The effects of regional environmental EU-funded research on firm innovation: A multilevel analysis

Lorena M. D'Agostino
University of Milano-Bicocca. Department of Economics, Management and Statistics.
Piazza dell'Ateneo Nuovo, 1 - 20126, Milan, Italy.
lorena.dagostino@unimib.it

Rosina Moreno
AQR-IREA, University of Barcelona. Department of Econometrics, Statistics and Applied Economics, Av. Diagonal 690, 08034, Barcelona, Spain
rmoreno@ub.edu

Damián Tojeiro-Rivero[1]
Department of Business, Universitat Autonoma de Barcelona. 08193 Bellaterra (Cerdanyola del Vallès), Barcelona, Spain.
damian.tojeiro@uab.cat

POST PRINT VERSION[2]

Abstract

Taking the long-established evidence on knowledge spillovers that states that part of the new created knowledge spills over to other firms mostly located in the physical proximity, we aim at providing evidence on the role of green knowledge spillovers on firms' innovation. We posit that in addition to internal factors, firm innovation is determined by external regional factors, among which we specifically focus on the spillovers generated by environmental EU-funded research at the regional level. The results indicate that the presence of partners engaged in EU-environmental projects in a region has a positive and significant effect on process innovation.

Keywords: innovation; environment; EU-funded research; Framework Programme, region; firm
JEL: R11; O31; O44

[1] Corresponding author.
[2] This paper is published as: D'Agostino, L., Moreno, R., Tojeiro-Rivero, D. (2025). The effects of regional environmental EU-funded research on firm innovation: A multilevel analysis. The Journal of Technology Transfer. doi.org/10.1007/s10961-025-10246-2

Statements and Declarations

Acknowledgements

Rosina Moreno acknowledges financial support provided by the Ministerio de Ciencia e Innovación for the project entitled ‘Innovation, Environment and Social Justice (JUST GREEN-INN), PID2020-119096RB-I00. All errors remain our own.

Author contributions

Lorena M. D’Agostino: Conceptualization; Writing - Original Draft; Writing - Review & Editing

Rosina Moreno: Conceptualization; Methodology; Writing - Original Draft; Writing - Review & Editing

Damián Tojeiro-Rivero: Data curation; Formal analysis; Investigation; Methodology; Software; Writing - original draft; Writing - review & editing.

Conflict of Interest

Lorena M. D’Agostino, Rosina Moreno, and Damián Tojeiro-Rivero declare not having any conflict of interest.

1. Introduction

Since the foundation of the European Community in 1957, the idea to support research and innovation at the European level has been central and the Framework Programmes implemented since the 1980s have been a key instrument to achieve that aim. Over the years, the European Union (EU) has increased its commitment to fund research that is relevant to solve societal challenges. Sustainable development has been central in the EU political agenda since the European Sustainable Development Strategy (EU SDS) adopted in 2006, and it has accelerated tremendously with the European *Green Deal* launched in 2019, and with the global shocks such as the COVID-19 pandemic and Ukraine crisis that demanded a more rapid transition towards a greener Europe.

In recent years, the EU has made strong financial investments to support scientific and industrial bases in the transition towards a sustainable economy. Part of this political commitment rests on the premises that the benefits will outweigh the costs of this transition in terms of new markets and new jobs created, efficiency gains, and overall improved well-being of the people and our planet.

The environmental innovation literature recognizes that the actions to reduce the environmental impact of economic activities could boost competitiveness through innovation at the country, industry or firm-level (Fabrizi et al., 2025, 2024; Rahmani et al., 2024). That is, innovation in the field of green technologies could spur overall innovation capacity of those agents (Lanoie et al., 2011). As discussed in Rennings (2000), environmental innovation has a “double externality” effect: on the one hand, the reduction of environmental externalities, and on the other, the typical R&D spillover effect (Jaffe et al., 1993). In this paper, we argue and provide evidence on the extent to which the innovation within the domain of environmental technologies carried out at the regional level thanks to EU-funded research projects could trigger not only specific environmental innovation but also other types of innovation in local firms. The mechanism through which a change in one of the environmental issues at the regional level can be associated to local firm innovation is knowledge spillovers.

For each funded project, a research consortium of domestic and foreign organizations (e.g. firms, universities) has teamed up to participate to a specific call; we use information on domestic organizations involved in EU research projects as a measure of the stock of green knowledge created in the region. The research consortia built around EU-funded projects both create and facilitate the circulation of knowledge, favour new recombination of existing knowledge, develop skills and expertise of people, and create institutional and geographical diverse networks that can persist over time even after the end of the projects (Alegre et al., 2024; Cassi et al., 2008). Such benefits can be extended from the organizations collaborating in the projects (see e.g. Barajas et al. (2012)) to other proximate actors through knowledge spillovers (Audretsch et al., 2021; Audretsch and Belitski, 2022; Fabrizi et al., 2025; Meliciani et al., 2022).

We construct on the long-established evidence on knowledge spillovers that posits that part of the newly created knowledge spills over to other firms mostly located in the physical proximity, and provide additional evidence of the role of green knowledge spillovers on firms' innovation. Our results are aligned to the majority of studies that points to positive effects of knowledge spillovers on firm process innovation. Conversely, for product innovation our results are aligned to the studies that indicate that such flows of knowledge may also be detrimental and reduce or delay certain types of innovation by firms; ; for example, they may favor imitation rather innovation (Audretsch and Belitski, 2022). In this regard, as far as we know, this study is the first to find that EU-funded research has a negative effect on firm product innovation. Extant studies take either a micro or a meso level of analysis, while few studies consider the interdependences between different levels (López-Bazo and Motellón, 2018; Rodríguez-Gulías et al., 2021). A multilevel approach has become particularly important in innovation studies that has increasingly recognized that both internal and external factors are important in firm innovation. This paper contributes to such literature by positing that firm innovation is determined by internal factors (i.e. R&D expenditures, size) and external regional factors, among which we specifically focus on environmental EU-funded research projects under the Seventh Framework Programme.

Therefore, this paper is about green knowledge spillovers at regional level, and it aims at evaluating the effect of regional environmental EU-funded research on firm product and process innovation. These effects are generally considered positive, but some negative relation may emerge for some types of innovation (Audretsch and Belitski, 2022).

This paper offers two original contributions. First, to the field of environmental innovation, we provide a link between environmental competitive research grants and firm general innovation through local green knowledge spillovers. Second, we contribute to the multilevel studies on firm innovation by incorporating local green knowledge among the relevant regional factors.

The paper is outlined as follows. After this introduction, section 2 presents the theoretical framework of the paper, whereas section 3 describes the dataset and variables. In section 4 we offer the methodology and model specification used in the empirical part of the paper, and the main results are given in section 5. The paper concludes with a discussion in section 6.

2. Theoretical framework

2.1 Green knowledge spillovers and the role of environmental EU-funded research

The knowledge spillovers literature suggests that green innovation (as such any general innovation) stimulate subsequent innovation; a great part of such knowledge flows is appropriated by actors located nearby, or with which firms have direct connections (e.g.

with suppliers, research centres, or competitors). Because of the specific nature of green innovation, green knowledge spillovers may be higher than other types of innovation, as shown by recent empirical evidence (Ardito et al., 2019; Barbieri et al., 2020; Colombelli and Quatraro, 2019; Dechezleprêtre et al., 2014; Popp and Newell, 2012). Such studies are based on the premise that green technologies may resemble general purpose technologies (GPTs), similarly to information and communication technologies (ICT), hence they may have multiple applications and spillovers across sectors. Popp and Newell (2012) find that green energy patents are cited more often than other patents in a variety of other technological domains. Colombelli and Quatraro (2019) show that, for startups in energy-related fields, green knowledge spillovers (measured as green patent stocks in Italian provinces) are stronger than spillovers from 'dirty' ones. By focusing on green ICT patents, Cecere et al. (2014) find high levels of pervasiveness of such patents, especially in some specific domains (e.g. energy), which signals the diverse potential fields of applications. Barbieri et al. (2020) find that green patents have a larger and more pervasive impact on subsequent developments than non-green technologies, as measured by forward citations. Dechezleprêtre et al. (2014) investigate knowledge spillovers of clean and dirty technologies in two fields where they can clearly distinguish between clean and dirty inventions: energy production (renewables vs. fossil fuel energy generation) and automobiles (electric cars vs. internal combustion engines). They find that clean patents receive on average 43% more citations than dirty patents. They show that this evidence is similar to other emerging technologies such as biotech, IT, nanotechnology, robot and 3D. Ardito et al. (2019) focus specifically on the green patents of public research centres, and they provide evidence of the conditions under which the research output of such organizations impact on subsequent technologies of firms.

All these studies investigate the impact of green innovation on subsequent innovation at the level of technology, with the exception of Colombelli and Quatraro (2019) that look at the spatial dimension of knowledge spillovers (in their cases, Italian provinces). Similar to the latter study, we use regions as loci for green knowledge spillovers, but differently than them our outcome measure is at the firm level, it is related to general innovation, and allows to distinguish between product and process innovation.

The evidence of the presence of knowledge spillovers from green innovation is extensive (e.g. Fabrizi et al., 2025). We contribute to this stream of literature by specifically focusing on the role of EU-funded research grants in environmental-related fields in creating new relevant knowledge in regions, which eventually positively impact firms' innovation in general, not just environmental innovation. This positive linkage is based on the presence of knowledge spillovers.

Across the years, one of the most important pillars of the system of financing research in EU is cooperation because it serves two main aims (Amoroso et al., 2018; Fabrizi et al., 2025, 2024; Nepelski and Van Roy, 2021). Firstly, the combination of dispersed knowledge and the leverage of distinctive expertise allows to achieve excellent science and innovative industrial solutions (Di Cagno et al., 2016; García Muñiz and Cuervo, 2018). Second, cooperation increases the diffusion of the new knowledge to the multiple actors involved, some of which are specifically targeted by the policies, such as small and medium enterprises (SMEs), or firms located in peripheral areas. Therefore, the research that emanates from the consortia funded by EU projects enables the exchange of knowledge, promotes recombination of extant knowledge, and favors the generation of long-lasting research networks (Cassi et al., 2008). As commented in the introduction, those benefits can be spread from the partners of the projects (see e.g. Barajas et al. (2012)) to other close agents through knowledge spillovers (Audretsch et al., 2021).

Among other examples of spillovers, we may think of observation and imitation of competitors, reverse engineering, labor mobility, supply chain relation, inter-personal networks, trade and professional associations, and the codification of knowledge (e.g. patents, manuals) (Audretsch and Belitski, 2022).

The international research network built around EU-funded grants fosters collaboration in innovative activities, which is recognized as an important determinant of firm innovation (Alegre et al., 2024; Tether, 2002). Collaboration with foreign partners could provide new or complementary knowledge that is lacking locally (Van Beers and Zand, 2014), as it provides access to country-specific resources, such as the access to the knowledge of the institutional community in a certain technological field (Miotti and Sachwald, 2003). International research collaboration occurs between firms, between firms and research organizations (universities, public or private research centers), and between research organizations located in different countries. The knowledge generated and exchanged in such collaboration is translated into innovative products or improved processes by the firms engaged in the network (Van Beers and Zand, 2014), but also by firms that are located in the proximity of any organization involved, through voluntary and involuntary knowledge spillovers (Audretsch et al., 2021).

We expect that the innovation output of local firms is positively affected by the involvement of local organizations in international research networks supported by EU funding specifically designed to boost transnational cooperation in environmental research. The technology transfer and spillovers effects of basic public research on innovation and economic performance is well documented (D'Este et al., 2013; Salter and Martin, 2001), also in green technologies (Ardito et al., 2019). In particular, EU-funded grants aim at fostering research at the cutting-edge of the technology, often addressing the challenges that private firms cannot solve alone. The research is often at a precompetitive stage of the innovation process and may be considered more basic rather than applied research. Even if firms participate in the research consortium, their contribution is weakly related to commercialization, and more to monitoring or contributing to promising technologies; for example, Matt et al. (2012) find that firms consider EU-funded projects more exploratory than exploitative, and peripheral to their core business.

The mechanisms through which knowledge generated by EU-funded research projects ultimately benefit firm innovation rest on the premises that initially the participants to the project create new “green” knowledge. This knowledge stimulates process or product innovation in firms participating in the projects. Part of this knowledge is transmitted to other actors not directly involved in the project, e.g. firms that collaborate with universities that have participated in the projects, or suppliers that innovate as result of the innovation carried out by firms involved in the projects. Therefore, there is a chain of knowledge flows that goes from actors directly involved in the projects to other actors indirectly involved and located within the region. We can consider the knowledge directly produced as result of the EU-funded research projects as inherently “green”, but complementary and subsequent knowledge may not be necessarily green. Indeed, it is difficult to distinguish between green-oriented knowledge from non-green oriented knowledge, as environmental innovation requires multidisciplinary knowledge fields (Ghisetti and Pontoni, 2015) and have applications in multiple domains (Barbieri et al., 2020).

When looking at the innovation output affected by knowledge spillovers, and in particular by green knowledge spillovers, we argue that the sign of the effects on product or process innovation may be different. We discuss our hypotheses in detail in the following sections.

2.2. The effect on firm process innovation

The specific outputs of environmental-related research are likely to enter the production processes of firms to reduce costs, improve efficiency and increase the quality of final products. Examples of such environmental process innovation are: reduced material, energy, or CO2 'footprint'; replaced materials with less polluting or hazardous substitutes; reduced soil, water, noise, or air pollution. For example, D'Agostino and Moreno (2019) found that local green energy technologies impact positively firm process innovation probably because these alternative energy patents seem to produce more knowledge spillovers than other patents (Noailly and Shestalova, 2017; Popp and Newell, 2012). They are also more general than other patents and tend to be more used as input to production in many industries, serving in firm production processes, and constituting a process innovation. This may stimulate further process innovation both in the same firm and in other firms located nearby (D'Agostino and Moreno, 2019).

Related to it, process innovation is mainly driven by the internal needs for cost-savings and efficiency gains, or a change in the dominant technology, while market forces are less important (Damanpour and Gopalakrishnan, 2001; Ettlie and Reza, 1992; Salter and Martin, 2001; Utterback and Abernathy, 1975).

Extant innovation literature has found that process innovation benefits from collaboration especially upstream the value chain, such as with universities, research centers, and suppliers (Un and Asakawa, 2015), while relations with customers may be detrimental (Reichstein and Salter, 2006).

Linking the ideas above, we can conclude that environmental research made in collaboration (such as the one under the funding of the EU framework) may benefit the generation of process innovations, with the purpose of reducing costs and improving efficiency. Therefore, we expect knowledge spillovers from environmental EU projects to stimulate firms' process innovation. Hence, we posit our main first hypothesis as follows:

H1: Environment EU-funded research has a positive effect on firm process innovation

2.3. The effect on firm product innovation

We posit two alternative hypotheses on the effects of environment EU-funded research on product innovation, since there are arguments in favor of a positive effect (stemming from the complementarity with process innovation), or a negative effect (based on the idea that product and process innovation have different and rather divergent drivers).

On the one hand, product and process innovation may be complementary. The introduction of a more efficient process is often accompanied by changes in the product composition, while new products may require the use of a new technology, equipment, or organization (Ballot et al., 2015; Hullova et al., 2016; Reichstein and Salter, 2006). This complementarity should be particularly important for environmental innovation because novelties introduced in production processes are likely to be also extended to products (Gilli et al., 2014). For example, a firm using less-polluting substances in its production process will consider using less polluting or less hazardous materials in its final products.

A second argument suggesting a positive effect on product innovation is that environmental-related research could involve materials or specific intermediate products (e.g. batteries, filters, fabrics, etc.) that are incorporated in new green products, hence they constitute a product innovation. Product innovations could stimulate subsequent innovation in the same industry (e.g. a reaction by competitors) or related industries (e.g. suppliers of complementary inputs to new green products have to adapt to the new products, hence coming out with new solutions). This new solution can result in innovations that could be not necessarily green. Hence, we posit the next hypothesis:

H2a: Environment EU-funded research has a positive effect on firm product innovation

On the other hand, the linkage between EU-funded research and product innovation may be weak or even negative. First of all, product innovations have different determinants than process innovation, being the former mainly determined by market factors and are customer driven (Damanpour and Gopalakrishnan, 2001; Ettlie and Reza, 1992; Utterback and Abernathy, 1975). Therefore, product innovation could be less affected by the availability of knowledge in the local area, especially when such knowledge is accessible also to competitors. In this sense, Roper et al. (2017) find that firm innovation performance (i.e. sales shares from new products) is positively influenced by local knowledge externalities; however, there are strong negative externalities resulting from the intensity of local non-interactive knowledge search (i.e. informal ways of accessing to knowledge external to the firm, e.g. through patents, articles, conferences). This "competition effect" is due to the fact that local externalities may also generate local competition effects by intensifying market pressures and reducing the returns from innovation.

A second motivation against a positive effect on product innovation is related to the specificities of EU-funded research. Such type of knowledge is likely to affect process innovation, but at the same time be irrelevant for product innovation. As we argued above, the type of knowledge produced by environmental EU-funded research is likely to enter the production phases in the forms of energy and material savings, cost efficiency, or less polluting or hazardous materials, but less in the form of a new product.

Thirdly, studies that have taken the perspective of the complementarity of product and process innovations have also discussed the issue of the dynamic of adoption of product and process innovations. While Damanpour and Gopalakrishnan (2001) find support of a product–process pattern - for which US firms firstly adopt product innovations, then process innovations - from a theoretical point of view, a process-product pattern is also plausible. In particular, when improvements in production are introduced as an external shock (as for example the ones induced by IT), this leads to subsequent provision of new products (Barras, 1990). Environmental technologies have several commonalities with IT as they serve as GPTs introduced in the production phases of firms, and may trigger subsequent product innovation. However, this pattern implies a time lag between process and product innovation. During the period of introduction of process innovation, resources and managerial attention may be subtracted to the introduction of new products, making process innovation substitute to product innovation. Therefore, local knowledge produced by environmental EU-funded research is likely to delay or substitute the introduction of new products. Hence, we posit the following hypothesis:

H2b: Environment EU-funded research has a negative effect on firm product innovation

3. Dataset, variables and empirical strategy

We build our dataset on firm and regional data. At the firm level, we use the Spanish Survey on Business Strategies (ESEE), an unbalanced panel of manufacturing enterprises (see Appendix A.1 for a description). For the regional dataset, we use three sources: Eurostat, the Spanish National Institute of Statistics, and the Seventh Framework Programme for Research and Technological Development (FP7) – the EU's main instrument for funding research in Europe in 2008-2013.[3] We consider FP7 projects funded under the "Cooperation" block (representing two-third of the overall budget), which aimed to foster collaborative research across Europe and partner countries through transnational consortia of industry and academia. Specifically, we selected projects in the thematic area of Environment, including climate change, involving at least one Spanish institution or firm. The data period ranges from 2008 to 2014. The regional level in our study corresponds to NUTS 2 territorial units, representing administrative and policy authorities in Spain.

3.1. Firm-level variables

We use two dependent variables: product and process innovation. Product innovation (*IProd*) is binary, equal to one if the enterprise developed product innovations that year, and zero otherwise (López-Bazo and Motellón, 2018; Naz et al., 2015). Similarly, process innovation (*IProc*) is binary, equal to one if process innovations were developed that year, and zero otherwise.

As a key firm-level control, we consider *Environmental investments*, accounting for whether firms have made investments related to environmental protection (e.g., reduction of toxic emissions, waste management, or energy savings). This allows us to analyze the regional effect of environmental partners while controlling for firms' independent environmental efforts.

Other firm-level controls include *Collaboration*, indicating if the firm has acquired external knowledge, which significantly impacts innovative performance, particularly product innovation (Robin and Schubert, 2013). We also consider *Total R&D per worker* to account for internal capabilities (Cohen and Levinthal, 1990). Firm size (*Size*) is measured by the total number of employees. Additionally, we control for whether the

[3] Open data are available at https://cordis.europa.eu/projects/en

firm received public funding for R&D (*R&D government*) and the importance of accessing foreign markets (*Export*), as firms facing more competition tend to be more innovative. Finally, we account for whether the firm is part of a multinational corporate group (*Foreign*), which may provide access to key capabilities and resources such as advanced managerial practices, cutting-edge technologies, or greater financial resources (López-Bazo and Motellón, 2018).

3.2. Regional-level variables

This study examines the relationship between regional externalities, specifically environmental international research collaboration from FP7, and firm innovative performance. Our main variable is *EU-funded env. partners*, which is the number of partners[4] (i.e., Spanish organizations collaborating with foreign entities in environmental fields of the FP7 program) by region-year, both in total and by types of organizations: Higher or Secondary Education Establishments – HES (*Education*), Research Organisations – REC (*Research*), Private for-profit entities – PRC (*Business*), Public bodies – PUB (*Public*), and a residual category (Other, e.g., trade associations, regulatory bodies). By considering the number of partners as a proxy of EU-funded research, we are interested in the involvement of the region in EU projects. The higher the number of partners, the higher the possibility to create and disseminate knowledge locally.[5]

We also control for regional characteristics, including the number of regional R&D researchers (*Regional Researchers*), industrial specialization (*Manufacture share*),[6] and agglomeration economies (*Pop. density*). Additionally, we consider expenditures on

[4] The same organization (institution) might be participating in several projects in the same year. Therefore, to avoid counting the institution several times, we decided to count it only once. This is done to consider the real effect of having "more" local institutions doing EU-funded collaborations.

[5] EU-funded projects are very different in terms of budget (and then of received funds) and costly projects do not necessarily imply more knowledge created or diffused.

[6] Notice that we averaged these variables by region through all the period (see footnote 6).

environmental protection to reduce or eliminate pollution from firm activities in a region (*Environmental manufacture expenditure*).

To address industry-specific and temporal factors, we include industry and time dummy variables. All explanatory variables are lagged by one year to mitigate simultaneity problems.[7] A detailed descriptive analysis and a comprehensive description of all variables are provided in Appendix A1 and A2.

3.3. Empirical strategy

In this paper we account for regional differences through hierarchical models, which imply advantages that rely on several theoretical reasons (see section A.3 in the Appendix). The structure of our specification is hierarchical since firms are nested in regions. However, as we are dealing with a panel dataset, time is in fact our first level of analysis (Rabe-Hesketh and Skrondal, 2012). Therefore, the hierarchy is the following: individual observations (time-firms) are nested on firms, and firms are nested on regions.[8] In order to account for this scheme, our multilevel logit model is as follows, where subscript *t* refers to time, *i* refers to the firm and *j* refers to the region:

$$y_{tij} = \begin{cases} 1 & if\ y_{tij}^{*} > 0 \\ 0 & if\ y_{tij}^{*} \leq 0 \end{cases} \tag{1}$$

$$logit\{\Pr(y_{tij} = 1 | x_{tij}, x_{ij}, z_j, \mu_{0ij}, \nu_{0j})\} = log\left(\frac{y_{tij}}{1 - y_{tij}}\right) \tag{2}$$

$$= \beta_0 + \sum_{m=1}^{M} \beta_{1m} x_{tijm} + \sum_{n=1}^{N} \beta_{2n} x_{ijn} + \sum_{k=1}^{K} \beta_{3k} z_{jk} + \mu_{0ij} + \nu_{0j}$$

[7] At the firm level, regional classification is sufficiently high to prevent reverse causality, as a single firm is unlikely to impact the entire region.

[8] To study regional differences in firms' innovative performance, note that higher-level variables in a multilevel framework do not vary at lower levels. All firms in a region share the same regional variable value, averaged over time to remove fluctuations.

where y_{tij}^{*} is a continuous unobserved latent variable (propensity to innovate) that is related to the observed y_{tij}, which refers to the outcome variable under consideration; x_{tij} represents *M* time-varying firm level variables, x_{ij} are *N* time-invariant firm level variables as for instance means fixed effects (Mundlak) and industrial fixed effects, and z_j are the *K* regional variables. Moreover, $\mu_{0ij} \sim N(0, \sigma_{\mu 0})$ and $\nu_{0j} \sim N(0, \sigma_{\nu 0})$ are the random parts of the model accounting by the unobserved heterogeneity at firm and regional level, respectively. These random effects are assumed independent of each other, of the covariates, and across regions.[9]

[9] The random part of the first-level, equivalent to ε_{tij}, is fixed ($\frac{\pi^2}{3}$), since we are estimating a latent class model (Rabe-Hesketh and Skrondal, 2012).

4. Results

In the current section, we present the results of the multilevel logit model as in equation (2), in which we distinguish between firm-level and regional-level determinants of product and process innovations. In our case, The Hausman test is uninformative for choosing between fixed and random effects estimation since we are accessing the same within-effect as in the fixed effect estimation.[10] Due to the poor within-variability of our set of variables (see Table A1), we think it is more appropriate to use random effects, since the estimation by fixed effects only exploits within-variabilities.

Table 1 presents the main results, where columns 1 and 2 have as dependent variable *IProd*, and *IProc*, respectively. They are estimated as a function of the number of environmental partners engaged in EU projects in the region, and a set of firm- and regional-level controls.[11] Specifically, we estimate the probability of engaging in product and process innovation and we observe that our key variable, *EU-funded env. partners,* is positive and highly significant for process innovations (column 2), but it is non-significant for product innovations (column 1). It seems, therefore, that hypothesis 1 is working in the case of Spanish firms, indicating that firms located in a region with one additional regional environmental partner are almost 2.6% more likely of being a process innovator. As commented in the literature review, this is probably related to the fact that the generation of process innovations benefits from collaboration especially upstream the value chain (suppliers, universities and research centers), so that environmental research made in collaboration thanks to the funding of the EU framework would enhance the development of process innovations with the purpose of reducing costs and improving efficiency. However, the non-significant impact on product innovation can be the result

[10] Running a Wald test to the means of the firm level variables is asymptotically equivalent to a Hausman test (Rabe-Hesketh and Skrondal, 2012).

[11] Tables show odds ratios: positive if greater than 1, negative if less than 1, except for variances in random part of the models.

of the two forces given in hypotheses H2a and H2b: the first implying a positive effect due to the complementarity between product and process innovations, and the latter presenting a negative influence due to the competition relationship in managerial resources between the two types of innovations as well as of being mainly driven by the market and less affected by the existing knowledge in the region.

[Table 1]

The control variables at the firm level present the expected sign. *Environmental investment* results highly significant for process, but not for product innovations. It seems that the environmental investments made by the firm has a positive impact on the outcome of the firm's innovative processes. These investments tap into the productive processes of firms (e.g. tangible and intangible assets) that are new to the firm, hence they are more likely to be tied in with process innovations. Thus, the commitment towards the environment ultimately impacts on the firms' innovation output, in particular, on the likelihood to have process innovations but not product innovation. As for the other control variables, larger firms are more likely to implement environmental investments and more likely of being product/process innovators. The variable that proxies for the technological intensity of the firm (*R&D per worker*) is positive and significant for product innovation and receiving public R&D funding influences positively environmental investments and process innovation. The variables *Cooperation* and *Foreign* at the firm level do not turn out to be statistically significant. As for the regional control variables, none is statistically significant. Finally, the Wald test to check for the significance of the set of industry and time dummy variables, as well as for the firms' mean values, conclude that all of them are jointly significant.

We turn now to consider the potential non-linearity in the effect of the regional number of partners in EU environmental projects on firms' innovation, as discussed in detail in Appendix B. We take account of this potential non-linearity through a logarithmic model (columns 3-4 in Table 1), and we observe that both product and process innovations are affected by the number of partners involved in environmental projects in the region, although with a different sign.[12] Again, the impact on the firm's process innovations is highly significant and positive whereas the effect on product innovations is significant but negative.[13] This result aligns with hypothesis H2b. It seems that product innovation is determined by market factors and is mainly customer driven, being less affected by the availability of knowledge in the local area, especially when such knowledge is accessible also to competitors. At the same time, the specificities of EU-funded research, devoted to collaborative research, would affect mostly process innovation, while being irrelevant and potentially detrimental for the generation of new products. All in all, we can conclude that the effect of the number of partners in regional environmental projects on the firms' innovative performance is a non-linear one and we will consider the use of logs in the remaining tables of this paper.

[12] When comparing the model using the regressor for EU-funded env. partners in levels with the model where the regressor is log-transformed —based on the log-likelihood, Akaike information criterion (AIC), and Bayesian information criterion (BIC)— the log-transformed model showed a marginally better fit both for IProd as well as for IProc estimation. The same conclusions hold when using McFadden's Pseudo R^2 (see Wooldridge, 2010. Chapter 15). While the differences are small, the results support our preference for the log-transformed specification. Notably, both AIC and BIC are commonly used to compare models by balancing goodness of fit and complexity in non-nested mixed-effects models (Rabe-Hesketh and Skrondal, 2012). We are grateful to a reviewer for this suggestion. Furthermore, Appendix B provides an extensive analysis of the non-linearity of EU-funded env. partners, reinforcing the log-transformed variable as the appropriate functional form.

[13] We explored the possibility of redefining the dependent variable as innovation intensity rather than propensity. While the ESEE dataset does not include the number of process innovations, or other measures commonly used to assess innovation intensity, it does provide the number of product innovations (NPI). Therefore, we re-estimated the model using NPI as the dependent variable to test the robustness of our findings. As shown in the results (not shown in the paper, but available upon request), the results are qualitatively and quantitatively similar to those obtained with the binary measure of product innovation, with coefficients being marginally significant. This reinforces our conclusion that the propensity to innovate, despite its limitations, provides a consistent and reliable proxy for both product and process innovation in the context of our study. We are grateful to a reviewer for this suggestion.

As a further step, we take advantage of the possibility of knowing the different type of organizations that participate in the EU-funded projects (*Education*, *Research*, *Business*, *Public*, *Other*) to study if the different kinds of knowledge –business oriented, basic knowledge or public knowledge –affects the firm's innovative performance differently. We estimate a separate model for the knowledge coming from each of the five types of organizations[14], as well as for the case of research-intensive organizations together (*Education and Research*), which tend to be the more common type of organizations in the EU-funded research projects. Tables 2 and 3 offer the results when the dependent variable refers to process and product innovations, respectively. For the case of process innovation, we observe that all kind of partners are positively and significantly correlated with process innovation, except the knowledge from partners in public organizations. It seems, therefore, that the local knowledge spillovers generated by the existence of partners participating in environmental EU projects influence more importantly the probability of the firms to carry out process innovations if such partners are from education organizations (universities) and research centers, followed by those from the business sector. Also, it is worth commenting that the category of *Others* (e.g. trade associations, regulatory bodies, among others) has the highest influence, although the miscellaneous types of organizations here make the interpretation more difficult. As for the case of product innovations, it is exactly the other way around. The only significant parameter is observed for public organizations, but in this case, with a negative sign. Thus, it seems that the negative impact observed in the general case of product innovations is mainly driven by this negative and significant parameter of the number of public organizations involved in environmental EU projects in the region.[15]

[14] We decided to include them separately to avoid multicollinearity problems.

[15] The same analysis as in Tables 2 and 3 has been performed without the logs in the main variables showing even higher statistical significance for them. Results can be provided upon request.

[Tables 2 and 3]

All in all, from the disaggregated results we may extract several conclusions. First, the general pattern of environment EU-funded research having a positive impact on firm process innovation and a negative one on firm product innovation is maintained. This is probably due to the idea of process innovation being driven by mainly cost reduction and increase in the efficiency which can be more easily done in collaboration with upstream agents (suppliers but also research centers and universities). While product innovation is more market driven and therefore less affected by the knowledge portfolio of the region. Second, the reason behind the negative influence of public bodies can be related to the type of organizations included (e.g. ministries, city governments, consortia related to public services such as water administration or transportation). These types of organizations may be weakly engaged in scientific research and innovation, although they may produce some relevant knowledge (e.g. related to the management of public resources). Their involvement in EU-funded projects seems to be particularly detrimental for firm product innovation (not process), since public bodies probably produce knowledge which is the most distant from the commercialization phase. This knowledge drains resources from firm product innovation, yet it is not strong enough to stimulate firm process innovation that, as we have seen, benefit more from knowledge created by suppliers and research-intensive organizations.

4.1. Robustness analysis

In a first step, we explore to what extent the results observed for the effect of local environmental projects may be driven by outliers, in particular, the richest and largest regions in Spain, such as Catalonia and Madrid. When we eliminate the firms belonging to these two regions (Table C1 in Appendix), we observe that they do not seem to be driving the significance and signs of the parameters of interest. On the contrary, the effect of the number of environmental partners in the region on the innovation carried out by the firms in the region remains equal, being positive in the case of process innovation and negative for product innovations.

We have also estimated the main models separately for SMEs and Large Enterprises (LEs) (Table C2 in Appendix), with the purpose of disentangling to what extent the size of the firm may imply a different role of environmental EU-funded research. As observed in previous literature, LEs and SMEs differ in the intensity of getting involved in collaborative projects, with SMEs focusing more on outsourcing rather than alliances because of the higher risks and costs of managing different partners while LEs prefer collaborative projects due to their larger portfolio of projects to offer to their partners (Narula, 2004). The signs of the two parameters of interest remain equal in both cases. However, their significance changes according to the size of the firms. We observe that the positive influence of the number of environmental partners in the region on the likelihood of firms generating process innovations is mainly observed in the case of SMEs, which is coherent with the evidence that SMEs have lower internal resources and it is easier for them to engage in process innovation. The negative impact on the generation of product innovation is mainly driven by LEs, suggesting that green knowledge spillovers slow down investment in new products, which require inhouse R&D and competitive technology base; under the presence of a high level of local green or non-green knowledge spillovers, LEs may consider that they cannot fully appropriate the investments made to get product innovations.

5. Conclusions and discussion

In this study, the relationship between environmental partnerships (through the FP7) in a region and firm-level product and process innovation was investigated using a multilevel model. The results indicate that the presence of partners engaged in EU-environmental projects in a region has a positive and significant impact on process innovation, but only a limited impact on product innovation. The study also reveals a non-linear effect of the number of regional environmental partners on the firm's innovation again, with a positive impact on process innovation and a negative one on product innovation.

Moreover, the study explores the effect of different types of organizations participating in the environmental projects (education, research, business, public, and others) on firm-level innovation and finds that local knowledge spillovers from education organizations and research centers, plus business sector have a positive impact on process innovation, while knowledge from public organizations is the one presenting a negative impact on product innovation.

This paper offers two original contributions. First, to the field of environmental innovation (Barbieri et al., 2016; Ghisetti and Pontoni, 2015), we provide a link between environmental EU-funded research under cooperation between different partners and firm general innovation through local green knowledge spillovers. Despite the impact of green knowledge spillovers on subsequent innovation has been investigated (e.g. Barbieri et al., 2020; Colombelli and Quatraro, 2019; Dechezleprêtre et al., 2014; Fabrizi et al., 2025, 2024), our original contribution to previous studies is on i) the aggregated regional green knowledge as an input of the innovation process, ii) the firm as the final level of observation for the innovation output, and iii) the separated effects on product and process innovation. Second, we contribute to the multilevel studies on firm innovation by incorporating local green knowledge among the relevant external regional factors (López-Bazo and Motellón, 2018; Rodríguez-Gulías et al., 2021).

Based on the results of the study presented, some policy recommendations can be made. The results suggest that a higher number of local organizations engaged in FP7-Environment projects has a positive and significant effect on the probability of local firms obtaining process innovations. Hence, policy makers can encourage local organizations to participate in such international research projects in the technological frontier of environmental innovation. On top of that, this may positively impact other local actors through knowledge spillovers. The results also indicate that different types of knowledge spillovers from different types of organizations affect product and process innovations differently. Policy makers can therefore design differentiated policies for product and process innovations to better support the local firms. Finally, public organizations seem to have a negative effect on product innovations. Policy makers can promote/reinforce partnerships between public organizations and firms to address this challenge and improve the impact of public organizations on firm's innovative performance.

This research is not without limitations. Our study assumes that all organizations participating in environmental projects are equally important, but different organizations may have different levels of influence and this may affect the type (and the intensity) of knowledge spillovers affecting the firm's innovation performance. The study makes some assumptions on the channels of knowledge transmissions among organizations that are very common in the knowledge spillover literature. A future research line would be to study this more in deep using other datasets that would allow the identification of such channels.

Declarations of interest: none

References

Alegre, I., Berbegal-Mirabent, J., Martin-Sanchez, V., 2024. The role of experience and diversity on research consortia' performance: an exploratory approach. Small Bus.

Econ. 64, 113–132.
Amoroso, S., Coad, A., Grassano, N., 2018. European R&D networks: a snapshot from the 7th EU Framework Programme. Econ. Innov. New Technol. 27, 404–419. https://doi.org/10.1080/10438599.2017.1374037
Ardito, L., Petruzzelli, A.M., Ghisetti, C., 2019. The impact of public research on the technological development of industry in the green energy field. Technol. Forecast. Soc. Change 144, 25–35. https://doi.org/10.1016/J.TECHFORE.2019.04.007
Audretsch, D.B., Belitski, M., 2022. The knowledge spillover of innovation. Ind. Corp. Chang. 00, 1–29.
Audretsch, D.B., Belitski, M., Caiazza, R., 2021. Start-ups, Innovation and Knowledge Spillovers. J. Technol. Transf. 46, 1995–2016. https://doi.org/10.1007/s10961-021-09846-5
Ballot, G., Fakhfakh, F., Galia, F., Salter, A., 2015. The fateful triangle: Complementarities in performance between product, process and organizational innovation in France and the UK. Res. Policy 44, 217–232. https://doi.org/10.1016/J.RESPOL.2014.07.003
Barajas, A., Huergo, E., Moreno, L., 2012. Measuring the economic impact of research joint ventures supported by the EU Framework Programme. J. Technol. Transf. 37, 917–942. https://doi.org/10.1007/S10961-011-9222-Y/TABLES/9
Barbieri, N., Ghisetti, C., Gilli, M., Marin, G., Nicolli, F., 2016. a Survey of the Literature on Environmental Innovation Based on Main Path Analysis. J. Econ. Surv. 30, 596–623. https://doi.org/10.1111/joes.12149
Barbieri, N., Marzucchi, A., Rizzo, U., 2020. Knowledge sources and impacts on subsequent inventions: Do green technologies differ from non-green ones? Res. Policy 49, 103901. https://doi.org/10.1016/j.respol.2019.103901
Barras, R., 1990. Interactive innovation in financial and business services: The vanguard of the service revolution. Res. Policy 19, 215–237. https://doi.org/10.1016/0048-7333(90)90037-7
Cassi, L., Corrocher, N., Malerba, F., Vonortas, N., 2008. The impact of EU-funded research networks on knowledge diffusion at the regional level. Res. Eval. 17, 283–293. https://doi.org/10.3152/095820208X364535
Cecere, G., Corrocher, N., Gossart, C., Ozman, M., 2014. Technological pervasiveness and variety of innovators in Green ICT: A patent-based analysis. Res. Policy 43, 1827–1839. https://doi.org/10.1016/J.RESPOL.2014.06.004
Cohen, W.M., Levinthal, D.A., 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. Adm. Sci. Q. 35, 128–152.
Colombelli, A., Quatraro, F., 2019. Green start-ups and local knowledge spillovers from clean and dirty technologies. Small Bus. Econ. 52, 773–792. https://doi.org/10.1007/S11187-017-9934-Y/METRICS
D'Agostino, L.M., Moreno, R., 2019. Green regions and local firms' innovation. Pap. Reg. Sci. 98, 1585–1608. https://doi.org/10.1111/pirs.12427
D'Este, P., Guy, F., Iammarino, S., 2013. Shaping the formation of university-industry research collaborations: What type of proximity does really matter? J. Econ. Geogr. 13, 537–558. https://doi.org/10.1093/jeg/lbs010
Damanpour, F., Gopalakrishnan, S., 2001. The Dynamics of the Adoption of Product and Process Innovations in Organizations. J. Manag. Stud. 38, 45–65. https://doi.org/10.1111/1467-6486.00227
Dechezleprêtre, A., Martin, R., Mohnen, M., 2014. Knowledge spillovers from clean and dirty technologies: a patent citation analysis.
Di Cagno, D., Fabrizi, A., Meliciani, V., Wanzenböck, I., 2016. The impact of relational

spillovers from joint research projects on knowledge creation across European regions. Technol. Forecast. Soc. Change 108, 83–94. https://doi.org/10.1016/J.TECHFORE.2016.04.021
Ettlie, J.E., Reza, E.M., 1992. Organizational integration and process innovation. Acad. Manag. J. 35, 795–827. https://doi.org/10.2307/256316
Fabrizi, A., Fiorelli, C., Meliciani, V., 2025. The role of green networks for environmental innovation in European regions. J. Ind. Bus. Econ. 1–32.
Fabrizi, A., Guarini, G., Meliciani, V., 2024. The impact of environmental research networks on green exports: An analysis of a sample of European countries. Struct. Chang. Econ. Dyn. 69, 143–154. https://doi.org/10.1016/J.STRUECO.2023.11.017
García Muñiz, A.S., Cuervo, M.R.V., 2018. Exploring research networks in Information and Communication Technologies for energy efficiency: An empirical analysis of the 7th Framework Programme. J. Clean. Prod. 198, 1133–1143. https://doi.org/10.1016/J.JCLEPRO.2018.07.049
Ghisetti, C., Pontoni, F., 2015. Investigating policy and R&D effects on environmental innovation: A meta-analysis. Ecol. Econ. 118, 57–66. https://doi.org/10.1016/J.ECOLECON.2015.07.009
Gilli, M., Mancinelli, S., Mazzanti, M., 2014. Innovation complementarity and environmental productivity effects: Reality or delusion? Evidence from the EU. Ecol. Econ. 103, 56–67. https://doi.org/10.1016/J.ECOLECON.2014.04.004
Hameri, A.P., 1996. Technology transfer between basic research and industry. Technovation 16, 51–92. https://doi.org/10.1016/0166-4972(95)00030-5
Hullova, D., Trott, P., Simms, C.D., 2016. Uncovering the reciprocal complementarity between product and process innovation. Res. Policy 45, 929–940. https://doi.org/10.1016/J.RESPOL.2016.01.012
Jaffe, A.B., Trajtenberg, M., Henderson, R., 1993. Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations. Source Q. J. Econ. 108, 577–598.
Lanoie, P., Laurent-Lucchetti, J., Johnstone, N., Ambec, S., 2011. Environmental Policy, Innovation and Performance: New Insights on the Porter Hypothesis. J. Econ. Manag. Strateg. 20, 803–842. https://doi.org/10.1111/J.1530-9134.2011.00301.X
López-Bazo, E., Motellón, E., 2018. Innovation, heterogeneous firms and the region: evidence from Spain. Reg. Stud. 52, 673–687. https://doi.org/10.1080/00343404.2017.1331296
Matt, M., Robin, S., Wolff, S., 2012. The influence of public programs on inter-firm R&D collaboration strategies: Project-level evidence from EU FP5 and FP6. J. Technol. Transf. 37, 885–916. https://doi.org/10.1007/S10961-011-9232-9/METRICS
Meliciani, V., Di Cagno, D., Fabrizi, A., Marini, M., 2022. Knowledge networks in joint research projects, innovation and economic growth across European regions. Ann. Reg. Sci. 68, 549–586. https://doi.org/10.1007/S00168-021-01092-9/TABLES/10
Miotti, L., Sachwald, F., 2003. Co-operative R&D: why and with whom?: An integrated framework of analysis. Res. Policy 32, 1481–1499. https://doi.org/10.1016/S0048-7333(02)00159-2
Narula, R., 2004. R&D collaboration by SMEs: New opportunities and limitations in the face of globalisation. Technovation 24, 153–161. https://doi.org/10.1016/S0166-4972(02)00045-7
Naz, A., Niebuhr, A., Peters, J.C., 2015. What´s behind the disparities in firm innovation rates across regions? Evidence on composition and context effects. Ann. Reg. Sci. 55, 131–156. https://doi.org/10.1007/s00168-015-0694-9
Nepelski, D., Van Roy, V., 2021. Innovation and innovator assessment in R&I

ecosystems: the case of the EU Framework Programme. J. Technol. Transf. 46, 792–827. https://doi.org/10.1007/S10961-020-09814-5/TABLES/10
Noailly, J., Shestalova, V., 2017. Knowledge spillovers from renewable energy technologies: Lessons from patent citations. Environ. Innov. Soc. Transitions 22, 1–14. https://doi.org/10.1016/J.EIST.2016.07.004
Popp, D., Newell, R., 2012. Where does energy R&D come from? Examining crowding out from energy R&D. Energy Econ. 34, 980–991. https://doi.org/10.1016/J.ENECO.2011.07.001
Rabe-Hesketh, S., Skrondal, A., 2012. Multilevel and longitudinal modeling using Stata.
Rahmani, A., Bonyadi Naeini, A., Mashayekh, J., Aboojafari, R., Daim, T., Yalcin, H., 2024. Green innovation for a greener future: A meta-analysis of the impact on environmental performance. J. Clean. Prod. 460, 142547. https://doi.org/10.1016/J.JCLEPRO.2024.142547
Reichstein, T., Salter, A., 2006. Investigating the sources of process innovation among UK manufacturing firms. Ind. Corp. Chang. 15, 653–682. https://doi.org/10.1093/ICC/DTL014
Rennings, K., 2000. Redefining innovation — eco-innovation research and the contribution from ecological economics. Ecol. Econ. 32, 319–332. https://doi.org/10.1016/S0921-8009(99)00112-3
Robin, S., Schubert, T., 2013. Cooperation with public research institutions and success in innovation: Evidence from France and Germany. Res. Policy 42, 149–166. https://doi.org/10.1016/j.respol.2012.06.002
Rodríguez-Gulías, M.J., Rodeiro-Pazos, D., Fernández-López, S., Nogueira-Moreiras, M.Á., 2021. The effect of regional resources on innovation: a firm-centered approach. J. Technol. Transf. 46, 760–791. https://doi.org/10.1007/S10961-020-09811-8/FIGURES/8
Roper, S., Love, J.H., Bonner, K., 2017. Firms' knowledge search and local knowledge externalities in innovation performance. Res. Policy 46, 43–56. https://doi.org/10.1016/j.respol.2016.10.004
Salter, A.J., Martin, B.R., 2001. The economic benefits of publicly funded basic research: a critical review. Res. Policy 30, 509–532. https://doi.org/10.1016/S0048-7333(00)00091-3
Scarrà, D., Piccaluga, A., 2022. The impact of technology transfer and knowledge spillover from Big Science: a literature review. Technovation 116, 102165. https://doi.org/10.1016/J.TECHNOVATION.2020.102165
Tether, B.S., 2002. Who co-operates for innovation, and why. Res. Policy 31, 947–967. https://doi.org/10.1016/S0048-7333(01)00172-X
Un, C.A., Asakawa, K., 2015. Types of R&D Collaborations and Process Innovation: The Benefit of Collaborating Upstream in the Knowledge Chain. J. Prod. Innov. Manag. 32, 138–153. https://doi.org/10.1111/JPIM.12229
Utterback, J.M., Abernathy, W.J., 1975. A dynamic model of process and product innovation. Omega 3, 639–656. https://doi.org/10.1016/0305-0483(75)90068-7
Van Beers, C., Zand, F., 2014. R&D cooperation, partner diversity, and innovation performance: An empirical analysis. J. Prod. Innov. Manag. 31, 292–312. https://doi.org/10.1111/jpim.12096
Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data, 2nd ed. The MIT press, London.

Table 1. Environmental EU-funded research

VARIABLES	(1) IProc	(2) IProd	(3) IProc	(4) IProd
EU-funded env. partners	1.026**	0.984		
	(0.011)	(0.024)		
EU-funded env. partners (in logs)			1.497**	0.610**
			(0.246)	(0.129)
Environmental investment	1.453**	1.324	1.452**	1.325
	(0.249)	(0.236)	(0.249)	(0.236)
Collaboration	1.298*	1.275	1.299*	1.273
	(0.199)	(0.210)	(0.199)	(0.210)
R&D per worker	1.032	1.095***	1.032	1.096***
	(0.032)	(0.038)	(0.032)	(0.038)
Size	2.562***	1.442***	2.569***	1.437***
	(0.356)	(0.184)	(0.356)	(0.181)
R&D government	1.328**	0.827	1.327**	0.828
	(0.181)	(0.165)	(0.181)	(0.165)
Export	1.136	1.479*	1.138	1.476*
	(0.198)	(0.323)	(0.198)	(0.320)
Foreign	0.827	1.306	0.829	1.303
	(0.191)	(0.374)	(0.191)	(0.374)
Regional Researchers	0.706	1.897	0.787	1.550
	(0.190)	(0.854)	(0.203)	(0.694)
Manufacture share	1.003	0.968	1.002	0.974
	(0.009)	(0.026)	(0.009)	(0.022)
Pop density	1.000	1.000	0.999*	1.001
	(0.000)	(0.001)	(0.001)	(0.001)
Environmental manufacture expenditure	0.988	1.305	0.816	1.800***
	(0.099)	(0.213)	(0.138)	(0.340)
Constant	0.132	0.001***	3.203	0.001***
	(0.281)	(0.000)	(10.265)	(0.000)
Observations	9,817	9,817	9,817	9,817
Number of groups	17	17	17	17
LR test Firm random intercept	1311***	1015***	1308***	1011***
LR test region random intercept	1.21e-09	8.76e-09	9.18e-08	1.32e-08
Wald Test Mean values	204.8***	469***	202***	440.1***
Wald Test Time dummies	34.42***	42.66***	34.51***	42.61***
Wald Test Sector dummies	2890***	2428***	621.8***	2826***

Note: Robust SE in parentheses. *** p<0.01, ** p<0.05, * p<0.1. *IProc* and *IProd* equas 1 if the enterprise developed process innovations or product innovations, respectively, and 0 otherwise.

Table 2. Environmental EU-funded research by type of partner. Process innovation

	(1)	(2)	(3)	(4)	(5)	(6)
EU-funded env. partners (Res and Educ)	1.667**					
	(0.351)					
EU-funded env. partners (Education)		1.428*				
		(0.269)				
EU-funded env. partners (Research)			1.370*			
			(0.246)			
EU-funded env. partners (Business)				1.250*		
				(0.142)		
EU-funded env. partners (Public)					1.694	
					(0.618)	
EU-funded env. partners (Other)						1.798**
						(0.428)
Regional and Firm-level controls	YES	YES	YES	YES	YES	YES
Constant	4.543	0.143	0.273	0.138	0.017***	0.045*
	(15.094)	(0.344)	(0.723)	(0.340)	(0.021)	(0.073)
Observations	9,817	9,817	9,817	9,817	9,817	9,817
Number of groups	17	17	17	17	17	17
LR test Firm random intercept	1305***	1308***	1310***	1312***	1313***	1312***
LR test region random intercept	3.03e-08	2.15e-09	7.30e-09	1.30e-08	3.41e-09	2.33e-07
Wald Test Mean values	204.6***	192.8***	210.8***	199.8***	191.6***	204.9***
Wald Test Time dummies	34.40***	34.41***	34.38***	34.46***	34.44***	34.46***
Wald Test Sector dummies	552.2***	629.7***	475.7***	4012***	571.1***	2502***

Note: Robust SE in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is *IProc* equals to 1 if the enterprise developed process innovations and 0 otherwise. Controls as in Table 1 included.

Table 3. Environmental EU-funded research by type of partner. Product innovation

	(1)	(2)	(3)	(4)	(5)	(6)
EU-funded env. partners (Res and Edu)	0.686					
	(0.241)					
EU-funded env. partners (Education)		1.136				
		(0.341)				
EU-funded env. partners (Research)			0.720			
			(0.240)			
EU-funded env. partners (Business)				0.764		
				(0.184)		
EU-funded env. partners (Public)					0.115***	
					(0.056)	
EU-funded env. partners (Other)						0.756
						(0.383)
Regional and Firm-level controls	YES	YES	YES	YES	YES	YES
Constant	0.000***	0.001***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	9,817	9,817	9,817	9,817	9,817	9,817
Number of groups	17	17	17	17	17	17
LR test Firm random intercept	1014***	1017***	1015***	1013***	1006***	1016***
LR test region random intercept	-9.25e-08	3.57e-08	3.56e-08	-1.11e-06	-1.33e-09	-1.84e-08
Wald Test Mean values	447.7***	459.9***	426.6***	479.7***	451.1***	461.6***
Wald Test Time dummies	42.67***	42.49***	42.57***	42.61***	42.18***	42.60***
Wald Test Sector dummies	2723***	13443***	3105***	2416***	37882***	20134***

Note: Robust SE in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The dependent variable is *IProc* equals to 1 if the enterprise developed process innovations and 0 otherwise. Controls as in Table 1 included.

Appendix A.

A.1. Descriptive analysis of the dataset

In the ESEE, firms are classified into twenty industries using the two-digit European classification NACE. The ESEE's population of reference is composed of firms with 10 or more employees within the manufacturing industry. The SEPI carries out an initial selection combining exhaustiveness for firms with more than 200 employees and random sampling for firms employing 10 to 200 workers. These firms were selected through a stratified, proportional, and systematic sampling with a random seed. Given that the ESEE is a survey in which values are self-reported, one could think of the problem of measurement errors and/or self-reported values. However, in this kind of survey, where anonymity is a legal concern, we do not expect a systematic propensity for over or under-reporting the innovation carried out by the enterprise.

Next, we make a descriptive analysis of the variables used in this paper. Table A1 shows the descriptive statistics at the firm-level. First thing to notice is that the percentage of firms doing process innovations doubles the one of firms doing product innovations. Also, around 23 percent of firms have done investments in environmental issues, while nearly one third of the firms collaborate with other institutions. We also see that around 8 percent of firms have received public funding from the government to carry out R&D investments, while they spend, on average, around 1528 euros per employee in R&D. While 13 percent of firms are multinational, 68 percent are oriented to international markets.

Going to the regional variables, Table A2 shows our key variable: the number of partners by region and type of partners. There is high variability in the number of environmental partners for the different regions. We observe that Catalonia and Madrid have approximately 42 and 32 times more partners than Castile Leon, respectively. The latter is especially true for the case of *Research* and *Business* partners, being the regional differences less appreciated in the case of the *Education* and *Public* partners. It is also interesting to notice the number of regions with zero number of partners in some of the categories, leading to some of the regions only presenting one type of partner, like for instance the case of Balearic Islands as well as Extremadura, in which the relevance is only placed in the *Business* category. This high variance is partially explained by differences in the size of the regions.

As for the regional controls (Table A3), we see regions like Catalonia, Andalusia, and Basque Country representing the share of the lion of the environmental expenditures (*Env. Total Manuf. Expenditure*). For the case of the manufacture share of employment, there are regions more specialized in production activities, and in some cases, they are also the wealthiest regions of the country (e.g. Basque country, Catalonia). We find another important regional difference with respect to the density of the regions, where the difference between the most densely populated region (Madrid) is around 30 times bigger than the least densely populated (Castile Leon). Finally, the regions having the highest percentage of researchers are Basque Country, Navarre, and Madrid.

Table A1. Descriptive statistics of firm-level variables

Variable		Mean	Std. Dev.	Min	Max	Observations
IProd	overall	0.176	0.381	0	1	N = 14589
	between		0.300	0	1	n = 2948
	within		0.245	-0.699	1.051	Tbar = 4.948
IProc	overall	0.334	0.472	0	1	N = 14589
	between		0.379	0	1	n = 2948
	within		0.314	-0.541	1.209	Tbar = 4.948
Environmental investment	overall	0.229	0.420	0	1	N = 12580
	between		0.349	0	1	n = 2730
	within		0.247	-0.628	1.086	Tbar = 4.608
Collaboration	overall	0.310	0.462	0	1	N = 14589
	between		0.404	0	1	n = 2948
	within		0.229	-0.565	1.185	Tbar = 4.948
R&D per worker	overall	1527.776	4852.449	0	122595.5	N = 14536
	between		4450.089	0	95887.4	n = 2941
	within		1986.355	-44578.93	36829.24	Tbar = 4.942
Size	overall	192.884	666.656	1	13091	N = 14589
	between		585.820	1	12449.25	n = 2948
	within		78.219	-1805.616	2943.509	Tbar = 4.948
R&D government	overall	0.076	0.265	0	1	N = 14588
	between		0.204	0	1	n = 2947
	within		0.172	-0.799	0.951	Tbar = 4.950
Export	overall	0.681	0.466	0	1	N = 14589
	between		0.453	0	1	n = 2948
	within		0.169	-0.194	1.556	Tbar = 4.948
Foreign	overall	0.139	0.345	0	1	N = 14589
	between		0.316	0	1	n = 2948
	within		0.107	-0.736	1.014	bar = 4.948

Table A2. Regional-level variables: Average number of partners in Environment field by type of partner

Regions	Total	Education	Research	Business	Public	Other
Andalusia	5.143	1.857	0.429	2.571	0.286	0
Aragon	1.429	0.571	0.143	0.286	0.143	0.286
Asturias	0.857	0.286	0.143	0.429	0	0
Balearic Islands	0.143	0	0	0.143	0	0
Canary Islands	0.857	0.429	0.143	0	0.286	0
Cantabria	1.286	0.714	0	0.429	0.143	0
Castile Leon	0.429	0.286	0	0.143	0	0
Castile la Mancha	1.571	0.286	0.571	0.714	0	0
Catalonia	18.143	2.857	6.286	7.857	0.429	0.714
Valencia	5	1.714	1.857	1.286	0.143	0
Extremadura	0.143	0	0	0.143	0	0
Galicia	1.857	0.714	.286	0.429	0.429	0
Madrid	13.714	1.857	3.571	6	1.714	0.571
Murcia	0.857	0.429	0.143	0.143	0	0.143
Navarre	0.714	0.143	0.143	0.429	0	0
Basque Country	4.857	0.143	2.857	1.143	0.429	0.286
La Rioja	0	0	0	0	0	0
National average	3.352	0.723	0.975	1.303	0.235	0.118

Table A3. Descriptive statistics of regional-level variables

Regions	Env. Total Manuf. Expenditure	Manuf. Share of Employment	Density	Regional Researchers
Andalusia	280.6203	7.762	96.237	0.507
Aragon	82.8673	17.587	28.163	0.762
Asturias	84.28124	12.8	100.925	0.582
Balearic Islands	7.548311	5.8	220.125	0.283
Canary Islands	31.59475	4.337	279.2	0.357
Cantabria	48.45491	14.988	111.638	0.5
Castile Leon	131.8557	14.55	26.913	0.626
Castile la Mancha	114.39	14.713	26.337	0.224
Catalonia	563.7107	17.762	232.85	0.823
Valencia	203.1768	15.963	215.6	0.615
Extremadura	15.626	8.887	26.938	0.362
Galicia	130.9953	14.637	94	0.539
Madrid	102.5309	8.1	801.013	1.046
Murcia	67.49979	11.938	128.938	0.711
Navarre	68.76095	24.7	61.325	1.173
Basque Country	194.1381	20.625	301.913	1.213
La Rioja	21.35299	23.988	63.188	0.617
National Average	126.4355	14.066	165.605	0.6434

Note: Env. Total Manuf. Expenditure is divided by 1 million to ease the reading of the variable.

A.2. Variables description

Firm-level variables

We use two different dependent variables: product and process innovation. First, we proxy for the innovative output of the enterprises in terms of product innovations, *IProd*, which is equal to one in case the enterprise developed product innovations in the current year, and zero otherwise (López-Bazo & Motellón, 2018; Naz et al., 2015). In the same line, we build a similar dichotomous variable for the case of process innovation, *IProc* – equal to one in case the enterprise developed process innovations in the current year, and zero otherwise.

As a key firm-level control, we consider if firms have made investments related to the protection of the environment (e.g. reduction of toxic emissions, waste management, or energy savings). The variable *Environmental investments* proxies for the firm's environmental investment, being equal to one in case the enterprise does an environmental investment, and zero otherwise. We use this explanatory variable when studying product and process innovations to account for the investment effort firms do in green innovations in order not to confound with our main objective. This way we can analyse the regional effect of the environmental partners discarding the effort that some firms do in environmental issues irrespectively of collaborating in the FP.

To control for other firm-level characteristics we use the variable *Collaboration*, which captures whether the firm has acquired external knowledge, an issue that has been observed to have an important role on the firm's innovative performance, specifically on product innovation (Robin & Schubert, 2013). It is measured as a dummy variable equal to one if the firm cooperates in innovation activities in a given year with other organizations, and zero otherwise. To account for the internal capabilities of firms (Cohen & Levinthal, 1990), we use the amount of total R&D per worker in the enterprise (*Total*

R&D per worker). To measure the size of the firm (*Size*), we use the total number of employees. We also include a dummy variable which equals 1 in the case the firm received public funding – regional, central, or others – above the average, to develop R&D, and zero otherwise (*R&D government*). We also capture the importance of accessing foreign markets with the idea that a firm facing more competition tends to be more innovative (*Export*). This variable is a dummy equal to 1 if the firm sells its products in the international market, and zero otherwise. Finally, another relevant variable is whether the firm belongs to a multinational corporate group, since this may imply the access to key capabilities and resources (e.g. best managerial practices, cutting-edge technologies, or greater financial resources) (López-Bazo & Motellón, 2018; Nieto & Santamaría, 2010). We proxy it with a dummy variable (*Foreign*) being 1 in the case the firm has more than 50 percent of its capital from abroad.

Regional-level variables

The interest of the present study is on the relation between the externality coming from the regional context, and specifically, from the indicator of environmental international research collaboration – from the FP7 – and the firm's innovative performance. Therefore, our main focal variable is EU-funded env. partners, which is the number of partners[16] (i.e. Spanish organizations collaborating with foreign organizations in environmental fields of the FP7 program) by region and year, which we also disaggregate into the different types of partners: Higher or Secondary Education Establishments – HES (*Education*), Research Organisations – REC (*Research*), Private for-profit entities (excluding Higher or Secondary Education Establishments) – PRC (*Business*), Public

[16] The same organization (institution) might be participating in several projects in the same year. If it is so, to avoid counting the institution several times, we decided to count it only once. This is done to consider the real effect of having "more" local institutions doing EU-funded collaborations.

bodies (excluding Research Organisations and Secondary or Higher Education Establishments) – PUB (*Public*), and then a residual category that we call *Other* (e.g. trade association, regulatory bodies, among others).

In addition, we control for other regional characteristics to isolate as much as possible the relation between the two variables of interest, avoiding the bias due to confounding with other context specific characteristics (Manski, 1993). We consider the number of regional R&D researchers as a percentage of the total number of employees (*Regional Researchers*). We also control for the industrial specialization, which is proxied with the employment share in manufacturing (*Manufacture share*);[17] as well as for the agglomeration economies, using the number of inhabitants per squared kilometer (*Pop. density*). Finally, we account for the sum of the current expenditures and investments on environmental protection made by all firms to avoid, reduce or eliminate the pollution resulting from their activities in a region (*Environmental manufacture expenditure*).[18]

We introduce industry and time dummy variables to account for industrial and specificities of the economic context. All the explanatory variables are one-year lagged to lessen simultaneity problems.[19]

A.3. Hierarchical model

First, the use of standard estimations (e.g. OLS) does not take into account the dependence of those firm observations within the same region ending in a smaller standard error, which would lead to artificially higher significance of the parameters (Hox, 2002). They

[17] Notice that we averaged these variables by region through all the period (see footnote 5 in the paper).

[18] Expenditures are defined as "those operating expenses […] whose main objective is the prevention, reduction, treatment or elimination of the pollution or any other degrading of the environment arising as a result of the activity of the establishment" ; and investments are defined as "the capital resources acquired to be used in the productive process for more than one year, purchases of capital goods or intangible assets carried out by the company during the reference year–." See methodological note: http://www.ine.es/en/daco/daco42/ambiente/metoemin_en.pdf

[19] Especially at the firm level, since the regional classification is high enough to guarantee no reverse causality, since it is unlikely that a single firm can affect the whole region.

are usually assumed to be independent under this method of estimation, whereas firms within the same region are more likely to be more similar among them than those in different regions (van Oort et al., 2012). Second, the use of the multilevel approach allows us to model variances instead of means as in the case of standard OLS regressions. This allows dividing the total effect into firm-level effects and regional-level effects through random intercepts accounting for unobserved heterogeneity (van Oort et al., 2012).

Since our number of regions is not too high – 17 groups – we are aware of a possible bias in our estimates, specifically, in the case of the regional variance component (Maas & Hox, 2005). Previous research on the topic making use of multilevel modeling with a similar number of regions can be found in (López-Bazo & Motellón, 2018), also with 17 groups, and (Srholec, 2015) with 15 groups. Following Stegmueller (2013), the random intercept model is the best-case scenario when the amount of the highest level group is in between 15 and 20. In such a case, the bias of the macro effects as well as the confidence interval are virtually inexistent, justifying the use of the random intercept model instead of the random slope one.

One of the assumptions of the multilevel model is the absence of correlation among the explanatory variables and the random effects, otherwise leading to inconsistent estimations (Rabe-Hesketh & Skrondal, 2012). We correct this possible endogeneity relying on Mundlak (1978) and divide the time varying explanatory variables at the firm level into between and within effects using the mean of those variables (Snijders & Bosker, 2012). This way, we guarantee the absence of endogeneity due to the correlation among the firm level variables and the firm's random effects. In addition, with the fixed effect estimation it is not possible to model the effect of the regional context on the firm level performance, which can be done in the multilevel model. That is, with the fixed effect estimation it is not possible to do inferences about time invariant variables as well as for higher-level variances (Bell & Jones, 2015).

Appendix B. Non-linearity in the relationship between environmental EU-funded research and firms' innovation.

The non-linearity in the relationship between environmental EU-funded research and firms' innovation can be observed at Figure B1 and B2, where the predicted probability of the number of environmental partners on process and product innovations are shown, respectively, for different levels of partners (based on square terms as shown in Table B1). As we can see, the regions taking the most benefit from the externality coming from partners associated in environmental projects are those with a high number of partners in the case of process innovation and with a low number of partners in the case of product innovation

Figure B1. Predicted probability of environmental partners on process innovation.

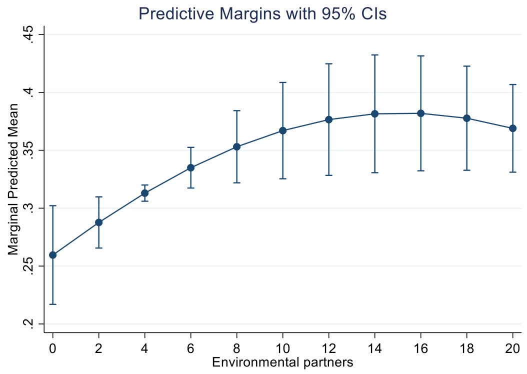
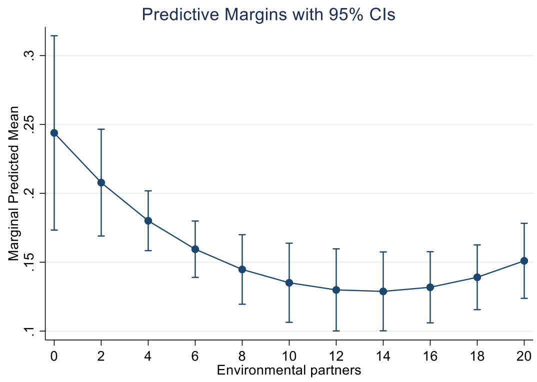


Figure B2. Predicted probability of environmental partners on product innovation.



To gain deeper insights about the U-shape of the relationship between environmental partners and product innovations, as well as about the inverted U-shape of the relationship between environmental partners and process innovations, we next perform several robustness analyses (Haans et al., 2016). First thing to notice is that the turning point in all the cases is located within the data range (Figure B1 and B2). Second, we check that the slope at both high and low levels of the number of environmental partners has the hypothesized sign and significance (Table B1 at bottom columns 1-2). Third, in order to check that the functional form is quadratic, we re-estimate the model with a cubic term (Table B1 columns 3-4), finding that the cubic pattern does not hold, since it does not improve the fit of the model. We also convert the Environmental partners variable into 5 dummy variables (quintiles) taking the first one as the reference category (Table B2 columns 1-2). With the latter, we let the Environmental partners variable to freely take its shape instead of imposing it. In this case, the pattern is close to a non-lineal one in all the cases but not exactly a quadratic one. For the cases of environmental partners and product innovations, we can see that the effect is lower (negative) the more partners in environmental projects the region has; however, in the case of process innovations, it is quite the opposite, being positive and higher the more partners the region has, being most of them significant.

We also check if the quadratic shape of the model might be driven by the presence of outliers. We re-estimate the model censoring the data and eliminating the top/bottom 10^{th} percentile from the estimation as can be seen in columns 3-5 in Table B2. The results show that the quadratic shape remains only for the case of process innovation. Finally, we estimate the models in logs (tables in the main text) and observe that both product and process innovations are affected by the number of partners involved in environmental projects in the region, and also confirm that the non-lineal pattern is not a quadratic one, but a logarithmic one. In any case, we can conclude that the effect of the partners in regional environmental projects on the firms' innovative performance is a non-linear one.

Table B1. Testing the quadratic shape.

VARIABLES	(1) IProc	(2) IProd	(3) IProc	(4) IProd
EU-funded env. partners	1.157**	0.779**	1.182	0.728**
	(0.071)	(0.088)	(0.121)	(0.103)
EU-funded env. partners (squared)	0.995**	1.009**	0.990	1.026
	(0.002)	(0.005)	(0.016)	(0.033)
EU-funded env. partners (cubic)			1.000	0.999
			(0.001)	(0.001)
Environmental investment	1.452**	1.324	1.452**	1.325
	(0.249)	(0.236)	(0.249)	(0.236)
Collaboration	1.299*	1.274	1.299*	1.275
	(0.199)	(0.210)	(0.199)	(0.210)
R&D per worker	1.032	1.096***	1.032	1.096***
	(0.032)	(0.038)	(0.032)	(0.038)
Size	2.568***	1.433***	2.570***	1.430***
	(0.357)	(0.180)	(0.357)	(0.183)
R&D government	1.328**	0.828	1.328**	0.828
	(0.181)	(0.166)	(0.181)	(0.166)
Export	1.137	1.475*	1.138	1.473*
	(0.198)	(0.321)	(0.198)	(0.322)
Foreign	0.830	1.298	0.830	1.300
	(0.190)	(0.371)	(0.191)	(0.373)
Regional Researchers	0.754	1.628	0.758	1.596
	(0.193)	(0.751)	(0.181)	(0.739)
Manufacture share	1.005	0.967	1.004	0.972
	(0.009)	(0.024)	(0.010)	(0.028)
Pop density	0.999*	1.001*	0.999	1.001
	(0.001)	(0.001)	(0.001)	(0.001)
Environmental manufacture expenditure	0.835	1.831***	0.831	1.865***
	(0.124)	(0.361)	(0.132)	(0.336)
Constant	2.333	0.000***	2.532	0.000***
	(6.701)	(0.000)	(7.719)	(0.000)
Observations	9,817	9,817	9,817	9,817
Number of groups	17	17	17	17
LR test Firm random intercept	1306***	1009***	1306***	1010***
LR test region random intercept	2.92e-08	-3.54e-08	2.82e-09	-1.42e-07
Wald Test Mean values	200.3***	441.8***	196.7***	447.7***
Wald Test Time dummies	34.44***	42.99***	34.44***	43.01***
Wald Test Industry dummies	3434***	3466***	1653***	2772***
Test lowest value	0.137**	-0.255**		
Test highest value	-0.0259	0.0947		
Turning point	15.57	13.50		

Table B2. Testing the quadratic shape.

VARIABLES	(1) IProc	(2) IProd	(3) IProc	(4) IProd
EU-funded env. partners 2nd	1.478**	0.465**		
	(0.230)	(0.148)		
EU-funded env. partners 3rd	1.755**	0.597		
	(0.413)	(0.235)		
EU-funded env. partners 4th	1.539**	0.424**		
	(0.294)	(0.145)		
EU-funded env. partners 5th	2.544***	0.340*		
	(0.885)	(0.191)		
EU-funded env. partners			1.505**	1.232
			(0.292)	(0.419)
EU-funded env. partners (squared)			0.983*	0.988
			(0.009)	(0.017)
Environmental investment	1.451**	1.327	1.341	1.358
	(0.249)	(0.236)	(0.277)	(0.360)
Collaboration	1.301*	1.268	1.187	1.428*
	(0.199)	(0.211)	(0.148)	(0.296)
R&D per worker	1.032	1.095***	1.041	1.102**
	(0.032)	(0.038)	(0.048)	(0.055)
Size	2.568***	1.451***	2.354***	1.266
	(0.355)	(0.184)	(0.420)	(0.231)
R&D government	1.324**	0.830	1.366*	0.826
	(0.180)	(0.166)	(0.230)	(0.253)
Export	1.139	1.481*	1.059	1.354
	(0.198)	(0.321)	(0.251)	(0.322)
Foreign	0.829	1.298	0.926	1.309
	(0.191)	(0.369)	(0.318)	(0.599)
Regional Researchers	1.171	1.312	0.903	1.819
	(0.356)	(0.822)	(0.191)	(0.678)
Manufacture share	0.982	0.973	1.010	0.959
	(0.020)	(0.033)	(0.013)	(0.030)
Pop density	0.999	1.000	0.998*	0.999
	(0.000)	(0.001)	(0.001)	(0.002)
Environmental manufacture expenditure	0.849	1.631**	0.441*	0.636
	(0.122)	(0.370)	(0.191)	(0.435)
Constant	1.811	0.000***	102,635.827	11.468
	(5.086)	(0.000)	(801,571.117)	(141.182)
Observations	9,817	9,817	6,444	6,444
Number of groups	17	17	11	11
LR test Firm random intercept	1303***	1006***	701.3***	508.3***
LR test region random intercept	2.46e-08	3.14e-08	2.60e-08	1.38e-07
Wald Test Mean values	195.6***	470.7***	101.1***	293.6***
Wald Test Time dummies	34.53***	42.61***	20.99***	27.52***
Wald Test Industry dummies	3040***	1607***	277.8***	160.7***

Appendix C. Tables of the robustness checks

Table C1. Main regressions excluding Catalonia and Madrid

VARIABLES	(1) IProc	(2) IProd
EU-funded env. partners (in logs)	1.446*	0.485***
	(0.272)	(0.113)
Environmental investment	1.269	1.161
	(0.272)	(0.280)
Collaboration	1.066	1.114
	(0.142)	(0.290)
R&D per worker	1.078**	1.127**
	(0.034)	(0.057)
Size	2.235***	1.545**
	(0.407)	(0.299)
R&D government	1.310*	0.739
	(0.194)	(0.208)
Export	1.052	1.426
	(0.252)	(0.438)
Foreign	0.649	1.044
	(0.289)	(0.580)
Regional Researchers	0.739	1.552
	(0.209)	(0.609)
Manufacture share	1.002	0.962
	(0.011)	(0.024)
Population density	0.999	1.002
	(0.001)	(0.001)
Environmental total manufacture expenditure	0.829	1.916***
	(0.137)	(0.347)
Constant	1.856	0.000***
	(5.863)	(0.000)
Observations	6,590	6,590
Number of groups	15	15
LR test Firm random intercept	815.9***	575.4***
LR test region random intercept	-5.16e-08	5.35e-10
Wald Test Mean values	80.96***	483.6***
Wald Test Time dummies	20.41***	20.79***
Wald Test Sector dummies	497.4***	728.6***

Note: Robust SE in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table C2. Main regressions for SMEs (columns 1-2) and LEs (columns 3-4)

	(1) IProc	(2) IProd	(3) IProc	(4) IProd
EU-funded env. partners (in logs)	1.645**	0.761	0.784	0.274***
	(0.350)	(0.176)	(0.347)	(0.087)
Env Investments	1.472**	1.405**	1.239	1.213
	(0.289)	(0.206)	(0.272)	(0.478)
Collaboration	1.213	1.241	1.804	1.556
	(0.267)	(0.196)	(0.681)	(0.732)
R&D per worker	1.020	1.064**	1.077	1.256**
	(0.031)	(0.031)	(0.060)	(0.124)
Size	3.335***	2.259***	1.321	0.633
	(0.665)	(0.447)	(0.340)	(0.243)
R&D government	1.144	0.943	1.509**	0.831
	(0.257)	(0.208)	(0.298)	(0.198)
Export	1.124	1.443	0.901	1.460
	(0.196)	(0.336)	(0.638)	(0.472)
Foreign	0.746	1.782	0.842	0.962
	(0.215)	(0.700)	(0.291)	(0.325)
Regional Researchers	0.994	2.380*	0.312	0.516
	(0.224)	(1.206)	(0.463)	(0.497)
Manufacture share	0.999	0.968	1.009	0.989
	(0.014)	(0.021)	(0.059)	(0.055)
Pop Density	0.999**	1.000	1.002	1.003**
	(0.001)	(0.001)	(0.002)	(0.001)
Environmental manufacture expenditure	0.792	1.583**	1.159	2.603***
	(0.162)	(0.345)	(0.583)	(0.911)
Constant	4.915	0.000***	0.016	0.000***
	(19.138)	(0.000)	(0.143)	(0.000)
Observations	7,725	7,725	1,893	1,893
Number of groups	17	17	16	16
LR test Firm random intercept	889.6***	566.5***	319.5***	321.6***
LR test region random intercept	-2.46e- 09	-5.91e- 08	-9.12e- 09	2.02e-08
Wald Test Mean values	136.5***	147.3***	60.23***	80.72***
Wald Test Time dummies	32.75***	90.13***	16.74***	25.20***
Wald Test Sector dummies	567.5	3635	555.8	1053

References

Bell, A., & Jones, K. (2015). Explaining Fixed Effects: Random Effects Modeling of Time-Series Cross-Sectional and Panel Data. *Political Science Research and Methods*, *3*(01), 133–153. https://doi.org/10.1017/psrm.2014.7

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, *35*(1), 128–152. http://links.jstor.org/sici?sici=0001-8392%28199003%2935%3A1%3C128%3AACANPO%3E2.0.CO%3B2-5

Haans, R. F. J., Pieters, C., & He, Z. L. (2016). Thinking about U: Theorizing and testing U- and inverted U-shaped relationships in strategy research. *Strategic Management Journal*, *37*(7), 1177–1195. https://doi.org/10.1002/smj.2399

Hox, J. (2002). *Multilevel analysis: Thechniques and applications*. Lawrence Erlbaum

Associates.
López-Bazo, E., & Motellón, E. (2018). Innovation, heterogeneous firms and the region: evidence from Spain. *Regional Studies*, *52*, 673–687. https://doi.org/10.1080/00343404.2017.1331296
Maas, C. J., & Hox, J. (2005). Sufficient Sample Sizes for Multilevel Modeling. [References]. *Journal of Research Methods for the Behavioral and Social Sciences*, *1*, 86–92. https://doi.org/10.1027/1614-1881.1.3.86
Manski, C. F. (1993). Identification of Endogenous Social Effects: The Reflection Problem. *The Review of Economic Studies*, *60*(3), 531–542. https://doi.org/10.2307/2298123
Mundlak, Y. (1978). On the Pooling of Time Series and Cross Section Data. *Econometrica*, *46*(1), 69–85.
Naz, A., Niebuhr, A., & Peters, J. C. (2015). What´s behind the disparities in firm innovation rates across regions? Evidence on composition and context effects. *Annals of Regional Science*, *55*(1), 131–156. https://doi.org/10.1007/s00168-015-0694-9
Nieto, M. J., & Santamaría, L. (2010). Technological collaboration: Bridging the innovation gap between small and large firms. *Journal of Small Business Management*, *48*(1), 44–69. https://doi.org/10.1111/j.1540-627X.2009.00286.x
Rabe-Hesketh, S., & Skrondal, A. (2012). *Multilevel and longitudinal modeling using Stata*.
Robin, S., & Schubert, T. (2013). Cooperation with public research institutions and success in innovation: Evidence from France and Germany. *Research Policy*, *42*(1), 149–166. https://doi.org/10.1016/j.respol.2012.06.002
Snijders, T. A. B., & Bosker, R. J. (Roel J. . (2012). *Multilevel analysis : an introduction to basic and advanced multilevel modeling*.
Srholec, M. (2015). Understanding the diversity of cooperation on innovation across countries: Multilevel evidence from Europe. *Economics of Innovation and New Technology*, *24*, 159–182. http://www.circle.lu.se/publications
Stegmueller, D. (2013). How many countries for multilevel modeling? A comparison of frequentist and bayesian approaches. *American Journal of Political Science*, *57*(3), 748–761. https://doi.org/10.1111/ajps.12001
van Oort, F. G., Burger, M. J., Knoben, J., & Raspe, O. (2012). Multilevel approaches and the firm-agglomeration ambiguity in economic growth studies. *Journal of Economic Surveys*, *26*(3), 468–491. https://doi.org/10.1111/j.1467-6419.2012.00723.x