Does regional knowledge capacity mediate the acquisition of external knowledge?

Damián Tojeiro-Rivero*[a], Rosina Moreno*[b]

Abstract

Much has been said about the role that the acquisition of external knowledge plays on the innovation process of firms, but little is known about the importance of contextual factors moderating the channels for accessing such external knowledge. The present paper tries to answer the question of how regional knowledge capacity affects firms' innovative performance through external sources of acquisition of knowledge, namely, R&D cooperation and R&D outsourcing. Making use of a multilevel analysis due to the hierarchical structure of the dataset, we focus on how the regional level of knowledge – through the stock of regional patents and regional R&D expenditures – moderate the effect of firms' cooperation and outsourcing in innovation activities. We provide evidence for Spanish manufacturing enterprises in the period 2000-2012. Although the regional context seems to have a lower importance than that usually found in the international literature, the regional R&D capability has different effects depending on the sources of external knowledge, having a more favorable impact in the case of cooperation than for outsourcing. Finally, we find that those regions in which the business sector expends more in R&D obtain a higher impact from cooperating while having a detrimental effect for those firms doing outsourcing. Whereas, those regions with higher R&D expenditure in government research organizations have an unfavorable influence on the cooperation strategy while a positive one for outsourcing strategy.

*AQR-IREA Research Group. University of Barcelona. Department of Econometrics, Statistics and Applied Economics, Av. Diagonal 690, 08034 Barcelona, Spain.

Keyword: R&D cooperation, R&D Outsourcing, Knowledge Spillovers; Multilevel; Panel data; Spanish Firms.

[a] dtojeiro@ub.edu

[b] rmoreno@ub.edu

1. Introduction

Literature on innovation economics has extensively analyzed how the combination and recombination of previously unconnected ideas lead to new knowledge production and subsequent technological innovations (Aghion et al. 1998; Jones, 1995). Knowledge diffusion in the form of knowledge spillovers is crucial in this literature as a cause of the geographic agglomeration of firms (Audretsch & Feldman, 1996; Jaffe et al. 1993). Back to the end of the 19th century, Marshall (1890) already described how firms could benefit from spatial concentration: taking advantage of input-output relationships within industries, thanks to labour market pooling, as well as benefiting from positive knowledge externalities arising from other firms. Almost one century later, endogenous growth models (Grossman & Helpman, 1991; Lucas, 1988; Romer, 1986, 1990) turned the emphasis on knowledge spillovers again with the consideration that firms create new knowledge profiting from the amount of knowledge of the whole society.

As a consequence of the existence of shared agglomeration externalities, and more specifically for our case, the existence of knowledge spillovers, most geography of innovation scholars have recapped the role of physical proximity in fostering knowledge diffusion. It is widely believed that firms sharing the same environmental conditions are more similar in their innovation performance than firms that do not share the same environment. Co-location creates an *industrial atmosphere* (Becattini, 1979) or *local buzz* (Storper & Venables, 2004), where ideas flow and knowledge is transferred continuously through informal linkages and serendipitous encounters.

In contrast to this broadly belief, some scholars have raised the argument that co-location is not enough for acquiring the local knowledge, but some kind of formal mechanism such as the involvement in networks is needed (Breschi & Lissoni, 2009). According to this view, without denying that knowledge spillovers might be a powerful agglomeration force, formal knowledge exchanges based on market conditions may play even a higher role as a mechanism of knowledge transfer (Breschi & Lissoni, 2001). Among other mechanisms, we can think of having technological collaboration agreements or R&D outsourcing, which act as formal, intentional channels through which knowledge is transferred throughout the space allowing for new recombination of ideas (Fratesi & Senn, 2009). These formal mechanisms do not restrict to the knowledge in the region where the firm is located but firms may build pipelines to benefit from knowledge hotspots around the world (Bathelt et al. 2004; Owen-Smith & Powell, 2004).

However, far less is known about differences between formal and informal mechanisms of acquisition of knowledge and its mediation on the innovative performance at the firm level. Therefore, the novelty of the present study and our primary research question is to analyze how regional characteristics, and in particular the generation of knowledge spillovers, may influence the role played by formal mechanisms for acquisition of external knowledge on firms' innovative performance. In other words, we study to what extent the characteristics of the region where the firm is located can influence the impact exerted by different external sources of knowledge, namely technological cooperative agreements and knowledge outsourcing, on the innovative performance of firms.

From a methodological perspective, we will take into account the fact that regional level characteristics are not automatically reproduced at the firm level because information on the variance between firms is lost when data at an aggregated regional level are used (van Oort et al. 2012), what is known as the ecological fallacy. Therefore, using multilevel modelling allows the micro and the macro levels to be modeled simultaneously (Hox, 2002) and can be understood as a natural way to assess the relevance of the context. We use a panel of manufacturing enterprises in Spain starting from 2000 until 2012 and take into account some characteristics related to the knowledge generation capacity of the region where the firm is located as well as its distinction between public and private knowledge, which is another remarkable point in the present study.

The paper is outlined as follows. In the second section we offer the literature review and theoretical framework. Section three offers the dataset and describes the variables, while the methodology is subsequently presented in section four. The main results are given in the fifth section and the last section concludes.

2. Literature review and theoretical framework

A firm that wants to survive and grow needs to be innovative and adapt to more dynamic and global markets. Having knowledge to do it is of outmost importance, and it can be found within the firm but also beyond its boundaries. Indeed, the current tendency to acquire external knowledge through formal mechanisms such as cooperation agreements or through outsourcing (OECD, 2008) is gaining weight as entrepreneurial strategies to become more innovative.

Most of the papers providing empirical evidence at a micro level reach the conclusion that external knowledge-sourcing strategies have a positive and significant impact on innovation performance (Laursen & Salter, 2006; Mihalache et al. 2012; Nieto & Rodríguez, 2011), whereas as pointed by Dachs et al. (2012, p. 10) studies that find a negative impact are very scarce. In this sense, the open innovation literature (Chesbrough, 2003) stressed the necessity for firms to access to such knowledge external to the firm in order not to be lock-in the internal structure/way of thinking of the enterprise.

On the one hand, collaborative research with a broad range of external partners may enable innovating firms to acquire required information from a variety of sources which could lead to more synergies and intake of complementary knowledge, thus promoting innovation performance (Belderbos et al. 2006; Laursen & Salter, 2006; Nieto & Santamaría, 2007; Van Beers & Zand, 2014).

In this sense, collaboration with other organizations is due to the necessity of solving new kind of problems for which the market does not have a proper solution, leading to the need of a higher amount of interactions among organizations. This kind of strategy requires more face to face contacts reducing the likelihood of appropriation of some specific ideas/projects due to the fact that both enterprises have knowledge of each other´s projects while building a relationship of trust. At the same time, collaboration may give access to a more intangible and tacit component of knowledge and know-how not easy to spill over (Teirlinck & Spithoven, 2013). Previous literature though, recognized the idea of cooperation having embedded a more complex/technical knowledge structure which fit with the idea previously stressed related to the appearance of new type of problems-solving requirements (Dhont-Peltrault & Pfister, 2011; Phene & Tallman, 2014; Teirlinck & Spithoven, 2013).

On the other hand, outsourcing part of the innovation process allows an enterprise to gain access to a new source of well-prepared labor, as pointed out by Lewin et al. (2009), as well as to capture external knowledge cheaply. Another relevant advantage of outsourcing is the widening of the scope of internationalization of the firm, gaining access to new markets and new knowledge, increasing the efficiency of its internal capabilities and leading to an improvement in its competitiveness and a positive impact on its innovation capacity (Cassiman and Veugelers, 2006; Grimpe and Kaiser, 2010; Love et al., 2014; OECD, 2008, pp. 20, 91). These theoretical advantages of knowledge outsourcing are expected to be translated into a positive impact on innovation performance.

In fact, the innovation literature recognizes the importance this kind of acquisition of knowledge has for the enterprise in general, but specifically for smaller ones which do not have enough technological and/or financial resources to move geographically and take advantage of other region´s knowledge and markets (Nieto & Rodríguez, 2011). At the same time, the idea with outsourcing is that an enterprise gain in productivity and efficiency through an improved re-conduction of its internal resources, like managerial attention and the focus on core competences in what the firm does best while taking advantage in what the contracted firm is specialized in.

However, this kind of strategy – outsourcing – may have a higher risk of appropriation of internal knowledge (Nieto & Rodríguez, 2011) by the contracted firm so that this could be a reason why the outsource of non-core activities might be more profitable (Teirlinck & Spithoven, 2013). [1,2] In this sense, the use of a more standardized and codified knowledge is embedded on this type of acquisition of knowledge since the outsource of non-core activities imply a less technical and more standard dimension of knowledge.

All in all, firms innovate thanks to the combination and recombination of existing knowledge that goes beyond the limits of their boundaries, accessing to external sources of knowledge to expand new visions in their production process (Rosenkopf & Almeida, 2003). However, it is sensible to think that the environment where the firm is located can be essential to recombine and exploit such knowledge. Indeed, at an aggregate level, empirical studies in the geography of innovation (Feldman & Audretsch, 1999; Jaffe et al., 1993) and economic geography literature (Martin & Ottaviano, 1999) highlight that knowledge produced by a firm is only partially appropriated by the producer, whereas part of such knowledge spills over to other firms and institutions. Among the different mechanisms that imply informal exchange of ideas, and as a consequence, knowledge spillovers, we find those of face-to-face interactions between employees and frequent meetings (Allen, 1977; Krugman, 1991),

[1] However, the outsourcing of core activities allows the firm to access to a different kind of knowledge and new technology that could be relevant for its survival (Teirlinck & Spithoven, 2013).

[2] Nevertheless, in the Spanish case, as a member of the European Union, the presence of solid property laws could guarantee the role played by some mechanisms of protection like patents, design, trademarks, contractual clauses, etc. (Dhont-Peltrault & Pfister, 2011).

monitoring of competitors (Porter, 1990), spin-offs (Audretsch & Feldman, 2004) and trust building (Glaeser et al., 2002), among others.

We can stress two key points here. First, a clear assumption within this literature is that knowledge spills over easily from its source to other agents, and this is more the case with physically close actors than with firms located far apart. A second key point is the informal nature of such knowledge spillovers and the little effort needed to benefit from them since flows are more or less automatically received when being close in the space due especially to the public good definition of knowledge.

In this paper, we follow this strand of literature and we want to give a step forward and analyse how the impact of the capacity the region has to generate new knowledge and knowledge externalities can mediate certain channels through which knowledge is acquired from outside the firm. In particular, our main objective is to study the role that regional knowledge generation may play on the benefit firms gain from formal mechanisms of acquisition of external knowledge, namely technological cooperation agreements and knowledge outsourcing. In other words, we plan to analyze whether two different mechanisms to access external sources of knowledge, cooperation and outsourcing, may have different benefits depending on the characteristics of the region where the firm is located, due to the presence of higher or lower knowledge externalities.

When analysing how the regional component may affect the impact of the formal channels of acquisition of knowledge, an important point is the explicit differentiation between tacit and codified/explicit knowledge (Polanyi, 1966). Codified knowledge may travel frictionless across the space and across agents through, among other things, information and communication technologies. On the contrary, tacit knowledge, highly contextual and hard to articulate in articles, patents, or books, is difficult to transfer and is better transmitted in the form of face-to-face interactions. In the first case, standard knowledge can be purchased in markets for technology and little interaction with other agents is needed. However, when the knowledge to acquire is tacit, the sources tend to be embodied in people and organizations, so that they cannot be obtained through market transactions. This implies the necessity of interactive learning (Maskell & Malmberg, 1999) that would give place to cooperation agreements for which the characteristics of the context where the firm is located can be of higher relevance than in the case of standard knowledge that tend to be the case when outsourcing R&D.

Following Malmberg & Maskell (2006), formal and informal mechanisms of acquisition of knowledge could complement each other. On the one hand, the existence of neighborhood effects could make local buzz reinforce pipelines due to local capabilities into particular trajectories and similar experience solving specific kind of problems allowing a novel recombination/implementation of such knowledge. On the other hand, knowledge spillovers may signal opportunities for accessing knowledge external to the firm through a more market oriented type of acquisition due to the necessity of sharing a more tacit knowledge, while internalizing the appropriation of such knowledge and building a relationship of trust. Moreover, too much geographical proximity among firms leads to the combination of redundant information, so that the interaction with a more formal type of acquisition of external knowledge might be needed.

Besides, there could be some detrimental effects coming from knowledge externalities; for instance, enterprises in regions where the knowledge pool is high may face a ferocious degree of competition, which would lead to the necessity of incorporating a higher degree of novelty embedded in new acquired technologies. For those enterprises, in order to approach to leadership in the market, the knowledge generated by their direct competitors is dangerous as well as the fact of their own knowledge being spread into the region (Phene & Tallman, 2014). Therefore, enterprises in a more favorable environment (with lower degree of competition) could benefit more from their surrounding knowledge as well as keep its own knowledge safer. In particular, in regions with a higher level of knowledge externalities, and possibly with a higher level of competition, the negative effects of knowledge spillovers could overcome the positive ones. In this line, (Grillitsch & Nilsson, 2017) obtain that firms cooperating in the periphery will get higher profitability of such formal acquisition of knowledge than those in urban areas.

From a more regional perspective, those firms in regions with a lower share of knowledge pool need not to be as innovative as their counterparts in richer regions in order to catch up/converge. For them, an imitation strategy could be far better and more profitable to gain positions and converge with respect to the most advanced regions. Furthermore, not only knowledge externalities could reinforce formal acquisitions of knowledge as highlighted previously, but the other way around: enterprises in those regions with a lower capacity in terms of knowledge generation have the opportunity of accessing to technology coming from beyond their regional borders. In such a case, those pipelines could reinforce the local buzz due to the inclusion of a new knowledge, possibly generating a virtuous circle.

Previous literature has mainly focused on the impact of regional characteristics – in the sense of social and economic aspects like unemployment, crime rate, regional GDP, etc. – on the innovative performance of the firm (Dautel & Walther, 2014; Naz et al., 2015; Srholec, 2015). An exception is López-Bazo & Motellón (2017) who study how regional aspects have an influence on the internal capacity of enterprises in the case of Spain. Other authors have recently analyzed the role of the region mainly using patent citations and how this impacted on cooperative agreements (Grillitsch & Nilsson, 2015; Phene & Tallman, 2014). However, to the best of the authors' knowledge, this is the first attempt of studying the mechanisms by which regional factors – using input/output proxies for the generation of knowledge – operate at the firm level, modifying the relationship between the external acquisition of knowledge through R&D cooperation and outsourcing in the innovative performance.

3. Dataset and variables

3.1 Dataset

The main dataset used for this study is the Spanish *Survey on Business Strategies* – ESEE from now on – that consists on an unbalanced panel of manufacturing enterprises starting from 1990 until 2014 with around 1800 firms surveyed yearly. The reference population of the dataset comprises manufacturing firms, classified into twenty industries using the two digit European classification NACE (see table A1 in the Appendix).[3] As for the regional dataset on the contextual factors affecting innovation, we use Eurostat at the NUTS 2 level. We decided to use this regional classification as in the Spanish case these are territorial units representing administrative and policy authorities.

Our period of analysis starts in the year 2000 and goes until 2012. On the one hand, this is due to the fact that the ESEE started to cover some of the innovation strategies used in our study for the first time in the 1998 survey (Santamaría et al. 2009). On the other hand, some of the contextual variables taken from the Eurostat take place from 2000 until 2012.

[3] All enterprises with more than 200 workers are enforced to participate, while those in between 10 and 200 employees are selected through a stratified sampling. More details on the sample, the quality and validation of the information can be obtained from: https://www.fundacionsepi.es/investigacion/esee/en/spresentacion.asp

3.2 Dependent variable

Our dependent variable is the number of product innovations (*NIP*) which is a measure of the innovative output rather than patents. In this sense, we follow Feldman & Audretsch (1999) who recognize that using patents is not a direct measure of an innovative output since not all innovations are patented, not all patents end in a product, they present a high component of strategic behavior, as well as they differ greatly in their economic impact. On top of that, we try to go further in our study compared with previous literature that mostly focus their interest on the decision to engage on product innovation (Naz et al. 2015; Srholec, 2010; Wixe, 2016). We think this is more appropriate due to the fact that an enterprise that performs a higher amount of product innovations should be in a better position with respect to those that only develop a few of them.[4]

Moreover, we have reasons to focus our attention only on product instead of process innovations. Building on previous evidence, the existence of a higher effect of the external acquisition of knowledge on product rather than on process innovations (Bertrand & Mol, 2013; Nieto & Rodríguez, 2011), is mainly due to the type of knowledge required in each case. For product innovations the knowledge required tends to be more explicit, while for process innovations organizational closeness among the enterprises is also required, which is more difficult (Phene et al. 2006).[5]

3.3 Independent variables

3.3.1 Firm level variables

Our aim is to disentangle the effect that the regional knowledge capacity has on the number of product innovations of firms through two different strategies of acquisition of knowledge. *Cooperation* is a dummy equal to 1 if the enterprise cooperates with at least one partner[6] and zero otherwise. The second one (*Outsourcing*) is a dummy equal

---

[4] Of course, this also depends on the novelty of the innovation developed, that is, if it has embedded a more radical component or if on the contrary it is only an incremental innovation. Unfortunately, this information is unavailable in the dataset.

[5] We restrict the range of the variable to be in between zero and thirty product innovations, which account for the 99% of the observations and discard just a 0.1% of enterprises in the sample. In our opinion, this is a necessary process since (I) outliers can bias the estimations when dealing with non-linear multilevel models, (II) this seems to be a more appropriate range for the variable and (III) due to convergence problems in the estimation when dealing with the entire range of the variable.

[6] The partners could be universities, suppliers, competitors or customers. A Cronbach alpha analysis was performed having a value higher than 0.7; therefore, our variable has a high degree of internal consistency.

to 1 if the enterprise has declared to have a positive external R&D expenditure and zero in other cases.

To control for other relevant firm characteristics, we compute the log of the internal R&D expenditures per employee (*Internal R&D*).[7] This measure is relevant since it captures part of the firm´s absorptive capabilities (Cohen & Levinthal, 1990). To measure the size of the firm (*Size*), we employ the log of the total number of staff and its squared term to account for a non-linear relationship.

Another relevant variable in the innovation literature is if the firm belongs to a multinational corporate group. This variable is a dummy being one in case the firm has more than 50% of its capital from abroad (Srholec, 2010). Generally, we expect that being part of a higher group may imply more resources, such as better financial resources and an innovative environment that could lead to a more profitable knowledge (Belderbos et al. 2013).

Moreover, the government tends to be an important player on the innovativeness process. We try to account for a direct effect through the variable *R&D government* which is a dummy equal to 1 in case the firm received public funding from a government – regional, central, or others – for developing R&D and zero otherwise. As there are some enterprises receiving very few amount of funding, we decided to build this variable using as a threshold the average amount in all the period. That is, *R&D government* is a dummy equal to one in case the enterprise received an amount of money from any governmental institution higher than the average value.

3.3.2 Regional level variables

Regional statistics provide us with some relevant characteristics about the innovative capacity of the region which are the same for all firms belonging to a specific region in a given year, which we will use as a proxy for knowledge spillovers. On the input side, the variable *GERD* refers to R&D expenditures; this variable is very important to account for the regional public and private effort on R&D when explaining firm´s performance (Sternberg & Arndt, 2001). This variable is also divided into the regional R&D expenditure of private organizations (*GERD business*), government (*GERD government*), and higher educational sector (*GERD HES*). In order to account for the accumulative process characterizing innovation, we employ a measure of the

[7] The variables *Internal R&D* as well as *R&D Government* have been deflated using the Consumer Index Price. As the range of Internal R&D is widely opened, we decided to rescale the variable using logs.

stock of such knowledge. Thus, we use the perpetual inventory method (as in Peri, 2005) with a geometric mean of the growth rates of R&D spending in the region and a depreciation rate of five percent. The advantages of using the stock instead of the flow of R&D expenditures relates to the fact that it accounts for the accumulative process of innovation as well as it is less affected by punctual shocks.

On the output side of innovation, we propose to use regional patents[8] (*Regional patents*) which had been found as an important regional characteristic when explaining firm-level product innovation (Lederman, 2010). This variable is measured as the stock of the number of patents generated in a region using the perpetual inventory method. On one hand, this is a more direct way of measuring the regional generation of knowledge, as it is the case that patents are mostly generated with a commercial purpose embedding a degree of novelty. On the other hand, patents are an important channels through which knowledge spillovers can be traced while having a spatial/regional boundedness.

Finally, in order to control for the size, the wealth of the region as well as its educational level, we employ the GDP per capita in purchased power parity at constant prices of 2005 plus the percentage of people with age among 25-64 with tertiary education. In addition, we take into account a technological sectoral classification (see table A1 in the appendix) following the Eurostat guidelines and time dummies in order to capture any external shock. All variables in the model were lagged one period in order to lessen simultaneity problems, while the main regional variables in our analysis – GERD and Regional Patents – were centered with respect to their yearly grand mean to improve the interpretability and the convergence of the model.

4. Methodology

The use of a hierarchical approach allows for modelling the macro and micro aspects under study. Even though it has been used for some time in other economic fields such as health and educational economics (see for example Raftopoulou, 2017), it is quite recent that researchers on the innovation literature has realized of the importance of accounting for spatial differences on top of spatial econometrics (Corrado & Fingleton, 2012). This way, we expect to take into account the effect of those regional characteristics affecting/moderating our measure of innovative performance of the firm through the acquisition of knowledge. Apart from the empirical reasons

[8] Regarding knowledge spillovers, we recognize what Krugman (1991) argued about the impossibility of measuring knowledge flows. However, as Jaffe et al. (1993) point out, knowledge flows can sometimes be traced through patented inventions and new product introductions (see also Feldman & Audretsch, 1999).

highlighted in the literature section, there are some theoretical reasons in favor of considering the use of the multilevel model, also known as Hierarchical or mixed models.

With respect to these theoretical reasons, the use of standard estimations – OLS – does not take into account the dependence of those firm observations under the same region ending in a smaller standard error which leads to artificially higher significance of the parameters (Hox, 2002). They are usually assumed to be independent under this kind of estimation, whereas firms within the same region are more likely to be more similar among them than those in different regions. This is due to the fact that they are more exposed to the same regional effects and/or regional infrastructure in the sense of regional strategies, shocks, or policies than firms in other regions (Corrado & Fingleton, 2012). Second, the use of the multilevel approach allows us to model variances instead of means as in the case of standard OLS regressions. The latter is important in the sense of dividing the total effect into firm-level effects and regional effects through the random intercepts accounting for the unobserved heterogeneity (van Oort et al., 2012). Third, the *ecological fallacy* stresses that the study of individual relationships – firms in our case – cannot be analyzed using aggregated data, which at the end can lead to erroneous conclusions

In this paper we study the benefit that the region obtains through the acquisition of knowledge on the performance of the enterprise. As the 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 standard error of the regional variance (Maas & Hox, 2005). Previous research on the topic making use of multilevel modelling with such amount of regions can be found in López-Bazo & Motellón (2017), also with 17 groups, and Srholec (2015) with 15 groups. Following Stegmueller (2013), the random intercept 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. This justifies the use of random intercept model instead of random slope model. Moreover, in order to determine those regional characteristics affecting the innovation performance of firms, we plan to use cross interactions between our firm and regional characteristics. In this sense, we follow Snijders & Bosker (2012) who stressed the latter as a more appropriated strategy than using random slopes when having theoretical/empirical reasons as in our case in the literature section. Moreover, adding random slopes to the model for extending the analysis can bias the estimates; instead, we claim that using random intercept leads to a more robust model.

One of the assumptions of the multilevel model is the absence of correlation among the explicative variable and the random effects, with the no fulfillment of the latter leading to inconsistent estimations (Rabe-Hesketh & Skrondal, 2012). Contrary to previous studies on the topic making use of multilevel methodology, 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). With this, we guarantee the absence of endogeneity among the firm level variables and the firms' random effects.[9]

Besides, the Hausman test adds no information in our case in order to choose between the fixed effect and the random effect estimation since we are accessing to the same within effect as in the fixed effect estimation.[10] On the one hand, due to the poor within variabilities of our set of variables (see table A2 and A3 in the appendix) we think it is more appropriated to use random effects on top of fixed effects that only exploit within variabilities. On the other hand, with the fixed effect estimation it is not possible to model the effect of the regional context on the firm level performance as it is in the multilevel model. Thus, it is not possible to do inferences about time invariant variables as well as for higher-level variances (Bell & Jones, 2015).

Another important issue is that given the nature of our dependent variable, which is a count variable with non-negative integer, a normal distribution is not satisfactory due to the skewness of the variable and, consequently, a Poisson model is usually preferred. However, as the Poisson distribution is very restrictive in the sense that it assumes that the mean is equal to the variance, we decided to use the Negative Binomial model that allows for overdispersion, being the latter the most preferable and robust (Snijders & Bosker, 2012. chapter 17). Moreover, Bell et al., (2016) stressed that when dealing with count level models such as the Poisson and the negative binomial, the multilevel

---

[9] We also tested the endogeneity among the highest-level group variables and the regional random effects using the means of its time varying variables. We obtain that it is not significant, pointing to the absence of problem of this type of level-3 endogeneity (results upon request from the authors).

[10] Doing a Wald test to the means of the firm level variable is asymptotically equivalent to a Hausman test (Rabe-Hesketh & Skrondal, 2012). Moreover, other researchers stressed the misconception of many studies at the time to choose between the fixed effect and random effect estimation based on this test (Bell & Jones, 2015).

random effect augmented with the between-within effects is the best choice to produce within effects with the lower bias due to omitted higher-level variables.[11]

4.1 Model specification

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 (see Rabe-Hesketh & Skrondal, 2012), that is, the hierarchy is the following: individual observations (time-firms) are nested on firms, and firms are nested on regions. In order to account for this scheme, we first perform a time varying firm-level equation where subscript i refers to the firm, j refers to the region and t refers to time (see equation 1). Then, the firm-region as well as region-level group is captured by equations 2 to 5. Combining all the equations leads to equation 6, which is our main focus.

$$log\left[E\left(Y_{ijt}|X_{ijt}, X_{ij}, Z_{tj}, \mu_{1j}, \mu_{0ij}\right)\right] = log\ (\eta_{ijt}) = \beta_{0ij} + \sum_{m=1}^{2} \beta_{1j} X_{ijtm} + \sum_{m=3}^{M} \beta_{2j} X_{ijtm} \quad (1)$$

$$\beta_{0ij} = \alpha_{00j} + \sum_{k=1}^{K} \gamma_{01} X_{ijk} + \mu_{0ij} \qquad \mu_{0ij} \sim Normal(0, \sigma_{\mu 0}^{2}) \quad (2)$$

$$\alpha_{00j} = \gamma_{00} + \sum_{n=1}^{N} \gamma_{10} Z_{jtn} + \mu_{1j} \qquad \mu_{1j} \sim Normal(0, \sigma_{\mu 1}^{2}) \quad (3)$$

$$\beta_{1j} = \gamma_{010} + \sum_{n=1}^{1} \gamma_{11} Z_{jtn} \quad (4)$$

$$\beta_{2j} = \gamma_{001} \quad (5)$$

$$log\ (\eta_{ijt}) = \gamma_{00} + \sum_{k=1}^{K} \gamma_{01} X_{ijk} + \sum_{m=3}^{M} \gamma_{001} X_{ijtm} + \sum_{m=1}^{2} \gamma_{010} X_{ijtm} + \sum_{n=1}^{N} \gamma_{10} Z_{jtn} + \sum_{m=1}^{2} \sum_{n=1}^{1} \gamma_{11} X_{ijtm} Z_{jtn} + \mu_{1j} + \mu_{0ij} \quad (6)$$

where Y_{ijt} refers to our dependent variable, X_{ijtm} refers to the time varying firm-level characteristics where $(m = 1, \ldots, M)$ are the set of these variables, X_{ijk} are the time invariant firm characteristics where $(k = 1, \ldots, K)$ are the set of these variables, Z_{jtn} will proxy for regional variables where $(n = 1, \ldots, N)$ are the set of these variables and $\mu_{1j} + \mu_{0ij}$ are the random part of the model accounting for the error term of the region and the firm. Summarizing, we are estimating a multilevel negative binomial random effect model with two random intercepts, one for the firm and another for the region. The variance of the residual $\mu_{0ij} + \mu_{1j}$ is assumed to have a normal distribution with zero mean and independent of the residual error.

5. Results

5.1 Descriptive analysis

[11] This is extremely important in our case since the low amount of highest-level units in the sample restrict us to use only a small set of highest-level controls.

Table 1 provides summary statistics of the main regional variables by regions for the starting and final year of analysis. It shows that those regions with the highest stock of R&D are Madrid and Catalonia through all the period, whereas those with the lowest stock are La Rioja and Balearic Islands. Similarly, those regions with the highest stock of patents are Catalonia and Madrid, whereas those having the lowest stock of patents are Cantabria and La Rioja in 2000, and Extremadura and La Rioja in 2012.

[Insert table 1 around here]

Interesting differences can be extracted when comparing those firms that develop one of the two strategies of acquisition of external knowledge or not, that is, cooperation and outsourcing (see Table 2). Regarding those that cooperate, we observe that the average internal expenditure on R&D per employee is around fourteen times higher than those that do not. They develop more number of product innovations, have four times more workers, and receive one hundred times more governmental R&D support. In addition, the number of cooperative firms doing outsourcing is ten times higher in size than those not cooperating. A similar conclusion can be extracted when looking to those enterprises doing outsourcing and comparing with respect to those not doing outsourcing. In summary, those firms doing cooperation and/or outsourcing seem to be more innovative and have more resources than those other innovative and non-innovative enterprises that do not cooperate or outsource R&D.

[Insert tables 2 and 3 around here]

5.2 Main results

Table 4 contains seven different estimations analyzing how firm and regional characteristics affect the number of product innovations. Our first specification (column 1) shows the specification when only firm characteristics – level-1 as well as level-2, that is, time varying and time invariant firm characteristics – explain the variability of our dependent variable. The most important results are that the variance of the firm as well as the variance of the region are highly significant, being the first one bigger than the second one. This is in line to what recent literature has found, that is, that regional characteristics are important for the innovativeness of firms, but firm characteristics are more important when explaining its innovative performance. This result guarantees that we are taking into account the existence of a certain correlation among the observations for a given firm as well as the correlation among all firms pertaining to a given region. Regarding the latter, it is clear that the use of a simple Poisson or negative binomial estimation would bias our results, which points to the use of the multilevel methodology. Another interesting result is that the overdispersion of our dependent, which can be evaluated with the ln(alpha) parameter in all of our estimations. Therefore, the negative binomial estimation is the most reasonable one in our case.

[Insert table 4 around here]

This first specification illustrates that all the controls present the expected sign. For instance, *Internal R&D* has a positive and significant impact on the number of product innovations, validating the necessity of more internal capabilities not only to develop, but also to understand and implement external knowledge (Cohen & Levinthal, 1990). Regarding the *size* of the firm, we found evidence of a negative non-linear relationship, pointing to a more advantaged position of bigger enterprises until a certain threshold for which the biggest companies take not profit on the expected number of innovations. In addition, the impact of receiving public funding and of belonging to an international group are not significant.

Our two main independent variables, that is, *cooperation* and *outsourcing*, present a positive and highly significant effect on the number of product innovations. This result follows what previous literature had been stressing, which is related with the idea of the external acquisition of knowledge is especially relevant for the innovative performance of the firm (Nieto & Rodríguez, 2011; Nieto & Santamaría, 2007). On the one hand, cooperation allows the enterprise to take advantage of a more complex/technical relationship that could facilitate the entrance to a new market. The latter has to do with new ideas, competences and knowledge that are not easily transferable. On the other hand, outsourcing could be the best option if the firm wants to reduce management costs while focusing in core activities and taking advantage of the specific knowledge of the external enterprise, which at the end could explain the standardization concept (Dhont-Peltrault & Pfister, 2011).

Lastly, the technological sectorial variables put in a more advantaged position those firms pertaining to the Low-tech sectors while the Wald test for the time and means fixed effects stress that all of them are jointly significant. With this, we guarantee that our firm level results are causal effects in the sense that they are not driven by being correlated with the enterprises random effects, something found in all of our specifications. Another important result when looking to all our different specifications in table 4 is that the direction as well as the magnitude of the parameters at the firm level barely change. Finally, the regional variance is reduced in columns 2 to 7, in comparison with the baseline specification in column one. This reflects that our model has accounted for part of the regional variability in each step.

To start analyzing the major hypothesis of the paper, we employ the specifications 2 to 7 taking into account different measures of the absorptive capacity of regions.[12] In particular, specifications in columns two and three[13], explain the effect that the regional stock of patents has on the firm-level number of product innovations. It can be noted the importance the external acquisition of knowledge has for the firm, as can be seen in the parameters of cooperation and outsourcing which are positive and highly significant for those firms in a region with the yearly national average of the stock of patents. The variable measuring the regional stock of patents is not significant, being the same for the regional controls *GDP per capita* and *Tertiary education*. This seems to point to the fact that being surrounded by more innovative firms – measured by the stock of patents – as well as being in a richer region or having a higher pool of educated people in a given region, does not seems to have a significant impact.

However, when we look to the indirect effect that the regional environment may have on the impact that firms obtain from the cooperation and/or outsourcing in innovation activities, we obtain a different perspective. For instance, being in a region with more knowledge capacity is more beneficial for those enterprises that cooperate, something clear by the sign and significance of the interaction parameter between cooperation and the stock of regional patents. While it is not beneficial for those firms doing outsourcing. The explanation for this may come from the type of knowledge embedded in each strategy, which in the case of cooperation is more technical and tacit. This would imply that firms might obtain a higher benefit from the knowledge pool present in the region in order to be able to gather a higher impact from the cooperation agreements they carry out. While for outsourcing the knowledge embedded is less complex and more standard (D'Agostino et al. 2013; Dhont-Peltrault & Pfister, 2011)

[12] Although not presented in the paper, we performed an alternative model with only the firm's characteristics and the interactions of the strategies of acquisition of knowledge with each regional dummy. The reasoning for doing this relies on the expectation of a different regional impact depending on the two sources of external knowledge. The computation of an F-Test for the interactions between cooperation and regional dummies as well as between outsourcing and regional dummies leads to significant values for such crossing. This is taken as an indication of a differential pattern of the acquisition of external knowledge strategies depending on the region where the firm is located, which advocates for the use of interactions as will be done subsequently in the paper.

[13] Due to a high correlation between *GDP per capita* and *Tertiary education*, we decided not to include both control at the time while using each separately (see table A4 in the appendix).

and would not take advantage of the knowledge spilling from other firms within the region with a higher knowledge capacity as in the case of a region with a lower knowledge pool.

Indeed, cooperation needs personal contacts, and dedicating internal resources for developing new solutions to a given problem. Following this, a firm in a region with more knowledge capacities has more resources to find new solutions that only can be made through personal contact and sharing experiences. On the contrary, the outsourcing strategy uses the knowledge created by others – that is present in the market – to solve the enterprise´s necessities. As this kind of knowledge is more transferable across organizations than tacit knowledge, it is easier to any firm to take advantage of such knowledge through the outsourcing solution specifically if the level of innovativeness of the business environment found in the region is lower.

Results in the specification of columns 4 and 5 take into account another way of measuring the capacity the region has for generating knowledge externalities through the regional stock of R&D expenditure and controlling again by *GDP per capita* (column 4) and *Tertiary education* (column 5). Firm-level controls remain as in previous specifications and the variable *stock of GERD* is positive but is not significant – only marginally significant when controlling for tertiary education – while the controls *GDP per capita* and *Tertiary education* behave as in the previous specifications. Moreover, cooperation and outsourcing remain almost the same in magnitude with respect to specification 2 and 3 being positive and highly significant.

Summarizing, even though we find a similar pattern of cooperation and outsourcing irrespective if the knowledge capacity of the region is measured as an output – stock of regional patents – or as an input – stock of R&D expenditure – it is clear that for the latter it is not significant.

In order to understand what is happening in the case of the regional stock of R&D expenditure as well as in the study of those reasons behind the higher profitability of outsourcing in a region with a lower stock of knowledge generation, we divide the variable *Stock of GERD* and into the regional stock of R&D expenditures of business, government, and higher educational sectors separately. This division reflects the different types of knowledge embedded in each kind of R&D expenditure more basic in the case of universities and centers of research and more applied in the case of business. The analysis is done in columns 6 and 7. The cooperation and outsourcing parameters remain the same in magnitude and significance as in specifications two to five.

Regarding the regional stock of R&D expenditures of the business and government sectors, they are not significant, while the parameter for the higher education sector is positive, and significant in specification 6, a result coherent with the parameter of regional stock of R&D in column 5.

However, when crossing the stock of R&D disaggregated with cooperation, we observe that those firms cooperating in regions in which there is a higher magnitude of stock of business R&D are in a better position. On the contrary, those enterprises in a region with a higher governmental stock of knowledge, even though the effect of cooperation is positive, it has a lower and more detrimental impact; whereas cooperating in a region with a higher stock of regional university R&D does not seem to have a significant effect. Therefore, this point to the fact that the positive effect – although not significant – found in the specifications four and five between cooperative firms in regions with higher knowledge pool is in fact due to the amount of R&D expended by private organizations in those regions. Even more, it seems that the non-significance of the cross product between cooperation and stock of GERD in specifications four and five could be due to the different directions in such a cross product when splitting GERD into the public/private definition cancelling the effect.

We do the same to study the reasons behind the detrimental impact found in specifications two to five in the case of enterprises doing outsourcing when the regions has a higher amount of stock of knowledge. We observe that such unfavorable effect could be due to the negative relation between outsourcing and the amount of regional stock of R&D done by private business in those regions. A first explanation of this results is that enterprises in regions where the knowledge pool is low face a lower degree of competition, so that they take more profits from a less complex and more standard type of knowledge with respect to those firms in a more ferocious environment with the necessity of a higher degree of novelty embedded in the incoming technology. Second, doing outsourcing – and assuming that the knowledge is generated in the region as well as coming from other regions due to a more codified and standard type of knowledge – when the region has a lower amount of knowledge externalities could have a virtuous circle effect. The reasoning for this comes from the fact that the technology that a firm from such a region could outsource will be spread to other firms in the region thanks to knowledge spillovers, and given that firms in those regions face a lower degree of competition this could have a reinforcement effect. Third, from a more regional perspective, those regions with a lower share of knowledge pool need not to be as innovative as richer regions to converge, since an imitation strategy could fit better for firms in those poorer regions. That is, it is more easily done by means of an outsourcing strategy allowing a faster convergence to the more advanced regions.

At this point, it is important to notice that an alternative explanation for this result could be related to the fact that enterprises in those regions with a lower capacity of knowledge generation are in fact compensating the lack of knowledge spillovers by doing more R&D outsourcing as in Grillitsch & Nilsson (2015) for the case of firms cooperating in peripheral regions. However, a simple descriptive analysis shows that in fact, there is the same amount of regions with a lower stock of knowledge – measured by our both proxies – and having a high degree of regional outsourcing than having a low degree of regional outsourcing. Therefore, this does not seem to be the reason behind.

When studying the effect that regional knowledge coming from the government has on R&D outsourcing, it is clear that this type of knowledge is playing a highly significant and positive role as can be seen from specifications 6 and 7. However, take into account that those regions with a lower stock of business knowledge tend to be those that present a higher share of knowledge made by governmental organizations with respect to the one made by private organizations. Therefore, it may be the case that the government could be compensating the lower amount of knowledge externalities in those regions. Therefore, the possible explanation might not have to do with the type of knowledge developed by governmental institutions while just because those improvements are on the less developed regions in the sense of knowledge generation capacity.

5.3 Robustness section

In the present study, we are using an unbalance panel possibly leading to attrition problems. We correct for this using information present in the survey collecting the reasons why an enterprise leave, leading to the assumption that missing values are random (Snijders & Bosker, 2012).[14] Table A5 in the appendix control for this and show that the model does not change qualitatively and barely change quantitatively for our main results with respect to those in table 4. Moreover, other growth rates for our measure of stock of knowledge are tested. We use a 15% depreciation rate as in Rahko

[14] We include a categorical variable with the following categories: it has splitted; it has acquired other firms; it has born after a split process; it is a result of a merger process; it has changed the trademarks and legal form; without change.

(2016)[15] and as can be seen from table A6 in the appendix, results behave with the same pattern just with a small quantitative change due to the greater importance given to today's knowledge when increasing the depreciation´s rate.

Finally, we have taken Wooldridge´s (2010. chapter 3) advice, and independent of the multicollinearity between our two main regional variables – GERD and Patents – we included jointly in the model in order not to confound their relation with our dependent variable. Table A7 show that in fact this seems not to be an important issue since the pattern behave the same qualitatively and barely change quantitatively.

6. Conclusion

The study of the effect of regional characteristics on the firms´ innovation performance is not a recent topic of research but is only in recent times that researchers have realized of the importance of the hierarchical structure of the data when working with macro and micro levels simultaneously.

The present study analyzes how regional characteristics in the sense of the regional knowledge base affect the number of product innovations at the firm-level. This impact is studied through two different strategies of external acquisition of knowledge – cooperation and outsourcing – and as far as the authors know, this is the first attempt studying this effect. In line with very recent studies, we perform the analysis taking into account the multilevel structure of the data in the estimation, while having the advantage of a panel dataset structure.[16] The evidence provided in this paper refers to Spanish manufacturing enterprises in the period 2000 to 2012.

The empirical evidence points to a higher relevance of firm´s characteristics than regional ones, something in line with recent studies in the field (Backman, 2014; López-Bazo & Motellón, 2017; Naz et al., 2015; van Oort et al., 2012). However, the regional context explains part of the variability in our dependent variable and has to be accounted for.

Another interesting result in line with previous literature is the positive and significant effect that cooperation and outsourcing have on the innovative performance of the firm. However, as it is our main objective in the paper, this effect could be moderated by some external factor. In this study, we claim that the capacity the region

[15] We also use a 10% as in Peri (2005) and results behave the same (results upon request of the authors).

[16] To the best of our knowledge, only two studies incorporate the panel structure of the data in the analysis on related topics making use of a multilevel model (Acosta et al., 2012; Naz et al., 2015).

has for generating new knowledge is also relevant on this relationship between the acquisition of external to the firm knowledge and the number of product innovations. In this sense, we find evidence of a reinforcement effect between being in a region with a higher capacity in terms of knowledge creation and cooperate technologically with other organizations. Besides, we find that enterprises that mostly acquire external knowledge through the outsourcing strategy have a higher return when they are installed in a region with a lower knowledge capability.

This could be due in part to the type of knowledge embedded in each strategy that at the end depends on the necessity of the firm. That is, for those enterprises cooperating, it could be more profitable being in a more developed region in the sense of accessing to a higher knowledge pool, because the type of knowledge needed tend to be more tacit and implies a higher technical requirement. Cooperation involves a higher amount of personal contact and new approaches to solving new problems. While in the case of outsourcing, the knowledge needed is more standard with a lower technical component. Following the latter, the type of solution needed by the enterprise might be different having a higher requirement for implementing non-core activities for which personal contact is less relevant.

In order to shed more light on this, one of the novelty of the present study is that we disaggregate regional R&D expenditures on those made by private firms, government, and higher educational centers. The results give support to the idea presented, that is, the differential effect of the regional knowledge capacity on the two strategies. On the one hand, the evidence points to a higher effect of the regional context when the firm is developing a cooperative strategy mostly due to the regional knowledge capability of private organizations. On the contrary, this cooperative impact is less beneficial for those firms in regions where the government present the highest amount of R&D. On the other hand, firms in regions where private knowledge pool is lower as well as being higher the share of the one created by governmental organizations relative to the one of the business sector, are the ones having reinforcement effect on the outsourcing strategy. Therefore, the outsourcing strategy is important for Spanish firms, but it has a decisive relevance for those enterprises in a region with lower knowledge externalities.

The results of this study have some important implications. First, the Spanish government should not enforce the pursue of the winning or one-size-fit-all type of policy. Innovative performance of firms is likely to differ in terms of knowledge requirements, problem-solving, managerial capabilities and learning potential (Lucena, 2011; Teirlinck & Spithoven, 2013) for which the chosen solution requires an specific strategy of knowledge acquisition that fits with the necessities of the enterprise. Second, there are regional differences like cognitive or institutional trajectories that need to be taken into account when developing such a policy (Asheim, Boschma, & Cooke, 2011). In this sense, the type of necessities and problem-solving dimension of the firm is highly relevant, having a different contextual profitability depending on the knowledge capacity the region has.

In Spain, the government has paid too much attention on the public-private relationship being one of the most important objectives in terms of public policy (Vega-Jurado et al., 2009). However, in light of our results, in order to increase the innovative performance of firms, policy makers should focus on strengthening the relationship among organizations through a more formal or market oriented type of acquisition of knowledge by encouraging and promoting knowledge transmission among relevant actors.

Limitations and future research

Our study has some limitations that should be taken into consideration in future research. First, a possible endogeneity problem due to the higher-level variables may arise. However, this problem is relaxed thanks to the use of time lagged variables as well as by the fact that multilevel random effects augmented with the between-within effects are used. Indeed, this is the best choice to produce within effects with the lower bias due to omitted higher-level variables (Bell et al., 2016). Second, some enterprises might have an impact on regional performance; yet, this is not probably the case since our territorial units are very big and represent administrative authorities where a single firm is not sufficiently important to affect regional performance.

As in most of previous studies, the present research assumes that spatial sorting is exogenous to the firm. Therefore, the interpretation of the model must to account for the fact that location choice is not affecting the impact of our regional externalities measures. However, even though panel data may help to control for this, we do not have information for the location of enterprises before the beginning of the survey. Finally, another interesting point is to study the external validity of our results, in the sense of to what extent the results can be extrapolated to other economies.

Acknowledgments

We thank Antonio Di Paolo, Fernando Bruna, Ernest Miguélez, Enrique López-Bazo, Malcom Fairbrother and Carla Rampichini as well as the participants of the XX Applied Economics Meeting for their useful comments. Damián Tojeiro-Rivero gratefully acknowledges financial support from the University of Barcelona (APIF). Rosina Moreno acknowledges financial support provided by the Ministerio de Economía y Competitividad for the project entitled "Innovation and territory. Technological collaboration, international competitiveness and location factors", ECO2014-59493-R, as well as to the Program ICREA Acadèmia. However, any mistakes or omissions remain the authors' alone.

References

Acosta, M., Coronado, D., & Martínez, M. Á. (2012). Spatial differences in the quality of university patenting: Do regions matter? *Research Policy*, *41*, 692–703. https://doi.org/10.1016/j.respol.2012.01.002

Aghion, P., Howitt, P., Brant-Collett, M., & García-Peñalosa, C. (1998). *Endogenous growth theory*. MIT Press. Retrieved from https://books.google.es/books?hl=ca&lr=&id=tLuqjIVJUcoC&oi=fnd&pg=PA1&dq=Endogenous+growth+theory&ots=mwL32oMn1O&sig=v46riKDkXD4UjY45Z6K-Z8Pvi5A&redir_esc=y#v=onepage&q=Endogenous growth theory&f=false

Allen, T. J. (Thomas J. (1977). *Managing the flow of technology : technology transfer and the dissemination of technological information within the R&D organization*. [MIT Press].

Asheim, B. T., Boschma, R., & Cooke, P. (2011). Constructing Regional Advantage: Platform Policies Based on Related Variety and Differentiated Knowledge Bases. *Regional Studies*, *457*(May), 893–904. https://doi.org/10.1080/00343404.2010.543126

Audretsch, D. B., & Feldman, M. P. (1996). R&D Spillovers and the Geography of Innovation and Production. *The American Economic Review*, *86*(3), 630–640. Retrieved from http://www.jstor.org/stable/2118216

Audretsch, D. B., & Feldman, M. P. (2004). Knowledge Spillovers and the Geography of Innovation. In V. Thisse & H. and J. (Eds.), *Handbook of Urban and regional Economics*. Retrieved from http://spol.unica.it/didattica/paci/Economia applicata avanzata (1mod)/audretsch-feldman.pdf

Backman, M. (2014). Human capital in firms and regions: Impact on firm productivity. *Papers in Regional Science*, *93*(3), 557–575. https://doi.org/10.1111/pirs.12005

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, *28*(1), 31–56. https://doi.org/10.1191/0309132504ph469oa

Becattini, G. (1979). Dal settore industriale al distretto industriale. Alcune considerazioni sull'unità di indagine dell'economia industriale. *Rivista Di Economia E Politica Industriale*, *5*(1), 7–21. Retrieved from https://scholar.google.com/scholar?cluster=3651355325230740693&hl=ca&as_sdt=2005&sciodt=0,5

Belderbos, R., Carree, M., & Lokshin, B. (2006). Complementarity in R & D Cooperation Strategies. *Review of Industrial Organization*, *28*(4), 401–426. https://doi.org/10.1007/s11151-006-9102-z

Belderbos, R., Van Roy, V., & Duvivier, F. (2013). International and domestic technology transfers and productivity growth: Firm level evidence. *Industrial and Corporate Change*, *22*(1), 1–32. https://doi.org/10.1093/icc/dts012

Bell, A., Fairbrother, M., & Jones, K. (2016). *Fixed and Random effects : making an informed choice*.

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*(1), 133–153. https://doi.org/10.1017/psrm.2014.7

Bertrand, O., & Mol, M. J. (2013). The antecedents and innovation effects of domestic and offshore R&D outsourcing: The contingent impact of cognitive distance and absortive capacity. *Strategic Management Journal*, *34*, 751–760. https://doi.org/10.1002/smj.2034

Breschi, S., & Lissoni, F. (2001). Localised knowledge spillovers vs . innovative milieux : Knowledge "tacitness" reconsidered. *Papers Reg . Sci*, *80*, 255–273. https://doi.org/10.1007/PL00013627

Breschi, S., & Lissoni, F. (2009). Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows. *Journal of Economic Geography*, 1–30. https://doi.org/10.1093/jeg/lbp008

Cassiman, B., & Veugelers, R. (2006). In Search of Complementarity in Innovation Strategy: Internal R&D and External Knowledge Acquisition. *Management Science*, *52*(1), 68–82. https://doi.org/10.1287/mnsc.1050.0470

Chesbrough, H. (2003). *Open Innovation. The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

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

Corrado, L., & Fingleton, B. (2012). Where is the economics in spatial econometrics? *Journal*

of Regional Science, *52*(2), 210–239. https://doi.org/10.1111/j.1467-9787.2011.00726.x
D'Agostino, L. M., Laursen, K., & Santangelo, G. D. (2013). The impact of R&D offshoring on the home knowledge production of OECD investing regions. *Journal of Economic Geography*, *13*(1), 145–175. https://doi.org/10.1093/jeg/lbs012
Dachs, B., Kampik, F., Scherngell, T., Zahradnik, G., Hanzl-Weiss, D., Hunya, G., … Urban, W. (2012). *Internationalisation of business investments in R&D and analysis of their economic impact*. (Publications Office of the European Union, Ed.). Luxembourg. https://doi.org/10.2777/60978
Dautel, V., & Walther, O. (2014). The geography of innovation in a small metropolitan region: An intra-regional approach in Luxembourg. *Papers in Regional Science*, *93*(4), 703–725. https://doi.org/10.1111/pirs.12019
Dhont-Peltrault, E., & Pfister, E. (2011). R&D cooperation versus R&D subcontracting: empirical evidence from French survey data. *Economics of Innovation and New Technology*, *20*(4), 309–341. https://doi.org/10.1080/10438591003669743
Feldman, M. P., & Audretsch, D. B. (1999). Innovation in cities: Science-based diversity, specialization and localized competition. *European Economic Review*, *43*(2), 409–429. https://doi.org/10.1016/S0014-2921(98)00047-6
Fratesi, U., & Senn, L. (2009). Regional Growth, Connections and Economic Modelling: An Introduction. In *Growth and Innovation of Competitive Regions* (pp. 3–27). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-70924-4_1
Glaeser, E. L., Laibson, D., Sacerdote, B., Bowles, S., Haveman, R., Katz, L., … Shleifer, A. (2002). An economic approach to social capital. *The Economic Journal*, *112*, 437–458. Retrieved from http://scholar.harvard.edu/files/glaeser/files/economicapproachsocialcapital.pdf
Grillitsch, M., & Nilsson, M. (2015). Innovation in peripheral regions: Do collaborations compensate for a lack of local knowledge spillovers? *Annals of Regional Science*, *54*(1), 299–321. https://doi.org/10.1007/s00168-014-0655-8
Grillitsch, M., & Nilsson, M. (2017). Firm performance in the periphery: on the relation between firm-internal knowledge and local knowledge spillovers. *Regional Studies* , *51*(8), 1219–1231. https://doi.org/10.1080/00343404.2016.1175554
Grimpe, C., & Kaiser, U. (2010). Balancing internal and external knowledge acquisition: The gains and pains from R & D outsourcing. *Journal of Management Studies*, *47*(8), 1483–1509. https://doi.org/10.1111/j.1467-6486.2010.00946.x
Grossman, G. M., & Helpman, E. (1991). *Innovation and growth in the global economy*. MIT Press.
Hox, J. (2002). *Multilevel analysis: Thechniques and applications*. New Jersey: Lawrence Erlbaum Associates.

Jaffe, A. B., Trajtenberg, M., & Henderson, R. (1993). Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations. *Source: The Quarterly Journal of Economics*, *108*(3), 577–598. Retrieved from http://www.jstor.org/stable/2118401

Jones, C. 1. (1995). R&D-Based Models of Economic Growth. *Journal of Political Economy*, *103*(4), 759–784. Retrieved from http://www.jstor.org/stable/2138581

Krugman, P. (1991). Increasing Returns and Economic Geography. *The Journal of Political Economy*, *99*(3), 483–499.

Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal*, *27*(2), 131–150. https://doi.org/10.1002/smj.507

Lederman, D. (2010). An international multilevel analysis of product innovation. *Journal of International Business Studies*, *41*(41), 606–619. https://doi.org/10.1057/jibs.2009.30

Lewin, A. Y., Massini, S., & Peeters, C. (2009). Emerging Global Race for Talent. *Journal of International Business Studies*, (October), 2009. https://doi.org/10.1057/jibs.2008.92

López-Bazo, E., & Motellón, E. (2017). Innovation, heterogeneous firms and the region: evidence from Spain. *Regional Studies*, *3404*(October), 1–15. https://doi.org/10.1080/00343404.2017.1331296

Love, J. H., Roper, S., & Vahter, P. (2014). Dynamic complementarities in innovation strategies. *Research Policy*, *43*(10), 1774–1784. https://doi.org/10.1016/j.respol.2014.05.005

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22*, 3–42. Retrieved from http://ac.els-cdn.com.sire.ub.edu/0304393288901687/1-s2.0-0304393288901687-main.pdf?_tid=81f50a2e-0288-11e7-9169-00000aacb35f&acdnat=1488817277_a2b48ef2297639f79956adede50c2b06

Lucena, A. (2011). The organizational designs of R&D activities and their performance implications: empirical evidence for Spain. *Industry & Innovation*, *18*(2), 151–176. https://doi.org/10.1080/13662716.2011.541103

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

Malmberg, A., & Maskell, P. (2006). Localized learning revisited. *Growth and Change*, *37*(1), 1–18. https://doi.org/10.1111/j.1468-2257.2006.00302.x

Marshall, A. (1890). *Principles of Economics: An introductory volume*. Londom: McMillan. Retrieved from http://www.jslysx.net/lib/pdf/4030002.PDF

Martin, P., & Ottaviano, G. I. P. (1999). Growing locations: Industry location in a model of endogenous growth. *European Economic Review*, *43*, 281–302. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.962.7102&rep=rep1&type=pdf

Maskell, P., & Malmberg, A. (1999). Localised learning and industrial competitiveness. *Cambridge Journal of Economics*, *23*(2), 167–185. https://doi.org/10.1093/cje/23.2.167

Miguélez, E., & Moreno, R. (2013). Research Networks and Inventors' Mobility as Drivers of Innovation: Evidence from Europe. *Regional Studies*, *47*(10), 1668–1685. https://doi.org/10.1080/00343404.2011.618803

Mihalache, O. R., Jansen, J. J. J. P., Van Den Bosch, F. A. J., & Volberda, H. W. (2012). Offshoring and firm innovation: The moderating role of top management team attributes. *Strategic Management Journal*, *33*, 1480–1498. https://doi.org/10.1002/smj.1983

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., & Rodríguez, A. (2011). Offshoring of R&D: Looking abroad to improve innovation performance. *Journal of International Business Studies*, *42*(3), 345–361. https://doi.org/10.1057/jibs.2010.59

Nieto, M. J., & Santamaría, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. *Technovation*, *27*(6–7), 367–377. https://doi.org/10.1016/j.technovation.2006.10.001

OECD. (2008). *The Internationalisation of Business R&D: Evidence, Impacts and Implications*. France: OECD publishing. Retrieved from http://www.oecd.org/sti/sci-tech/theinternationalisationofbusinessrdevidenceimpactsandimplications.htm

Owen-Smith, J., & Powell, W. W. (2004). Knowledge Networks as Channels and Conduits: The Effects of Spillovers in the Boston Biotechnology Community. *Organization Science*, *15*(1), 5–21. https://doi.org/10.1287/orsc.1030.0054

Peri, G. (2005). Determinants of Knowledge Flows and Their Effect on Innovation. *The Review of Economics and Statistics*, *87*(2), 308–322.

Phene, A., Fladmoe-Lindquist, K., & Marsh, L. (2006). Breakthrough innovations in the U.S. biotechnology industry: The effects of technological space and geographic origin. *Strategic Management Journal*, *27*(4), 369–388. https://doi.org/10.1002/smj.522

Phene, A., & Tallman, S. (2014). Knowledge spillovers and alliance formation. *Journal of Management Studies*, *51*(7), 1058–1090. https://doi.org/10.1111/joms.12088

Polanyi, M. (1966). *The tacit dimension.* ([1st ed.].). Garden City N.Y.: Doubleday. Retrieved from http://www.worldcat.org/title/tacit-dimension/oclc/374908

Porter, M. (1990). *The Competitive Advantage of Nations*. London: McMillan. Retrieved from https://business.illinois.edu/aguilera/Teaching/Porter Competitive Advantage of Nations

HBR.pdf
Rabe-Hesketh, S., & Skrondal, A. (2012). *Multilevel and longitudinal modeling using Stata*.
Raftopoulou, A. (2017). Geographic determinants of individual obesity risk in Spain: A multilevel approach. *Economics & Human Biology*, *24*, 185–193. https://doi.org/10.1016/j.ehb.2016.12.001
Rahko, J. (2016). Internationalization of corporate R&D activities and innovation performance. *Ind. Corp. Change*, dtw012-. https://doi.org/10.1093/icc/dtw012
Romer, P. M. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy*, *94*(5), 1002–1037. Retrieved from http://www.jstor.org/stable/1833190
Romer, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy*, *98*(2), 71–102. Retrieved from http://www.jstor.org/stable/2937632
Rosenkopf, L., & Almeida, P. (2003). Overcoming Local Search Through Alliances and Mobility. *Management Science*, *49*(6), 751–766. https://doi.org/10.1287/mnsc.49.6.751.16026
Santamaría, L., Nieto, M. J., & Barge-Gil, A. (2009). Beyond formal R&D: Taking advantage of other sources of innovation in low- and medium-technology industries. *Research Policy*, *38*(3), 507–517. https://doi.org/10.1016/j.respol.2008.10.004
Snijders, T. A. B., & Bosker, R. J. (Roel J. . (2012). *Multilevel analysis : an introduction to basic and advanced multilevel modeling*.
Srholec, M. (2010). A Multilevel Approach to Geography of Innovation. *Regional Studies*, *449*, 1207–1220. https://doi.org/10.1080/00343400903365094
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. Retrieved from 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
Sternberg, R., & Arndt, O. (2001). The Firm or the Region : What Determines the Innovation Behavior of European Firms ? *Economic Geography*, *77*(4), 364–382.
Storper, M., & Venables, A. J. (2004). Buzz: face-to-face contact and the urban economy. *Journal of Economic Geography*, *4*, 351–370. https://doi.org/10.1093/jnlecg/lbh027
Teirlinck, P., & Spithoven, A. (2013). Research collaboration and R&D outsourcing: Different R&D personnel requirements in SMEs. *Technovation*, *33*(4–5), 142–153. https://doi.org/10.1016/j.technovation.2012.11.005
Van Beers, C., & Zand, F. (2014). R&D cooperation, partner diversity, and innovation performance: An empirical analysis. *Journal of Product Innovation Management*, *31*(2), 292–312. https://doi.org/10.1111/jpim.12096

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

Vega-Jurado, J., Gutiérrez-Gracia, A., & Fernández-De-Lucio, I. (2009). Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry. *Industrial and Corporate Change*, *18*(4), 637–670. https://doi.org/10.1093/icc/dtp023

Wixe, S. (2016). Neighbourhood related diversity, human capital and firm innovation. *Papers in Regional Science*. https://doi.org/10.1111/pirs.12255

Wooldridge, J. M. (2010). *Introducción a la econometría. Un enfoque moderno* (4a ed.). Cengage Learning.

Table 1. Descriptive statistics of the regional variables in the analysis for the years 2000 and 2012

	Year 2000							Year 2012						
Regions	GERD	GERD business	GERD government	GERD HES	Regional patents	GDP per capita	Tertiary education	GERD	GERD business	GERD government	GERD HES	Regional patents	GDP per capita	Tertiary education
Andalusia	7,739	1,578	743.0	2,793	121.7	16,57	18.80	16,419	5,103	3,093	6,795	679.8	16,817	26.50
Aragon	1,815	1,088	152.9	377.4	102.2	23,45	23.80	3,622	2,068	623.7	818.8	629.2	24,470	35.10
Asturias	994.7	765.9	124.6	704.9	29.22	18,816	21.70	2,265	1,181	349.2	1,062	161.7	20,140	35.90
Balearic Isl.	330.0	25.55	34.38	396.5	22.92	28,084	17.60	928.0	145.5	257.0	591.8	91.98	23,564	24.80
Canary Isl.	1,271	135.1	423.6	772.5	18.60	21,905	18.40	2,851	540.0	856.7	1,485	93.52	19,234	26
Cantabria	413.1	48.29	47.52	170.5	0.499	20,923	23.40	1,210	372.8	219.3	526.8	86.99	20,643	36.10
Castile Leon	1,811	706.4	212.8	1,661	124.7	20,22	23.40	6,077	3,253	600.5	2,643	382.8	21,348	34
Castile La Mancha	1,319	650.5	114.9	424.6	23.29	17,412	15.50	2,520	1,289	325.5	844.5	170.9	18,025	25.30
Catalonia	13,616	14,330	642.8	4,104	3,135	27,241	23.50	32,847	23,233	4,300	8,193	5,982	26,282	32.80
Valencia	5,969	1,516	391.5	2,548	973.0	21,344	20.10	11,931	4,187	1,319	5,600	1,518	19,435	30.10
Extremadura	602.1	68.73	47.30	218.4	4.008	14,182	16.20	1,458	240.4	349.1	729.5	25.02	15,407	23.70
Galicia	2,550	485.1	462.6	1,555	22.40	17,412	18.70	5,771	2,232	920.0	2,614	304.1	19,636	31.30
Madrid	23,746	9,229	5,790	3,521	1,136	29,909	31.40	44,133	22,682	11,267	7,293	2,974	30,915	44.50
Murcia	809.5	341.4	160.4	478.0	27.50	18,676	20.80	2,341	960.2	435.8	1,040	179.6	18,327	26.30
Navarre	820.9	431.3	5.874	398.8	87.46	28,505	29.90	3,311	2,190	217.9	910.5	513.8	27,592	40.20
Basque Country	4,627	3,901	99.87	1,436	698.0	27,382	32	12,906	10,180	585.5	2,563	1,580	29,404	46
La Rioja	202.3	133.1	11.46	112.0	1.505	24,995	22.90	730.0	430.3	136.0	189.5	62.98	24,067	34.30

Note: GERD (total, business, government and HES) and Regional patents are measured in stock while Tertiary education is the percentage of people with an undergraduate, master or PhD. Yearly and regional values.

Table 2. Descriptive statistics for the whole sample and dividing between those enterprises cooperating and not cooperating

	Full Sample					Non Cooperative Firms					Cooperative Firms				
VARIABLES	mean	sd	N	min	max	mean	sd	N	min	max	mean	sd	N	min	max
NIP	2.196	17.87	43,445	0	950	0.984	10.29	19,557	0	500	3.666	20.40	8,992	0	900
Cooperation (dummy)	0.319	0.466	28,931	0	1										
Outsourcing (dummy)	0.218	0.413	44,125	0	1	0.059	0.236	19,706	0	1	0.605	0.489	9,188	0	1
Internal R&D	986.3	3,217	30,738	0	110,769	190.2	1,358	19,685	0	54,383	2,717	4,972	9,140	0	110,769
Size	247.3	786.8	44,238	1	25,363	113.0	388.8	19,716	1	12,311	489.1	1,128	9,215	5	15,003
R&D government (dummy)	0.067	0.251	30,849	0	1	0.005	0.072	19,716	0	1	0.205	0.403	9,213	0	1
Foreign (dummy)	0.170	0.375	44,184	0	1	0.104	0.306	19,707	0	1	0.292	0.455	9,206	0	1

Table 3. Descriptive statistics for enterprises doing outsourcing and not doing outsourcing

	No R&D Outsourcing					R&D Outsourcing				
VARIABLES	mean	sd	N	min	max	mean	sd	N	min	max
NIP	1.627	15.93	34,036	0	950	4.25	23.48	9,325	0	900
Cooperation (dummy)	0.164	0.37	22,172	0	1	0.827	0.378	6,722	0	1
Internal R&D (dummy)	419.4	2,001	23,637	0	110,769	2,875	5,183	7,096	0	73,057
Size	154.2	491.3	34,514	1	17,412	576.3	1,348	9,611	2	25,363
R&D government (dummy)	0.015	0.12	23,711	0	1	0.244	0.43	7,101	0	1
Foreign (dummy)	0.135	0.342	34,475	0	1	0.291	0.454	9,597	0	1

Table 4. Effect of the acquisition of knowledge on the number of product innovations

VARIABLES	(1) NIP	(2) NIP	(3) NIP	(4) NIP	(5) NIP	(6) NIP	(7) NIP
Cooperation $_{t-1}$	1.307***	1.290***	1.292***	1.303***	1.305***	1.285***	1.286***
	(0.087)	(0.057)	(0.058)	(0.082)	(0.083)	(0.055)	(0.055)
Outsourcing $_{t-1}$	1.217**	1.246***	1.245***	1.227***	1.226***	1.235***	1.236***
	(0.093)	(0.069)	(0.068)	(0.082)	(0.082)	(0.064)	(0.064)
Internal R&D $_{t-1}$	1.044***	1.043***	1.043***	1.044***	1.044***	1.043***	1.043***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Size $_{t-1}$	2.140***	2.141***	2.150***	2.146***	2.157***	2.151***	2.155***
	(0.308)	(0.306)	(0.305)	(0.309)	(0.310)	(0.309)	(0.308)
Size $^{2}_{t-1}$	0.960***	0.960***	0.959***	0.960***	0.959***	0.960***	0.959***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
R&D government $_{t-1}$	1.082	1.081	1.081	1.083	1.084	1.081	1.080
	(0.077)	(0.077)	(0.077)	(0.076)	(0.076)	(0.075)	(0.076)
Foreign $_{t-1}$	1.154	1.162	1.162	1.158	1.158	1.167	1.163
	(0.222)	(0.225)	(0.226)	(0.225)	(0.226)	(0.225)	(0.225)
High tech	0.885	0.877	0.883	0.874	0.880	0.876	0.885
	(0.089)	(0.091)	(0.089)	(0.090)	(0.089)	(0.089)	(0.087)
Medium-High tech	0.871	0.867	0.873	0.865	0.870	0.859	0.870
	(0.122)	(0.123)	(0.124)	(0.121)	(0.122)	(0.121)	(0.122)
Medium-Low tech	0.619***	0.620***	0.622***	0.618***	0.621***	0.616***	0.620***
	(0.063)	(0.063)	(0.064)	(0.063)	(0.064)	(0.064)	(0.065)
Regional stock of patents $_{t-1}$		1.053	1.065*				
		(0.042)	(0.037)				
Cooperation $_{t-1}$ * Regional stock of patents $_{t-1}$		1.064***	1.063***				
		(0.016)	(0.016)				
Outsourcing $_{t-1}$* Regional stock of patents $_{t-1}$		0.937***	0.936***				
		(0.021)	(0.021)				
Stock GERD $_{t-1}$				1.008	1.011*		
				(0.007)	(0.006)		
Cooperation $_{t-1}$* Stock GERD $_{t-1}$				1.004	1.004		
				(0.005)	(0.005)		
Outsourcing $_{t-1}$* Stock GERD $_{t-1}$				0.994	0.994		
				(0.006)	(0.006)		
Stock GERD business $_{t-1}$						0.974	0.995
						(0.027)	(0.027)
Cooperation $_{t-1}$ * Stock GERD business $_{t-1}$						1.027***	1.027***
						(0.005)	(0.005)
Outsourcing $_{t-1}$* Stock GERD business $_{t-1}$						0.980***	0.980***
						(0.007)	(0.007)
Stock GERD government $_{t-1}$						0.973	0.975
						(0.025)	(0.037)
Cooperation $_{t-1}$* Stock GERD government $_{t-1}$						0.963***	0.962***
						(0.007)	(0.007)
Outsourcing $_{t-1}$ * Stock GERD government $_{t-1}$						1.015***	1.014***
						(0.005)	(0.005)
Stock GERD HES $_{t-1}$						1.156**	1.105
						(0.082)	(0.077)
Cooperation $_{t-1}$* Stock GERD HES $_{t-1}$						0.978	0.977
						(0.026)	(0.026)
Outsourcing $_{t-1}$* Stock GERD HES $_{t-1}$						1.025	1.024
						(0.038)	(0.038)
GDP per capita		1.000		1.000		1.000*	
		(0.000)		(0.000)		(0.000)	
Tertiary education			0.988		0.985		0.993
			(0.012)		(0.011)		(0.015)
Constant	0.007***	0.002***	0.004***	0.002***	0.005***	0.002***	0.004***
	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)
Random Part of the Model							
ln(alpha)	0.477***	0.477***	0.477***	0.477***	0.477***	0.476***	0.477***
	(0.111)	(0.111)	(0.111)	(0.111)	(0.110)	(0.111)	(0.111)
Variance (Region)	0.109	0.096	0.081	0.096	0.076	0.048	0.053
Variance (Firm-Region)	4.511	4.501	4.503	4.504	4.506	4.494	4.497
Observations	21,031	21,031	21,031	21,031	21,031	21,031	21,031
Number of groups	17	17	17	17	17	17	17
Likelihood ratio test Firm random intercept	4416***	4390***	4393***	4355***	4358***	4258***	4273***
Likelihood ratio test Region random intercept	19.15***	14.12***	14.12***	14.79***	10.27***	3.394**	4.156**
Wald Test Mean values (Mundlak)	1213***	1199***	1159***	1167***	1111***	1183***	1167***
Wald Test Time dummies	674.9***	774.5***	415.7***	805.3***	409.9***	915.4***	406.7***

Robust SE in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Incidence rate ratios. Means and time fixed effects included. The null hypothesis for the likelihood ratio tests does not follow a χ^2 distribution because it is not on the boundary of the parameter space. We corrected for this following Rabe-Hesketh & Skrondal (2012. pp. 88-89). Our main regional variables are yearly grand mean centered.

Appendix

Table A1

Sector	Denomination	NACE Rev.1	NACE Rev.2
	Low-Tech		
1	Meat products	151	101
2	Food and tobacco	152 to 158+160	102 to 109, 120
3	Beverage	159	110
4	Textiles and clothing	171 to 177 and 181 to 183	131 to 133, 139, 141 to 143
5	Leather, fur and footwear	191 to 193	151 + 152
6	Timber	201 to 205	161 + 162
7	Paper	211+212	171 + 172
8	Printing (before Printing and Edition)	221 to 223	181 + 182
19	Furniture	361	310
20	Other manufacturing	362 to 366, 371 to 372	321 to 325, 329
	Medium Low-tech		
10	Plastic and rubber products	251 to 252	221 + 222
11	Nonmetal mineral products	261 to 268	231 to 237, 239
12	Basic metal products	271 to 275	241 to 245
13	Fabricated metal products	281 to 287	251 to 257, 259
	Medium High-tech		
14	Machinery and equipment	291 to 297	281 to 284, 289
16	Electric materials and accessories	311 to 316 y 321 a 323	271 to 275, 279
17	Vehicles and accessories	341 to 343	291 to 293
18	Other transport equipment	351 to 355	301 to 304, 309
	High-tech		
9	Chemicals and pharmaceuticals (before Chemical products)	241 to 247	201 to 206, 211 + 212
15	Computer products, electronics and optical	300 + (331 to 335)	261 to 268

Source: ESEE and Eurostat. http://www.fundacionsepi.es/investigacion/esee/en/svariables/disponibles.asp

Table A2. Descriptive statistics of the regional variables in the empirical analysis

VARIABLES		mean	sd	min	max	Observations	
Stock GERD	Overall	6313	9146	202.3	44133	N	221
	Between		9039	437.7	33652	n	17
	Within		2530	-3593	16794	T	13
Stock GERD business	Overall	3336	5571	25.55	23233	N	221
	Between		5528	83.54	18682	n	17
	Within		1463	-3413	10040	T	13
Stock GERD government	Overall	980.2	2020	5.874	11267	N	221
	Between		1994	57.74	8392	n	17
	Within		566.7	-1622	3855	T	13
Stock GERD HES	Overall	1898	1963	112	8193	N	221
	Between		1916	146	6039	n	17
	Within		618.5	-37.57	4082	T	13
Stock Regional patents	Overall	638.2	1165	0.499	5982	N	221
	Between		1158	15.58	4610	n	17
	Within		297.2	-836.5	2010	T	13
GDP per capita	Overall	24272	4861	14182	35607	N	221
	Between		4749	16446	32846	n	17
	Within		1518	20478	27429	T	13
Tertiary education	Overall	27.87	6.574	15.50	46	N	221
	Between		5.806	20.72	39.70	n	17
	Within		3.367	20.17	35.28	T	13

Table A3. Descriptive statistics of the firm level variables in the empirical analysis

VARIABLES		mean	sd	min	max	Observations	
Cooperation (dummy)	Overall	0.319	0.466	0	1	N	27248
	Between		0.402	0	1	n	4035
	Within		0.254	-0.614	1.253	T	6.753
Outsourcing (dummy)	Overall	0.218	0.413	0	1	N	42448
	Between		0.327	0	1	n	5297
	Within		0.261	-0.739	1.174	T	8.014
log (Internal R&D)	Overall	2.235	3.432	0	11.62	N	29066
	Between		3.069	0	10.71	n	4186
	Within		1.644	-6.700	10.79	T	6.944
log (Size)	Overall	4.250	1.494	0.693	10.14	N	42555
	Between		1.375	0.693	9.548	n	5304
	Within		0.299	-1.389	6.626	T	8.023
R&D Government (dummy)	Overall	0.068	0.251	0	1	N	29166
	Between		0.188	0	1	n	4188
	Within		0.169	-0.870	1.005	T	6.964
Foreign (dummy)	Overall	0.171	0.377	0	1	N	42501
	Between		0.329	0	1	n	5302
	Within		0.142	-0.785	1.128	T	8.016

Table A4. Correlation matrix of the variables in the empirical analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Cooperation	1												
(2) Outsourcing	0.611	1											
(3) log (Internal R&D)	0.711	0.575	1										
(4) log (Size)	0.494	0.440	0.477	1									
(5) R&D Government	0.376	0.396	0.446	0.322	1								
(6) Foreign	0.231	0.174	0.216	0.446	0.094	1							
(7) Stock of GERD	0.002	-0.007	0.046	-0.000	-0.019	0.070	1						
(8) Stock of GERD business	0.062	0.042	0.115	0.061	0.005	0.115	0.904	1					
(9) Stock of GERD government	-0.048	-0.048	-0.021	-0.041	-0.030	0.031	0.886	0.366	1				
(10) Stock of GERD HES	-0.002	-0.015	0.032	-0.024	-0.045	0.030	0.848	0.821	0.590	1			
(11) Stock of Regional patents	0.083	0.059	0.132	0.072	0.005	0.109	0.713	0.915	0.326	0.803	1		
(12) GDP per capita	0.066	0.063	0.115	0.071	0.067	0.118	0.671	0.704	0.574	0.384	0.529	1	
(13) Tertiary education	0.049	0.056	0.085	0.032	0.091	0.056	0.410	0.369	0.436	0.110	0.157	0.746	1

Table A5. Assuming missing at random

VARIABLES	(1) NIP	(2) NIP	(3) NIP	(4) NIP	(5) NIP	(6) NIP	(7) NIP
Cooperation $_{t-1}$	1.307***	1.290***	1.291***	1.303***	1.305***	1.285***	1.285***
	(0.088)	(0.057)	(0.058)	(0.083)	(0.084)	(0.054)	(0.054)
Outsourcing $_{t-1}$	1.224***	1.253***	1.252***	1.234***	1.232***	1.242***	1.243***
	(0.094)	(0.068)	(0.068)	(0.083)	(0.082)	(0.064)	(0.064)
Internal R&D $_{t-1}$	1.044***	1.043***	1.043***	1.044***	1.044***	1.043***	1.043***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Size $_{t-1}$	2.191***	2.192***	2.200***	2.197***	2.207***	2.202***	2.206***
	(0.316)	(0.315)	(0.313)	(0.318)	(0.318)	(0.318)	(0.317)
Size $^{2}{}_{t-1}$	0.960***	0.960***	0.960***	0.960***	0.960***	0.960***	0.959***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
R&D government $_{t-1}$	1.089	1.088	1.088	1.090	1.091	1.088	1.087
	(0.076)	(0.076)	(0.076)	(0.075)	(0.075)	(0.074)	(0.075)
Foreign $_{t-1}$	1.157	1.164	1.164	1.160	1.160	1.169	1.166
	(0.223)	(0.225)	(0.226)	(0.226)	(0.226)	(0.226)	(0.225)
High tech	0.885	0.876	0.883	0.874	0.879	0.876	0.885
	(0.088)	(0.089)	(0.088)	(0.089)	(0.088)	(0.087)	(0.086)

Medium-High tech	0.871	0.868	0.873	0.866	0.871	0.860	0.870
	(0.122)	(0.123)	(0.123)	(0.121)	(0.121)	(0.121)	(0.121)
Medium-Low tech	0.618***	0.619***	0.621***	0.618***	0.621***	0.616***	0.620***
	(0.063)	(0.062)	(0.063)	(0.063)	(0.064)	(0.064)	(0.065)
2.CAMBIO	1.117	1.113	1.111	1.109	1.105	1.123	1.118
	(0.371)	(0.367)	(0.366)	(0.367)	(0.365)	(0.372)	(0.364)
3.CAMBIO	0.450*	0.450*	0.447*	0.454*	0.452*	0.449*	0.446*
	(0.209)	(0.206)	(0.206)	(0.209)	(0.209)	(0.209)	(0.206)
4.CAMBIO	1.615	1.614	1.604	1.614	1.601	1.611	1.603
	(0.796)	(0.785)	(0.782)	(0.790)	(0.785)	(0.793)	(0.785)
5.CAMBIO	0.943	0.947	0.946	0.943	0.942	0.945	0.946
	(0.310)	(0.308)	(0.308)	(0.308)	(0.307)	(0.310)	(0.305)
6.CAMBIO	1.036	1.039	1.036	1.036	1.033	1.035	1.034
	(0.306)	(0.303)	(0.303)	(0.303)	(0.303)	(0.303)	(0.298)
Regional stock of patents $_{t-1}$		1.051	1.063*				
		(0.042)	(0.036)				
Cooperation $_{t-1}$ * Regional stock of patents $_{t-1}$		1.064***	1.063***				
		(0.015)	(0.016)				
Outsourcing $_{t-1}$* Regional stock of patents $_{t-1}$		0.938***	0.937***				
		(0.021)	(0.021)				
Stock GERD $_{t-1}$				1.008	1.011*		
				(0.007)	(0.006)		
Cooperation $_{t-1}$* Stock GERD $_{t-1}$				1.004	1.004		
				(0.005)	(0.005)		
Outsourcing $_{t-1}$* Stock GERD $_{t-1}$				0.994	0.994		
				(0.006)	(0.006)		
Stock GERD business $_{t-1}$						0.974	0.994
						(0.027)	(0.027)
Cooperation $_{t-1}$ * Stock GERD business $_{t-1}$						1.027***	1.027***
						(0.005)	(0.004)
Outsourcing $_{t-1}$* Stock GERD business $_{t-1}$						0.981***	0.980***
						(0.007)	(0.007)
Stock GERD government $_{t-1}$						0.973	0.975
						(0.025)	(0.036)
Cooperation $_{t-1}$* Stock GERD government $_{t-1}$						0.963***	0.961***
						(0.007)	(0.007)
Outsourcing $_{t-1}$ * Stock GERD government $_{t-1}$						1.016***	1.015***
						(0.005)	(0.005)
Stock GERD HES $_{t-1}$						1.156**	1.106
						(0.082)	(0.077)
Cooperation $_{t-1}$* Stock GERD HES $_{t-1}$						0.978	0.977
						(0.024)	(0.025)
Outsourcing $_{t-1}$* Stock GERD HES $_{t-1}$						1.024	1.023
						(0.038)	(0.038)
GDP per capita		1.000		1.000		1.000*	
		(0.000)		(0.000)		(0.000)	
Tertiary education			0.989		0.986		0.993
			(0.012)		(0.011)		(0.015)
Constant	0.006***	0.002***	0.004***	0.002***	0.005***	0.002***	0.004***
	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)
Random part of the model							
ln(alpha)	0.476***	0.475***	0.475***	0.476***	0.476***	0.476***	0.476***
	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)
Variance (Region)	0.110	0.097	0.082	0.097	0.078	0.049	0.053
Variance (Firm-Region)	4.508	4.499	4.501	4.502	4.504	4.491	4.495
Observations	21,031	21,031	21,031	21,031	21,031	21,031	21,031
Number of groups	17	17	17	17	17	17	17
Likelihood ratio test Firm random intercept	4423***	4391***	4394***	4357***	4359***	4259***	4274***
Likelihood ratio test Region random intercept	19.24***	14.22***	14.22***	14.92***	10.39***	3.439**	4.199**
Wald Test Mean values (Mundlak)	1121***	1104***	1071***	1076***	1029***	1082***	1070***
Wald Test Time dummies	725.5***	827.9***	433.7***	860.5***	416***	971.9***	422.1***

Robust SE in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Incidence rate ratios. Means and time fixed effects included. The null hypothesis for the likelihood ratio tests does not follow a χ^2 distribution because it is not on the boundary of the parameter space. We corrected for this following Rabe-Hesketh & Skrondal (2012. pp. 88-89). Our main regional variables are yearly grand mean centered.

Table A6. Using a depreciation rate of 15%

VARIABLES	(1) NIP	(2) NIP	(3) NIP	(4) NIP	(5) NIP	(6) NIP	(7) NIP
Cooperation $_{t-1}$	1.307***	1.291***	1.292***	1.303***	1.304***	1.287***	1.289***
	(0.087)	(0.059)	(0.059)	(0.080)	(0.081)	(0.055)	(0.055)
Outsourcing $_{t-1}$	1.217**	1.244***	1.243***	1.229***	1.227***	1.236***	1.235***
	(0.093)	(0.068)	(0.067)	(0.080)	(0.079)	(0.068)	(0.067)
Internal R&D $_{t-1}$	1.044***	1.043***	1.043***	1.043***	1.044***	1.043***	1.043***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Size $_{t-1}$	2.140***	2.141***	2.150***	2.148***	2.158***	2.147***	2.132***
	(0.308)	(0.306)	(0.304)	(0.311)	(0.311)	(0.308)	(0.313)
Size $^{2}{}_{t-1}$	0.960***	0.960***	0.959***	0.960***	0.959***	0.960***	0.961***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
R&D government $_{t-1}$	1.082	1.081	1.082	1.082	1.084	1.080	1.081
	(0.077)	(0.077)	(0.077)	(0.076)	(0.076)	(0.076)	(0.076)
Foreign $_{t-1}$	1.154	1.161	1.162	1.159	1.159	1.167	1.164
	(0.222)	(0.225)	(0.226)	(0.226)	(0.226)	(0.226)	(0.226)
High tech	0.885	0.878	0.885	0.873	0.879	0.875	0.889
	(0.089)	(0.091)	(0.090)	(0.091)	(0.090)	(0.088)	(0.088)
Medium-High tech	0.871	0.868	0.874	0.865	0.870	0.859	0.842
	(0.122)	(0.123)	(0.124)	(0.122)	(0.122)	(0.122)	(0.122)
Medium-Low tech	0.619***	0.620***	0.622***	0.618***	0.621***	0.616***	0.614***
	(0.063)	(0.063)	(0.064)	(0.063)	(0.064)	(0.063)	(0.067)
Regional stock of patents $_{t-1}$		1.071	1.102				
		(0.089)	(0.075)				
Cooperation $_{t-1}$ * Regional stock of patents $_{t-1}$		1.127***	1.123***				
		(0.032)	(0.033)				
Outsourcing $_{t-1}$* Regional stock of patents $_{t-1}$		0.887***	0.884***				
		(0.040)	(0.039)				
Stock GERD $_{t-1}$				1.016	1.021**		
				(0.013)	(0.010)		
Cooperation $_{t-1}$* Stock GERD $_{t-1}$				1.010	1.009		
				(0.010)	(0.010)		
Outsourcing $_{t-1}$* Stock GERD $_{t-1}$				0.988	0.987		
				(0.011)	(0.011)		
Stock GERD business $_{t-1}$						0.947	0.955
						(0.056)	(0.033)
Cooperation $_{t-1}$ * Stock GERD business $_{t-1}$						1.062***	1.062***
						(0.009)	(0.009)
Outsourcing $_{t-1}$* Stock GERD business $_{t-1}$						0.966**	0.964**
						(0.015)	(0.016)
Stock GERD government $_{t-1}$						0.978	1.006
						(0.077)	(0.034)
Cooperation $_{t-1}$* Stock GERD government $_{t-1}$						0.901***	0.898***
						(0.020)	(0.018)
Outsourcing $_{t-1}$ * Stock GERD government $_{t-1}$						1.035**	1.033**
						(0.016)	(0.016)
Stock GERD HES $_{t-1}$						1.305**	1.301***
						(0.138)	(0.132)
Cooperation $_{t-1}$* Stock GERD HES $_{t-1}$						0.973	0.971
						(0.037)	(0.038)
Outsourcing $_{t-1}$* Stock GERD HES $_{t-1}$						1.021	1.024
						(0.067)	(0.070)
GDP per capita		1.000		1.000		1.000	
		(0.000)		(0.000)		(0.000)	
Tertiary education			0.988		0.985		0.995
			(0.012)		(0.011)		(0.011)

Constant	0.007***	0.002***	0.004***	0.002***	0.005***	0.002***	0.004***
	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)
Random part of the model							
ln(alpha)	0.477***	0.476***	0.476***	0.477***	0.477***	0.477***	0.478***
	(0.111)	(0.111)	(0.110)	(0.110)	(0.110)	(0.111)	(0.111)
Variance (Region)	0.109	0.100	0.085	0.096	0.076	0.045	3.41e-16
Variance (Firm-Region)	4.511	4.502	4.504	4.504	4.506	4.494	4.525
Observations	21,031	21,031	21,031	21,031	21,031	21,031	21,031
Number of groups	17	17	17	17	17	17	17
Likelihood ratio test Firm random intercept	4416***	4391***	4394***	4356***	4360***	4259***	4275***
Likelihood ratio test Region random intercept	19.15***	14.79***	14.79***	14.63***	10.39***	3.234**	2.54e-05
pvalue Likelihood ratio region	1.21e-05	0.000120	0.000120	0.000131	0.00127	0.0721	0.996
Wald Test Mean values	1213***	1209***	1168***	1169***	1114***	1204***	1079***
Wald Test Time dummies	674.9***	765.6***	453.8***	828.2***	391.7***	982.2***	435.6***

Robust SE in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Incidence rate ratios. Means and time fixed effects included. The null hypothesis for the likelihood ratio tests does not follow a χ^2 distribution because it is not on the boundary of the parameter space. We corrected for this following Rabe-Hesketh & Skrondal (2012. pp. 88-89). Our main regional variables are yearly grand mean centered.

Table A7. Including jointly both measures of regional knowledge generation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	NIP	NIP	NIP	NIP	NIP	NIP	NIP
Cooperation $_{t-1}$	1.307***	1.290***	1.292***	1.304***	1.305***	1.285***	1.286***
	(0.087)	(0.057)	(0.058)	(0.082)	(0.083)	(0.056)	(0.055)
Outsourcing $_{t-1}$	1.217**	1.246***	1.245***	1.227***	1.226***	1.235***	1.236***
	(0.093)	(0.069)	(0.068)	(0.082)	(0.082)	(0.064)	(0.064)
Internal R&D $_{t-1}$	1.044***	1.043***	1.043***	1.044***	1.044***	1.043***	1.043***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Size $_{t-1}$	2.140***	2.143***	2.155***	2.143***	2.154***	2.148***	2.155***
	(0.308)	(0.307)	(0.307)	(0.309)	(0.309)	(0.312)	(0.309)
Size $^{2}_{t-1}$	0.960***	0.960***	0.959***	0.960***	0.960***	0.960***	0.959***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.013)	(0.012)
R&D government $_{t-1}$	1.082	1.081	1.082	1.082	1.083	1.081	1.080
	(0.077)	(0.077)	(0.077)	(0.076)	(0.076)	(0.075)	(0.076)
Foreign $_{t-1}$	1.154	1.162	1.162	1.158	1.158	1.167	1.163
	(0.222)	(0.226)	(0.226)	(0.225)	(0.226)	(0.225)	(0.225)
High tech	0.885	0.876	0.881	0.874	0.880	0.876	0.885
	(0.089)	(0.091)	(0.090)	(0.090)	(0.089)	(0.089)	(0.087)
Medium-High tech	0.871	0.867	0.872	0.865	0.870	0.858	0.870
	(0.122)	(0.122)	(0.123)	(0.121)	(0.122)	(0.122)	(0.123)
Medium-Low tech	0.619***	0.620***	0.622***	0.618***	0.621***	0.616***	0.620***
	(0.063)	(0.063)	(0.064)	(0.063)	(0.064)	(0.063)	(0.064)
Regional stock of patents $_{t-1}$		1.034	1.018	1.042	1.024	1.035	0.997
		(0.055)	(0.040)	(0.055)	(0.040)	(0.129)	(0.120)
Cooperation $_{t-1}$ * Regional stock of patents $_{t-1}$		1.064***	1.063***				
		(0.016)	(0.016)				
Outsourcing $_{t-1}$* Regional stock of patents $_{t-1}$		0.937***	0.936***				
		(0.021)	(0.021)				
Stock GERD $_{t-1}$		1.003	1.008	1.003	1.008		
		(0.010)	(0.008)	(0.010)	(0.007)		
Cooperation $_{t-1}$* Stock GERD $_{t-1}$				1.004	1.004		
				(0.005)	(0.005)		
Outsourcing $_{t-1}$* Stock GERD $_{t-1}$				0.994	0.994		

				(0.006)	(0.006)		
Stock GERD business $_{t-1}$						0.966	0.995
						(0.048)	(0.047)
Cooperation $_{t-1}$ * Stock GERD business $_{t-1}$						1.027***	1.027***
						(0.005)	(0.004)
Outsourcing $_{t-1}$* Stock GERD business $_{t-1}$						0.980***	0.980***
						(0.007)	(0.007)
Stock GERD government $_{t-1}$						0.981	0.974
						(0.053)	(0.061)
Cooperation $_{t-1}$* Stock GERD government $_{t-1}$						0.963***	0.962***
						(0.007)	(0.007)
Outsourcing $_{t-1}$ * Stock GERD government $_{t-1}$						1.015***	1.014***
						(0.005)	(0.005)
Stock GERD HES $_{t-1}$						1.148**	1.105
						(0.078)	(0.073)
Cooperation $_{t-1}$* Stock GERD HES $_{t-1}$						0.977	0.977
						(0.025)	(0.025)
Outsourcing $_{t-1}$* Stock GERD HES $_{t-1}$						1.025	1.024
						(0.038)	(0.038)
GDP per capita		1.000		1.000		1.000*	
		(0.000)		(0.000)		(0.000)	
Tertiary education			0.986		0.986		0.993
			(0.012)		(0.012)		(0.015)
Constant	0.007***	0.002***	0.005***	0.002***	0.005***	0.002***	0.004***
	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)
Random part of the model							
ln(alpha)	0.477***	0.476***	0.477***	0.477***	0.477***	0.477***	0.477***
	(0.111)	(0.110)	(0.111)	(0.111)	(0.111)	(0.111)	(0.111)
Variance (Region)	0.110	0.094	0 .075	0.094	0.075	0.046	0.053
Variance (Firm-Region)	4.511	4.501	4.503	4.503	4.506	4.493	4.497
Observations	21,031	21,031	21,031	21,031	21,031	21,031	21,031
Number of groups	17	17	17	17	17	17	17
Likelihood ratio test Firm random intercept	4416***	4368***	4373***	4354***	4358***	4240***	4246***
Likelihood ratio test Region random intercept	19.15***	13.24***	13.24***	13.17***	10.02***	2.578*	3.730**
Wald Test Mean values	1213***	1128***	1086***	1103***	1062***	1139***	1119***
Wald Test Time dummies	674.9***	846.8***	409.2***	807.6***	395.1***	939.9***	420.8***

Robust SE in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Incidence rate ratios. Means and time fixed effects included. The null hypothesis for the likelihood ratio tests does not follow a χ^2 distribution because it is not on the boundary of the parameter space. We corrected for this following Rabe-Hesketh & Skrondal (2012. pp. 88-89). Our main regional variables are yearly grand mean centered.