Regional Perspective on R&D Policies for SMEs: Does Success Breed Success?

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Abstract: In this paper, we examine the effects of EU policy schemes that support innovation in small and medium-sized enterprises. Since the effectiveness of innovation schemes can be expected to differ across Europe as entrepreneurship and innovation tend to be more intense in more developed regions, we postulate that the effect of EU instruments on additionality increases with the level of development. We offer a multi-country perspective using two waves of Community Innovation Survey data (CIS 2008 and CIS 2012). We find that the impact of EU funding depends on the level of country's innovativeness: both national and EU public schemes exhibit smaller additionality in less developed countries, while crowding-out is observed only in recently joined EU members.

1. Introduction

All countries have national public policy schemes to help companies innovate. General justification for public policy interventions is that it is a corrective mechanism for market failure that is created by firms' inability to appropriate the returns to research and development (R&D) resulting from knowledge spillover mechanisms [1,2]. The public policy programs are costly, which makes it important to investigate their achieved impacts. While a non-efficient outcome is when firms substitute the public money for their own investments, the desired outcome is that recipients invest even more of their own resources in innovation development, thus augmenting the effect of the public instrument and creating input additionality.

Our focus in this paper is on EU instruments. Namely, for EU countries, in addition to a variety of national policies, there are also EU instruments operated by the EU agencies. While national funding schemes differ from country to country, the EU mechanisms are either the same or very similar in form and implementation across the whole EU. Effectiveness of any innovation scheme can be expected to differ across countries and regions, as entrepreneurship and innovation are linked to overall level of development [3,4]. There is a lack of studies on cross-country comparison of public instruments in general, and those existing ones make comparisons on the basis of a small number of countries [5–9].

In this paper, we focus on small and medium-sized companies (SMEs) and examine the effects of EU public policy schemes compared to national policies. To our knowledge, there are only few papers to date which address this issue. Czarnitzki and Lopes-Bento [10] analyze the effects of a national versus EU policy mix on innovation input and output of firms in Germany while Radicic and Pugh [11] examine the same for SMEs using pulled data from 28 European countries. Additionally, Orlic et al. [9] explore the case of six Western Balkan countries, while Mulligan et al. [12] study the case of five old EU members. We attempt to broaden the view on the same issue by offering a multi-country perspective

using the Community Innovation Survey data. We group the EU countries in four clusters according to their geographical location, which, according to European Innovation Scoreboard, coincides with their economic strength and innovative prowess: northern countries, southern countries, new member states that joined in 2004, and the three most recent member states (Bulgaria, Romania and Croatia). EU instruments were envisioned as a tool that will, among other purposes, aid the convergence by helping to close the gap in innovation output between old and new member states, which is still persisting after decades [13–15]. However, little is known about the impact of EU innovation policies. The academic literature that explores the impact of EU public instruments is scarce and focuses on collaborative programs [16–18]. Even less is known about the impact of EU instruments on new member states [6,19].

In this paper, we investigate to which degree the EU instruments produce additionality compared to the national policies, specifically focusing on new member states. We recognize that the firms that use EU policy incentives are very likely to use the national instruments as well, which raises the question how "valuable" the EU instrument is by itself, i.e., whether the addition of the EU instruments produces a significant impact over the impact produced by national policies only. To generate deeper insight, we add temporal dimension, because the impact of the instruments likely depends on the overall economic situation that may change with time. This is why we examine additionality in the period from 2006 to 2008 right before the global financial crisis and the period of 2010 to 2012 after most of the EU countries had entered recovery.

We single out SMEs because of their significance for every EU economy and their vulnerability to market failure. Innovation policy instruments are very important for SMEs, because such firms rely on innovation to an even greater extent than large firms. At the same time, SMEs find it more difficult to extract rents associated with innovation [20,21], as the asymmetric information prevents them from securing external capital for innovation. Thus public money is of larger significance for SMEs than for large firms. An overview of empirical studies evaluating the effectiveness of SMEs grants is given in Dvouletý et al. [22].

In summary, we seek to contribute to the body of knowledge in the following way:

- We conduct a cross-country analysis of input additionality in SMEs, which received national and EU support for innovation; in particular, we explore the added effect of EU instrument over national instrument in firms that use both;
- We examine the effects of EU instruments in new member states (our data includes all new member states since 2004 except for Cyprus and Malta),

The paper is organized as follows. The next section provides a review of the existing literature linking public subsidies and firm-financed R&D. Out of the large body of empirical literature, it primarily highlights the studies that relate to SMEs, studies that include cross-country comparisons as well as those that take into account the effects of economic recessions and/or crisis. Following the development of the hypothesis, a description of the model is given in the third and the description of data in the fourth section. The fifth section brings the discussion of results while verification of the hypothesis follows in the sixth section. The paper ends with a discussion on the limitations of the analysis along with the concluding remarks.

2. Literature Background and Hypotheses Development

2.1. Literature Background

Economic theory does not give us a clear answer on the effect of public subsidies on the level of company-financed R&D. Counteracting effects are working in the direction of "crowding-out" and "crowding-in", and the final net effect depends on a number of factors. Testing the additionality hypothesis is, therefore, a policy-relevant issue for evaluating the use of public funds used to subsidize private R&D activities.

Over time, this has induced a large number of empirical studies. In surveys of literature, David et al. [23] and Cerulli [24] emphasized the problem of endogeneity, present in the empirical studies up to the end of the 1990s due to the use of linear regression models. In the 2000s, improved datasets along with the advances in the applied micro-econometrics have allowed for controlling many of the previous deficiencies. The empirical studies undertaken since the beginning of the 2000s have relied primarily on matching methods, instrumental variables methods, and selection models. Despite the heterogeneity of empirical results, that cannot be explained only by methodological differences, the majority of empirical studies find that R&D subsidies lead to the additionality effects [25].

Despite a large number of studies, those that investigate the impact of public subsidies on R&D activities within a multi-country context have remained scarce as the majority, due to data availability, focus on individual countries. There are several exceptions. Hashi and Stojčić [6] investigated the link between innovation activities and firm performance in two different institutional settings: Western European countries and EU newcomers from Central and Eastern Europe. In respect to national and EU subsidies, they concluded that recipients spent more on innovation activities but had not achieved additional innovation output. A study by Charnitzki and Lopes-Bento [5] on five developed countries of rather different industrial structures identified positive effects of public subsidies on R&D activity just as Carboni [8] on the sample of developed European countries. However, by using the firm-level data for the largest EU states during the 2008/09 financial crisis, Aristei et al. [7] could not confirm additionality effects of R&D subsidies.

Zúñiga-Vicente et al. [25] noted that the majority of studies focused on developed countries with very little evidence on the impact of public subsidies in developing and emerging economies. Exceptions are studies for Eastern Germany where additionality in public R&D grants was confirmed [26,27]. Additionally, Franco and Gussoni [19] included transition countries, Romania and the Czech Republic, in their sample while analyzing the effects of subsidies on cooperation.

In this paper we focus on SMEs, as they are vulnerable when it comes to innovation activity due to their size and financial constraints. The R&D subsidy programs for SMEs have been scarcely evaluated within the applied micro-econometric literature. The exceptions include the Small Business Innovation Program in the US evaluated by Wallsten [28] who finds no effects of subsidies on R&D expenditures. Lee and Cin [29] and Cin et al. [30] for the case of South Korea and Charnitzki and Lopes-Bento [31] for the case of Flemish firms in Belgium find that R&D incentive programs for SMEs had positive effects on at least some of the input indicators, such as R&D expenditures and/or R&D investment and/or R&D employees. Hud and Hussner [32] also found positive results for SMEs in Germany. In the case of Finnish SMEs, Karhunen and Huovari [33] got ambiguous results as positive results after receiving the public grant change to negative in the succeeding years. More recently, Mariani and Mealli [34] evaluated the small-business program implemented in Tuscany (Italy) and found, at least, some positive effects such as the increase of R&D activity for former non-performers and upskilling. However, the program has not had positive effects on innovation or commercial output of SMEs. Avellar and Botelho [35] confirmed additionality in the case of Brazilian SMEs, where support programs for the acquisition of machinery and equipment were more effective than other programs.

Within the EU, the R&D activities are underpinned through national support schemes and a range of EU instruments and programs, out of which Framework Programmes (FPs) are the most important. In general, the literature suggests that publicly funded collaborative research projects have positive effects on innovative activities of its participants (see, for example, the literature survey in Hagedoorn [36]). However, the results of studies investigating EU framework programs are not so straightforward [16,17,37]. Maggioni et al. [38] have used data on FP5 and found that networks affect innovation but geographical proximity still plays a major role. Additionally, Di Cagno et al. [39] concluded that for countries with high levels of R&D expenditure R&D spillovers contribute to the generation of new knowledge, while for low R&D spenders, knowledge spillovers facilitate technological imitation and catching up. Wanzenböck et al. [40] emphasized how distinct regional

factors affect positioning in the European Union-funded R&D network, while Koišova et al. [41] confirmed differences between regions in the use of EU funds to finance innovation in SMEs.

The periods of recessions or economic crisis are particularly harmful to R&D activities. Either due to financial constraints [42,43] or as a response to the overall weaker demand [44,45] firms commonly reduce R&D investments in such times. Bloom et al. [46] have shown that the response of firms to policy actions, including subsidies, is much lower in times of high uncertainty (such as recessions and crisis) than otherwise. The global 2008/09 financial crisis has severely affected the world economy accompanied by a drop in overall investment as well as R&D investment. Policymakers in a number of EU countries reacted by increasing national public R&D budgets (for example, Austria, Belgium, Sweden, and Germany), while in other countries (particularly southern Europe) that was not possible due to strong fiscal consolidation [14,15]. Studies that investigate the impact of these actions have so far been rare. For example, Hud and Hussinger [32] investigate the impact of public R&D subsidies on R&D investment of SMEs in the case of Germany and find an overall positive effect of subsidies. In 2009, at the height of the crisis a crowding-out effect was present while in the pre-crisis period as well as in 2010, when the recovery started, the subsidy effect was positive but smaller than before the crisis. Aristei et al. [7] analyzed firm-level data for the largest EU states over the period 2007–2009 and tested whether manufacturing firms receiving public subsidies spent more on R&D. Although firms did not replace their own resources with public grants, they did not allocate additional funds to R&D and consequently additionality effects of R&D subsidies could not be confirmed.

2.2. Hypotheses Development

Based on the above review, we formulate two hypotheses. Earlier studies that examine the additional effect of EU instruments versus the national ones [10,11] find that when national subsidies are combined with EU money, the recipients invest more than in the counterfactual situation of only getting a national subsidy. Due to the nature of our data, we cannot differentiate among different EU programs, so we adopt the approach outlined in [10,11]. We expand this discussion using temporal and multi-country dimension, asking whether this is true regardless of the country's development level or whether these effects change with time.

To generate better insight into input additionality, we consider investment in internal and external R&D. Adopting Community Innovation Survey (CIS) definitions, by internal R&D we mean research and development activities undertaken by the firm to create new knowledge or to solve scientific or technical problems (including software development in-house that meets this requirement). By external R&D we mean R&D that the firm contracted-out to other enterprises (including enterprises in its own group) or to public or private research organizations. These are defined in Table 3. In line with previous studies, we expect that EU instrument will generate input additionality for internal R&D. Since EU programs foster collaboration, which may induce firms to outsource some R&D activities to partners, we expect that additionality will be created in external R&D as well.

Radicic and Pugh [11] have shown that compared to national support, EU support is more effective in raising R&D expenditures. However, we expect that the benefit from the EU instruments will depend on the overall level of development of the country/region where it is applied. It is known that EU was not able to stimulate sufficient R&D spending in new members from Central and Eastern Europe, and consequently these groups of countries seem to be permanently lagging behind [15]. Therefore, we expect that this lag will be reflected in the impact generated by the public instruments; namely, we expect that new member states will show smaller additionality compared to more developed older EU states, and we expect this effect to persist over time. To get a more detailed picture, we explore these effects in two time periods, before and after the economic crises of 2008. Economic crisis can induce firms to lower their R&D investments, but after the crisis is over, things should be returning to normal with time [32].

We formulate the following hypotheses:

The input additionality effects of EU funding over national funding are larger in more developed countries. In particular, new member states are less successful in generating input. This is true for:

(a)　internal R&D and

(b)　external R&D.

3. Model

3.1. Matching Method

In this paper, we evaluate effects of public policy instruments via the nearest neighbor matching method using Mahalanobis distance as matching metric, which includes the propensity score as one of the covariates. The goal of this exercise is to estimate what would have happened with the firms that used public instruments if they had not used them. Since this counterfactual scenario has never existed in reality, we need to find matches to the treated firms which can serve as an approximation of their counterfactual self. To do this, we follow Rubin [47] who introduced the conditional independence assumption (CIA). CIA states that potential outcomes are independent of treatment assignment if the selection into treatment is based on a set of observable covariates *X*, which are themselves not affected by the treatment. Consequently, this allows for the firms that used instruments to be paired with those that did not, where the later are as similar as possible on pre-treatment characteristics. These non-participant "twins" can be used to estimate the counterfactual scenario, and are usually referred to as "control observations".

We match treated-control pairs using the Mahalanobis distance metric [48]; we match on a number of covariates including propensity score. Propensity score, $p(X)$, is defined as the conditional probability of receiving a treatment (in this context treatment refers to use of public policy instruments) given a vector of covariates *X* [49]. In line with CIA assumption, after conditioning on these covariates, we expect outcomes to be independent of the treatment condition.

Let $D \in \{0, 1\}$ be an indicator which shows whether the firm participated in the program (1 stands for participation, 0 otherwise). Then for a firm *i*, propensity score can be written as $p(X_i) = p(D_i = 1|X_i) = F(h(X_i))$, where F is a cumulative distribution function (either normal or logistic) and $h(X_i)$ is a linear function of covariates and their interactions. Propensity score matching means finding controls that are closest to the treated firms in terms of propensity score. To improve the quality of matching, propensity scores are usually restricted to the area of common support, which is the intersection of the intervals of propensity scores for treated and control observations.

As for Mahalanobis, the distance metric measures dissimilarity between observations based on the vector of covariates *X*. The Mahalanobis distance between observations *i* and *j* is defined by the formula:

$$D_{ij} = \left(X_i - X_j\right)\prime\Sigma^{-1}\left(X_i - X_j\right) \tag{1}$$

where X_i is the vector of covariates, and Σ is the variance-covariance matrix of X_i in the control sample.

3.2. Modeling Joint Use of National and EU Instruments

We study the situation where firms can choose to use national policy instruments, EU instruments, both, or none. The national instruments may include financial support via tax credits or deductions, grants, subsidized loans, and loan guarantees. EU instruments come in the form of grants and participation in collaborative programs such as FPs. So instead of a simple selection into treatment that can be modeled by a logit or a probit function, we have two simultaneous and correlated decisions that we model using seemingly unrelated bivariate probit. Here we follow the approach of Radas et al. [50], Czarnitzki and Lopes-Bento [10], and Radicic and Pugh [11], who used the Mahalanobis distance metric augmented with bivariate propensity scores to model the use of two different non-exclusive policy instruments.

We specify the seemingly unrelated probit where the two dependent variables are as follows: $y_1 = 1$ if national instrument was used, $y_2 = 1$ if EU instrument was used. Let y_1^* and y_2^* denote latent variables underlying binary variables y_1 and y_2, then we can write the model as:

$$y_1^* = \beta_1 X_1 + \varepsilon_1, \; y_1 = 1 \text{ if } y_1^* > 0 \text{, } 0 \text{ otherwise; } \varepsilon_1 \sim N(0,1) \tag{2}$$

$$y_2^* = \beta_2 X_2 + \varepsilon_2, \; y_2 = 1 \text{ if } y_2^* > 0 \text{, } 0 \text{ otherwise; } \varepsilon_2 \sim N(0,1). \tag{3}$$

The correlation between the disturbances is denoted as $Cov(\varepsilon_1, \varepsilon_2 | X_1, X_2) = \rho$. In general, it is possible that participation in each of the two instruments depends on different set of variables, but in our study we assume $X_1 = X_2 = X$. This model produces four conditional probabilities, these are $P(y_1 = 1, y_2 = 0 | X)$, $P(y_1 = 0, y_2 = 1 | X)$, $P(y_1 = 1, y_2 = 1 | X)$, and $P(y_1 = 0, y_2 = 0 | X)$. In this paper, we consider only three of the above four possibilities, because the firms that use only EU instruments without national instruments are almost nonexistent in our dataset.

We consider each of the three comparisons: (1) firms that used national instrument only compared to firms that did not participate in any programs, (2) firms that used both national and EU instruments compared to firms that did not participate in any programs, and (3) firms that used both national and EU instruments compared to firms that used a national instrument only. In each of the models (1), (2), and (3), we use the vector of selected covariates together with the relevant propensity score. The scores are $P(y_1 = 1, y_2 = 0 | X)$ for model (1) and $P(y_1 = 1, y_2 = 1 | X)$ for model (2) and (3). Although the propensity score is the same variable $P(y_1 = 1, y_2 = 1 | X)$ in both models, the difference between models (2) and (3) is in the set of firms on which we perform matching. In model (2) we take the firms that used both instruments and firms that did not use any, while in (3) we take the firms that used both instruments and firms that used only a national instrument.

Our procedure goes as follows: we determine the appropriate propensity score and add it to a smaller set of chosen covariates used in Mahalanobis distance computation. We keep only those observations that are on common support. Then we perform nearest neighbor matching where for every treated firm we choose the non-treated one with the minimal Mahalanobis distance from the treated observation. Nearest neighbor matching is done with a replacement, which means that once a control observation is used as a match, it is returned to the pool and can be reused.

The effects on the output are measured using ATT which is defined as $ATT = \frac{1}{N^T} \sum_{i \in T} \left(Y_i^T - Y_i^C \right)$, where the sum goes over all the treated units and N^T is the number of treated units, Y_i^T is the value of the outcome variable in the matched pair i, while Y_i^C is the value of the outcome variable for the control observation in the matched pair i. Analytical standard errors are computed using Abadie–Imbens formula [51], which takes replacement into account. The matching is performed using Stata package PSMATCH2 [52].

Although in this paper we follow the established methodology for policy evaluation in economics, we would like to point out that recently there have been some development in new methodological approaches to policy evaluation based on machine learning. For more information, please see [53–55].

3.3. Robustness Tests

A limitation of matching methods is the assumption that the covariates in the model completely determine the selection into treatment. If some unobserved variables simultaneously affect assignment to treatment and the outcome variable, matching methods can suffer from "hidden bias".

The sensitivity of our results to hidden bias is tested with Rosenbaum's bounding approach [56], which has been increasingly used as an alternative to the instrumental variables (IV) estimation, which typically relies on additional untestable assumptions [57,58]. The Rosenbaum bounds method relies on the sensitivity parameter Γ that estimates which magnitude of the hidden bias would render the test statistics of the study inference insignificant. The larger magnitude of Γ implies larger robustness of the outcome.

4. Data

4.1. Data Source

We use the data collected by CIS, which is routinely conducted in two-year intervals in the EU and some associated countries. The analysis was conducted in the Eurostat Safe Room, where we had access to anonymized data from 21 EU countries. We divided them in 4 groups: North (Germany, Finland, France, Norway, Sweden, Netherlands, Luxemburg), South (Portugal, Spain, Italy), EU2004 (Slovenia, Slovakia, Hungary, Czech Republic, Poland, Estonia, Lithuania, Latvia), and NewEU (Bulgaria, Romania, Croatia).

To elicit information about public support for innovation, the CIS questionnaire asks whether in the prior two-year period the enterprise had received any financial support for innovation activities from: (1) national governmental sources which involve local or regional authorities, or central government (including central government agencies or ministries), and (2) The European Union (EU). The financial support could have been in the form of tax credits or deductions, grants, subsidized loans, and loan guarantees.

To explore the effects of EU instruments before and after recession, we analyzed two waves of CIS data. The first was for the period 2006–2008, just before the recession. The second is for the period 2010–2012, after the recession was over in most of the EU countries.

4.2. Variables

We define three variables that are used for measuring the type of instrument that was used: national, EU instrument, or both (Table 1). They represent treatment variables in the matching exercise. We do not have information about different programs that constitute treatment in each country; however, in this study we are interested only in the general effect of EU versus national policies.

Table 1. Treatment variables.

natfun	1 if the firm received any public funding from local or regional authorities, or central government, 0 otherwise
eufun	1 if the firm received any public funding from the EU (including FPs), 0 otherwise
nateufun	1 if the firm received public funding from both national bodies and the EU), 0 otherwise

The list of covariates used in the first stage model is presented in the Table 2. To avoid simultaneity, the covariates should be either (1) measured at the beginning of the period covered by CIS survey, or (2) they must be constant throughout this period. Covariates measured at the beginning of the CIS survey period are turnover and firm size: these two variables give rise to the variables *micro, small, lnturn_b, lnturn_bsq*. Since industry sector variables have large inertia, the covariates constant throughout each two-year long CIS period are the industry sector variables *kis, lkis, mht, mlt*. Group membership is also not likely to change, so we also consider it a constant.

Other variables from the Table 2 in CIS survey refer to questions about the entire two-year period, but here we use them as proxies for the firm capabilities that existed in the beginning of the period. For example, the variables *inno_good, inno_pro, inno_serv* and *inno_org* specify whether a firm brought an innovation to market, but in this study we use them as indicators for the capacity to innovate. Our rational is that the resources and capabilities required for innovation cannot be developed overnight, and therefore must be present in a company even before they become embodied in a specific outcome. So in order to be able to bring an innovation to market, the company must have had the competency to do so. We use exporting variable in the same vein, as an indicator that at the beginning of the two-year period the company has required resources and capabilities to become an exporter [59].

Table 2. Covariates used for matching.

kis	Knowledge intensive service according to NACE Rev.2: 1 yes, 0 no
lkis	Less knowledge intensive service according to NACE Rev.2: 1 yes, 0 no
mht	Belonging to high or medium high technology manufacturing sector according to NACE Rev.2: 1 yes, 0 no
mlt	Belonging to low or medium low technology manufacturing sector according to NACE Rev.2: 1 yes, 0 no
micro	If the firm is a micro enterprise: 1 yes, 0 no
small	If the firm is a small enterprise: 1 yes, 0 no
lnturn_b	Logarithm of total turnover in EUR (microaggregated) measured at beginning of each CIS round
lnturn_bsq	Squared logarithm of total turnover in EUR (microaggregated) measured at beginning of each CIS round
gp	Is the firm part of an enterprise group: 1 yes, 0 no
inngood	Introduced onto the market a new or significantly improved good: 1 yes, 0 no
innserv	Introduced onto the market a new or significantly improved service: 1 yes, 0 no
innorg	Did the enterprise introduce any organizational innovation: 1 yes, 0 no (This includes: New business practices for organizing procedures, new methods of organizing work responsibilities and decision making, new methods of organizing external relations)
innpro	Did the enterprise introduce any process innovation: 1 yes, 0 no (This includes: introducing a new or significantly improved method of production, introducing a new or significantly improved logistic, delivery or distribution system, introducing a new or significantly improved supporting activities)
exp	If the enterprise is an exporter: 1 yes, 0 no
	INTERACTIONS
medium_ kis	Medium size and knowledge intensive services
medium_ mht	Medium size and high or medium high technology manufacturing
medium_ lnturn	Medium size and ln(turnover)
medium_ lnturnsq	Medium size and square of ln(turnover)
medium_ gp	Medium size and group membership
medium_ inn	Medium size and innovator (either of good, process, service or organization)
medium_ exp	Medium size and exporter
lnturn_exp	ln(turnover) and exporter
lnturnsq_exp	Squared ln(turnover) and exporter
inn_exp	Innovator and exporter

Within covariates we also include interactions, following the advice by Caliendo and Kopeining [60], which is that higher order terms and interactions in the propensity score specification can improve the matching. In addition, these interactions capture the synergistic effects of size and sector (*medium_ kis, medium_ mht*), size and earnings (*medium_ lnturn, medium_lnturnsq*), size and group membership (*medium_ gp*) and size and innovative capability (*medium_ inn*). While the variable *medium* measures size in number of employees, we add the interaction of turnover and exporting to capture financially strong companies with exporter capabilities. Finally, we include an interaction between exporting and innovation, capturing propulsive global SMEs.

To measure the effects of public instruments, we look at companies' internal and external R&D investments as percent of their turnover measured at the end of the observed period. The CIS definitions of the output variables are presented in Table 3.

Table 3. Output variables.

rdin_turn	Internal or in-house R&D Creative work undertaken within the enterprise to increase the stock of knowledge for developing new and improved products and processes (including software development in-house that meets this requirement)
rdex_turn	External R&D Same activities as for in-house R&D, but performed by other enterprises (including other enterprises or subsidiaries within firm's group) or by public or private research organizations, and purchased by the firm

5. Empirical Results

The seemingly unrelated probit estimation results are presented in Table A1 in Appendix A for the period before recession, and in Table A2 for the period after the recession. In both periods, we observe that firms that have capabilities for more than one type of innovation are more likely to obtain both national and EU funding. As for the other firm characteristics, being classified as operating in higher technology or knowledge sector also improved the probability of getting both types of funding. Firms that belong to a group are less likely to get both types of funding. These findings are true both before and after the crisis. So we can say that the factors that determine funding award remain the same regardless of the economic conditions. As for differences among country groups, we observe that in the case of NewEU, these effects are much smaller compared with more developed northern and southern states. Also, considering national and EU instruments, we find that almost the same variables are significant for both outcomes, which leads to the conclusion that the European and national agencies have similar selection criteria, as Czarnitzki and Lopes-Bento [10] found for Germany.

The effects of the funding on internal and external financing are presented in Table 4, and the findings will be interpreted in the next section. The matching quality is shown by balancing in Table A3, Table A4, and Table A5, which confirm that after matching there is no significant difference in covariates between the treated observations and their matched pairs.

Table 4. Results of matching: Average treatment effect on the treated (ATT) estimations.

	2008			2012		
	National Support Only vs. No Treatment	National support and EU Support vs. No Treatment	National Support and EU Support vs. National Support Only	National Support Only vs. No Treatment	National Support and EU Support vs. No Treatment	National Support and EU Support vs. National Support Only
Output	ATT (S.e.)	ATT (S.e.)	ATT (S.e.)	ATT (S.e.)	ATT (S.e.)	ATT (S.e.)
			NORTH			
	N = 1341	N = 299	N = 298	N = 427	N = 94	N =94
rdin_turn	2.10 (0.31) ***	7.08 (1.09) ***	4.14 [c] (1.21) ***	3.24 (0.45) ***	10.41 (0.99) ***	6.77 (1.09) ***
rdex_turn	0.40 (0.11) ***	0.81 (0.16) ***	0.15 (0.20)	0.23 (0.14) **	1.27 (0.32) ***	0.93 (0.32) ***
			SOUTH			
	N = 5984	N= 463	N= 465	N = 2983	N = 472	N= 475
rdin_turn	3.42 (0.15) ***	11.94 (1.04) ***	8.56 [c] (1.08) ***	4.29 (0.26) ***	12.01 (1.02) ***	5.47 (1.29) ***
rdex_turn	0.54 (0.05) ***	2.07 (0.33) ***	1.33 (0.38) ***	0.6 (0.07) ***	1.72 (0.22) ***	0.77 [b] (0.44) **
			EU2004			
	N = 466	N = 221	N = 221	N = 291	N = 161	N = 161
rdin_turn	2.27 (0.39) ***	5.43 (1.07) ***	2.65 [c] (1.12) ***	2.66 [a] (0.58) ***	5.42 (1.28) ***	1.96 [b] (1.13) **
rdex_turn	0.26 (0.11) **	1.05 (0.40) ***	0.95 [b] (0.41) ***	0.20 (0.19)	0.26 [a] (0.27)	−0.01 (0.21)
			NewEU			
	N = 75	N = 50	N = 47	N = 179	N = 52	N = 51
rdin_turn	0.08 (3.38)	−6.04 (3.16) **	−8.34 (3.4) ***	1.35 (0.58) **	1.15 (1.38)	−2.56 (2.10)
rdex_turn	0.46 (1.65)	0.77 (0.31) ***	0.80 (0.31) ***	0.27 (0.17)	0.09 (0.21)	−0.07 (0.41)

Notes: [a] denotes Rosenbaum delta up to 0.1 (10% hidden bias). [b] denotes Rosenbaum delta up to 0.2 (20% hidden bias). [c] denotes Rosenbaum delta up to 0.3 (30% hidden bias). No letter denotes Rosenbaum delta greater than 0.3 (more than 30% hidden bias). ** denotes one-tailed t-test significance to 5%, *** denotes one-tailed t-test significance to 1%. S.e. represents standard errors.

6. Hypotheses Verification

The national public policies are shown to produce significant additionality in internal R&D investments in all the clusters, except for NewEU in the period before recession. Adding EU instruments to the national ones considerably improves internal R&D spending, significantly increasing additionality. That effect is robust and persists over time. The only exception is NewEU countries, where EU instruments used in conjunction with national ones seem to generate no effect. Considering the added effect of EU funding on top of national policies, the results suggest that in NewEU, they may be used as substitutes for own funding (here caution is needed as those effects are not confirmed by Rosenbaum tests). For the remaining three groups of countries, these added effects of EU instruments are all positive and significant (although robustness tests do not support the results for northern countries in 2012).

Regarding the external R&D investments, the effects are much smaller compared to internal R&D. However, the same pattern exists, except that some of the effects are not confirmed in robustness tests. As a general trend, we observe that public instruments generate larger additionality effects on development of internal capabilities than on external R&D links (which include purchasing or outsourcing of R&D).

Examining the differences among the country clusters, we observe that northern and southern countries are very similar in the produced effects. Interestingly, there is one difference between northern and southern countries: the input additionality for the joint use of national and EU instruments is stronger for southern countries, indicating that there EU instruments are more effective in motivating SMEs to increase their own efforts. The EU2004 member states show much lower effects, while the NewEU group is the weakest of all. This supports the expectation that benefits of EU instruments are stronger when used by more developed economies, which confirms our Hypothesis.

Considering the temporal dimension, in 2010–2012 in northern countries we observe increase of internal R&D additionality for both instruments, although some effects are not robust. One explanation is that in developed economies less efficient firms disappeared after crisis of 2008, and those remaining ones are even more motivated to use EU instruments to bust their innovation powers and in that effort they increase their own R&D investments to a larger extent. Comparison of northern and southern countries shows that the additionalities for EU instruments are larger in southern countries in 2006–2008. In 2010–2012, the effect of joint instruments remains almost the same, but the differential effect of EU instrument decreases. This is true for internal as well as external R&D. So we can conclude that by depleting internal resources, crisis of 2008 may have weakened internal "power" of SMEs to invest in R&D, except for the very best performers (northern economies). As is known, developed EU members invested more in R&D during the crisis, while southern and less developed countries did not due to fiscal contraction measures.

In EU2004 countries, the situation for internal additionality is similar to the one in southern countries, but the effects are much smaller. For the external R&D, we observe absence of additionality, although the result is not robust to Rosenbaum bounds test. The only region where we observe crowding-out for internal R&D in both time periods is NewEU. There is a small improvement in the period 2010–2012: the effect of joint use of national and EU instruments on internal R&D investment seem to improve from negative one to an effect statistically indistinguishable from zero. The effect of EU instrument itself is still negative, but smaller, suggesting that some improvement may be expected with time.

7. Conclusions

In this paper we examine the effects of EU public policy schemes for innovation compared to national ones in four clusters of EU countries. We consider old member states separately from the more recently joined ones. The older states are divided into northern and southern ones, to recognize the fact that EU innovation is concentrated mainly in northern and western Europe. The more recently

joined states are divided into those that joined in the first wave (EU2004), and the three states that joined last (NewEU).

We observe that the extent to which EU instruments create additionality depends on the level of the development, and that effect persists through time. All groups of countries except for NewEU increase their own R&D investments when using EU funding, meaning that programs are effective. However, both national and EU public instruments exhibit smaller effects in less developed regions. Joint use of instruments creates larger effect than the use of national policies alone for all groups except for NewEU. As a rule, the effects on development of internal capabilities are larger than effects on external R&D investments, which include activities such as purchasing or outsourcing of R&D.

If we consider temporal dimension, we observe that the input additionality of the best innovators is consistently high in northern countries. In southern countries and EU2004 it starts high before 2008, but then it shrinks somewhat in the period 2010–2012. The only group where we observe consistent crowding-out for internal R&D is NewEU, suggesting that SMEs in those countries use EU funding to substitute for their own investments (interestingly this substitution is not detected for the use of national programs). These countries also show lowest effectiveness of national policies compared to the other groups. It seems that for them, EU instruments do not bring any contribution to additionality of internal R&D expenditure, which suggests that in NewEU, in the observed time periods SMEs countries may not have been strong enough to extract full potential of EU instruments.

As for limitations, in this paper we define treatment as being a national or an EU instrument, without going into details about the programs. It is a usual practice in policy evaluation to aggregate several types of programs into one treatment, although this has been done for public policies within one country. We are aware that we are dealing with a higher level of aggregation here, and that a more detailed picture of EU policy effectiveness could be obtained from specifically constructed databases that contain specificities of national programs. We consider this paper as the first step in the exploration of this important topic.

Appendix A

Table A1. Seemingly unrelated probit regression estimation results for 2008.

	North		South		EU2004		NewEU	
	National funding							
kis	0.126 *	(0.0525)	0.407 ***	(0.0308)	−0.116	(0.0790)	0.00475	(0.161)
lkis	−0.322 ***	(0.0518)	−0.168 ***	(0.0271)	−0.490 ***	(0.0736)	−0.456 ***	(0.133)
mht	0.338 ***	(0.0591)	0.238 ***	(0.0384)	−0.263 *	(0.106)	0.132	(0.166)
mlt	0.0761	(0.0454)	0.0659 **	(0.0249)	−0.153 *	(0.0599)	−0.380 **	(0.122)
micro	14.47	(7.632)	1.521	(3.616)	4.823	(7.906)	−21.02 *	(10.57)
small	14.67	(7.637)	1.162	(3.620)	5.030	(7.914)	−20.81 *	(10.59)
medium	0	(.)	0	(.)	0	(.)	−32.48 **	(10.25)
lnturn_b	−1.359 **	(0.497)	0.553 *	(0.259)	0.314	(0.772)	2.809	(1.529)
lnturn_b_sq	0.0446 **	(0.0166)	−0.0183 *	(0.00878)	−0.0107	(0.0266)	−0.107	(0.0551)
gp	−0.191 ***	(0.0358)	−0.0865**	(0.0270)	−0.295 ***	(0.0713)	−0.0206	(0.141)
inngood	0.619 ***	(0.0308)	0.426 ***	(0.0199)	0.501 ***	(0.0442)	0.548 ***	(0.0668)
innserv	0.185 ***	(0.0332)	0.200 ***	(0.0216)	0.237 ***	(0.0469)	0.256 ***	(0.0736)
innpro	0.496 ***	(0.0301)	0.637 ***	(0.0191)	0.680 ***	(0.0475)	0.505 ***	(0.0704)
innorg	0.0761 **	(0.0292)	0.124 ***	(0.0180)	0.160 ***	(0.0423)	0.302 ***	(0.0674)
exp	−5.529	(4.333)	−2.440	(2.405)	−6.726	(5.815)	3.523	(10.03)
medium_kis	−0.220 **	(0.0755)	−0.172 ***	(0.0471)	0.135	(0.100)	0.356*	(0.164)
medium_mht	−0.152 *	(0.0759)	0.0702	(0.0559)	0.405 ***	(0.121)	−0.150	(0.172)
medium_lnturn	1.891 *	(0.955)	0.0904	(0.463)	0.551	(1.049)	1.243	(1.892)
medium_lnturnsq	−0.0605 *	(0.0299)	−0.00133	(0.0148)	−0.0162	(0.0348)	−0.0307	(0.0665)
medium_gp	−0.0946	(0.0603)	0.0104	(0.0411)	0.0553	(0.0920)	−0.199	(0.177)
medium_inn	0.304 ***	(0.0819)	0.249 ***	(0.0417)	0.567 ***	(0.122)	0.669 ***	(0.182)
medium_exp	−0.148	(0.0837)	−0.192 ***	(0.0471)	−0.229 *	(0.106)	−0.360 *	(0.156)
lnturn_exp	0.722	(0.571)	0.235	(0.319)	0.840	(0.782)	−0.595	(1.390)
lnturnsq_exp	−0.0230	(0.0188)	−0.00429	(0.0105)	−0.0264	(0.0262)	0.0244	(0.0479)
inn_exp	0.408 ***	(0.0608)	0.230 ***	(0.0352)	0.414 ***	(0.103)	0.328	(0.205)
_cons	−6.606	(7.797)	−7.207 *	(3.532)	−9.377	(7.406)		

Table A1. *Cont.*

	North		South		EU2004		NewEU	
			EU funding					
kis	0.152	(0.0788)	0.305 ***	(0.0587)	−−0.0799	(0.0904)	0.655 **	(0.241)
lkis	−0.248 **	(0.0809)	−0.152 **	(0.0556)	−0.603 ***	(0.0888)	0.112	(0.220)
mht	0.125	(0.0902)	−0.0106	(0.0786)	−0.0400	(0.111)	0.664 **	(0.249)
mlt	0.0404	(0.0699)	−0.0819	(0.0504)	−0.168 *	(0.0661)	0.520 *	(0.205)
micro	−2.790	(10.44)	8.500	(6.922)	2.690	(9.099)	−11.80	(10.38)
small	−2.732	(10.45)	8.511	(6.931)	2.792	(9.111)	−11.61	(10.39)
medium	0	(.)	0	(.)	0	(.)	−30.18 **	(10.97)
lnturn_b	0.138	(0.814)	−0.556	(0.517)	0.470	(0.943)	1.261	(1.490)
lnturn_b_sq	−0.00516	(0.0272)	0.0194	(0.0174)	-0.0181	(0.0326)	−0.0477	(0.0533)
gp	−0.0905	(0.0524)	−0.0400	(0.0536)	-0.151	(0.0801)	0.0565	(0.153)
inngood	0.396 ***	(0.0445)	0.298 ***	(0.0370)	0.465 ***	(0.0483)	0.569 ***	(0.0708)
innserv	0.242 ***	(0.0466)	0.251 ***	(0.0377)	0.167 **	(0.0517)	0.155 *	(0.0785)
innpro	0.402 ***	(0.0445)	0.346 ***	(0.0379)	0.695 ***	(0.0542)	0.603 ***	(0.0772)
innorg	0.110 *	(0.0429)	0.144 ***	(0.0353)	0.134 **	(0.0467)	0.438 ***	(0.0741)
exp	−2.660	(6.619)	−9.428 *	(4.569)	−13.74 *	(6.841)	−1.380	(1117.0)
medium_kis	−0.0178	(0.103)	0.0106	(0.0792)	−0.0176	(0.112)	0.367 *	(0.179)
medium_mht	0.0605	(0.112)	0.0213	(0.104)	−0.0591	(0.127)	−0.338	(0.204)
medium_lnturn	−0.346	(1.318)	1.081	(0.890)	0.264	(1.216)	2.209	(1.921)
medium_lnturnsq	0.0116	(0.0415)	−0.0342	(0.0286)	−0.00549	(0.0406)	−0.0658	(0.0670)
medium_gp	−0.278 **	(0.0871)	0.0134	(0.0760)	−0.0987	(0.101)	−0.159	(0.188)
medium_inn	0.308 *	(0.134)	0.114	(0.0836)	0.449 ***	(0.127)	0.676 *	(0.309)
medium_exp	−0.213	(0.124)	0.159	(0.0876)	−0.132	(0.121)	−0.00749	(0.173)
lnturn_exp	0.399	(0.873)	1.331 *	(0.606)	1.798	(0.920)	−0.268	(1.486)
lnturnsq_exp	−0.0139	(0.0287)	−0.0461 *	(0.0200)	−0.0585	(0.0308)	0.00773	(0.0510)
inn_exp	0.299 **	(0.0959)	0.112	(0.0753)	0.368 **	(0.118)	3.770	(1116.9)
_cons	−0.981	(10.64)	−7.275	(6.607)	−8.152	(8.411)		
_cons	0.865 ***	(0.0327)	0.452 ***	(0.0212)	0.542 ***	(0.0328)	0.794 ***	(0.0593)
N	31,983		52,604		15,698		13,576	

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A2. Seemingly unrelated probit regression estimation results for 2012.

	North		South		EU2004		NewEU	
	National funding							
kis	0.248 ***	(0.0564)	0.478 ***	(0.0329)	0.0355	(0.0785)	−0.0297	(0.129)
lkis	−0.290 ***	(0.0638)	−0.239 ***	(0.0311)	−0.311 ***	(0.0770)	−0.640 ***	(0.113)
mht	0.473 ***	(0.0619)	0.261 ***	(0.0425)	0.175	(0.0934)	0.216	(0.135)
mlt	0.165 **	(0.0511)	0.0859 **	(0.0294)	−0.0699	(0.0642)	−0.0800	(0.0934)
micro	3.706	(8.052)	7.408	(4.284)	0.379	(7.599)	−2.443	(9.978)
small	4.093	(8.057)	7.267	(4.287)	0.371	(7.607)	−2.437	(9.996)
medium	0	(.)	0	(.)	0	(.)	0	(.)
lnturn_b	−0.465	(0.545)	0.272	(0.316)	2.261 *	(0.886)	2.225	(1.303)
lnturn_b_sq	0.0134	(0.0183)	−0.00800	(0.0106)	−0.0791 **	(0.0302)	−0.0799	(0.0458)
gp	−0.309 ***	(0.0330)	0.00743	(0.0270)	−0.0558	(0.0619)	−0.313 **	(0.117)
inngood	0.695 ***	(0.0294)	0.469 ***	(0.0223)	0.544 ***	(0.0441)	0.643 ***	(0.0626)
innserv	0.255 ***	(0.0325)	0.288 ***	(0.0238)	0.319 ***	(0.0480)	0.242 **	(0.0785)
innpro	0.448 ***	(0.0284)	0.531 ***	(0.0213)	0.657 ***	(0.0442)	0.777 ***	(0.0639)
innorg	0.164 ***	(0.0279)	0.114 ***	(0.0206)	−0.0291	(0.0420)	0.0331	(0.0623)
exp	1.112	(4.628)	−0.958	(2.740)	9.982	(6.382)	9.774	(8.835)
medium_kis	−0.0895	(0.0710)	−0.223 ***	(0.0482)	−0.0820	(0.100)	−0.113	(0.153)
medium_mht	−0.0804	(0.0738)	0.0513	(0.0605)	−0.176	(0.107)	−0.341 *	(0.151)
medium_lnturn	0.550	(1.006)	0.908	(0.543)	−0.0880	(1.000)	−0.427	(1.384)
medium_lnturnsq	−0.0178	(0.0314)	−0.0285	(0.0172)	0.00768	(0.0329)	0.0174	(0.0479)
medium_gp	−0.0749	(0.0613)	−0.0355	(0.0433)	−0.135	(0.0861)	0.247	(0.144)
medium_inn	0.137	(0.0776)	0.235 ***	(0.0454)	0.353 ***	(0.101)	0.323 **	(0.110)
medium_exp	0.0900	(0.0899)	−0.0323	(0.0534)	−0.181	(0.119)	0.0166	(0.135)
lnturn_exp	−0.0654	(0.614)	0.124	(0.362)	−1.439	(0.857)	−1.357	(1.219)
lnturnsq_exp	0.0000148	(0.0203)	−0.00340	(0.0119)	0.0507	(0.0287)	0.0473	(0.0419)
inn_exp	0.347 ***	(0.0542)	0.319 ***	(0.0359)	0.611 ***	(0.0819)	0.217 *	(0.103)
_cons	−2.296	(8.468)	−11.53 **	(4.300)	−18.66 *	(8.060)	−15.29	(9.582)

Table A2. *Cont.*

	North		South		EU2004		NewEU	
	EU funding							
kis	0.271 ***	(0.0770)	0.405 ***	(0.0592)	0.142	(0.0745)	0.0267	(0.150)
lkis	−0.428 ***	(0.0978)	−0.174 **	(0.0583)	−0.349 ***	(0.0750)	−0.476 ***	(0.135)
mht	0.252 **	(0.0854)	0.114	(0.0743)	0.0653	(0.0916)	0.306 *	(0.154)
mlt	0.0569	(0.0708)	−0.0420	(0.0535)	−0.147 *	(0.0620)	0.172	(0.111)
micro	4.730	(10.39)	10.70	(7.060)	15.47 *	(7.735)	9.536	(11.72)
small	4.840	(10.40)	10.58	(7.067)	15.77 *	(7.742)	9.877	(11.73)
medium	0	(.)	0	(.)	0	(.)	0	(.)
lnturn_b	−1.666 *	(0.741)	−0.817	(0.593)	2.004 *	(0.915)	0.642	(1.435)
lnturn_b_sq	0.0552 *	(0.0248)	0.0293	(0.0198)	−0.0731 *	(0.0314)	−0.0273	(0.0509)
gp	−0.167 ***	(0.0452)	−0.0195	(0.0476)	−0.204 **	(0.0624)	−0.258 *	(0.126)
inngood	0.473 ***	(0.0400)	0.369 ***	(0.0356)	0.482 ***	(0.0430)	0.437 ***	(0.0674)
innserv	0.196 ***	(0.0429)	0.221 ***	(0.0369)	0.228 ***	(0.0471)	0.332 ***	(0.0838)
innpro	0.406 ***	(0.0390)	0.542 ***	(0.0375)	0.703 ***	(0.0428)	0.774 ***	(0.0692)
innorg	0.108 **	(0.0382)	0.180 ***	(0.0352)	−0.0268	(0.0409)	−0.135 *	(0.0675)
exp	−9.156	(6.302)	−4.741	(4.765)	8.431	(6.509)	−5.907	(9.557)
medium_kis	−0.0836	(0.0939)	−0.162 *	(0.0759)	−0.141	(0.0947)	0.142	(0.165)
medium_mht	−0.0642	(0.100)	−0.104	(0.0979)	−0.134	(0.105)	−0.00217	(0.159)
medium_lnturn	0.715	(1.301)	1.452	(0.901)	1.938	(1.023)	1.191	(1.636)
medium_lnturnsq	−0.0258	(0.0407)	−0.0488	(0.0287)	−0.0583	(0.0338)	−0.0354	(0.0570)
medium_gp	−0.120	(0.0824)	−0.0693	(0.0712)	−0.0447	(0.0849)	0.104	(0.157)
medium_inn	0.240 *	(0.122)	0.0923	(0.0849)	0.502 ***	(0.0953)	0.235 *	(0.116)
medium_exp	0.0743	(0.125)	0.103	(0.0907)	−0.213	(0.117)	0.0504	(0.147)
lnturn_exp	1.281	(0.836)	0.787	(0.629)	−1.198	(0.880)	0.852	(1.324)
lnturnsq_exp	−0.0435	(0.0277)	−0.0298	(0.0207)	0.0422	(0.0296)	−0.0306	(0.0457)
inn_exp	0.229 **	(0.0789)	0.112	(0.0680)	0.608 ***	(0.0761)	0.377 ***	(0.110)
_cons	5.048	(11.07)	−7.867	(7.027)	−31.56 ***	(8.333)	−15.98	(10.49)
_cons	0.873 ***	(0.0289)	0.522 ***	(0.0217)	0.501 ***	(0.0282)	0.693 ***	(0.0452)
N	26,823		45,475		16,294		14,994	

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A3. National funding only vs. No funding: Verification of balancing, common support included.

	North						South						EU2004						NewEU					
	2008			2012			2008			2012			2008			2012			2008			2012		
	Treated = 1539			Treated = 1874			Treated = 5988			Treated = 4372			Treated = 623			Treated = 576			Treated = 183			Treated = 290		
	T[a]	C[b]	p[c]	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p
kis	0.3	0.3	1	0.29	0.29	1	0.2	0.2	1	0.25	0.25	1	0.21	0.2	0.9	0.22	0.22	1	0.24	0.24	1	0.17	0.17	1
lkis	0.47	0.47	1	0.05	0.05	1	0.14	0.14	0.98	0.14	0.14	1	0.1	0.1	1	0.11	0.11	1	0.12	0.12	1	0.07	0.07	1
mht	0.23	0.22	0.9	0.25	0.25	0.9	0.14	0.14	1	0.17	0.17	1	0.17	0.17	1	0.19	0.19	1	0.27	0.27	1	0.17	0.17	0.9
mlt	0.34	0.34	0.9	0.35	0.35	1	0.38	0.38	1	0.3	0.3	1	0.37	0.37	0.9	0.39	0.39	1	0.31	0.31	1	0.48	0.49	0.9
micro	0.06	0.06	1	0.02	0.02	1	0.06	0.06	1	0.05	0.05	1	0.01	0.01	1	0.03	0.03	1	0.4	0.4	1	0.39	0.39	1
small	0.54	0.54	1	0.69	0.69	0.9	0.6	0.6	0.91	0.57	0.57	1	0.44	0.45	0.7	0.48	0.48	1	0.37	0.39	0.9	0.39	0.41	0.7
medium	0.4	0.4	1	0.29	0.29	0.9	0.34	0.34	0.91	0.38	0.38	1	0.55	0.53	0.7	0.49	0.49	1	0.58	0.57	0.9	0.57	0.55	0.7
lnturn_b	15.3	15.3	1	15.26	15.27	0.8	15.19	15.19	0.73	15.35	15.35	0.9	14.98	14.92	0.4	15.05	15.05	0.9	14.29	14.34	0.8	14.72	14.66	0.6
lnturn_b_sq	236.29	236.11	0.9	234.24	234.55	0.8	232.42	232.15	0.69	237.18	237.2	1	225.82	223.78	0.3	228.24	227.92	0.9	205.56	206.71	0.8	218.1	216.07	0.6
gp	0.36	0.37	0.7	0.38	0.38	0.8	0.25	0.25	0.7	0.39	0.39	0.9	0.33	0.33	1	0.4	0.41	0.7	0.24	0.24	1	0.28	0.26	0.7
inngood	0.67	0.66	0.9	0.8	0.8	0.8	0.5	0.5	0.93	0.71	0.71	0.9	0.66	0.66	0.9	0.7	0.68	0.6	0.95	0.95	1	0.85	0.85	1
innserv	0.45	0.44	0.9	0.41	0.41	0.9	0.31	0.31	0.97	0.47	0.47	0.96	0.42	0.42	1	0.41	0.4	0.8	0.52	0.51	0.9	0.32	0.32	1
innpro	0.7	0.7	1	0.58	0.57	0.9	0.7	0.7	1	0.67	0.67	1	0.79	0.79	1	0.68	0.68	0.8	0.73	0.75	0.9	0.74	0.72	0.6
innorg	0.68	0.68	1	0.58	0.58	0.9	0.56	0.56	0.87	0.61	0.61	1	0.64	0.64	0.9	0.48	0.48	1	0.79	0.8	0.8	0.64	0.61	0.5
exp	0.8	0.8	1	0.78	0.78	1	0.59	0.59	0.99	0.71	0.71	0.9	0.68	0.69	0.9	0.81	0.82	0.9	0.57	0.59	0.9	0.78	0.76	0.7

Notes: [a] denotes means of treated observations. [b] denotes means of control observations. [c] denotes p-value of two-sided t-test for difference in means.

Table A4. National and EU funding vs. No funding: Verification of balancing, common support included.

	North						South						EU2004						NewEU					
	2008			2012			2008			2012			2008			2012			2008			2012		
	Treated = 1539			Treated = 1874			Treated = 5988			Treated = 4372			Treated = 623			Treated = 576			Treated = 183			Treated = 290		
	T^a	C^b	p^c	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p
kis	0.2	0.2	1	0.4	0.4	1	0.41	0.41	1	0.4	0.4	1	0.24	0.24	1	0.25	0.25	1	0.32	0.32	1	0.29	0.29	1
lkis	0.14	0.14	1	0.02	0.02	1	0.12	0.12	1	0.11	0.11	1	0.04	0.04	1	0.04	0.04	1	0.08	0.08	1	0.02	0.02	1
mht	0.14	0.14	1	0.24	0.24	1	0.12	0.12	1	0.15	0.15	1	0.18	0.18	1	0.23	0.23	1	0.2	0.2	1	0.14	0.14	1
mlt	0.38	0.38	1	0.28	0.28	1	0.25	0.25	1	0.24	0.24	1	0.36	0.36	0.9	0.36	0.36	1	0.4	0.4	1	0.48	0.48	1
micro	0.06	0.06	1	0.01	0.01	1	0.05	0.05	1	0.05	0.05	1	0.01	0.01	1	0.02	0.02	1	0.04	0.04	1			
small	0.6	0.6	1	0.67	0.67	0.9	0.51	0.51	0.9	0.53	0.53	1	0.37	0.37	1	0.4	0.41	0.8	0.32	0.3	0.8	0.42	0.38	0.7
medium	0.34	0.34	0.9	0.32	0.31	0.9	0.44	0.44	0.9	0.41	0.41	1	0.62	0.62	1	0.58	0.57	0.8	0.64	0.66	0.8	0.58	0.62	0.7
lnturn_b	15.2	15.2	0.7	15.28	15.29	0.9	15.2	15.2	0.9	15.25	15.24	0.9	15.05	15.06	1	15.05	15.04	1	14.34	14.27	0.7	14.55	14.57	0.9
lnturn_b_sq	232.42	232.15	0.7	234.97	235.21	0.9	232.57	232.27	0.9	233.72	233.92	0.9	227.78	227.78	1	227.68	227.39	0.9	206.69	204.53	0.7	212.5	213.13	0.9
gp	0.25	0.25	0.7	0.4	0.4	0.9	0.33	0.33	1	0.38	0.38	1	0.34	0.35	0.8	0.35	0.37	0.6	0.16	0.12	0.6	0.23	0.27	0.6
inngood	0.5	0.5	0.9	0.77	0.77	1	0.55	0.55	0.9	0.77	0.77	1	0.71	0.71	1	0.74	0.74	1	0.92	0.9	0.7	0.85	0.85	1
innserv	0.31	0.31	1	0.5	0.49	0.8	0.49	0.49	1	0.59	0.59	1	0.46	0.45	0.9	0.42	0.41	0.9	0.52	0.52	1	0.4	0.4	1
innpro	0.7	0.7	1	0.63	0.62	0.9	0.7	0.7	0.9	0.77	0.77	1	0.83	0.83	1	0.71	0.71	1	0.84	0.86	0.8	0.77	0.77	1
innorg	0.56	0.56	0.9	0.62	0.62	1	0.66	0.66	1	0.76	0.76	0.9	0.63	0.63	1	0.51	0.53	0.7	0.92	0.92	1	0.48	0.5	0.8
exp	0.59	0.59	0.9	0.87	0.86	0.9	0.65	0.65	1	0.78	0.78	0.9	0.81	0.82	0.8	0.87	0.87	0.9	0.52	0.52	1	0.85	0.81	0.6

Notes: [a] denotes means of treated observations. [b] denotes means of control observations. [c] denotes p-value of two-sided t-test for difference in means.

Table A5. National and EU funding vs. National funding only: Verification of balancing, common support included.

	North						South						EU2004						NewEU					
	2008			2012			2008			2012			2008			2012			2008			2012		
	Treated = 298			Treated = 94			Treated = 465			Treated = 472			Treated = 221			Treated = 161			Treated = 47			Treated = 51		
	T[a]	C[b]	p[c]	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p	T	C	p
kis	0.3	0.31	0.9	0.4	0.4	1	0.41	0.41	1	0.4	0.4	1	0.24	0.24	1	0.25	0.26	0.8	0.28	0.26	0.8	0.29	0.27	0.8
lkis	0.05	0.05	1	0.03	0.03	1	0.12	0.12	1	0.11	0.11	1	0.04	0.04	1	0.04	0.04	0.8	0.09	0.09	1	0.02	0.02	1
mht	0.22	0.22	1	0.24	0.24	1	0.12	0.12	0.9	0.15	0.15	1	0.18	0.17	0.9	0.22	0.22	0.9	0.21	0.23	0.8	0.12	0.1	0.7
mlt	0.34	0.34	0.9	0.28	0.28	1	0.25	0.26	0.9	0.24	0.24	1	0.36	0.37	0.7	0.36	0.36	1	0.43	0.43	1	0.49	0.53	0.7
micro	0.06	0.06	1	0.01	0.01	1	0.05	0.05	1	0.05	0.05	1	0.01	0.01	1	0.02	0.02	1	0.04	0.04	1	0	0	
small	0.54	0.56	0.7	0.67	0.67	0.9	0.51	0.51	0.9	0.53	0.54	0.8	0.37	0.36	0.8	0.4	0.41	0.8	0.34	0.32	0.8	0.41	0.35	0.6
medium																								
lnturn_b	15.33	15.36	0.7	15.28	15.27	0.8	15.2	15.19	0.9	15.24	15.23	0.8	15.05	15.14	0.4	15.04	15.12	0.4	14.3	14.25	0.8	14.58	14.76	0.3
lnturn_b_sq	236.2	237.13	0.7	234.97	234.27	0.7	232.62	232.12	0.8	233.68	233.12	0.8	227.78	230.14	0.4	227.58	229.82	0.4	205.39	203.98	0.8	213.39	218.82	0.9
gp	0.36	0.35	0.8	0.4	0.39	0.7	0.33	0.32	0.9	0.38	0.37	0.7	0.34	0.33	0.8	0.35	0.34	0.8	0.17	0.15	0.8	0.24	0.24	1
inngood	0.66	0.68	0.6	0.77	0.78	0.7	0.55	0.55	0.9	0.77	0.77	0.9	0.71	0.71	1	0.74	0.74	0.8	0.91	0.94	0.7	0.84	0.9	0.4
innserv	0.45	0.45	1	0.5	0.49	0.8	0.49	0.48	0.9	0.59	0.59	0.9	0.46	0.44	0.7	0.41	0.36	0.2	0.49	0.49	1	0.39	0.33	0.5
innpro	0.7	0.7	1	0.63	0.62	0.9	0.7	0.7	0.9	0.77	0.77	1	0.83	0.84	0.8	0.71	0.7	0.9	0.83	0.87	0.5	0.76	0.8	0.6
innorg	0.68	0.66	0.7	0.62	0.63	0.7	0.66	0.67	0.8	0.76	0.77	0.8	0.63	0.64	0.7	0.51	0.49	0.6	0.91	0.94	0.7	0.47	0.57	0.3
exp	0.8	0.8	0.9	0.87	0.87	0.7	0.65	0.65	1	0.78	0.78	0.9	0.81	0.82	0.8	0.87	0.88	0.6	0.55	0.55	1	0.84	0.86	0.8

Notes: [a] denotes means of treated observations. [b] denotes means of control observations. [c] denotes p-value of two-sided t-test for difference in means.

Table A6. Rosenbaum bounds for the comparison on National funding only vs. No funding.

	North				South				EU2004				NewEU			
	2008		**2012**		**2008**		**2012**		**2008**		**2012**		**2008**		**2012**	
	n = 1341		**n = 427**		**n = 5984**		**n = 2983**		**n = 466**		**n = 291**		**n = 75**		**n = 179**	
del_rdin_turn																
Gamma	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**
1.0	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0	0	0	0
1.1	0	0	0	0	0	0	0	0	0	0	0.07	0	0	0	0	0
1.2	0	0	0	0	0	0	0	0	0	0	0.17	0	0	0	0	0
1.3	0	0	0	0	0	0	0	0	0	0	0.33	0	0	0	0	0
1.4	0	0	0	0	0	0	0	0	0	0	0.52	0	0	0	0.01	0
1.5	0	0	0.01	0	0	0	0	0	0	0	0.69	0	0	0	0.02	0
1.6	0	0	0.03	0	0	0	0	0	0.01	0	0.82	0	0.01	0	0.03	0
1.7	0	0	0.08	0	0	0	0	0	0.05	0	0.91	0	0.01	0	0.06	0
1.8	0	0	0.18	0	0	0	0	0	0.12	0	0.95	0	0.01	0	0.1	0
1.9	0.01	0	0.32	0	0	0	0	0	0.23	0	0.98	0	0.02	0	0.14	0
2.0	0.06	0	0.48	0	0	0	0	0	0.37	0	0.99	0	0.03	0	0.19	0
del_rdex_turn																
Gamma	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**	**sig+**	**sig−**
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0.85	0.85	0	0
1.1	0	0	0	0	0	0	0	0	0	0	0.01	0	0.88	0.8	0	0
1.2	0	0	0	0	0	0	0	0	0	0	0.02	0	0.91	0.75	0	0
1.3	0	0	0	0	0	0	0	0	0	0	0.04	0	0.93	0.7	0	0
1.4	0	0	0	0	0	0	0	0	0	0	0.08	0	0.95	0.66	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0.13	0	0.96	0.61	0	0
1.6	0	0	0	0	0	0	0	0	0.01	0	0.2	0	0.97	0.56	0	0
1.7	0	0	0	0	0	0	0	0	0.02	0	0.29	0	0.98	0.52	0.01	0
1.8	0.01	0	0	0	0	0	0	0	0.04	0	0.38	0	0.98	0.48	0.01	0
1.9	0.03	0	0	0	0	0	0	0	0.08	0	0.48	0	0.99	0.44	0.02	0
2.0	0.11	0	0	0	0	0	0	0	0.13	0	0.57	0	0.99	0.4	0.03	0

Table A7. Rosenbaum bounds for the comparison on National and EU funding vs. No funding.

	North				South				EU2004				NewEU			
	2008		2012		2008		2012		2008		2012		2008		2012	
	n = 299		n = 94		n = 463		n = 472		n = 221		n = 161		n = 50		n = 52	
						del_rdin_turn										
Gamma	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−
1.0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0.8	0.15	0.15
1.1	0	0	0	0	0	0	0	0	0	0	0	0	0.72	0.87	0.21	0.10
1.2	0	0	0	0	0	0	0	0	0	0	0	0	0.64	0.91	0.26	0.07
1.3	0	0	0	0	0	0	0	0	0	0	0	0	0.56	0.94	0.33	0.05
1.4	0	0	0	0	0	0	0	0	0	0	0	0	0.48	0.96	0.39	0.03
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0.41	0.98	0.45	0.02
1.6	0	0	0	0	0	0	0	0	0	0	0	0	0.34	0.98	0.50	0.02
1.7	0	0	0	0	0	0	0	0	0	0	0	0	0.29	0.99	0.56	0.01
1.8	0	0	0	0	0	0	0	0	0	0	0	0	0.24	0.99	0.61	0.01
1.9	0	0	0	0	0	0	0	0	0	0	0.01	0	0.19	1	0.65	0
2.0	0	0	0.01	0	0	0	0	0	0	0	0.02	0	0.16	1	0.69	0
						del_rdex_turn										
Gamma	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−
1.0	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0.01	0.01	0.49	0.49
1.1	0	0	0	0	0	0	0	0	0	0	0.05	0.01	0.01	0	0.55	0.43
1.2	0	0	0	0	0	0	0	0	0	0	0.09	0	0.01	0	0.61	0.38
1.3	0	0	0	0	0	0	0	0	0	0	0.16	0	0.02	0	0.66	0.33
1.4	0	0	0	0	0	0	0	0	0	0	0.23	0	0.02	0	0.7	0.29
1.5	0	0	0	0	0	0	0	0	0	0	0.32	0	0.02	0	0.73	0.25
1.6	0	0	0	0	0	0	0	0	0.01	0	0.41	0	0.03	0	0.77	0.22
1.7	0	0	0.01	0	0	0	0	0	0.02	0	0.50	0	0.03	0	0.80	0.19
1.8	0	0	0.01	0	0	0	0	0	0.04	0	0.58	0	0.03	0	0.82	0.17
1.9	0	0	0.02	0	0	0	0	0	0.06	0	0.66	0	0.04	0	0.84	0.15
2.0	0	0	0.03	0	0	0	0	0	0.09	0	0.73	0	0.04	0	0.86	0.13

Table A8. Rosenbaum bounds for the comparison on National and EU funding vs. National funding only.

	North				South				EU2004				NewEU			
	2008		**2012**		**2008**		**2012**		**2008**		**2012**		**2008**		**2012**	
	n = 298		n = 94		n = 465		n = 472		n = 221		n = 161		n = 47		n = 51	
							del_rdin_turn									
Gamma	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−
1.0	0	0	0.07	0.07	0	0	0	0	0	0	0.01	0.01	0.33	0.33	0.01	0.01
1.1	0	0	0.15	0.04	0	0	0	0	0.01	0	0.02	0	0.23	0.43	0	0.02
1.2	0.01	0	0.25	0.01	0	0	0.01	0	0.04	0	0.06	0	0.16	0.53	0	0.03
1.3	0.05	0	0.37	0.01	0	0	0.06	0	0.11	0	0.12	0	0.11	0.62	0	0.04
1.4	0.14	0	0.49	0	0	0	0.19	0	0.22	0	0.22	0	0.07	0.70	0	0.06
1.5	0.28	0	0.60	0	0	0	0.40	0	0.36	0	0.34	0	0.05	0.77	0	0.09
1.6	0.46	0	0.70	0	0	0	0.63	0	0.52	0	0.47	0	0.03	0.82	0	0.12
1.7	0.63	0	0.78	0	0.01	0	0.81	0	0.66	0	0.59	0	0.02	0.87	0	0.15
1.8	0.77	0	0.85	0	0.04	0	0.92	0	0.78	0	0.70	0	0.01	0.90	0	0.19
1.9	0.87	0	0.89	0	0.09	0	0.97	0	0.86	0	0.79	0	0.01	0.92	0	0.23
2.0	0.94	0	0.93	0	0.20	0	0.99	0	0.92	0	0.86	0	0.01	0.94	0	0.27
							del_rdex_turn									
Gamma	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−	sig+	sig−
1.0	0.07	0.07	0.08	0.08	0	0	0	0	0.02	0.01	0.39	0.39	0.21	0.21	0.11	0.11
1.1	0.21	0.02	0.15	0.04	0.01	0	0.01	0	0.06	0	0.55	0.24	0.25	0.17	0.09	0.14
1.2	0.41	0	0.24	0.01	0.04	0	0.07	0	0.13	0	0.69	0.14	0.30	0.14	0.07	0.18
1.3	0.63	0	0.34	0.01	0.13	0	0.20	0	0.24	0	0.80	0.08	0.34	0.11	0.05	0.21
1.4	0.80	0	0.45	0	0.29	0	0.41	0	0.37	0	0.88	0.04	0.39	0.09	0.04	0.24
1.5	0.90	0	0.55	0	0.50	0	0.63	0	0.51	0	0.93	0.02	0.43	0.07	0.03	0.28
1.6	0.96	0	0.65	0	0.69	0	0.81	0	0.65	0	0.96	0.01	0.47	0.06	0.2	0.31
1.7	0.98	0	0.73	0	0.84	0	0.92	0	0.76	0	0.98	0	0.50	0.05	0.02	0.34
1.8	0.99	0	0.79	0	0.93	0	0.97	0	0.84	0	0.99	0	0.54	0.04	0.01	0.37
1.9	1	0	0.85	0	0.97	0	0.99	0	0.90	0	0.99	0	0.57	0.03	0.01	0.40
2.0	1	0	0.89	0	0.99	0	1	0	0.94	0	1	0	0.60	0.02	0.01	0.43

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