, this implementation is much more diffuse between them and the European agencies. In line with this study, Mulligan et al. (2019) analyse a sample of innovative European firms using PSM. They found that individual subsidies positively impact firms' innovation output, radical and incremental. In addition, their result indicates that receiving a mix of subsidies from the three funding sources does not crowd out the firm's innovation outcome.

Considering the above arguments and those exposed in the previous section, we suggest that the results produced by combining funds from different funding sources are unclear. Previous robust analysis does not have to consider the entire policy mix, and those who considered it conclude that they are not adequately designed. Thus, according to Zúñiga-Vicente et al. (2014), we think that, apart from analysis, if the combination produces an additional or substitutive effect on a firm's innovation, we need to measure whether combining funds from multiple agencies produces a greater or lesser effect on firm's innovation than individual effects. These hypotheses can be summarised as:

H3a: The combination of different funding schemes has a positive impact on firms' innovation effort

H3b: The combination of different funding schemes has a positive impact on firms' innovation performance

H4a: The combination of both funding schemes has a more positive impact on firms' innovation effort than individual subsidies

H4b: The combination of both funding schemes has a more positive impact on firms' innovation performance than individual subsidies

3 Research Strategy, Methodology and Data

This section presents our research strategy, the methodology used to analyse the treatment effect of innovation subsidies on innovation effort and performance, and the data used in our sample.

3.1 Research Strategy

The research strategy used in this paper is embedded with previous literature on R&D policies' complementariness (Czarnitzki & Lopes-Bento, 2014; Huergo & Moreno, 2017; Radicic & Pugh, 2017). First, we investigate what firm attributes determine the firm's likelihood of receiving funding from each source and whether they are positively linked. Using this information, we analyse how the firm's receiptof each funding scheme impacts on firms' innovation effort and performance.

First, to analyse the determinants that influence the firm's likelihood of receiving subsidies and if national and European subsidies are highly aligned and positively linked, we use a multivariate probit panel model regression with interactions. Second, to analyse the causal effects of each type of funding case relying on panel data with more than two observations (Abadie, 2005; Blundell & Costa Dias, 2009; Imbens & Wooldridge, 2009), we apply a novel econometric approach based on the combination of a matching technique and a difference in difference estimator known as Flexible Conditional Difference in Difference approach (Dettmann et al., 2020).

The Flexible Conditional DiD approach is appropriate when different treatment times and potential dynamic treatment effects could bias estimates in a two-way fixed-effects approach. This method is based on the non-parametric conditional DiD approach introduced by Heckman et al. (1997, 1998), It requires that "conditional independence assumption" for matching and the "common trend assumption" for DID are replaced by the "conditional parallel trend assumption" (Callaway & Sant'Anna, 2020; Dettmann et al., 2020). The conditional parallel trend assumption implies that unobservable individual characteristics must be invariant over time for units with the same observed characteristics. This technique also assumes no spillover effects and that potential carryover effects do not influence the matching variables at the matching time (Dettmann et al., 2020; Imai et al., 2020).

Following Dettmann et al. (2020), the Flexible Conditional DiD method involves a pre-processing phase using a matching technique (PSM) followed by a Difference in Difference estimator. This approach differs from the traditional DiD approach in that each treated unit is assigned individual controls. Here, treated units can only be matched to one control unit in the same time of treatment. This feature lets us match treatment and control firms in the same period, letting us increase the sample without introducing time effects, something that other DiD analyses could suffer from (Vanino et al., 2019). In the second stage, we estimate average treatment effects in the entire observed period after the innovation subsidy is received.

3.2 Methodology

First, in order to discover what are the relevant determinants to receipt each type of innovation subsidy and if they are heterogenous, we define an equation to estimate the likelihood of receiving a subsidy. This equation is formalised in terms of a multivariate probit panel model given by:

$$Probit\left[P\left(Subsidy_{m,i,t}\right)\right] = \beta_0 + \beta_1 C_{i,t-1} + \beta_2 Z_{i,t} + \varepsilon_{i,t} + \alpha_i, \qquad (1)$$

Where m denotes the type of subsidies (regional, national or European) received by a firm i in the period t. The vector $C_{i,t-1}$ addresses the innovation subsidies status in the previous year considering all the possible combinations. These scenarios take the value 1 if it is the situation of firm i in $t-1$ and 0 otherwise. Finally, vector $Z_{i,t}$ catchs the firm's control variables. This vector also controls for sectoral, time and regional fixed effects. Second, to analyse how the firm's participation in these supporting programmes affects firm's innovation performance, we use the flexible conditional DiD approach to estimate the average treatment effect on the treated (ATT). Thus, we reorganise our data, limiting the set of potential partners for every treated unit to those observed at the individual matching date. Then, the matching algorithm selects statistical twins among these pre-selected units using the control variables of equation 1.

In this step, we normalise the observation time of the matching variables and the outcomes such that they are measured with respect to the individual treatment start (Dettmann et al., 2020). After that, we continue with the matching. Each matching process that allows for (at least partial) exact matching is suitable. This exact matching option is required in order to consider the time information from the pre-selection process (Dettmann et al., 2020).

$$\mathrm{ATT} = \frac{1}{\mathrm{I}} \sum_{\mathrm{i}=1}^{\mathrm{I}} \left[\left(\mathrm{Y}_{\mathrm{i},\mathrm{t}_{2\mathrm{i}}+\beta_{\mathrm{i}}} - \mathrm{Y}_{\mathrm{i},\mathrm{t}_{2\mathrm{i}}} \right) - \left(\mathrm{Y}_{\mathrm{j},\mathrm{t}_{2\mathrm{i}}+\beta_{\mathrm{i}}} - \mathrm{Y}_{\mathrm{j},\mathrm{t}_{2\mathrm{i}}} \right) \right] \quad (2)$$

As can be observed from equation 2, we include individual treatment start dates, denoted by index $\mathrm{t}_{2\mathrm{i}}$, reflecting that the individual duration from treatment starts after two periods. Here, □ denotes the firm's innovation performance analysed in each case.

Due to this iterative process, we cannot use the commonly applied propensity score estimate as the distance measure. Instead, we apply a combined statistical distance function that can be regarded as the weighted average of scale-specific distance functions. We combine the mean absolute difference for continuous variables and the generalised matching coefficient for categorical variables for our analysis. Weighting the functions by the respective number of variables, the distance function for a treated establishment i and a non-treated establishment j can be described as follows:

$$Dist_{ij} = \frac{1}{N} \left[N_m \cdot AD_{ij} + N_n \cdot \left(1 - GMC_{ij} \right) \right] \quad (3)$$

The terms $Dist_{ij}$, AD_{ij} and GMC_{ij} of equation 3, denote the aggregated distance function and the scale specific distances, N is the total number of variables with $N = N_m + N_n$, where N_m is the number of continuous variables and number of continuous variables and N_n that of the categorical ones (Dettmann et al. (2020).

After the matching process, we estimated the Average Treatment effect for the Treated (ATT). Within the conditional DID model framework, usually the mean outcome developments in the treated and the control group are compared. Unlike the standard model, the flexible conditional DID compares individual differences in outcome development between the treated firms □ and their respective controls □. The estimator is the mean of the individual comparisons. Finally, note that the matching protocol is implemented using the "nearest neighbour with replacement" protocol (Abadie et al., 2004; Abadie & Imbens, 2006, 2011).

3.3 Dataset

The data used to test our hypotheses is extracted from the Spanish Technological Innovation Panel (PITEC), the Spanish version of the Community Innovation Survey (CIS). To build a panel dataset that collects the firms' receiptof innovation subsidies, we use continuous survey waves during 2008-2016. Hence, following previous CIS studies, we exclude firms that had undergone sudden employment changes resulting from mergers or acquisitions (Acebo et al., 2021b; Haus-Reve et al., 2019). As a result, we obtained an unbalanced sample composed of 110,660 observations from 12,810 innovative firms.

3.4 Variables

Based on previous literature, we use the following variables to answer our research questions (Czarnitzki & Lopes-Bento, 2014; Huergo & Moreno, 2017). The main question of the analysis is whether firms' innovative activities are stimulated by public innovation subsidies, and by the type of funding they are receiving. To answer this question, first, we have to analyse the determinants for receiving each type of subsidy and analyse if they are heterogeneous. That is why we construct throw dummy variables: $regional\ subsidy_{i,t}$, $national\ subsidy_{i,t}$ and $European\ subsidy_{i,t}$. Table 1 displays the mean values for all variables used in the analysis by the baseline situations. We can see that although there is a similarity between national and regional subsamples, national and European subsidies are more interrelated. Correlation coefficients shown in Appendix Table A support this first insight.

Insert Table 1 about here

Next, Table 2 shows the distribution of the sample by type of funding. As we can see, near 80.44% of the firms do not receive any type of public funding in the period. In those supported firms, 20.70% of the firms receive regional funding, a 22.88% national funding and only 3.90% European funding. Here, we can see the dual nature of the Spanish innovation funding system. Only 2.22% of firms receive simultaneously a regional and a European subsidy, while the combination of national and European subsidies increases to 4.01%. In addition, Appendix Table B expands the information about the distribution of the sample by type of public funding source and year. This table shows how the relationship between the European and national funds has increased after 2010 and how the relationship between regional and national funding decreased in the same period.

Insert Table 2 about here

To measure if firm innovative performance might be affected by the different public grants, we must operationalise the firm's innovation. To do that, we differentiated between its two more common aspects): innovative effort and performance. First, to address the firm's innovative input performance, we focussed our analysis on the firm's $R\&D\ intensity_{it}$ This variable is computed as the ratio of R&D expenditures over the total firm's turnover. Notice that R&D activities are those "comprising creative work undertaken on a systematic basis to increase the firm's stock of knowledge and the use of this stock of knowledge to devise new applications such as a new or improved product or process" (OCDE, 2018). Second, we analysed to what extent a firm's innovation output performance varies according to whether or not firms receive subsidies and the kind of subsidy or combination of subsidies received. We measured $R\&D\ innovative\ sales_{it}$. This variable is the ratio between a firm's innovation sales over total turnover. Firms' innovation sales are those sales of firms' goods and services considered new for the firm or the market (Czarnitzki & Lopes-Bento, 2014; Huergo & Moreno, 2017).

As control variables, we used several indicators that might impact on whether a firm receives a subsidy and the firm's innovation performance. We can group them between the firm's technical characteristics and general attributes. The technical characteristics analysed are the percentage of R&D employees over the total number of employees ($R\&D\ employees_{it}$) This ratio directly impacts the firm's likelihood of receiving a subsidy and the firm's innovation performance (Herrera & Nieto, 2008). In addition, we considered another relevant determinant of firms' innovation, collaboration with different types of partners ($technological\ collaboration_{it}$). Specifically, previous literature has pointed out that collaboration with external partners increases the firms' access to external knowledge, thus increasing the firm's innovation performance. Previous studies have pointed that the impact of each type of external partner is not homogeneous (Acebo et al., 2021b; Haus-Reve et al., 2019). We differentiate between with $\mathrm{customer_{it}}$, $\mathrm{competitors_{it}}$, other firms from the $\mathrm{group_{it}}$, $\mathrm{suppliers_{it}}$, $\mathrm{consultants}_{\mathrm{it}}$, and $\mathrm{scientific\ partners_{it}}$.

Firm's general attributes are those commonly used in the literature. Firm size is measured in terms of number of employees ($\mathrm{size_{it}}$) and a firm's age in terms of years since its foundation. These two variables are a constant in the impact assessment of R&D policies (Radicic & Pugh, 2017). However, there is no strong agreement in the literature about whether or not the R&D supporting schemes tend to support small and young firms with an innovative project or, on the other hand, if public institutions prefer to support well-established firms with a solid background of innovation activities. As the firm's size distribution is skewed, this variable enters in logarithmic form. To avoid any potential non-linear relationships, we included its square value ($size_{it}^2$). In addition, we included a dummy variable to analyse the impact of firm's belonging to a ($group_{it}$*).* This variable lets us determine if the firm is part of a multinational company or a holding. It is accepted that the cost to access external resources is lower than for firms that are not part of any group (González-Blanco et al., 2019). And, we also control if the firm has $export\ activity_{it}$ or not. As previous studies have pointed out, there is a direct relationship between innovation and exports, directly impacting the firm's likelihood of receiving a subsidy (Garcia & Mohnen, 2010).

Finally, to control for location and industrial effects, we recorded the firm's location and activity. First, although the dataset is anonymised and the exact location is not divulged, we construct a proxy variable, based on the firm's location, of R&D internal expenses. In order to control the firm's regions, we construct a categorical variable based on the firm's location of the R&D expenses using the Spanish NUTS 2 classification. In addition, to control for the firm's sector we construct several dummy variables based on the NACE indicators. Notice that one of the main advantages of this survey is that it covers a sample of innovative firms from the manufacturing as well as business-related services sectors. Appendix Table C shows the main sectorial structure of our sample. This distribution is similar to previous pooled correctional studies for the United Kingdom (Pless, 2020), Germany (Czarnitzki & Lopes-Bento, 2014; Hottenrott et al., 2017) and, Spain (Huergo & Moreno, 2017).

4 Results

In this section, we present the *R&D* subsidy program. Second, we analyse how the receiptof the subsidy affects the R&D effort of the firm's innovative performance.

4.1 Determinants of Receipt an R&D subsidy

Table 3 shows the estimation of the determinants of firm's receiptof each type of innovation subsidy based on equation 1. Considering that we have information about three funding sources as well as panel data, we decided to implement a probit panel model and analyse the interactions between them to determine their relationship.

As expected, receipt of a subsidy in the previous year has a significant impact on the propensity to receive one in t without regard to the previous funding source. In this respect, the interaction term between the different funding sources shows a strong relationship between the national and European subsidies. As discussed in Section 2 and according to Czarnitzki & Lopes-Bento (2014) and Huergo & Moreno (2017), they are positively linked. A first look at the statistically significant determinants shows that both funding sources consider the same firm's technological and general attributes. Regarding the influence of each type of subsidy on the other, Appendix Table D shows the transition rates between subsidies over the panel period. As discussed before, most non-supported firms remain in the that status, while awarded firms do not vary significantly. Finally, let us focus on the transition rates between one and two funding schemes. In that case, we can see that the most important transition is obtaining a European subsidy and complimenting it with a national one.

Insert Table 3 about here

An analysis of the explanatory variables shows minor differences among the three funding schemes. Having a closer look at the magnitude of the technological characteristic's coefficients, we can see that all agencies positively consider the relative number of R&D personnel and the firm's patent-filing in the previous year. The impact of this last variable is more significant in the national scheme. Regarding the firm's cooperation, we can see more differences. While all the three agencies positively consider collaboration with scientific partners and customers, regional agencies are the only ones which consider positive collaboration with suppliers and external consultants, and national-European agencies consider positively collaboration with competitors.

Regarding the firm's general characteristics, belonging to a group is negative to achieving a regional or European subsidy. The exporting firm's activity is only evaluated in accessing national and European funding and being established in a scientific park is determinant for the three funding schemes. Finally, we consider that regional funding sources preferred to fund young firms while national and European preferred well-established firms and that size also follows different patterns. Specifically, the firm's size follows an inverted U-pattern, while the national agency follows an indirect relationship and the European funding a direct one.

Thus, we can continue with our research strategy of analysing how the receiptof funding from each subsidy affects the R&D performance of a firm's innovative performance. Specifically, due to its relationship and similar determinants, we will consider national and European sources as the same type of funding.

4.2 Subsidy Effect on Firm's Innovation effort and expenditures

According to Section 3, to match each case with a fictitious situation, counterfactual anlysis, we need have a sufficient sample of common support firms in the pre-treatment stage. In order to assess the success of the matching routine as outlined before, we estimate each probit model based on the respective treatment indicator defined for each case using the matched pairs. Although, in the methodology of Gerfin & Lechner (2002), it is natural that many observations have to be dropped for some cases. The application of the flexible conditional DiD estimator produces smaller but more robust samples. Appendix Table E lists the size of the treated group and their respective control group. Table 4 presents the flexible conditional DiD estimator for a firm's innovation expenses intensity and innovation sales intensity.

Insert Table 4 about here

Table 4 presents the matching results for our sample of innovation input performance proxied by the firm's R&D total expenses. Cases 1, 2 and 3 show that both funding schemes and the combination of both produce an additional effect. These results and their contrafactual status (Cases 4, 7 and 10) mean that firms that receive a subsidy experience a positive impact on R&D. In addition, Cases 5 and 8 show that, individually, regional funding schemes produce a more significant effect than national or European subsidies. Finally, Cases 6 and 9 and their counterfactuals 11 and 12 show that both funding schemes produce a complementary effect on firms' R&D intensity, larger than individual ones. In addition, Table 4 also presents the matching result for our sample regarding innovation output proxied by innovative sales. Cases 1 and 2 show that an innovation subsidy positively impacts the firm's innovation performance. What differs from the input analysis is that the combination of both funding schemes, Case 3, do not produce an additional effect. In addition, this table shows that, regarding innovation performance, the additional effect is more significant when only national or European subsidies are considered.

5 Discussion

We used data of 12,810 innovative firms to examine the determinants for obtaining an innovation subsidy and how innovation subsidies interact between them, and also impact firms' innovation effort and performance. We examined a multilevel governance design in which regional, national and European institutions interact and pursue complementary objectives. Specifically, we analysed the criteria for giving a grant, similarities between different funding agencies, and the impact of receipt of subsidies.

Our results suggest that there are two main funding schemes. On one hand, regional agencies and on the other, national and European ones. The former support incremental innovations and help firms take the first R&D step, while the second focuses on promoting radical innovation based on scientific knowledge (Acebo et al., 2021a; Czarnitzki & Lopes-Bento, 2013; Mulligan et al., 2019) National and European subsidies are highly related because both agencies see each other as a proxy of a “winning project”. Based on these two funding schemes, we focus or analysis in the combined effects of these two funding schemes (Blanes & Busom, 2004).

In addition, our counterfactual analysis shows that R&D innovation subsidies provided by regional agencies individually have an additional effect - bigger than national or European subsidies (González-Blanco et al., 2019). Only combining both subsidies could have a more significant effect. However, these results differ if we analyse the impact on innovation output. There, regional subsidies do not show a clear impact, while national and innovation subsidies do. Moreover, there is no clear evidence of complementary effects between the two funding schemes in this innovation indicator.

The results suggest that institutions use innovation subsidies to promote innovation in multilevel-governance countries, focusing on two primary goals. On one hand, regional agencies are focussed on promoting innovation in those firms which do not spend a significant amount of their budget on innovation. These agencies positively consider cooperation with external partners, specifically, external advisors. The regional support pursues measures assuring that the firms acquire some new routines and capabilities to increase their innovation activity (Jensen et al., 2007; Teece et al., 1997). On the other hand, national and European funds, while also focusing on promoting additional effects on innovation efforts, aim to increase firms' performance and obtain value from scientific knowledge of the market(Czarnitzki & Lopes-Bento, 2013; Mulligan et al., 2019). This goal has increased its relevance during the last ten years, aligning innovation programs with the sustainable goals agenda.

Our results also hint that the combination of both funding schemes has an additional and complementary effect on firms’ innovation effort and non-significant results on firms’ performance. These results are in accordance with previous studies that have analysed the combination of national and European ones (Czarnitzki & Lopes-Bento, 2014; Huergo & Moreno, 2017; Radicic & Pugh, 2017). A plausible justification for these more nuanced outcomes could be that innovation expenses could be an inverted U-shaped relationship between the amount of money and the additional effect obtained (Acebo et al., 2020). As previous studies have pointed out, the internal firms' capacities probably could moderate this relationship to avoid crowding-out effects (Dimos & Pugh, 2016; Segarra-Blasco & Teruel, 2016).

6 Conclusions

To address the impact of innovation subsidies "policy mix" in a multilevel governance context, this study set out to understand whether and how the regional, national and European funding agencies interact between them and their effect on firms' innovation effort and performance. Building on previous studies, we proposed that the institutional design allows firms to receive public funds from more than one source simultaneously. Considering this situation, let us analyse the real effect of innovation subsidies, relying on data from 12,891 firms that benefitted from regional, national and European support. Our results suggest that there are two funding schemes: regional agencies and national-European ones. Both have demonstrated an additional effect on firms' R&D efforts, but only the second one produces positive effects on firms' innovative performance. In addition, by shaping the nature of the interaction between the two funding schemes, we suggest that both have a complementary impact on firms' innovation effort and a non-significant effect on performance.

These results provide three main contributions to the literature. First, we contribute to innovation subsidies by extending prior analyses of complementary effects on firms' innovation. We move beyond the multilevel governance design (Varsakelis, 2001), where analysis has been done only on national and European levels, considering regional subsidies (Czarnitzki & Lopes-Bento, 2014; Huergo & Moreno, 2017; Radicic & Pugh, 2017). In addition, using a robust and novel non-parametric technique, we analyse all possible counterfactual situations considering the firms' unobservable and non-unobservable characteristics, precisely matching the year of treatment and industry. We thus respond to recent calls to further innovation subsidies research in the interaction between different institutions.

Second, we contribute to the literature on innovation policy by examining whether and how the individual effects of different public schemes are designed, and their impact on firms' innovation. We show that, *ceteris paribus*, firms who receive funds from regional institutions tend to experience more significant additional effects on firms' R&D expenses. And, those who receive national and European subsidies have more significant effects on innovation output. Both have an additional and complementary effect on R&D effort and a non-significant effect on firms' innovation outcome. While the literature has provided evidence that different policy instruments may lead to different effects (Busom et al., 2014; Czarnitzki et al., 2007), it has been mostly silent regarding the effect of the policy mix on innovation.

Third, we add to the institutional literature by providing evidence that different institutions address policies differently and reflect on complementary or substitutive effects between them (Flanagan et al., 2011; Flanagan & Uyarra, 2016). In addition, our results suggest that, despite the firms observed or unobserved characteristics and the year of treatment, firms benefit from the combination of different funding schemes to promote innovation effort but not for innovation performance (Caloghirou et al., 2004). This opens the door to analyse how policy programs are designed and how public institutions evaluate their results.

Our findings suggest some policy implications. First, while all institutions want to address as many goals as possible, our results suggest that regional institutions are focused on help firms on the first step of increasing their R&D expenses. In contrast, national and European ones are more focused on innovative performance (Georghiou et al., 2017). Thus, those agencies that focus on obtaining financial results in the short term must address goals similar to national and European ones. In contrast, those who want to introduce firms in the R&D activities must follow regional subsidies. In particular, policy-makers can reorganise and rationalise funds so as not to duplicate them to generate the most efficient additional effect on firms' innovation input and output.

Finally, this study is not without limitations, and addressing them may open new research directions. First, this study relies on survey data on firms from a European developed country to examine whether there are national differences in the extent of the benefits that policy mix effects have on others explained by national or international characteristics. Second, because our data do not provide the amount of subsidy from each institution, we do not quantify additional and substitutive effects. Future studies might consider the degree of the radicalness of the innovation (Czarnitzki & Lopes-Bento, 2013) and analyse other quality indicators (Mulligan et al., 2019). Third, future analysis could be done to examine the long-term effect in view of the treatment year (Dettmann et al., 2018, 2020; Vanino et al., 2019). Due to the nature of our sample and other studies comprising only firms in wealthy European countries, we cannot be sure that these results will be generalizable to less advanced economies or non-European cultural contexts (Orlic et al., 2019).

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8 Tables

Table 1. Descriptive data

Variables	Regional Subsidy Mean	Regional Subsidy Std. Dev.	National Subsidy Mean	National Subsidy Std. Dev.	European Subsidy Mean	European Subsidy Std. Dev.	All Sample Mean	All Sample Std. Dev.
Firm's Innovation								
- R&D total intensity	19.470	30.668	18.039	29.230	30.235	37.702	29.907	43.617
- Innovative performance	30.774	36.920	31.327	36.750	31.956	37.116	13.432	29.180
Subsidies (0/1)								
- Regional subsidy	1	0	0.417	0.493	0.557	0.497	0.115	0.319
- National subsidy	0.491	0.500	1	0	0.698	0.459	0.135	0.342
- Euopean subsidy	0.204	0.403	0.217	0.413	1	0	0.042	0.201
Technological characteristics								
- R&D personnel (%)	27.284	31.364	26.055	29.420	35.797	35.407	7.567	18.940
- Inno. in developing (0/1)	0.803	0.397	0.846	0.361	0.870	0.336	0.339	0.473
- Technological cooperation (0/1)	0.633	0.481	0.656	0.475	0.793	0.405	0.201	0.401
• costumers	0.289	0.454	0.309	0.462	0.469	0.499	0.074	0.263
• competitors	0.194	0.396	0.223	0.417	0.379	0.485	0.050	0.218
• other firms from the group	0.191	0.393	0.228	0.420	0.266	0.442	0.068	0.252
• suppliers	0.288	0.453	0.315	0.464	0.417	0.493	0.091	0.288
• consultants	0.231	0.421	0.250	0.433	0.366	0.482	0.062	0.242
• scientific partners	0.511	0.499	0.531	0.499	0.731	0.443	0.133	0.339
Other firm Characteristics								
- Belongin to a group (0/1)	0.441	0.497	0.532	0.499	0.470	0.499	0.323	0.468
- Exporter (0/1)	0.669	0.470	0.722	0.448	0.685	0.465	0.403	0.490
- Size (log.)	4.144	1.545	4.510	1.593	4.594	1.800	3.076	2.346
- Size^2 (log.)	19.559	14.198	22.874	15.837	24.351	18.447	14.968	16.038
- Age (log.)	3.023	0.713	3.109	0.722	3.070	0.700	2.392	1.452
- Scientific Park (0/1)	0.135	0.342	0.127	0.333	0.218	0.413	0.036	0.186
Number of observations	12,694		14,931		4,649		110,660	

Table 2. Distribution of the sample by type of public funding.

	Yearly observations		Firms (in period 2008-2016)	
No R&D subsidy	60,398	(54.58%)	10,305	(80.44%)
Only Regional funding	6,022	(5.44%)	2,652	(20.70%)
Only National funding	7,602	(6.87%)	2,931	(22.88%)
Only European funding	961	(0.87%)	499	(3.90%)
Regional & National funding	4,082	(3.69%)	1742	(13.60%)
Regional & European funding	1,098	(0.99%)	514	(4.01%)
National & European funding	441	(0.40%)	285	(2.22%)
All types of public funding	2,149	(1.94%)	685	(5.35%)
Total	110,660		12,810	

Table 3. Determinants of each type of public R&D subsidies. Multivariate panel probit model

	Regional Subsidy		National Subsidy		European Subsidy	
Variables	Coefficients	Robust S.E.	Coefficients	Robust S.E.	Coefficients	Robust S.E.
Previous subsidies (0/1)						
- Regional subsidy$_{t-1}$	1.655***	0.032	0.417***	0.028	0.227***	0.070
- National subsidy$_{t-1}$	0.343***	0.030	1.648***	0.030	0.422***	0.039
- Euopean subsidy$_{t-1}$	0.188***	0.078	0.328***	0.072	2.265***	0.070
- Regional & National subsidies$_{t-1}$	1.769***	0.037	1.700***	0.034	0.583***	0.043
- National & European subsidies$_{t-1}$	0.375***	0.065	1.848***	0.064	2.330***	0.071
- Regional & European subsidies$_{t-1}$	1.645***	0.085	0.584***	0.087	2.153***	0.085
- All types of subsidies$_{t-1}$	1.99***	0.053	2.105***	0.053	2.469***	0.061
Technological characteristic						
- R&D personnel$_{t-1}$ (%)	0.007***	0.000	0.009***	0.000	0.008***	0.000
- Inno. in develop$_{t-1}$ (0/1)	0.323***	0.021	0.390***	0.020	0.195***	0.032
- Technological cooperation (0/1)						
• costumers$_{t-1}$	0.080***	0.028	0.126***	0.028	0.171***	0.034
• competitors$_{t-1}$	-0.006	0.030	0.139***	0.029	0.163***	0.035
• other firms from the grou	0.023	0.031	0.001	0.028	-0.039	0.038
• suppliers$_{t-1}$	0.052*	0.271	0.050*	0.026	-0.024	0.033
• consultants$_{t-1}$	0.079***	0.029	0.026	0.029	0.019	0.036
• scientific partners$_{t-1}$	0.258***	0.025	0.294***	0.024	0.322***	0.031
Other firm Characteristics						
- Belongin to a group (0/1)	-0.028***	0.022	0.109***	0.021	-0.070**	0.031
- Exporter (0/1)	0.093***	0.019	0.233***	0.018	0.073***	0.028
- Size$_{t-1}$ (log.)	0.325***	0.023	0.338***	0.023	0.093***	0.028
- Size$^2_{t-1}$ (log.)	-0.032***	0.003	-0.025***	0.002	0.000	0.003
- Age$_{t-1}$ (log.)	0.032**	0.012	0.021*	0.127	0.082***	0.017
- Scientific Park (0/1)	0.318***	0.038	0.255***	0.037	0.322***	0.045
Constant	-3.064***	0.0374	-3.300***	0.048	-3.410***	0.064
Log Likelihood	-17107.85		-17942.506		-7495.176	
Wald chi2	13015.62***		16309.27***		9244.61***	
Number of observations			96,146			
Number of firms			12,733			

Notes: S.E.: Standard Errors. ***, **, * indicate a significance level of 1%, 5% and 10%, respectively. t-1 denotes that the variable is included with one lag. All models include year, industry and regional fixed effects.

Table 4. Matching results: Subsidy effect on innovation

Counterfactual (I)	Dependent variable: R&D Total Intensity (% of total turnover) Actual Status (m)			
	No subsidies	Only Regional subsidies	National or European subsidies	both types of subsidies
No subsidies		*Case 1* 1.627***	*Case 2* 0.880**	*Case 3* *3.767****
Only Regional subsidies	*Case 4* *-14.396****		*Case 5* *-1.148**	*Case 6* *3.280****
National or European subsidies	*Case 7* *-6.541****	*Case 8* *1.448***		*Case 9* 2.692***
both types of subsidies	*Case 10* *-6.158****	*Case 11* *-3.653****	*Case 12* *-2.017***	

Counterfactual (I)	Dependent variable: Innovative Sales (% of total turnover) Actual Status (m)			
	No subsidies	Only Regional subsidies	National or European subsidies	both types of subsidies
No subsidies		*Case 1* *3.094***	*Case 2* *2.706**	*Case 3* *-1.673*
Only Regional subsidies	*Case 4* *0.473*		*Case 5* *3.468**	*Case 6* *1.8337*
National or European subsidies	*Case 7* *-8.115****	*Case 8* *-3.950**		*Case 9* *-5.781****
both types of subsidies	*Case 10* *-2.210****	*Case 11* *6.192****	*Case 12* *3.121***	

9 Appendices

Table A. Correlation Matrix

Variable	(1)	(2)	(3)	(4)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
Regional subsidy	1.000																			
National subsidy	0.375	1.00																		
Euopean subsidy	0.291	0.345	1.000																	
R&D personnel	0.375	0.386	0.312	1.000																
Technological coop.	0.388	0.448	0.309	0.359	1.000															
costumers	0.295	0.353	0.315	0.307	0.564	1.000														
other firms from the group	0.176	0.252	0.165	0.111	0.537	0.370	1.000													
suppliers	0.246	0.306	0.237	0.183	0.632	0.493	0.421	1.000												
consultants	0.251	0.307	0.264	0.215	0.513	0.436	0.356	0.468	1.000											
scientific partner	0.401	0.464	0.369	0.359	0.778	0.518	0.370	0.468	0.491	1.000										
competitors	0.237	0.315	0.315	0.253	0.458	0.415	0.269	0.356	0.406	0.441	1.000									
other firms from the group	0.091	0.177	0.066	0.012	0.245	0.134	0.391	0.188	0.149	0.163	0.099	1.000								
Inno. in developing	0.353	0.423	0.235	0.437	0.490	0.325	0.277	0.327	0.290	0.431	0.266	0.239	1.000							
Exporter	0.196	0.257	0.121	0.165	0.262	0.177	0.170	0.176	0.139	0.220	0.113	0.277	0.390	1.000						
Size	0.164	0.241	0.134	0.030	0.299	0.168	0.257	0.248	0.198	0.227	0.157	0.570	0.359	0.406	1.000					
$Size^2$	0.103	0.195	0.123	-0.060	0.250	0.139	0.267	0.242	0.192	0.189	0.147	0.551	0.263	0.265	0.934	1.000				
Age	0.158	0.195	0.098	0.123	0.260	0.138	0.162	0.184	0.141	0.195	0.111	0.391	0.3660	0.473	0.742	0.561	1.000			
Scientific park	0.191	0.193	0.204	0.265	0.168	0.165	0.068	0.096	0.126	0.189	0.152	0.047	0.154	0.060	0.061	0.028	0.0488	1.000		
R&D intensity	-0.086	-0.108	0.002	0.049	-0.183	-0.062	-0.125	-0.124	-0.074	-0.1132	-0.045	-0.401	-0.301	-0.450	-0.753	-0.556	-0.848	-0.006	1.000	
Innovative sales	0.214	0.242	0.133	0.288	0.283	0.200	0.163	0.187	0.1678	0.238	0.141	0.121	0.334	0.243	0.203	0.130	0.216	0.102	-0.179	1.000

Table B. Distribution of the sample by type of public funding and year

	Number of firms in										
	2008	2009	2010	2011	2012	2013	2014	2015	2016	At least one obs.	Total Observations
No R&D subsidy	7,765 (62.87%)	7,635 (62.21%)	7,546 (61.51%)	7,374 (59.67%)	7,355 (60.03%)	7,134 (57.80%)	4,971 (40.13%)	4,861 (39.88%)	5,757 (47.03%)	10,299 (80.44%)	60,398 (54.58%)
Only Regional subsidy	1,188 (9.62%)	1,031 (8.40%)	828 (6.75%)	697 (5.64%)	567 (4.63%)	483 (3.91%)	455 (3.67%)	404 (3.31%)	369 (3.01%)	2,652 (20.70%)	6,022 (5.44%)
Only National subsidy	979 (7.93%)	960 (7.82%)	923 (7.52%)	955 (9.57%)	873 (7.13%)	798 (6.47%)	730 (5.89%)	686 (5.63%)	698 (5.70%)	2,931 (22.88%)	7,602 (6.87%)
Only European subsidy	88 (0.71%)	75 (0.61%)	77 (0.63%)	75 (0.61%)	109 (0.89%)	122 (0.99%)	132 (1.07%)	146 (1.20%)	137 (1.12%)	499 (3.90%)	961 (0.87%)
Regional & National subsidies	785 (6.36%)	720 (5.87%)	613 (5.00%)	49 (4.02%)	361 (2.95%)	276 (2.24%)	318 (2.57%)	281 (2.31%)	231 (1.89%)	1,742 (13.60%)	4,082 (3.69%)
National & European subsidies	82 (0.66%)	82 (0.67%)	92 (0.75%)	119 (0.96%)	113 (0.92%)	121 (0.98%)	153 (1.24%)	173 (1.42%)	163 (1.33%)	514 (4.01%)	1098 (0.99%)
Regional & European subsidies	41 (0.33%)	45 (0.37%)	54 (0.44%)	42 (0.34%)	35 (0.29%)	45 (0.36%)	56 (0.45%)	56 (0.46%)	67 (0.55%)	285 (2.22%)	441 (0.40%)
All types of subidies	254 (2.06%)	248 (2.02%)	247 (2.01%)	218 (1.76%)	199 (1.62%)	193 (1.56%)	256 (2.07%)	273 (2.24%)	261 (2.13%)	685 (5.35%)	2149 (1.94%)
Total	12,351	12,272	12,267	12,359	12,252	12,343	12,386	12,190	12,240		110,660

Table C. Transition probabilities across participation status

	No subsidy	Only regional subsidy	Only national subsidy	Only European subsidy	Regional & national subsidies	National & European subsidies	Regional & European subsidies	All types of subsidies
No subsidy	95.24%	1.68%	2.14%	0.29%	0.39%	0.12%	0.06%	0.07%
Only regional subsidy	35.83%	46.87%	5.55	0.58%	8.65%	0.21%	1.54%	0.76%
Only national subsidy	29.82%	3.75%	54.93	1.09%	6.56%	2.56%	0.23%	1.05%
Only European subsidy	29.48%	2.31%	6.70	48.96%	0.85%	5.85%	3.90%	1.95%
Regional & national subsidies	15.04%	13.17%	15.15	0.29%	47.84%	1.43%	0.68%	6.40%
National & European subsidies	9.75%	1.07%	14.79	7.82%	2.36%	51.45%	1.18%	11.58%
Regional & European subsidies	19.62%	12.10%	4.03	8.87%	3.76%	2.96%	34.41%	14.25%
All types of subsidies	6.32%	1.75%	3.61	1.01%	8.50%	7.44%	2.60%	68.76%
Total	80.71%	4.92%	6.75%	0.89%	3.36%	1.04%	0.41%	1.93%

Table D. Main industries in the estimation sample

NACE Rev. 2		Number of Observations								
		Total	No subsidy	Only regional subsidy	Only national subsidy	Only European subsidy	Regional & national subsidies	National & European subsidies	Regional & European subsidies	All types of subsidies
1. Agriculture	1-3	1,256	899	81	154	22	55	21	10	14
2. Extractive industry and Energy	5-9	520	455	28	15	7	6	3	3	3
3. Construction	41-43	2,213	1,796	122	170	8	62	28	1	26
4. Low-tech Manufacturing	10-18, 31-32	24,576	20,976	1,066	1,495	222	504	129	72	112
5. High & medium-tech manufacturing	21, 26, 19, 22-25, 33, 20, 27-30	42,830	31,919	3,155	3,835	389	2,280	436	163	653
6. Low-tech Services	45-47, 49, 52-53, 55-56, 68, 77, 79, 81, 82, 94-96, 97-99	15,764	11,081	961	1,100	238	781	303	149	1,151
7. Knowledge Intensive Services	50-51, 58-63, 64-66, 69-75, 78, 70, 84-93	11,605	9,283	609	833	75	394	178	43	190
Total		110,660	76,409	6,022	7,602	961	4,082	1,098	441	2,149

Table E. Number of observations during the preprocessing stage and during average treatment effect for the treated analysis

	Total Number of treated	Number of treated dropped during preprocessing	Total Number of treated after preprocessing	Mean size of selection groups	No. of treated obs.	No. of unique controls	Variable
Case 1	2,652	64	2,588	439.14	1,767	1,035 939	R&D Total Intensity Innovative Sales
Case 2	3,311	35	3,276	550.941	2,367	1,281 1,289	R&D Total Intensity Innovative Sales
Case 3	2,167	12	2,155	507.85	1,240	513 599	R&D Total Intensity Innovative Sales
Case 4	10,305	3,227	7,078	20.830	5,036	91 95	R&D Total Intensity Innovative Sales
Case 5	3,311	39	3,272	46.133	1317	118 208	R&D Total Intensity Innovative Sales
Case 6	2,167	15	2,152	70.372	1,045	218 202	R&D Total Intensity Innovative Sales
Case 7	10,305	3,199	7,106	42.231	5,510	202 208	R&D Total Intensity Innovative Sales
Case 8	2,652	64	2,588	76.194	919	144 229	R&D Total Intensity Innovative Sales
Case 9	2,167	18	2,149	83.253	1,217	222 262	R&D Total Intensity Innovative Sales
Case 10	10,305	1,033	9,272	49.530	7,118	232 253	R&D Total Intensity Innovative Sales
Case 11	2,652	68	2,584	64.840	965	188 183	R&D Total Intensity Innovative Sales
Case 12	3,311	60	3,251	37.385	1,510	201 160	R&D Total Intensity Innovative Sales