ECONOMIC ANNALS, Volume LXVI, No. 228 / January – March 2021
UDC: 3.33 ISSN: 0013-3264

https://doi.org/10.2298/EKA2128007C

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THE EFFECTS OF EU R&I FUNDING ON SME INNOVATION AND BUSINESS PERFORMANCE IN NEW EU MEMBER STATES: FIRM-LEVEL EVIDENCE

ABSTRACT: *SMEs are the most dynamic and vibrant part of the enterprise sector in terms of start-ups and new jobs, and a significant share of the EU's total innovation activities take place within them. This paper uses the Community Innovation Survey (CIS) 2014 and eCORDA data to analyse whether SME participation in EU research and innovation (R&I) funding programmes has increased their innovation activities and business performance. To achieve this, we empirically test whether SMEs that received EU funds recorded an improvement in their innovation and economic performance. This is measured by research and development (R&D) expenditure, product innovation, turnover, and employment. The paper focusses particularly on new EU member countries and among them to those from Central and Eastern Europe (CEE). It explores the theoretical and methodological backgrounds that guided us in these analyses and performs treatment effect analysis at firm level, using CIS CD-ROM data that we received on request from Eurostat. The obtained results indicate that EU R&I funding is beneficial to the innovation activities of SME recipients, and to their overall business performance. It also assists new EU member states in the process of 'catching up' to the growth levels of more established EU economies.*

KEY WORDS: *SMEs, innovation, R&D, EU R&I funding*

JEL CLASSIFICATION: O31, O32, O38, O52

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1. INTRODUCTION

Small and medium-sized enterprises (SMEs) play an important role in the research and innovation value chain in the European Union (EU), as they are important innovation creators and knowledge spillover conduits. This is especially true of those that are fast growing or have a high growth potential. SMEs have been included in collaborative projects at the EU level that provided them with valuable financial assistance to stimulate their research, innovation, and creativity. EU policy aims to achieve more involvement from SMEs as recipients of European Union Research and Innovation (EU R&I) funding within the Horizon 2020 programme. This is justified by the need to surmount the previous fragmentation of funding programmes, and by the quest to create an integrated EU finance programme directed specifically at SME innovation growth needs. The purpose of increasing the availability of EU funding through Horizon 2020 is to limit market failure in SMEs' access to finance, especially in the early and risky stages of the innovation process. This facilitates the implementation of the EU2020 Strategy (European Commission, 2010a) and its flagship initiative Innovation Union (European Commission, 2010b).

Analyses and studies to date have identified a controversy that centres on identifying the net effects of national public and EU R&D funding on firm-level innovation.[1] This relates especially to the 'additionality' that such funding brings to the productivity and employment growth of an enterprise, particularly an SME (see, e.g., Radicic & Pugh, 2017; Radas et al., 2020). Because of data limitations, it is challenging to quantify this additionality in a methodologically convincing way, and to determine the causality of its impact. The net effects of public funding on innovation performance depend on a multitude of factors at firm level (age, size, labour skills) and characterise the technological level of specific industries (low-tech vs. high-tech industries). The specificities of national innovation systems also play an important role in determining the impact and effectiveness of innovation support measures, including public funding schemes. The latter is especially true in new EU member states (Stojčić et al., 2020). Although they often

1 We distinguish between R&I (research and innovation) and R&D (research and development). Prior to Horizon 2020, which extended finance to innovative activities, the term R&D was commonly used, whereas afterwards the term R&I became more standard. In this paper we refer mainly to EU R&I funding and to R&D expenditure and investment by businesses.

identify positive impacts, empirical studies to date have not reached a conclusive answer on this issue, particularly when it comes to determining the causality of impacts (see Zuniga-Vincente et al., 2014; Čučković & Vučković, 2018).

For these reasons, it is worth exploring different approaches to measuring the innovation impacts of EU R&I funding, at both firm and aggregate macroeconomic levels. The investigation of innovation impacts is pertinent to EU policy and decision-making, and essential to a proper evidence-based assessment of the EU2020 Strategy and its flagship initiative, Innovation Union.

This paper has two objectives. The first is to analyse whether SMEs' participation in EU R&I funded projects results in an increase in their innovation activities, performance, and R&D investments based on CIS 2014 data (received from Eurostat on CD-ROM). To do this, we perform a firm-level treatment-effect analysis in which innovation and economic performance specifications are considered as outcome variables. The countries analysed are those encompassed by CIS: Bulgaria, Cyprus, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, and Slovakia. In addition, we divide firms into the categories of high and medium-high technology manufacturing SMEs, and knowledge intensive services (KIS) SMEs

Since the CIS 2014 data mostly provide information on the use of EU funds prior to the current Horizon 2020 programme, the second objective is to analyse in more detail the effect that SME participation in Horizon 2020 has had on SMEs' economic performance (measured by turnover and employment). This analysis is based on data obtained on request from eCORDA and the European Commission Directorate General for Research and Innovation.

This text aims to contribute to current discussions within the field of innovation by further exploring how EU R&I funding policies under Horizon 2020 work in practice, and their impact on SMEs as important innovation actors and knowledge spillover conduits. We specifically want to test if improved access to and use of EU innovation funding has had a beneficial impact on the innovation performance of SMEs in new EU member states, in which those from Central and Eastern Europe (CEE) prevail in the CIS dataset. We are particularly interested in ascertaining how SMEs respond to EU R&I funding, and how it affects their consequent R&D and innovation investment decisions and business performance.

The analysis therefore attempts to answer two research questions (RQs):

RQ1: Does an SME's increased participation in EU R&I funding result in an increase in its product and process innovation activities?

RQ2: What are the business performance effects of such innovation funding (measured by turnover and employment)?

The specific research contribution of this paper is its analyses of the innovation impacts of EU R&I funding based on CIS 2014 survey data (received from Eurostat on CD-ROM), which are not publicly available. To do this, we utilise Propensity Score Matching (PSM), a method that estimates the effects of EU funds against the counterfactual. The paper's secondary contribution is its econometric analysis of Horizon 2020's impacts on SME innovation from 2014 to 2017, which is based on more aggregate data obtained on request from eCORDA and the European Commission Directorate General for Research and Innovation.

The paper is structured as follows. Following the introduction, in Section 2 we explore the theoretical and methodological backgrounds that guided us in our analyses, and assess the effects of EU funds on selected indicators of SME performance. This is based on a sample of 43,246 firms, of which 4.3% of SMEs received EU funds. Section 3 provides an overview of Horizon 2020 support provided to SMEs for R&I from 2014 to 2017. Section 4 reviews major issues determining the innovation performance of new EU member states from Central and Eastern Europe. In Section 5 we use panel data analysis to explore the specific effects of Horizon 2020 funding on SME innovation and business performance in EU member states, and explain their policy implications. The final section draws conclusions from the research, explains its limitations, and identifies areas for further study.

2. ASSESSMENT OF THE IMPACT OF INCREASED EU R&I FUNDING ON SMES' INNOVATION AND ECONOMIC PERFORMANCE

2.1. Literature review and methodological background

The positive impact of R&D on economic growth and productivity has been confirmed by a number of theoretical and empirical studies (see Hall, 2011; Mohnen & Hall, 2013; Grossman & Helpman, 1994; Aghion & Howitt, 1997; Howitt, 2004; Cameron et al., 2005; Kafouros, 2005; Coe et al., 2009; O'Mahony & Vecchi, 2009; Bravo-Ortega & Marin, 2011). An overview of empirical studies (see Peters et al., 2014) shows that firms that invest in R&D usually experience an increase in productivity. The relation between innovation and productivity can be direct (a positive relation between innovation expenditure and product and process innovation output, and from innovation output to productivity [Peters et al., 2014; Hall 2011]) or indirect (due to knowledge spillovers [see, e.g., Hall et al. 2010]). Because of market failures, however, access to finance is the largest obstacle to innovation that SMEs face, and it has a bigger impact on them than on larger firms. To resolve this problem, support measures for innovation and R&D activities is available from different institutional sources. Evidence of the impact of such support measures is plentiful, but it is diverse for several reasons, including methodology, sample size, and the specific type of innovation support source (national or EU).

The first methodological issue relates to innovation measurement: How should we measure the variables that make up innovation performance (product and process innovation) and productivity in SMEs to create a key economic performance indicator? The literature proposes different indicators, each with advantages and disadvantages. Most empirical studies use one of two ways to measure innovation: input indicators, such as R&D employees or expenditures, or output indicators, such as patents, new products and services, successfully introduced processes, and increases in sales, exports, profits, or efficiency (Mohnen & Hall, 2013). In practice, it has been shown that input and output measures are highly correlated (Becker, 2015). In this paper, we use the Community Innovation Survey's (CIS) definitions for different types of innovation, since it is our main data source. First, a product innovation is defined as the introduction of a product or service that has new or significantly improved characteristics or uses. This includes important augmentations to technical specifications, components and materials, incorporated software, user friendliness, or other functional characteristics. Second, process innovation is defined as the implementation of a new or significantly improved production or delivery method, and includes changes to techniques, equipment, and/or software. The empirical literature proves that these two types of innovation have distinct impacts on economic performance: generally positive for product innovation, and small or negative for process innovation (see Hall, 2011; Peters et al., 2014; Damijan et al., 2014). The former can be measured by sales of new products, but if this data is unavailable it can be captured by dummy variables (taking the value of 1 if the firm introduced an innovation, and 0 otherwise). In addition, a distinction can be made between 'new to the firm' and 'new to the market': Is the product novel for one firm but already on the market, or is it a product or process that did not exist before? Although measuring productivity is a challenge, in this research we will use productivity proxied by the firms' turnover. Another issue is the selection of a sample and of an appropriate model for the analysis. In the literature, authors use different models to estimate the effect of public support on aspects of economic and innovation performance at all levels (firm, sectoral, and aggregate), such as SEM, ALS, GMM, sequential IV, the panel VAR approach, and counterfactual analysis.

Because of the methodological challenges described, results in the literature are mixed, especially for different types of innovation (for a survey overview see, e.g., Aerts & Czarnitzki, 2004; Czarniki & Delanote, 2015; Catozzella & Vivarelli, 2011; Czarnitzki & Lopes Bento, 2013; Becker, 2015; Radas et al., 2020; Stojčić et al., 2020; Grabowski & Staszewska-Bystrova, 2020). For example, Grabowski and Staszewska-Bystrova (2020) investigate the impact of public support for innovation activities on propensities to introduce product, process, and organisational and marketing innovations in European SMEs, based on CIS 2014 data. Their results show that the EU New Member States (NMS) invest mainly in the acquisition of machinery, equipment, software, buildings, knowledge, and training, while the old EU countries invested in R&D and innovation. They point out that EU funds are more beneficial to manufacturing, while national and local support is more effective in the service sector. Radas, Mervar and Škrinjarić (2020) also perform SME-level analysis, using data from CIS 2008 and CIS 2012, and find that national and EU public funds lead to smaller additionality in less developed EU countries, while crowding-out was observed in the newest EU member states. Radicic and Pugh (2017) use a sample of SMEs from EU28 to evaluate the input and output additionality of national and EU R&D funds. Their analysis shows diverse results. While for innovation inputs they find positive treatment effects from both national and EU R&D funds, the results for innovation outputs show no evidence of additionality from national programmes, and cannot reject crowding-out from EU ones. We can thus confirm the European paradox for SMEs: EU support promotes innovation inputs but not innovation outputs. Czarnitzki and Delanote (2015) evaluate the impact of direct R&D subsidies on several R&D input measures, and on patents as an R&D output measure. The authors estimate the difference between the observed R&D of subsidised firms and the counterfactual situation, in which these firms would not have been subsidised. Their results support the prevailing policy position: to give preferential treatment to small, young, and independent firms active in high-tech sectors. They also show that previous estimations of innovation policy impacts may have been misleading, as they do not distinguish between preferential firm profiles in policy schemes.

As shown in the literature review, counterfactual analysis is the most frequently used methodological approach in recent studies. This method compares two groups of firms: the treatment group, whose firms have benefited from a specific programme, and the control or comparison group, which is similar in all aspects to the treatment group, except the firms within it have not been exposed to the programme in question. The control group shows what would have happened to treatment group members if they had not been exposed to the programme (European Commission, Centre for Research on Impact Evaluation). Without information on the counterfactual, the next best alternative is to compare the outcomes of treated individuals with those in an untreated comparison group. To do this, the comparison group must be as similar as possible to the treated group, so that the latter would have had outcomes similar to those of the former if the treatment had not been applied (World Bank, 2010). In the next sub-section we will explain the methods used in this paper (Propensity Score Matching [PSM] and Average Treatment Effect [ATE]), the data used, and the results obtained.

2.2. Model specification, data, and results

Theoretically, an ideal model would compare outcomes for SMEs that received EU funds with outcomes for the same group if they had not received those funds. In practice, however, once SMEs have received funds it is impossible to observe what would have happened if they had applied for the funding but did not receive it. Thus, based on previous research, we approximated the effects of EU funds by comparing the outcomes of SMEs that received the funds (treatment group) with the outcomes of similar SMEs that did not (comparison group). Researchers generally use one of two approaches to define the counterfactual of a treated group (see World Bank, 2010): either they create a comparator group through statistical design, or they modify the targeting strategy of the programme to remove differences that would have existed between the treated and non-treated groups before comparing outcomes across them. The latter approach is used in this paper, and we used Propensity Score Matching to estimate the effects of EU funds against the counterfactual. As previously stated, the goal is to estimate the effect of the EU funds on treated SMEs, taking into account what would have happened if they had not received them. We can thus estimate the difference between defined outcomes for firms that received funds and for those that did not: i.e., the average treatment on the treated (ATT) effect. The propensity score is a number that depicts the conditional probability of being assigned or not assigned to a particular treatment. Different approaches can be used to match participants and nonparticipants on this basis, including nearest neighbour (NN), caliper and radius, stratification and interval, kernel, and local linear matching (LLM) (see World Bank, 2010). In this paper we use the NN method, which is the most common form of matching in statistics literature. In this method each treated unit is matched to the untreated unit with the nearest propensity score. Once each treated unit is matched with an untreated unit, the difference between the outcomes of the treated and untreated matched units can be computed. The average treatment effect on the treated (ATET) is then obtained by averaging these differences. For the estimation we use Stata's built-in 'teffects' command, which is flexibile in terms of estimators and functional forms for outcome and treatment-assignment models (StataCorp, 2013).

The data used for the first part of the analysis were obtained from the Community Innovation Survey (CIS) 2014, received from Eurostat on CD-ROM. Their focus is on small and medium enterprises (SMEs) as defined by the European Commission: a) a medium-sized company has a staff headcount <250, turnover ≤ € 50 m or balance sheet total≤ € 43 m; b) a small company has a staff headcount <50, turnover ≤ € 10 m or balance sheet total ≤ € 10 m; and c) a micro company has a staff headcount <10, turnover ≤ € 2 m or balance sheet total ≤ € 2 m. The geographical focus includes firms in 10 new EU member states: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania, and Slovakia.

The sample consists of 43,246 SMEs, 4.3% of which received EU funds. The first cluster includes SMEs from all sectors, but we also performed analysis specifically for the high and medium-high manufacturing sectors, and the knowledge intensive services (KIS) sector (filtered according to Nace Rev.2 classification). In addition, we compared the efficiency of EU funds with those received from central government.

We performed treatment effects analysis from observational data using nearest neighbour (NN) matching. The variables chosen to estimate a propensity score should relate to outcomes as well as to participation decision, and should be based on economic theory and previous empirical findings (Caliendo & Kopeinig, 2005). Consequently, our analysis uses the variables of treatment, outcome, and control/explanatory, explained in Table 1.

The results show that SMEs in all sectors that obtained EU funds recorded better results in product and process innovation, innovation expenditures, and share of turnover from product innovations that were new to the market. Further, EU funds proved to be more efficient than national funds, although the latter had a positive impact on SME innovation performance, except in the category of process innovation where the estimated coefficient is not statistically significant. If we analyse two sectors – high and medium-high manufacturing and KIS – we can see the contrasting impact of public funding on innovation indicators. Although in the former sector public funding has a larger impact on innovation inputs than it does on output (the positive effect of EU funds on turnover from innovation is not statistically significant), the opposite is true for KIS (the impact of EU funds on process innovation is negative, and not statistically significant). Finally, in all cases, EU funds prove more efficient than national funds.

Table 1: Variables used in the analysis

	TREATMENT VARIABLES
fund_eu	1=firm received EU funds; 0=otherwise
fund_gmt	1=firm received central government funds; 0=otherwise
	OUTCOME VARIABLES
inn_process	1=firm introduced a new or significantly improved method of production; logistic, delivery, or distribution system; and/or supporting activities; 0=otherwise
inn_newmkt	1=firm introduced a product new to the market; 0=otherwise
inn_exp	total expenditure on innovation activities in 2014 (ratio/turnover), in log
turn_mkt	% of turnover from product innovations new to the market
	EXPLANATORY (CONTROL) VARIABLES
gp	1= firm is part of an enterprise group; 0=otherwise
co	1= firm has reported cooperation arrangements on innovation activities; 0=otherwise
mareur	1=firm is present in EU/EFTA/CC market; 0=otherwise
empud	1=more than 50% of employees have a tertiary education, 0=otherwise
marloc	1=firm present in local/regional market (within country); 0=otherwise
marnat	1=firm present in national market (other regions of country); 0=otherwise
maroth	1= firm present in all other countries; 0=otherwise
pub_proc	1= firm has procurement contracts for domestic and/or foreign public sector organisations; 0=otherwise

Source: Authors' compilation based on CIS 2014 CD-ROM data.

The results are presented in Table 2.

Table 2: Average Treatment Effects on the Treated (ATET)

OUTPUT	All sectors		High and Medium-High Manufacturing		Knowledge-Intensive Services (KIS)	
	EU funds (1 vs. 0)	Central government funds (1 vs. 0)	EU funds (1 vs. 0)	Central government funds (1 vs. 0)	EU funds (1 vs. 0)	Central government funds (1 vs. 0)
inn_process	0.045*	0.018	0.114*	0.052**	-0.087	-0.045
	(0.013)	(0.014)	(0.024)	(0.025)	(0.039)	(0.040)
inn_newmkt	0.085*	0.064*	0.086*	0.065**	0.161*	0.169*
	(0.017)	(0.018)	(0.029)	(0.031)	(0.046)	(0.045)
inn_exp	1.894*	1.768*	1.239*	0.951*	3.171*	3.221*
	(0.172)	(0.172)	(0.207)	(0.206)	(0.596)	(0.594)
turn_mkt	0.035*	0.031*	0.017	0.019	0.070*	0.059**
	(0.007)	(0.008)	(0.013)	(0.014)	(0.024)	(0.025)

Note: Standard errors in parentheses: * P < 0.01, **P < 0.05, *** P < 0.10

Source: Authors' calculation using CIS 2014 CD-ROM data.

The results for these two groups should, however, be read with caution, since the Rosenbaum test shows that they are sensitive to possible deviations from the identifying unconfoundedness assumption (for details see Becker & Caliendo, 2007). The Rosenbaum bounds approach uses the sensitivity parameter gamma (Γ) to test which magnitude of the hidden bias would render the test statistics of the study inference insignificant. A larger Γ magnitude implies a greater robustness of outcome. This is in line with findings in the literature (Caliendo & Kopeinig, 2005; Radas et al., 2020; Stojčić et al., 2020). Analysing each source of funding separately, sensitivity analysis suggests that in the case of EU funding, the models that are sensitive to selection bias are those with the outcome variables 'process' and 'product innovation' – however, at rather high values of gamma, and this holds only for two analysed sub-sectors. In the case of national funding, the models that are sensitive to selection bias are those with the outcome variables 'process' and 'product innovation', for all analysed sectors. Also, in the case of national funding, models are sensitive to unobserved heterogeneity at lower values of gamma. A summary of the Rosenbaum bounds approach is presented in Tables 3a and 3b.[2]

Table 3a: Sensitivity analysis by Rosenbaum bounds approach: hidden bias at 5% (overestimation) for EU funding (yes/no)

	All sectors	High and Medium-High Manufacturing Sectors	KIBS
inn_process	no	yes, when $\Gamma \geq 1.70$	no
inn_newmkt	no	yes, when $\Gamma \geq 1.20$	yes, when $\Gamma \geq 1.50$
inn_exp	no	no	no
turn_mkt	no	no	no

Source: Own calculation.

2 The detailed results of the Rosenbaum bounds tests are available from the authors upon of request.

Table 3b: Sensitivity analysis by Rosenbaum bounds approach: hidden bias at 5% (overestimation) for national funding (yes/no)

	All sectors	High and Medium-High Manufacturing Sectors	KIBS
inn_process	yes, when Γ ≥1.30	yes, when Γ ≥1.30	yes, when Γ ≥1; at Γ≥1.20 changes sign
inn_newmkt	yes, when Γ ≥1.10	yes, when Γ ≥1.10	yes, when Γ ≥1.60
inn_exp	no	no	no
turn_mkt	no	no	no

Source: Own calculation.

The sensitivity of our results was also tested with inverse probability weighted regression adjustment (IPWRA), which is seen as doubly robust (as in Stojčić et al., 2020). All tests can be found in the Appendix (Tables A1–A3). We also tested the overlap of the propensity score between treated and non-treated firms after matching (Figure A1. in the Appendix).

The performed analysis of the impact of EU funds confirms the positive effect of these funds on the innovation and economic performance of SMEs, based on CIS 2014 data. Because the CIS 2014 database covers the period prior to the Horizon 2020 programme, our paper is unique in its discussion of the effects of Horizon 2020 on SME turnover and employment.

3. HORIZON 2020 FUNDING FOR RESEARCH AND INNOVATION IN SMALL AND MEDIUM-SIZED ENTERPRISES

In this section, our analysis focuses on revealing how much of the available support SMEs used during Horizon 2020's implementation. The target was at least 20%. For comparison, the average participation of SMEs in the Seventh Framework Programme (FP7) budget was approximately 15%. The visible and measurable impact of funding in terms of 'additionality' (i.e., European added value [EAV]) and its effect on economic performance (see European Commission, PPMI study, 2017a) are discussed in Section 4 of this paper.

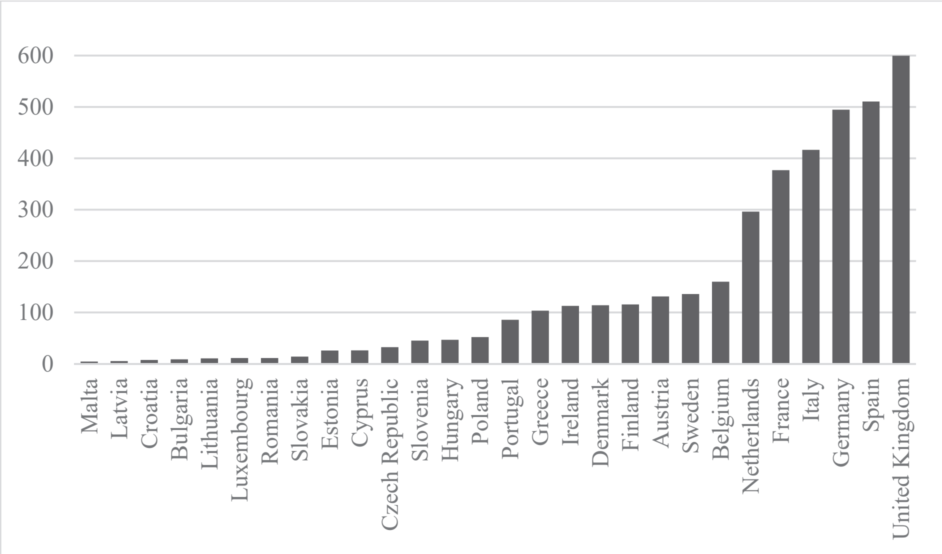
The Horizon 2020 programme is known to have brought an integrated and simplified approach to financing the R&I needs of SMEs. It was specifically designed to "develop, grow and internationalise highly innovative SMEs, regardless of whether they are high-tech or research-driven, or social or service companies whose innovations are not based on research" (European Commission, 2015). The rationale behind Horizon 2020 was to enable increased SME participation in EU R&I programmes in order to enhance innovation activities in the EU through improved access to finance.

According to Horizon 2020, data collected for the first three years (2014–2016) show increased levels of participation and overall satisfactory progress in specific SME participation across the programme.

The Interim Evaluation Report (European Commission, Annex 1, 2017b) shows that by January 2017, SMEs accounted for almost 24% of the value of approved grants from Horizon 2020's dedicated budget (approximately EUR 3.5 billion). These funds were allocated through the 'Societal Challenges' and 'Leadership in Enabling Industrial Technologies (LEIT)' programmes. This indicates that the policy plan for increased SME participation in funding through approved grants (with a target of 20%) was fulfilled in the first half of Horizon 2020's implementation. SME participation in the total number of supported projects was even higher, at almost 27%. It is envisaged that a total of EUR 6 billion from this combined budget will have been invested in Europe's most innovative SMEs by the end of 2020 by means of collaborative consortia grants, while an additional EUR 3 billion will be invested through the dedicated SME Instrument (SMEI).

According to eCORDA data from June 2017, total Horizon 2020 allocations to SME recipients in 2014–2017 amounted to approximately EUR 4 billion for collaborative and single beneficiary projects granted through the combined LEIT and Societal Challenges budgets (see Figure 1).

Figure 1: Total Horizon 2020 Budget Allocation for SMEs, 2014–2017, by EU member country (in EUR billion)

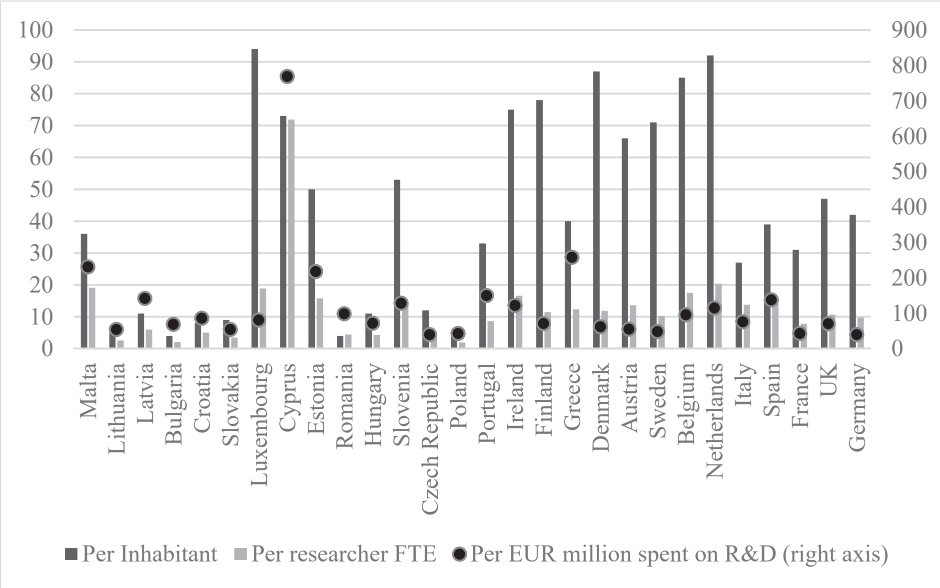


Source: eCORDA self-reported data by SME project beneficiaries, cut-off date June 2017. Obtained by request from the European Commission's Directorate General for Research and Innovation (DG R&I).

As Figure 1 shows, Croatia, Latvia, and Malta are among the lowest performing countries in terms of absorbing available Horizon 2020 SME funds in 2014–2017, while Slovenia, Slovakia, and Hungary were six times more successful. These figures should, however, be interpreted with caution, as they are not statistical, but rather self-reported SME project data collected by eCORDA surveys in the given period.

Figure 2 shows the value of Horizon 2020 contributions to total R&D investments, taking into account each country's population size, number of researchers, and national R&D investments.

Figure 2: Horizon 2020 contributions normalised by population size, number of researchers, and amount of R&D investment



Source: Authors' compilation based on the Horizon 2020 Interim Evaluation Report (European Commission, 2017b, Annex 1).

Figure 2 shows that when taking 'normalising' factors into account, Slovenia, Estonia, and Cyprus outperform the EU-15 countries, despite the modest increase in the trend of Horizon 2020 funding to EU-13 countries compared with that of the FP7 (from 4.2% to 4.4% in the observed period).

The analyses presented in the Horizon 2020 Interim Evaluation Report also show that the situation can be specific and heterogeneous at the country level, depending on the amount of national R&D investment, population size, and number of researchers. The results support the conclusion that countries that received a larger amount of EU R&I funding scored better in innovation performance when measured on the European Innovation Scoreboard. Although the data confirm the traditional dichotomy between the old (EU-15) and new (EU-13) member states in terms of participation and success rates, the divisions are not always consistent. In absolute terms, EU-15 countries received 85.7% of the total EC contribution for SME Instrument grants, compared to only 8.4% for

EU-13 countries, demonstrating the larger capabilities of innovative and growth-oriented SMEs. According to the Interim Report, despite having less funding, the SMEs in EU-13 countries demonstrated a significantly improved capability to catch up compared to that shown in the FP7 (European Commission, 2017b).

Table 4 shows the value of Horizon 2020's total R&D investments for different groups of EU countries from a comparative normalised perspective, to highlight the contrast between the absorption of funding in EU-15 and EU-13 member states.

Table 4: Horizon 2020 contributions normalised by population size, number of researchers, and national R&D investment

	Horizon 2020 contribution (EUR million)	Horizon 2020 contribution per researcher (EUR)	Horizon 2020 contribution per inhabitant (EUR)	Per EUR million spent on national R&D
EU-28	18,953	10,426	37	63,429
EU-13	907	3,812	9	67,524
EU- CEE (8)	721	4,821	13	73,766
EU-15	18,046	11.423	44	63,277

Source: Horizon 2020 Interim Evaluation Report (European Commission, 2017b, Annex 1). The amounts for the sub-group EU-CEE (8) are calculated by the authors.

These aggregate figures reveal interesting facts about the efficiency of investments in R&I, and underline the dichotomy between the established EU-15 states and the less advanced EU-13 members. Most interesting for this paper are the new member states from Central and Eastern Europe, which are the focus of the next section.

4. MAJOR ISSUES THAT DETERMINE INNOVATION PERFORMANCE OF NEW EU MEMBER STATES FROM CENTRAL AND EASTERN EUROPE

In this section we will outline some of the major issues accented in recent literature that largely determine the current position and innovation outcomes of CEE countries. This is necessary to gain a better understanding of the context in which innovating firms from this region operate, innovate, and consequently grow. In addition, this section will reveal that although increased access to and use of public R&D funding is important to drive and scale up innovation in SMEs, improving the innovation process at the firm level is a more complex undertaking in CEE countries.

Technology upgrades and innovation that lead to the creation of new and competitive market products and services have been a pivotal issue in the economic growth of most new EU members from Central and Eastern Europe (CEE), especially since the global financial crisis. A number of empirical studies by authors familiar with the region (see Radošević, 2017; Radošević et al., 2020, Hashi & Stojčić, 2013a; Hashi & Stojčić, 2013b; Stojčić, 2020; Stojčić et al., 2020; Radas et al., 2020) have detected and investigated the issues behind its modest innovation performance and low productivity gains, despite the continuous increase in external R&I funding, including public funds from the EU and national sources.

Several important findings have emerged from empirical studies that focus on the specific problems of innovation performance in new EU member states from this region. When analysing the determining channels and mechanisms that have the biggest effect on the innovation performance of CEE countries, Radošević (2017) considers that unlike advanced countries, their growth comes less from R&D-driven innovation and more from the spillover and absorption effects of the intensified interactions of domestic R&D with imported advanced technology. He argues that although a singular focus on R&D policies is important for CEE countries, it does not produce effects equal to those in advanced EU economies. This is because the former's R&D sector has traditionally been more suited to the absorption and adaptation of new knowledge brought by imported technology, rather than being an innovation driver itself. This reflects the structure of the CEE economies and the competiveness of certain industries in the EU and world markets.

One of Radošević's (2017) findings is that CEE countries base their current innovation policies mainly on imitating those of advanced EU member states, by "narrowly focusing on R&D drivers of innovation" (Radošević 2017). It may be more productive for CEE countries to pursue their own innovation policies instead, and adjust them to country-specific and regional economic characteristics and challenges so that they better reflect the innovation drivers in local economic structures. Radošević argues that technology upgrades and improvements to production capabilities that stem from the effective use of imported advanced technology would only generate the necessary R&D innovation-driven growth at its later stages. Improving productivity efficiency based on innovation would also stimulate the catching-up process, leading to a faster convergence with more developed EU economies.

Radošević (2017) emphasises the importance of additional factors that determine the mode of innovation and future growth of CEE countries. He argues that existing innovation policies in this region focus on "upstream" R&D activities and programmes (i.e., R&D-based growth), at the expense of equally important "downstream" innovation factors, such as skills, management quality, and engineering, as well as the quality of export products: "Instead of innovating based on R&D, these economies are much more likely to innovate based on incremental innovation, cost-oriented process innovations, and technology adoption. These are demand-driven innovations, rather than supply or R&D-driven ones" (Radošević, 2017). It is evident from Radošević's study that non-R&D innovating firms dominate in CEE countries, especially in those countries that are less developed. He finds that exports from CEE countries predominantly comprise the low value-added products in the global production chain. These factors determine the innovation and competitiveness rank of new CEE EU member states, and send important messages to their policymakers. Radošević argues that as well as upgrading their technology through imports, the technological progress of these countries should be augmented by upgrading their domestic technologies and advancing their position in global value chains. Finally, Radošević suggests the use of appropriate innovation metrics that reflect CEE-specific innovation factors and technological upgrades, as those currently in use (such as the EU Innovation Union Scoreboard) focus more on R&D and technology. In his later work (Radošević et al., 2020), Radošević develops a specific composite innovation policy index – the Technology Upgrading Intensity Index – to better reflect the significant contributions of non-R&D factors in CEE countries.

The findings of earlier studies by Hashi and Stojčić (2013a and 2013b) are consistent with those of Radošević (2017). The former define innovation as a complex multi-stage, non-linear process that is highly dependent on the diversity of incentives to innovate at the firm level. They argue that "in the presence of market imperfections, horizontal and vertical knowledge and technology spillovers generated through formal and informal enterprise networks, imitation of rivals' actions, and cooperation with universities, research laboratories, and other scientific institutions can help firms to overcome barriers to innovation and raise the quality-driven competitiveness of the entire industry" (Hashi & Stojčić, 2013a). In their study of CEE countries, Hashi and Stojčić examine the overlooked issues of innovation mechanisms at the industry level, focussing particularly on empirical investigations of the relationship between knowledge spillovers, innovation activities, quality upgrading, and industries' EU market share. They argue that it is important to look into the structure of exported products to better understand the differences in growth between CEE countries. Hashi and Stojčić's (2013a) empirical study of CEE countries examines their access to R&D subsidies, which is also the focus of our paper. They conclude that the coefficient of the variable on the use of EU subsidies is significantly positive, and is therefore more important than domestic subsidies as a channel for improving the quality of its export coefficient. Further, they confirm the causality of innovation performance on export and import quality in CEE countries, and find that these states gain important knowledge spillovers from international trade. Hashi and Stojčić state, "a 1% increase in the innovation output of an industry increases the relative quality of its exports by about 0.04%" (Hashi and Stojčić, 2013a). Their study also uncovers a positive and statistically significant coefficient in the examined firms' investment in machinery and equipment, finding that "a 1% increase in investment increases the relative quality of the industry's exports by about 0.13%" (Hashi & Stojčić, 2013a). Hashi and Stojčić's research demonstrates the range of important factors – including large discrepancies in leading industrial sectors – that determine the final innovation output of CEE countries.

Radošević and Yoruk (2018) investigate why middle-income countries, which prevail among the new EU members from CEE countries, are locked in the "middle income trap", in which innovation output does not adequately reflect general income and development levels. They also explore why increased technological upgrades and R&D investments in innovation activities are not appropriately reflected in the pace of CEE economic growth, as they are in more advanced EU member states. Although CEE countries are divergent, only a few (Slovenia, Estonia, and the Czech Republic) have managed to avoid this trap and move into the lower high-income group. These countries have displayed better productivity and management capabilities, as well as more efficient use of benefits from the innovation process that are designed to help them catch up with advanced EU economies.

In his recent study, Stojčić (2020) focuses on the importance of collaborative innovation activities to the innovation output of CEE countries. This is a distinctive feature of successful innovation activities, and Stojčić's study contributes to a better and deeper understanding of its impact. There is increasing evidence that innovation activities are a product of collaborative effort, which is particularly beneficial to the commercialisation of innovation. Based on empirical evidence, Stojčić argues that innovating firms from CEE countries build stronger innovation competences and capabilities for both the creation and commercialisation of innovations. His treatment analysis of a sample of over 10,000 firms from Eurostat's Community Innovation Survey finds that the innovation activities of firms are dependent on an extensive and diverse network of collaborators, which contribute to increased domestic innovation competencies and capabilities. Stojčić's research finds evidence of the positive impact of collaboration on the commercialisation of existing products, and to a lesser extent, on incremental and radical innovations.

Stojčić, Srhoj, and Coad's (2020) recent article focuses on the specificities of national innovation systems that largely determine the impact and effectiveness of innovation support measures. These measures include public procurement for innovation (PPI) and public funding schemes, particularly in the new CEE EU member states. When examining the additionality to the innovation output of 8 CEE countries based on CIS data, Stojčić, Srhoj, and Coad find that additionality is achieved when firms receive both public funding and innovation-oriented public procurement, and are able to benefit from its synergetic effects. However, they argue that the strongest effect on additionality relates to PPI, and thus more attention should be paid to this instrument if CCE policymakers wish to strengthen their indigenous innovation capabilities. Futher, the instrument should be tailored to specifically incentivise innovation through novel products and services. Such capabilities are crucial to the innovation process, which has a larger impact on the growth of these countries and on their catching up with advanced EU members.

To address the divergence of development in CEE countries, Radas, Mervar and Škrinjarić (2020) divide them into two clusters. Their study, based on Community Innovation Survey data from 2008–2012, reveals that SMEs from the newest EU member states (Bulgaria, Romania, and Croatia) were unable to benefit effectively from EU funding, and subsequently failed to produce the desired "additionality" to internal R&D activities at the firm level. An interesting insight from this study is that economically successful countries (those that joined in 2004) were able to extract more benefits from public funding, leading to the conclusion that success breeds success in innovation activities.

5. ABSORPTION OF HORIZON 2020 PROGRAMME BUDGETS BY SMES IN THE EU: PANEL DATA ANALYSIS

To determine the effects of participation in EU funding programmes on the innovation and economic performance of SMEs (in the period before Horizon 2020), we analysed its impact on a sample of firms from 10 new EU member states (more than 40,000 observations). We then investigated the aggregate impact for 25 EU states by assessing the impact of the total amount (in EUR) that SMEs received from the Horizon 2020 budget on two variables that capture their economic performance: turnover and number of employees. To achieve this, we used the first difference (FD) approach, since our sample covers only two years (T=2) (see Allison, 2009).

The model is expressed as:

$$\Delta y_{it} = \delta_0 + \beta_1 \Delta x_i + \Delta u_i, \quad t=2 \tag{1}$$

where y_{it} is the value of the dependent variable for i^{th} country at time t, and X_i encompasses the values of the independent variables. The advantage of using this model when T=2 is that there is no need to include further variables to control for unit-specific characteristics: by using the same units at both times these are automatically controlled for.[3] Due to missing data, the analysis includes all EU member states except Luxembourg, Malta, Croatia, Poland, the Czech Republic, Lithuania, and the UK, making a total of 21 Member States in the sample. The dependent variables in Models 1 and 2 are the SMEs' number of employees and total turnover (EUR millions) respectively, as reported at the beginning of the project and for the latest reporting period. The independent variable is the same in both models, and is defined as the total Horizon 2020 Budget Allocations to SMEs (in 2014 and 2016). Data on the employment and turnover of SMEs were obtained on request from DG R&I, A5 Unit, while data on the Horizon 2020 budget allocation came from eCORDA (self-reported data by the SMEs project beneficiaries). This approach enables us to specifically analyse those SMEs that received funds. The descriptive statistics of variables are shown in Table 5, and the results are presented inTable 6.

As expected, the results show that participation in the Horizon 2020 programme positively affected the economic performance of SMEs' employment and turnover. With a EUR 1 increase in Horizon 2020 funds, an SME's turnover increases by EUR 1.33, and a 1% increase in Horizon 2020's allocated budget increases employment by 0.12%. However, because many factors influence an SME's business performance, the impact of EU R&I funding cannot be assessed solely in relation to Horizon 2020 support. This is duly stressed in the Horizon 2020 Interim Report (Annex 1). Horizon 2020's impact on performance should therefore be interpreted with caution, particularly considering that its implementation and analysis covers a limited 2-year period, especially when interpreting the effect on turnover, the coefficient of which is statistically significant at the $p=0.1$ level.

3 Together, fixed effects and first differences are unbiased and consistent; and when T is 2 as in our case, the estimators produce identical estimates. The robustness is also tested by including both country and time-fixed effects (Table A4 in Appendix).

Table 5: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
turn	42	1.67e+08	3.29e+08	224200	1.66e+09
empl	42	2094	6589.344	6	33155
H2020budget	42	3.37e+07	4.56e+07	440775	1.83e+08

Source: Data obtained on request from DG R&I, A5 Unit, and eCorda.

Table 6: Results of the First Difference (FD) regression model [4]

VARIABLES	(Model 1) Employment	(Model 2) Turnover
H2020fund	0.117***	1.332*
	(0.022)	(0.792)
Observations	42	42
R-squared	0.510	0.263

Note: Robust standard errors clustered at the country level are given in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors' calculations, based on data obtained on request from the European Commission, DG R&I, A5 Unit.

When the figures are analysed at the aggregate level, it can be seen that countries in which SMEs received more Horizon 2020 funding recorded better business performance, measured by employment and turnover growth. Additionally, the data reveal divergent results between countries: unsurprisingly, new member states perform worse than old ones in terms of both their absorption of Horizon 2020 funds and firms' economic performance.

Our results, although only indicative at this phase, are in line with previous studies. They provide a solid foundation for further research using a more sophisticated econometric cause-effect analysis over a longer period of time, preferably one that covers the whole seven years of the Horizon 2020 programme.

[4] The authors used this approach in their research for Deliverable 2.2. of the Horizon 2020 'I3U' project, where the first results of their study were disseminated (see Vučković & Čučković, 2018. Available at www.i3u-innovationunion.eu).

5.1. Some policy implications

Policy implications that can be drawn from analyses of the Horizon 2020 data demonstrate that countries that received larger amounts of EU R&I funding (overwhelmingly the more developed member states) score better on the European Innovation Scoreboard in innovation performance and outcomes. The data confirms the traditional dichotomy of old (EU15) and new (EU13) member states in relation to funding participation and success rates, but the divisions are not always consistent, as the cases of Slovenia, Estonia, and Cyprus clearly show. In absolute terms, EU-15 countries received 85.7% of the total EC contribution for SME Instrument grants, compared to only 8.4% for EU-13 countries. This highlights the greater capabilities of innovative and growth-oriented SMEs. However, despite their lower funding, SMEs in more developed EU-13 countries demonstrated a significantly improved capability for catching up. In this respect, SMEs from less developed CEE countries, including Croatia, require concerted policy efforts at multiple levels to further develop their innovation and catching-up capabilities, and to increase their potential to absorb available R&I funds from EU and other sources, which will help them scale up this process.

Our review of other empirical studies on the key innovation capabilities of firms from this region shows that when the data are contextualised to fit CEE countries, policymakers must consider many other important factors when formulating their policies based on evidence. Effective policy design requires appropriate innovation metrics, which determine the specific factors and dominant drivers of regional firm-level innovation and technological upgrade.

6. CONCLUDING REMARKS

This paper presents significant empirical evidence of the positive impact of EU R&I funds on the innovation and economic performance of SMEs in new EU member states. In response to our first research question (RQ1), we find support for the conclusion that increased availability and use of EU and other public funding assists SMEs, which generally face greater financial restraints than larger businesses, particularly at the early stages of developing innovative products and processes. Our results are consistent with the Horizon 2020 Interim Evaluation, which shows that SMEs that participated in EU-funded projects delivered a substantial number of new innovations. This demonstrates that participation in such projects is beneficial to the advancement of SMEs' innovation and commercialisation activities, as well as to their technological upgrading and economic performance and efficiency (see EC, 2017a and EC, 2017b).

Regarding the potential leverage effect of Horizon 2020 funding on total SME R&I expenditures, when we compared the parameters at the beginning and end of the project (using data we received from DG R&I, A5 Unit), the results showed that participation in Horizon 2020 funding programmes positively affected the employment and turnover of SMEs. Although the potential bias and quality of SMEs' self-reported data should be taken into account, our results show that an increase in Horizon 2020 funds by EUR 1 increases the recipient SME's turnover by EUR 1.33, and a 1% increase in funding improves its employment rate by 0.12%. These results answer our second research question (RQ2).

Based on CIS 2014 data, and taking into consideration the methodological limitations, our analyses of the selected innovation and economic performance indicators show that SMEs that received EU funds perform better than than they would have done if they had not eceived EU funds. They also have a higher probability of receiving additional funding from other sources, including private investment.

However, the results presented here should be interpreted with caution, as the econometric analyses behind this paper's impact assessments are limited in scope and duration. This means they are more illustrative and indicative in nature, because they were hampered by data availability and quality. Additionally, because the selected models were based mainly on cross-sectional CIS data and eCORDA data on SMEs as funding recipients (which at that time captured only about 10% of completed projects), the correlations identified do not necessarily provide appropriate causality conclusions.

Future research avenues include assessment of the broader indirect impacts of public funding on SME business performance, such as its impact on SME competitiveness, and the quality of investments and exports within certain industries and types of SMEs. This could be studied in relation to fast-growing young firms, and the issues of crowding in/out (i.e., whether EU R&I funds should augment those financed by SMEs, or whether they are a substitute for private R&I) could be examined based on historical micro-data. Such research would shed more light on the complexity of SME performance, and direct our attention to the multiple factors and policy contexts of firm and sector levels in the CEE region that significantly affect SME innovation, such as underlying R&I behavioural and organisational aspects, firm age and size, and labour and management skills. The impact of other, non-financial, innovation incentives from the fragmented eco-innovation environment could also be explored, at EU, national, and regional levels. Identifying clusters of countries or sub-regions with similar innovation drivers within the divergent group of new EU members from Central and Eastern Europe might also provide policymakers with interesting new observations. Finally, performing country-level analyses, for example, on a sample of innovating SMEs in Croatia, could provide insight into the specifics of the important non-R&I factors that drive the innovation performance and growth of that country, which is lagging considerably behind its CEE peers.

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Received: July 28, 2020
Accepted: December 21, 2020

Acknowledgements: This paper is based on the authors' research for the Horizon 2020 project, 'Investigating the Impact of the Innovation Union – I3U', financed by the European Commission (Grant Agreement No. 645884).

We are grateful to EUROSTAT for allowing us to use the 2014 CIS CD-ROM data for our 'I3U' project analyses. We are also thankful for the eCORDA data we obtained on request from the European Commission DG RTD, A5 Unit. The results and conclusions are solely those of the authors and not those of Eurostat, the European Commission, or any of the establishments whose data have been used in the analysis.

The authors also thank participants of the Challenges of Europe: Growth, Competitiveness, Innovation and Well-being Conference, held from 22–24 May 2019 in Bol on the island of Brač, Croatia, for their valuable input on the first draft of this paper.

Finally, the authors are grateful to our two anonymous reviewers for their valuable comments, insights, and suggestions, which helped us prepare the final version of this text.

APPENDIX

Table A1: Sensitivity analysis – IPWRA and NNM estimations (all sectors)

	NNM		IPWRA	
OUTPUT	EU funds (1 vs. 0)	Central government funds (1 vs. 0)	EU funds (1 vs. 0)	Central government funds (1 vs. 0)
inn_process	0.045*	0.018	0.039*	0.017
	(0.013)	(0.014)	(0.013)	(0.014)
inn_newmkt	0.085*	0.064*	0.082*	0.064*
	(0.017)	(0.018)	(0.016)	(0.018)
inn_exp	1.894*	1.768*	1.939*	1.824*
	(0.172)	(0.172)	(0.168)	(0.169)
turn_mkt	0.035*	0.031*	0.034*	0.032*
	(0.007)	(0.008)	(0.008)	(0.008)

Note: Standard errors in parentheses; * P < 0.01, **P < 0.05, *** P < 0.10

Source: Authors calculation using CIS2014 CD-ROM data.

Table A2: Sensitivity analysis – IPWRA and NNM estimations (High and Medium-High Manufacturing Sectors)

	NNM		IPWRA	
OUTPUT	EU funds (1 vs. 0)	Central government funds (1 vs. 0)	EU funds (1 vs. 0)	Central government funds (1 vs. 0)
inn_process	0.114*	0.052**	0.104*	0.062**
	(0.024)	(0.025)	(0.022)	(0.024)
inn_newmkt	0.086*	0.065**	0.074*	0.071**
	(0.029)	(0.031)	(0.028)	(0.030)
inn_exp	1.239*	0.951*	1.223*	0.933*
	(0.207)	(0.206)	(0.202)	(0.193)
turn_mkt	0.017	0.019	0.021***	0.021
	(0.013)	(0.014)	(0.012)	(0.013)

Note: Standard errors in parentheses; * P < 0.01, **P < 0.05, *** P < 0.10

Source: Authors calculation using CIS2014 CD-ROM data.

Table A3: Sensitivity analysis – IPWRA and NNM estimations (KIBS)

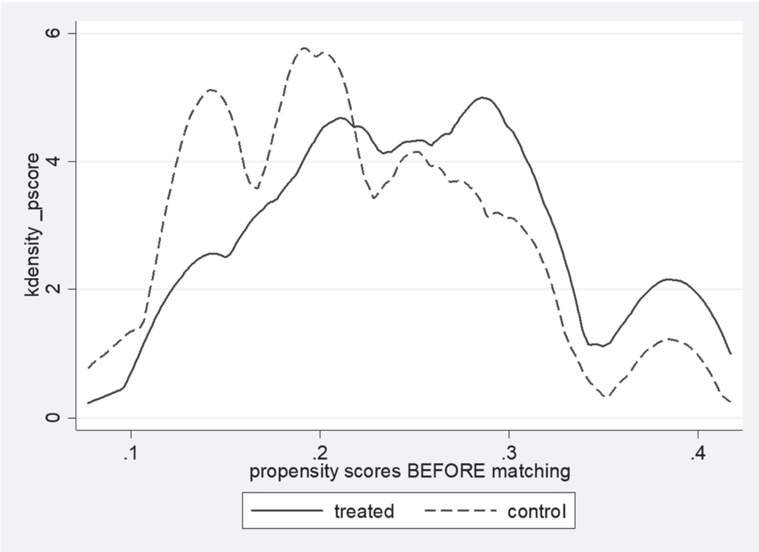
OUTPUT	NNM EU funds (1 vs. 0)	NNM Central government funds (1 vs. 0)	IPWRA EU funds (1 vs. 0)	IPWRA Central government funds (1 vs. 0)
inn_process	-0.087	-0.045	-0.827	-0.026
	(0.039)	(0.040)	(0.037)	(0.038)
inn_newmkt	0.161*	0.169*	0.130*	0.159*
	(0.046)	(0.045)	(0.042)	(0.043)
inn_exp	3.171*	3.221*	3.092*	3.155*
	(0.596)	(0.594)	(0.586)	(0.604)
turn_mkt	0.070*	0.059**	0.064*	0.061**
	(0.024)	(0.025)	(0.024)	(0.024)

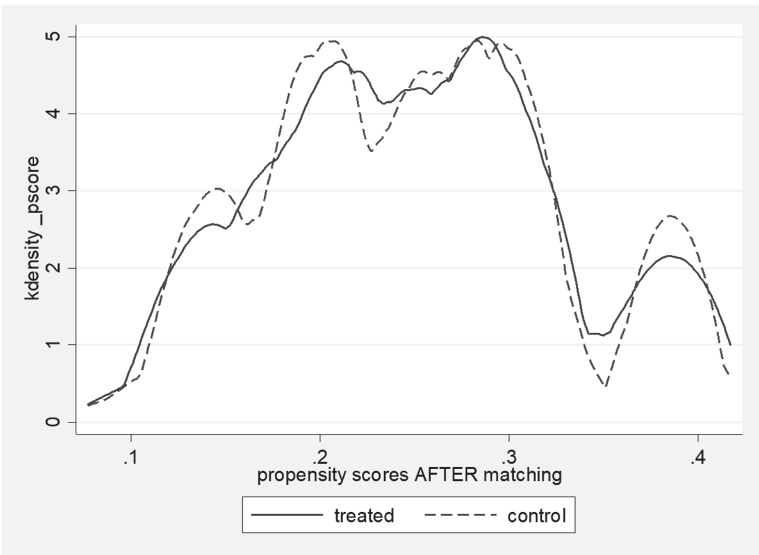
Note: Standard errors in parentheses; * P < 0.01, **P < 0.05, *** P < 0.10

Source: Authors calculation using CIS2014 CD-ROM data.

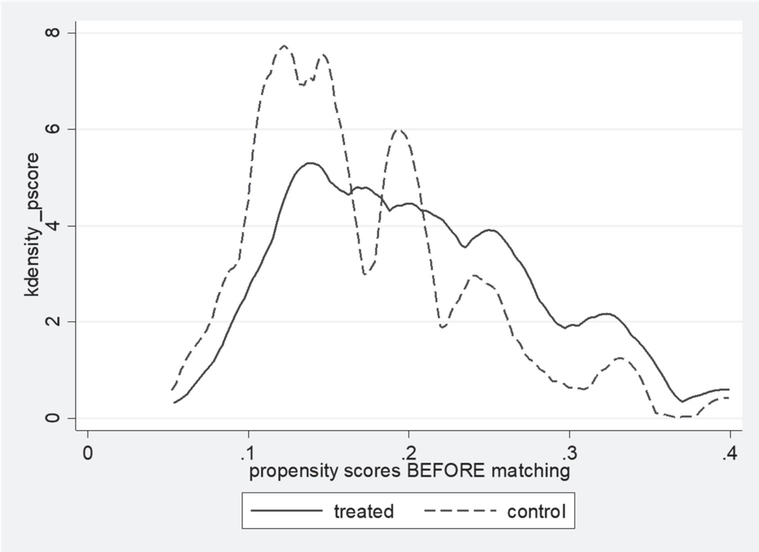
Figure A1. Kernel density of the estimated propensity scores before and after matching for each source of funding (total sample)

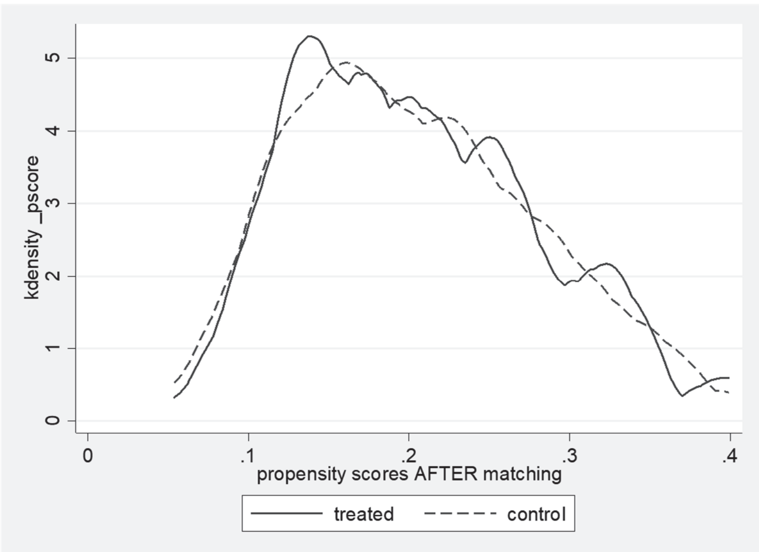
a) EU funds





b) National funds





Source: Authors calculations.

Note: *We also examined whether the treatment model balanced the covariates, and the weighted standardized differences are all close to zero and the variance ratios are all close to one implying that model balances the covariates.*

Table A4: Model including country and year fixed effects

VARIABLES	(Model 1) Employment	(Model 2) Turnover
H2020 fund	0.241***	1.395*
	(0.066)	(0.700)
Time fixed effects	YES	YES
Country fixed effects	YES	YES
Observations	42	42
R-squared	0.998	0.964

Note: **** p<0.01, ** p<0.05, * p<0.1.*

Source: Authors' calculations, based on data obtained on request from the European Commission, DG R&I, A5 Unit.