
“Technological cooperation and R&D outsourcing at the firm level: The role of the regional context”

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Abstract

Much has been said about the role that technological networking activities play on the innovative performance of firms, but little is known about the relevance of the context where the firm is located shaping the efficiency of such networking activities. In this article we hypothesize that the transformation of firms' networking activities into innovation may vary depending on the regional environment in which the firm is located. For Spanish manufactures in the period 2000-12 and through the use of a multilevel framework, we obtain that after controlling for the firm's characteristics, the regional context has not only a direct effect on firms' innovation performance, but it also conditions the returns to firms' networking activities, although differently in the case of cooperation and outsourcing. Cooperating in innovation activities is more beneficial for those firms located in a knowledge intensive region, whereas R&D outsourcing seems to be more profitable for firms in regions with a low knowledge pool.

JEL Classification: D21, D22, O31, R10, R15.

Keywords: Technological cooperation, R&D Outsourcing, Local Knowledge Spillovers; Multilevel; Panel data; Spanish Firms, Manufactures.

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Acknowledgements

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, the 4th Geography of Innovation Conference - GEOINNO 2018, the 6th PhD-Student Workshop on Industrial and Public Economics (WIPE), and the 21st Uddevalla Symposium for their useful comments on earlier versions. 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 locational factors: Diversification, knowledge and the environmental revolution", ECO2017-86976-R, as well as to the Program ICREA Acadèmia. However, any mistakes or omissions remain the authors' alone.

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). Knowledge diffusion in the form of knowledge spillovers is crucial in this literature as a cause of the geographic agglomeration of firms (Audretsch and Feldman, 1996; Jaffe et al., 1993). At the end of the nineteenth century, Marshall (1890) already described how firms could benefit from spatial concentration: taking advantage of input-output relationships within industries, thanks to labor market pooling, as well as benefiting from positive knowledge externalities arising from other firms. Almost one century later, endogenous growth models (Lucas, 1988; Romer, 1986, 1990; Grossman and Helpman, 1991) restored the emphasis on knowledge spillovers with the consideration that firms create new knowledge profiting from the body 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 confirmed 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, emphasizing the impact of the context in which the firm is located on the innovation ability of the firm (Cooke and Morgan, 1998; Storper, 1997). However, we believe that the mechanism by which the regional context shapes the innovative performance of firms is still poorly understood. This paper tries to give a step forward in this direction with the main objective of providing evidence on the hypothesis that the regional context not only exerts a direct effect on firms' innovation performance but also mediates with firms' internal characteristics/activities. Specifically, we hypothesize that the returns that the firms obtain from their networking activities may vary across regions depending on regional determinants.

Indeed, the networking activities carried by the firms have been considered in previous literature to be one of the main determinants of firms' innovation performance (Laursen and Salter, 2006; Nieto and Rodríguez, 2011). This is so as networking is a relevant tool to acquire knowledge external to the firm (Breschi and Lissoni, 2001), both at the local level but also through building pipelines to benefit from knowledge hotspots around the world (Bathelt et al.,

2004). Among other strategies, we can think of technological collaboration agreements or R&D outsourcing, which act as channels through which knowledge is transferred throughout the space allowing for new recombination of ideas (Fratesi and Senn, 2009). Although the positive impact of such strategies on firms' innovation performance is well documented in the literature, an important novel insight in this paper is that these benefits may not be the same across different regional contexts. Explicitly, we hypothesize that the transformation of firms' networking activities into innovation may vary depending on the regional environment in which the firm is located.

All in all, this paper aligns to the literature trying to analyze the role of the regional determinants of innovation using firm-level data. From a methodological perspective, we take into account the fact that characteristics at the regional level 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. Using multilevel modeling allows the micro and macro levels to be modeled simultaneously (Hox, 2002) and can be understood as a natural way to assess the relevance of the regional 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.

Among the main results, we obtain that the regional context seems to exert a positive direct influence on firms' innovative performance but not as much as firm characteristics themselves. Among such internal characteristics, technological cooperation and R&D outsourcing present a significant influence. However, the regional context implies a more subtle and indirect effect shaping the return that firms obtain from such networking activities. As such, firms located in knowledge-intensive regions obtain higher returns of cooperation agreements in terms of innovative performance. On the contrary, firms in regions with low knowledge levels tend to present higher returns to R&D outsourcing.

The article is outlined as follows. Next, we offer the literature review upon which this article is based, followed by the dataset section with the description of the variables, while the methodology is subsequently presented. Then, we offer the main results and conclude with some limitations of the paper and policy implications.

2 Literature review

2.1 Firm's networking activities

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

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

On the one hand, collaborative research with a broad range of partners may enable innovating firms to acquire the 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 and Salter, 2006). In this sense, collaboration with other organizations is due to the necessity of solving new kinds of problems for which the market does not have a proper solution, leading to the need for more interactions among organizations. This kind of strategy requires 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 knowledge and know-how not easy to spill over (Teirlinck and Spithoven, 2013). Indeed, previous literature has recognized that cooperation embeds a complex/technical knowledge structure which fits with the idea previously stressed related to the appearance of new types of problems-solving requirements (Teirlinck and Spithoven, 2013; Dhont-Peltrault and Pfister, 2011).

On the other hand, outsourcing part of the innovation process allows an enterprise to gain access to a new source of well-prepared labor (Lewin et al., 2009), to capture external knowledge

cheaply, as well as to widen the scope of internationalization of the firm, gaining access to new markets and new knowledge, increasing the efficiency of its internal capabilities (Cassiman and Veugelers, 2006; OECD, 2008, 20, 91). At the same time, outsourcing may allow the enterprise to gain in productivity and efficiency through an improved restructuring of its internal resources, like managerial attention and a focus on core competences in what the firm does best while taking advantage of what the contracted firm is specialized in. However, R&D outsourcing may have a higher risk of appropriation of internal knowledge (Nieto and Rodríguez, 2011) by the contracted firm, so that this could be a reason why firms tend to outsource non-core activities, which imply a less technical and more standardized and codified knowledge (Teirlinck and Spithoven, 2013).

On the basis of the arguments above and the empirical evidence obtained in previous literature, we posit our first hypothesis:

H1: Firms that cooperate in innovation activities and firms that do R&D outsourcing are expected to present a better innovative performance.

2.2 The firm's environment: Why does the region matter?

The regional development literature (Storper, 1997; Cooke and Morgan, 1998) stresses that the environment where the firm is located can be essential to recombine and exploit previous existing pieces of knowledge. Regions concentrating research and development expenditures, highly skilled workers, institutions enabling innovation, the presence of research centers and universities, among others, are in a better position to generate new knowledge and innovation. In addition, a main advantage of a firm located in such an environment is due to the fact that the knowledge produced by a firm is only partially appropriated by the producer, whereas part of such knowledge spills over to other firms and institutions (Feldman and Audretsch, 1999; Jaffe et al., 1993). Thanks to the presence of such knowledge spillovers, firms can get external economies of scale if they co-locate close to other firms, pointing to the relevance of the regional context for firms' innovative performance. The notions of industrial districts (Scott and Storper, 2003), innovation milieu (Keeble and Wilkinson, 1999) and clusters (Porter, 1990) are some of the labels used to refer to such context.

In addition, the regional innovation system (RIS) literature (Cooke et al., 1997) considers

that subnational units have the economic power and the capacity to use central funds in an autonomous way, or to finance and design their own innovation policies, so that differences in technological performance cannot be explained by firms in isolation but at the regional level (Uyarra, 2009). Besides, competitiveness and innovation are determined at regional levels basically because innovation is not homogenously distributed across space. Despite the spread of information and communication technologies (ICT), innovation is remarkably concentrated in the space probably as a consequence of the relevance of geographical proximity for the generation of new ideas and knowledge (Boschma, 2005; European Commission, 2014). Thus, face-to-face contacts, the application of the same interpretative schemes of new knowledges, a similar experience with a particular set of problem-solving techniques, and shared cultural traditions, make interaction less costly in a shorter distance such as the one within a region (Malmberg and Maskell, 2006, 9).

As a consequence of the existence of regional knowledge spillovers and the relevance of the RIS, there is broad agreement that firms benefit from being located in regions with a rich knowledge base (Audretsch and Dohse, 2007). Previous evidence suggests that R&D spillovers are more abundant in regions with a high concentration of knowledge activities (Love and Roper, 2001). Therefore, the presence of a higher knowledge endowment/base in a region is expected to impact positively the innovation performance of its firms. That is, the regional context is assumed to have a positive direct impact of the innovative performance of the firms located in it.

As a consequence of the arguments above, we posit the next hypothesis:

H2: Firms located in regions with a large knowledge base will obtain a higher innovation output.

2.3 The interplay of networking activities and the regional context

As stated in López-Bazo and Motellón (2018), a drawback in most of the previous studies analyzing the impact of the regional context on the firms' innovative performance is the lack of consideration of the interactions between firm characteristics and regional variables. In our case, we believe that the regional innovative endowment not only presents a direct impact on the firms' innovative performance but can also have an indirect one by shaping the effect of

firms' networking activities. Closely related to our objective, [Love and Roper \(2001\)](#) reported that the region affects the efficiency with which R&D, technology transfer and networking are translated into innovation outputs in Germany, Ireland and the UK. Indeed, knowledge acquisition through networking, such as technological cooperation and R&D outsourcing, can be assumed to link to the regional context, so that both become reciprocally supporting.

On the one hand, the more advanced the networking mechanisms that bring information about new technologies into a local environment, the more dynamic the milieu from which local actors profit. On the other hand, a more technologically advanced regional context presents stronger knowledge spillovers that may allow for better selection of external knowledge/partners ([European Commission, 2014](#)) as well as better translation and integration processes of such knowledge into the firm. Firms that work in more knowledge intensive environments will therefore have advantages in accessing new knowledge through networking activities in comparison to firms located in less innovative regions. This way, the regional context and firms' networking activities could complement each other ([Malmberg and Maskell, 2006](#)). This complementarity would imply a self-reinforcing mechanism between knowledge intensive firms and regions.

However, there are contrasting arguments pointing to negative effects coming from regions that present a lot of knowledge externalities. For instance, firms located in regions with a high knowledge pool may face a fierce degree of competition, which would lead to the necessity of firms incorporating a higher degree of novelty embedded in new technologies acquired through networking activities. Also, for enterprises with leading in-house knowledge, they would not benefit so much from the spillover of poorer knowledge, whereas they would lose if their richer knowledge spills over to competitors ([Phene and Tallman, 2014](#)). Another negative effect from locating in high knowledge regions in situations of intense rivalry is labor poaching, that is, the loss of qualified human capital to competitors, which in some cases can outweigh the benefits of labor market pooling ([Grillitsch and Nilsson, 2017](#)). As a consequence, 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.

Derived from the contradicting arguments above, it is not straightforward whether networking activities (technological cooperation and R&D outsourcing, among the main ones) should benefit equally from the regional context. Given that the knowledge acquired through technological cooperation agreements tend to present different characteristics than the one acquired

through R&D outsourcing, we argue that the role of the regional environment could be different in both strategies. The important point here 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, ICT and can be purchased in markets for technology with little interaction with other agents (e.g., R&D outsourcing). 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. This implies the necessity of interactive learning (Maskell and Malmberg, 1999) that would give place to cooperation agreements.

As a consequence of this differentiation, the endowment of knowledge available in the region where the firm is located conditions the returns of these two strategies, albeit in different ways. Indeed, in the case of firms carrying out technological cooperation agreements as a way to introduce external knowledge with a more tacit component, the gains from local knowledge spillovers can be stronger given that they will allow the firm to further elaborate the external knowledge acquired through cooperation. Thus, there would exist a reinforcement link between a firm pursuing cooperation in innovation activities and being located in a region with a high knowledge pool. This leads to our third hypothesis:

H3: Firms located in regions with high knowledge endowment will obtain higher returns to technological cooperation in terms of innovative output.

In contrast, when outsourcing codified knowledge, firms located in low-knowledge regions may prosper because they are less dependent on local knowledge spillovers (the knowledge acquired through outsourcing is standard and easy to codify) and are less likely to experience negative knowledge spillovers coming from closely located competitors given the low amount of innovation taking place in them. This way, the benefits associated with knowledge agglomerations may not be so necessary for firms that outsource part of their knowledge, at least the most codified knowledge. That is, firms that outsource part of their R&D activity are in a better position to get the knowledge produced elsewhere and to lessen the weaknesses of the region where they are located while not incurring in fierce competition. Thus, our fourth hypothesis stands as follows:

H4: Firms located in regions with low knowledge endowment will obtain higher returns to R&D outsourcing in terms of innovative output.

Since the research in a region can be made either by private or public institutions and given the different characteristics they present (Cohen and Levinthal, 1990), one may think that the role of the regional context can be different depending on the prevalence of one over the other at the regional level.

First, the research developed by the private sector presents a more applied component and is focused mainly on market profitability, cost effectiveness, reliability of new solutions and time to market, whereas the type of research developed by public research centers has a more science-based component and is not focused on market profitability, being far away from the necessities of private firms in several respects. Second, previous literature stresses the relevance of short term innovations in the case of private organizations in contrast to public research institutions that spend a much longer time frame for developing an innovation – around seven years as stressed by Feldman and Florida (1994). Finally, another important difference lies on the moment of the life-cycle of R&D, public institutions being more focused in the early stages and private organizations in the latter stages.

As argued in the hypotheses above, a firm that cooperates in innovation activities gets higher benefits from regional knowledge spillovers given that they will allow the firm to further elaborate the external knowledge acquired through cooperation which tends to be of a more tacit component. If the regional knowledge base is mainly the result of research developed by the private sector (i.e. with an applied component, market-oriented and focused in the latter stages of the life-cycle of R&D), the knowledge spillovers arising from such a region can make cooperation more effective in terms of generating higher returns to the firm's innovative performance. On the contrary, if the regional knowledge base is mainly the result of research developed by the public sector (i.e. being science-oriented and not market-oriented, devoting much longer time frame for developing an innovation, and focused in the early stages of the R&D), the knowledge spillovers arising from such a region will not be profitable for the firms' purpose and will make cooperation less effective since the firm may incur in a higher cost for implementing such a knowledge. As a consequence of the arguments above, our fifth hypotheses stand as follows:

H5a: The returns to cooperation activities will be higher if the firm is located in regions with higher research expenditures developed by private agents.

H5b: The returns to cooperation activities will be lower if the firm is located in regions

with higher research expenditures developed by public agents.

For a firm that outsources part of its R&D, we have given arguments above that the kind of knowledge that can be purchased is of a codified/standard nature, so that firms are less dependent on local knowledge spillovers (because the knowledge acquired through outsourcing is easy to codify). Thus, being in a region with a low knowledge base does not present a main disadvantage while benefiting from the fact of being less likely to experience fierce competition due to the low innovation activity in them. The same happens if the firm is located in a region where the knowledge base is mainly the result of research developed by the public sector, which does not imply competition in innovation terms and which, despite being not market-oriented, does not involve any disadvantage for the firm making outsourcing since the knowledge spillovers coming from regional context are less important in them. Quite the reverse would happen if the outsourcing firm is located in a region where the knowledge base is mainly the result of research developed by the private sector. In such a case, the competition for getting innovations is fierce (given that a lot of private innovation activity with a market-oriented profile is taking place) whereas the benefits from the knowledge spillovers stemming from the private sector are minimal in the case of the outsourcing strategy. Then, our last hypotheses arise:

H6a: The returns to R&D outsourcing activities will be higher if the firm is located in regions with higher research expenditures developed by public agents.

H6b: The returns to R&D outsourcing activities will be lower if the firm is located in regions with higher research expenditures developed by private agents.

3 Dataset and variables

3.1 Dataset

The dataset we use at the firm level 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 1,800 firms surveyed yearly by the SEPI Foundation with an agreement with the Ministry of Industry. Firms are classified into twenty industries using the two-digit

European classification NACE (see Table A1 in the online Appendix).¹ The ESEE's population of reference is composed of firms with 10 or more employees within the manufacturing industry. Moreover, the geographical scope of reference is the Spanish economy as a whole even though information of the location of the main plant is targeted in the survey. The initial selection was carried out combining exhaustiveness for firms with more than 200 employees and random sampling for firms employing 10 to 200 workers. These firms were selected through a stratified, proportional and systematic sampling with a random seed.

As for the regional dataset, we use Eurostat at the NUTS 2 level. In the Spanish case these territorial units represent administrative and policy authorities, and even though all of them belong to the same national context, they present an important heterogeneity. First, Spain is one of the four European countries presenting the widest regional heterogeneity in innovation (European Commission, 2014). Second, Spanish regions have legal competencies and financial autonomy in terms of innovation policies and present important socio-cultural differences that could lead to different learning process as stressed by Cooke et al. (1997). Third, the territorial coverage as well as the implementation of the operational programs of the European Structural funds – an instrument of the European Union cohesion policy that aim to reduce the regional disparities in R&D and innovation – in Spain is at NUTS 2 regional level (European Commission, 2014). Finally, regarding the socio-cultural aspect which is an important source of the learning process according to the RIS literature, Spain has four different languages apart from Spanish, which are officially talked in six regions – Catalonia, Valencia, Basque Country, Galicia, Balearic Island, and Navarre – highlighting a social and cultural diversity higher than in other European countries. All these reasons endorse the regional heterogeneity expected in our empirical exercise. The period under consideration ranges between 2000 and 2012, since some of the variables taken from Eurostat are not provided for more recent years.

Given that the ESEE is a survey in which values are self-reported, one could think of the problem of measurement errors and/or self-reported values. However, in this kind of survey, where anonymity is a legal concern, we do not expect a systematic propensity for over or under-reporting the innovation carried out by the enterprise (Aarstad et al., 2016).

¹More 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 Firm level variables

Our dependent variable is the number of product innovations (NIP), as a proxy for the innovative output, which has been used in previous studies at the firm level (Blundell et al., 1995; Chatterji and Fabrizio, 2014; Hagedoorn and Cloodt, 2003; Katila and Ahuja, 2002; Segarra-Ciprés et al., 2012). In our opinion, this measure is more accurate than just the decision to engage on product innovations (as in Naz et al., 2015; Srholec, 2010) since it takes into account the number of innovations made. Following the explanation given by Katila and Ahuja (2002), a firm developing a higher number of product innovations may see an improve in its markets share, its market value, as well as in its survivability. Moreover, we have reasons to focus on product instead of process innovations. Building on previous evidence, networking activities aiming at the acquisition of knowledge external to the firm has a higher impact on product rather than on process innovations (Bertrand and Mol, 2013; Nieto and Rodríguez, 2011). This is due to the type of knowledge required in each case, which for product innovations tends to be more explicit, while for process innovations organizational closeness among the enterprises is also required, which is more difficult.²

We consider two different networking strategies. Cooperation is a dummy equal to 1 if the enterprise cooperates in innovation activities in a given year with at least one partner and zero otherwise; whereas Outsourcing equals to 1 if the enterprise declares to have external R&D expenditures in a given year and zero otherwise.³

To control for other firm characteristics relevant to explain innovative performance, we use the log of internal R&D expenditures per employee (Internal R&D)⁴ to capture the firm's absorptive capacity (Cohen and Levinthal, 1990). To measure the size of the firm (Size),

²We restrict the range of the variable to be in between 0 and 30, which accounts for 99 percent of the observations and discard just 0.1 percent of enterprises in the sample. In our opinion, this is a necessary process for three reasons: 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) we find convergence problems in the estimation when dealing with the entire range of the variable.

³We are proxying the networking strategies used by the firm without any distinction between the knowledge coming from within the region or beyond its boundaries, information not available in our dataset. Moreover, the information from our dataset refers to technological cooperation instead of R&D cooperation, so that an enterprise can collaborate with other organization while having zero internal R&D expenditure (see Table 2). We thank an anonymous referee for pointing out this issue.

⁴This variable has been deflated using the Consumer Price Index.

we employ the total number of employees and its squared term to account for a non-linear relationship. Another relevant variable is whether the firm belongs to a multinational corporate group, since this may imply more resources, such as better financial resources and a better innovative environment (Belderbos et al., 2013). We proxy it with a dummy variable (Foreign) being one in the case that the firm has more than 50 percent of its capital from abroad (Srholec, 2010). Finally, we include a dummy variable which equals 1 in the case the firm received public funding from a government – regional, central, or others – for developing R&D above the total average and zero otherwise (R&D government).

3.3 Regional level variables

We are interested in measuring the knowledge endowment of a region. As highlighted in previous studies, it can be approximated by regional R&D expenditures (Tödting and Trippl, 2005) which are considered to be an important driver of economic growth accounting for the innovativeness of the region (European Commission, 2014). The concentration of R&D activities in a region provides knowledge, new scientific discoveries, and develops new opportunities for the firms located in the region (Feldman and Florida, 1994). Therefore, on the input side, we account for the regional effort on R&D (GERD referring to R&D expenditures) as a regional driver of firms' innovative performance (Sternberg and Arndt, 2001). This variable can be disaggregated into the regional R&D expenditure of private enterprises (GERD business), government (GERD government), and higher education sector (GERD HES).

In order to account for the accumulative process characterizing innovation, we employ a measure of the stock of such knowledge instead of the flows of expenditure. This has several advantages. First, it takes into account the fact that knowledge is path-dependence as well as cumulative. And second, the stock is less affected by punctual shocks (exogenous or endogenous to the region like certain policies) than the flows. Thus, we use the perpetual inventory method (Peri, 2005) with a geometric mean of the growth rates of R&D spending and a depreciation rate of five percent, all measured in purchased power parity at constant prices of 2005.

On the output side of the innovation process, we propose to use information on the number of patents in each region (Regional patents) through the computation of its stock using the perpetual inventory method. This measure has been considered a proxy of the regional differ-

ences regarding the regional innovation performance in previous studies (European Commission, 2014).⁵

Finally, in order to control for the wealth as well as the educational level of the region, we employ GDP per capita and the percentage of people aged 25-64 years with tertiary education (Tertiary education), respectively. In addition, we introduce technological sectoral dummies and time dummies. All variables in the model are lagged one period in order to lessen simultaneity problems.

4 Methodology

The importance of accounting for regional differences through hierarchical models relies on several theoretical reasons. First, the use of standard estimations – OLS – does not take into account the dependence of those firm observations within the same region ending in a smaller standard error, which would lead to artificially higher significance of the parameters (Hox, 2002). They are usually assumed to be independent under this method of estimation, whereas firms within the same region are more likely to be more similar among them than those in different regions (van Oort et al., 2012). Second, the use of the multilevel approach allows us to model variances instead of means as in the case of standard OLS regressions. This allows dividing the total effect into firm-level effects and regional effects through 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, so that the mixed of firm and regional level variables is an interesting type of analysis.

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

⁵Although there exist other indicators for measuring the regional knowledge base from the output side such as the number of product and process innovations, statistical information on them are not available at the regional level for Spain. We thank a referee for pointing this.

case, the bias of the macro effects as well as the confidence interval are virtually inexistent, justifying the use of the random intercept model instead of the random slope one. Moreover, in order to determine how regional characteristics affect the innovation performance of firms, we plan to use cross interactions between some of our firm and regional variables. In this sense, we follow [Snijders and Bosker \(2012\)](#) who stressed the latter as an appropriated strategy when having theoretical/empirical reasons for them.

One of the assumptions of the multilevel model is the absence of correlation among the explanatory variables and the random effects, otherwise leading to inconsistent estimations ([Rabe-Hesketh and Skrondal, 2012](#)). We correct this possible endogeneity relying on [Mundlak \(1978\)](#) and divide the time varying explanatory variables at the firm level into between and within effects using the mean of those variables ([Snijders and Bosker, 2012](#)). This way, we guarantee the absence of endogeneity due to the correlation among the firm level variables and the firm's random effects.

In our case, the Hausman test adds no information in order to choose between the fixed and the random effects estimation since we are accessing to the same within effect as in the fixed effect estimation.⁶ On the one hand, due to the poor within variabilities of our set of variables (see Tables A2 and A3 in the online Appendix) we think it is more appropriate to use random effects on top of fixed effects, since the latter 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, which can be done in the multilevel model. That is, with the fixed effect estimation it is not possible to do inferences about time invariant variables as well as for higher-level variances ([Bell and Jones, 2015](#)).

Another important issue is that given that the dependent variable is a count variable with non-negative values, a normal distribution is not satisfactory due to the skewness of the variable and, consequently, a Poisson model is preferred. However, as the Poisson distribution is very restrictive in the sense that it assumes that the mean equals the variance, we decided to use the Negative Binomial model that allows for overdispersion, being more robust ([Snijders and](#)

⁶Running a Wald test to the means of the firm level variables is asymptotically equivalent to a Hausman test ([Rabe-Hesketh and Skrondal, 2012](#)). Moreover, other researchers stressed the misconception of many studies when choosing between the fixed and the random effects estimation based on the Hausman test ([Bell and Jones, 2015](#)).

Bosker, 2012, chapter 17). Moreover, Bell et al. (2016) stressed that when estimating the Negative Binomial, the multilevel random effects augmented with the between-within effects is the best choice to produce within effects with the lower bias due to omitted higher-level variables.⁷

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 (Rabe-Hesketh and Skrondal, 2012). Therefore, the hierarchy is the following: individual observations (time-firms) are nested on firms, and firms are nested on regions.⁸ In order to account for this scheme, our reduced form specification is as follows, where subscript i refers to the firm, j refers to the region and t refers to time:

$$\begin{aligned} \log [E(Y_{ijt})] = & \gamma_{00} + \sum_{m=1}^s \gamma_{010m} X_{ijtm} + \sum_{m=s+1}^M \gamma_{001m} X_{ijtm} + \sum_{k=1}^K \gamma_{01k} X_{ijk} + \sum_{n=1}^N \gamma_{10n} Z_{jn} + \\ & + \sum_{m=1}^s \sum_{n=1}^h \gamma_{11mn} X_{ijtm} Z_{jn} + \mu_{0j} + \mu_{0ij} \end{aligned} \quad (1)$$

where Y_{ijt} refers to our dependent variable and X_{ijtm} refers to the M time varying firm-level characteristics, so that s is the number of time varying firm-level characteristics that are our key firm-level variables (technological cooperation and R&D outsourcing), the rest being control firm-level variables. X_{ijk} are the K time invariant firm-level characteristics (sectoral dummies plus between/Mundlak effects in our case), and Z_{jn} will proxy for N regional-level variables (being h the number of these regional-level characteristics that are our key region-level

⁷This is extremely important in our case since the low amount of highest-level units in the sample forces us to use only a small set of highest-level controls.

⁸As we aim to studying regional differences in the innovative performance of firms, it is important to highlight that in the multilevel framework, the variables of the higher levels do not have to vary at the lower levels. That is, all firms pertaining to a region will share the same value for a given regional variable. This is done by means of time averaging regional variables, which is also useful for removing fluctuations.

variables, that is, the ones proxying for the endowment of knowledge available in the region). Moreover, $\mu_{0j} \sim Normal(0, \sigma_{\mu 0}^2)$ and $\mu_{0ij} \sim Normal(0, \sigma_{\mu 0}^2)$ are the random parts of the model accounting for the error term of the region and the firm, respectively, which are assumed to be independent of each other, of the covariates, across regions, and μ_{0ij} is assumed to be independent across firms as well. Therefore, we are estimating a multilevel negative binomial random effect model with two random intercepts, one for the firm and another for the region.

5 Results

5.1 Descriptive analysis

Table 1 provides summary statistics of the regional variables in our first and last year of analysis. It is worth noting the huge diversity found among regions, since in the year 2000 the region with the highest value of R&D per capita (Madrid) is eight times higher than that of the region with the lowest amount (Balears). More impressive is the difference in the case of patents, since Catalunya has 40 times more patents per million inhabitants than Cantabria. This difference is much higher than the variability found in the case of GDP per capita and the share of tertiary education, which is only double. These figures show important regional differences in the innovative levels across Spanish regions, pointing to the necessity of controlling for them when studying firms' innovative performance. Another remarkable fact is that for some regions public R&D expenditures (government and universities) may compensate for the scarcity of private expenditure. This could be the case of the Balearic and Canary Islands where public expenditures per capita are 7 and almost 4 times higher than private ones, respectively, or Extremadura with 2.7 times higher in 2000 and 4.2 in 2012. In addition, these differences in the proxies for knowledge endowments in the Spanish regions have not been decreasing in time, but the contrary.

[Insert Table 1 around here]

Interesting observations can be extracted when comparing those firms that develop one of the two networking strategies (technological cooperation and R&D outsourcing) and those that

do not. As shown in Table 2, the average internal expenditure on R&D per worker is around ten times higher for those that cooperate and they develop more product innovations. A similar conclusion can be made when looking at those enterprises engaging in R&D outsourcing if compared with those not engaged (see Table 3). In summary, firms engaged in technological cooperation and/or outsourcing use more innovation resources and have a better innovative performance than those enterprises that do not cooperate or outsource R&D.

[Insert Tables 2 and 3 around here]

Table 4 contains seven different estimations in order to analyze how firm and regional characteristics affect firms' innovative performance. We present the incidence rate ratios so that the coefficients can be interpreted as ratios of expected counts, the influence being either positive (if the ratio is higher than one) or negative (if lower than one) (Rabe-Hesketh and Skrondal, 2012). In our first specification (column 1), we only include firm characteristics – level-1 as well as level-2, that is, time varying and time invariant firm characteristics – to explain the variability of our dependent variable. As observed by the results of the Likelihood Ratio tests, it is worth pointing out several conclusions. First, the variance of the firm as well as the variance of the region is highly significant, pointing to the necessity of using the multilevel methodology. This way, our method of estimation takes 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. Second, although the regional variance is significant, it is lower than the firm level one. This is in accordance with recent literature, concluding that regional characteristics are relevant for the innovativeness of firms but not as much as firm characteristics themselves. Another interesting result is the existence of overdispersion in our dependent variable, which can be evaluated with the $\ln(\alpha)$ parameter, so that the Negative Binomial is the most reasonable method of estimation in our case.

[Insert Table 4 around here]

This first specification illustrates that all the variables at the firm level present the expected sign. Internal R&D expenditures have a positive and significant impact on the number of

product innovations, validating the idea that more internal capabilities allow to develop new ideas that can be transformed into new products (Cohen and Levinthal, 1990). Regarding the size of the firm, we found evidence of a negative non-linear relationship, pointing to a more advanced position of larger enterprises until a certain threshold. The impacts of receiving public funding and of belonging to an international group do not seem to be different from zero. Our two key variables, Cooperation and Outsourcing, present a positive and highly significant effect on the number of product innovations, supporting our first hypothesis.

Lastly, the Wald test for the technological, time, and firms' mean values concludes that all of them are jointly significant. Therefore, it is guaranteed that our firm level coefficients are not driven by being correlated with the firm random effects. Another important result when looking at all our different specifications in Table 4 is that the sign as well as the magnitude of the control variables' 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, reflecting that our model accounts for a great part of the regional variability.

To start analyzing the rest of the hypotheses of the article, specifications 2 to 7 take into account different measures to proxy for the knowledge base of a region. In particular, specifications in columns 2 and 3 consider the regional stock of patents.⁹ Again, we note the relevance of the networking strategies. Also, the variable measuring the regional stock of patents is highly significant, pointing to the fact that being located in a knowledge-dense region is important, even for those firms not cooperating or not engaged in outsourcing. This is in accordance with our second hypothesis and with the wide agreement that firms benefit from being located in knowledge-intensive regions (Audretsch and Dohse, 2007).

When we look at the cross effect between the regional innovation context and the firm's networking activities on firms' performance, an interesting result appears. Firms obtain a higher return of technological cooperation if they are located in regions with higher knowledge capacity (measured through patents) given the significant and higher than one value of the interaction term. On the contrary, the significant and lower than one parameter between outsourcing and regional patents indicates that firms obtain a higher return from R&D outsourcing if they are located in regions with low knowledge endowment. As argued in the literature review section,

⁹Due to a high correlation between GDP per capita and Tertiary education, we decided not to include both controls at the time (see Table A4 in the online Appendix).

the explanation for this result may come from the type of knowledge embedded in each strategy. In the case of cooperating in technological activities, the knowledge is more technical and tacit, so that the gains from the regional context and, more specifically, from regional knowledge spillovers, can be important since they will allow the firm to further elaborate the external knowledge acquired through cooperation. While for outsourcing, the knowledge embedded tends to be less complex and more standard and it is not necessary to construct a very different knowledge from the one purchased, so that the knowledge spilling from other firms within the region is not so essential; and being located in low innovative performance regions would imply not being affected by fierce competition. These results give empirical support to our third and fourth hypotheses.

We now use the stock of R&D expenditures to proxy for the knowledge base of the region, controlling again by GDP per capita (column 4) and Tertiary education (column 5) as well as firm-level variables as in previous specifications. Again, we obtain that the regional stock of R&D exerts a positive and significant direct influence on the firm's innovative performance. However, when crossing the regional stock with our key variables (technological cooperation and R&D outsourcing), none of the parameters are significant.

In order to study the reason behind this non-significance of the cross-effect, as well as to provide empirical evidence for our hypotheses 5 and 6, we separate the regional stock of R&D into its different components, which could reflect a different type of research, more basic in the case of universities, research centers, and government, and more applied in the case of businesses. The results are shown in columns 6 and 7. When crossing the different types of stock of R&D with technological cooperation, we observe that the returns to technological cooperation are higher if the firm is located in regions with higher research expenditures developed by private agents. In contrast, the benefits that firms obtain from cooperation are lower if they are located in regions with a rich knowledge stock in the government and university sectors. These results support hypotheses 5. Moreover, it seems that the non-significance of such cross product in column 5 could be due to the different directions when splitting R&D expenditures into the public/business sectors canceling the significance of the effect. All in all, firms obtain higher returns from technological cooperation if they are located in regions with higher amount of private R&D expenditures or if they are located in regions with lower amount of public ones, given the nature of the knowledge embedded in both cases, more market-oriented in the first

case and science-based in the second.

On the contrary, we observe that firms located in regions with higher research expenditures by private agents obtain lower returns from their R&D outsourcing strategy; whereas those located in regions with higher amount of research developed by public institutions obtain higher returns from outsourcing. These figures go in line with hypotheses 6 in the case of R&D outsourcing. The result seems to indicate that firms in regions where the public research base is higher might benefit from a lower degree of competition (because the private research base would be lower), while not being penalized by the little knowledge spillovers with a market-oriented profile (which they do not need since the knowledge acquired through outsourcing is easily absorbed due to its standard nature).

5.2 Robustness section

Several robustness analyses are considered.¹⁰ In the analysis so far, we are using an unbalanced panel possibly leading to attrition problems. To correct for this, we use information present in the survey recording the reasons for an enterprise leaving the survey, so that once corrected by this, we may follow the assumption that missing values are random (Snijders and Bosker, 2012).¹¹ Estimations show that the results do not change for our key variables (see Table A5 of the Appendix online).

We acknowledge that some enterprises may move from one region to another during the period of analysis, possibly biasing our results due to the misrecognition of the characteristics of the region where the enterprise was previously located, as well as its contribution to the number of product innovations. According to Chung and Beretvas (2012), the bias due to the lack of control for this in a multilevel framework would be higher, the higher the percentage of firms changing locations, as well as the higher the number of regions they move to. We do not expect a high bias in our estimations since the number of firms changing locations in our sample is very low (3.8%) in comparison to theirs (10%). In any case, we re-estimated

¹⁰Because of space restrictions, all the results in this section are given in the online appendix. We thank the three anonymous referees for highlighting some of the robustness checks in this section.

¹¹We include a categorical variable with the following categories: the firm has split; it has acquired other firms; it is born after a split process; it is a result of a merger process; it has changed the trademarks and legal form; without change.

our model discarding these moving firms and the results show that, qualitatively speaking, our main conclusions are virtually the same (see Table A6 of the Appendix online).

Also, as suggested by [Narula \(2004\)](#), large enterprises (LEs) and small-medium sized enterprises (SME) differ in the intensity of use of the two networking strategies studied in this paper. In the case of a small sample of European firms, Narula obtains that SMEs focus more on outsourcing rather than alliances because of the higher risks and costs of managing different partners while LEs prefer collaborative projects due to their larger portfolio of projects to offer to their partners. Although our interest lies on the impact of networking and not the intensity in their use, we wonder whether our results would maintain if the sample was divided between SMEs and LEs. Even though most of our main results are maintained, it is worth stressing that the regional context does not affect LEs as much as in the case of SMEs (see Tables A7 and A8 in the Appendix online).

When using a multilevel model, some enterprises might have an impact on regional performance. Yet, this is probably not the case here since the territorial units we consider are large and represent administrative authorities where a single firm is not sufficiently important to affect regional performance. However, in order to test it, we skip very large enterprises – those with more than one thousand workers – and most of our results behave the same (see Table A9 in the Appendix online). The shortcoming of analyzing large regions – as in the case of NUTS2 level in Spain – is that it is assumed that all firms take a similar advantage of the regional capability; we acknowledge that a firm in Girona possibly should not take the same profit from its environment as another firm located in Barcelona (both being part of Catalonia). Unfortunately, we do not have further regional disaggregation to check for this.

In addition, we check the robustness of our results to the use of other proxies for some of our explanatory variables. First, in relation to the regional variables and specifically the use of the patents as a proxy for the knowledge base of the region, we acknowledge that patents are not always an equivalent measure of the innovative output across different sectors since some of them present a lower propensity to patent. Therefore, an alternative measure of the regional innovation base could be the employment in high and medium-high technological manufacturing industries, as stressed in [Feldman and Florida \(1994\)](#) and in [European Commission \(2014\)](#). Our results hold and behave in the same way, that is, those firms cooperating take more advantage of such cooperation if they are located in a region with a higher share of high and medium-high

tech manufacturing employment. While for those firms doing outsourcing, the return is higher if they are located in regions with lower share of employment in high and medium-high tech manufactures (see Table A10 in the Appendix online).

Second, among the firm level explanatory variables, even though we measure the internal knowledge capacity of firms with the amount of R&D expenditures per employee as in most previous studies, we analyzed the sensitivity of our results to the use of other proxies such as the total employment in R&D, the employment in R&D with tertiary education (both measured as the number of people), and hiring of engineers/graduates with governmental/corporate experience in R&D (a dummy variable). In all the cases, the conclusions are maintained (see Tables A11-A13 of the Appendix online).

Third, in order to account for the differential effect of sectors in the generation of new products innovations – instead of the technological classification – we include sector fixed effects. Moreover, to control for the cohort of firms as well as its possible different impact on our networking strategies, we include the age of the firm. In both cases the main conclusions are maintained (see Tables A14 and A15 of the Appendix online, respectively). We also consider the sensitivity of our results to several depreciation rates in the computation of the measure of the stock of knowledge. If we use a 10 percent depreciation rate as in [Peri \(2005\)](#), instead of 5 percent, the results follow the same pattern (see Table A16 of the Appendix online).¹²

Finally, we have taken [Wooldridge \(2010, chapter 3\)](#) advice, and despite the collinearity between our two main regional variables – GERD and Patents – we included them jointly in the model in order not to confound their relation with our dependent variable. Our results show that in fact this seems not to be an important issue since the pattern of our main results behaves the same qualitatively and barely changes quantitatively (see Table A17 of the Appendix online).

6 Conclusion

This paper aligns in the literature that assesses the role of the regional context to firms' innovative performance. In addition to the direct effect of the regional characteristics where the firm is located, we hypothesize that it also shapes the returns to firms' networking activities. Specif-

¹²We also use 15 percent as in [Rahko \(2016\)](#) and results behave the same (results upon request from the authors).

ically, we analyze how the knowledge endowment of the region can influence the efficiency of the networking activities carried out by the firm, explicitly technological cooperation agreements and R&D outsourcing. We estimate a multilevel framework that combines information at the firm level as well as the regional level for the case of Spanish manufactures in the 2000-2012 period, allowing to take explicit account of the multilevel structure of the data as well as its panel structure.¹³

Among the main results, first we find that although firms' characteristics are obtained to be more relevant than regional ones, something already stressed in recent studies (Backman, 2014; López-Bazo and Motellón, 2018; Naz et al., 2015; van Oort et al., 2012), the regional context explains an important part of the variability of firms' innovative performance measured through the number of product innovations introduced by the firm. We then give a step forward and try to analyze the mechanisms through which the regional environment exerts influence on firms' performance. Our analysis considers that regional innovation environments condition the returns of firms' networking activities. As a consequence, the efficiency of the technological cooperation and the R&D outsourcing carried out by the firm differs depending on the characteristics of the region in which it is located. Explicitly, we find evidence of a reinforcement effect between being in a highly knowledge endowed region and the returns obtained from cooperating technologically with other organizations. In contrast, enterprises that acquire external knowledge through an outsourcing strategy have a higher return when they are located in a region with a lower knowledge endowment.

In addition, we analyze if the results are maintained when we consider separately the regional research effort made by the private sector as compared to the public one. It seems that the benefits obtained from technological cooperative agreements are higher in regions with a high endowment of knowledge made by the private sector. On the other hand, the R&D outsourcing strategy is more beneficial in regions where the knowledge pool available is mainly due to public institutions. All in all, we can conclude that a firm's ability to exploit external knowledge acquired through networking activities depends crucially on the endowments of the region in which it operates.

Some policy implications are envisaged. First, our results illustrate that although firms'

¹³To our knowledge, this has been done only in two papers on topics related to innovation (Acosta et al., 2012; Naz et al., 2015).

characteristics are of clear importance for innovative outcomes, firms are also influenced by the regional environment in which they are located, which is at the core of the ‘smart specialisation’ strategy of the European Commission (McCann and Ortega-Argilés, 2015). Second, the results in this paper align with the thinking that governments should not enforce winning or one-size-fits-all types of policy. The mechanism to incorporate new knowledge into the firm needs to fit with the requirements, the kind of problem-solving involved, managerial capabilities, and learning potential (Lucena, 2011; Teirlinck and Spithoven, 2013) of the enterprise but also take into account the regional context. That is, policies used in an undifferentiated manner for all kinds of regions may be misleading. Finally, in Spain, the government has paid much attention to the public-private innovation 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 improve the innovative performance of firms, policy makers should encourage and promote knowledge transmission among relevant actors through networking activities, while taking into account the contextual environment in which the firm is located.

Limitations & Future Research

Some limitations of our study are as follows. First, a possible endogeneity problem due to the higher-level variables may arise. However, this problem is solved thanks to the use of the time averaged regional variables as well as by the fact that we estimate a multilevel random effects model augmented with the between-within effects. According to the literature, this is the best choice to produce within effects with lower bias due to omitted higher-level variables (Bell et al., 2016). Second, as in most previous studies, the present research assumes that spatial sorting is exogenous to the firm. Therefore, the interpretation of the model must account for the fact that firms’ location choice does not influence the impact of our measures of regional knowledge endowment. However, even though panel data may help to control for this, we do not have information on the location of the enterprises before the beginning of the survey. Moreover, the study of the drivers of firms’ location is beyond the scope of the article.

Finally, there is previous evidence on the importance of distance as a barrier to knowledge sharing in case of collaborations while offering the possibility to access more different knowledge (Acosta et al., 2011; Hoekman et al., 2010). Due to the lack of data on the geographical extent

of the networking activities in the survey used in this paper, we do not address this study empirically. However, it would be interesting to consider in future analyses how the regional context can condition the returns to both regional and international collaboration, separately.

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, the 4th Geography of Innovation Conference - GEOINNO 2018, the 6th PhD-Student Workshop on Industrial and Public Economics (WIPE), and the 21st Uddevalla Symposium for their useful comments on earlier versions. 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 locational factors: Diversification, knowledge and the environmental revolution”, ECO2017-86976-R, as well as to the Program ICREA Acadèmia. However, any mistakes or omissions remain the authors’ alone.

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Table 1: Descriptive statistics of the variables proxying for the regional knowledge base (regional level)

Regions	Year 2000					Year 2012							
	GERD	GERD business	GERD government	HES	Regional patents	GDP per capita	Tertiary education	GERD business	GERD government	HES	Regional patents	GDP per capita	Tertiary education
Andalusia	99.2	32.5	18.9	47.6	5.16	16,570	18.8	175.3	37.5	74.2	10.02	16,817	26.5
Aragon	149.1	84.1	23.5	40.6	31.35	23,450	23.8	230.9	53.8	55.4	54.01	24,470	35.1
Asturias	143	70.3	19.2	50.3	7.84	18,816	21.7	180.9	26.4	60.5	9.18	20,140	35.9
Balearic Isl.	56.8	7	12.3	37.4	12.89	28,084	17.6	81	13.2	30	37.7	23,564	24.8
Canary Isl.	96	20.6	22.4	53	6.85	21,905	18.4	100.6	20.7	29.3	5.05	19,234	26
Cantabria	89.9	22.5	19.8	40.2	1.32	20,923	23.4	211.3	40.2	107	16.88	20,643	36.1
Castile Leon	120.2	49.8	10.2	59.8	8.77	20,220	23.4	241.4	21.1	71	12.28	21,348	34
Castile La Mancha	90.7	58.5	8.2	24	3.99	17,412	15.5	108.6	17.3	27.1	8.11	18,025	25.3
Catalonia	267.8	180.4	20	64.6	53.01	27,241	23.5	394.8	81.1	91.7	57.04	26,282	32.8
Valencia	139.9	59.1	11.9	66.6	20.69	21,344	20.1	199.6	25.5	93.4	21.4	19,435	30.1
Extremadura	71.1	18.8	16.7	35.6	2.65	14,182	16.2	115.4	31.4	66	1.36	15,407	23.7
Galicia	103.3	33.2	17.8	51.9	2.30	17,412	18.7	174.6	30.3	69.1	10.84	19,636	31.3
Madrid	438.3	238.8	119.5	75.3	25.26	29,909	31.4	530.1	140.2	97.7	38.29	30,915	44.5
Murcia	118.9	51.5	19.3	48.1	9.22	18,676	20.8	154.6	25.8	68.9	20.1	18,327	26.3
Navarre	230.1	150.3	5	74.5	41.21	28,505	29.9	537.4	44.2	126.1	60.81	27,592	40.2
Basque Country	294	229.9	8.4	54.2	36.77	27,382	32	649.8	44.2	111.8	64.38	29,404	46
La Rioja	133.3	81.6	10	41.7	3.73	24,995	22.9	214.2	51.8	49.9	12.99	24,067	34.3
National average	155.4	81.7	21.4	50.9	16.1	22,178	22.2	252.9	42.9	73.9	24.2	22,076.8	32.5

Note : GERD (total, business, government and HES, in purchased power standard at constant prices) and Regional patents are measured in units per million inhabitants. Tertiary education is the percentage of people with an undergraduate, master or PhD. GDP per capita is measured in euros.

Table 2: Descriptive statistics for enterprises cooperating and not cooperating (firm level)

VARIABLES	Full Sample					Non Cooperative Firms					Cooperative Firms				
	mean	sd	N	min	max	mean	sd	N	min	max	mean	sd	N	min	max
Innovative Performance															
NIP	0.863	2.935	26,506	0	30	0.382	1.981	18,241	0	30	1.924	4.163	8,265	0	30
Networking activities															
Cooperation (dummy)	0.312	0.463	26,506	0	1										
Outsourcing (dummy)	0.228	0.420	26,506	0	1	0.0576	0.233	18,241	0	1	0.605	0.489	8,265	0	1
Controls															
Internal R&D	960.3	3,215	26,506	0	110,769	173.2	1,278	18,241	0	54,383	2,698	5,016	8,265	0	110,769
Size	223.0	692.1	26,506	1	15,003	108.5	350.4	18,241	1	10,100	475.9	1,083	8,265	5	15,003
R&D government (dummy)	0.067	0.250	26,506	0	1	0.005	0.069	18,241	0	1	0.204	0.403	8,265	0	1
Foreign (dummy)	0.162	0.368	26,506	0	1	0.103	0.305	18,241	0	1	0.290	0.454	8,265	0	1

Table 3: Descriptive statistics for enterprises doing outsourcing and not doing outsourcing (firm level)

VARIABLES	No R&D Outsourcing					R&D Outsourcing				
	mean	sd	N	min	max	mean	sd	N	min	max
Innovative Performance										
NIP	0.547	2.404	20,457	0	30	1.931	4.089	6,049	0	30
Networking activities										
Cooperation (dummy)	0.160	0.366	20,457	0	1	0.826	0.379	6,049	0	1
Controls										
Internal R&D (dummy)	402.8	2,013	20,457	0	110,769	2,846	5,194	6,049	0	73,057
Size	132.3	393.7	20,457	1	12,939	530.0	1,205	6,049	3	15,003
R&D government (dummy)	0.014	0.118	20,457	0	1	0.245	0.430	6,049	0	1
Foreign (dummy)	0.127	0.332	20,457	0	1	0.281	0.449	6,049	0	1

Table 4: Role of regional knowledge endowment on the benefits obtained from the acquisition of external knowledge

VARIABLES	(1) <i>NIP</i>	(2) <i>NIP</i>	(3) <i>NIP</i>	(4) <i>NIP</i>	(5) <i>NIP</i>	(6) <i>NIP</i>	(7) <i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>)	1.308*** (0.062)	1.242*** (0.081)	1.242*** (0.081)	1.302*** (0.098)	1.303*** (0.098)	1.373*** (0.116)	1.375*** (0.115)
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>)	1.158** (0.083)	1.284*** (0.110)	1.284*** (0.110)	1.244** (0.128)	1.245** (0.128)	1.191 (0.169)	1.192 (0.169)
<i>InternalR&D</i> _{<i>t</i>-1} (<i>in log</i>)	1.051*** (0.012)	1.050*** (0.012)	1.050*** (0.012)	1.050*** (0.012)	1.050*** (0.012)	1.050*** (0.012)	1.050*** (0.012)
<i>Size</i> _{<i>t</i>-1} (<i>in log</i>)	2.041*** (0.255)	2.045*** (0.254)	2.045*** (0.254)	2.042*** (0.252)	2.042*** (0.252)	2.023*** (0.254)	2.025*** (0.254)
<i>Size</i> ² _{<i>t</i>-1} (<i>in log</i>)	0.962*** (0.008)	0.962*** (0.008)	0.962*** (0.008)	0.963*** (0.008)	0.963*** (0.008)	0.963*** (0.008)	0.963*** (0.008)
<i>R&D government</i> _{<i>t</i>-1} (<i>dummy</i>)	1.067 (0.076)	1.067 (0.076)	1.067 (0.076)	1.068 (0.076)	1.068 (0.076)	1.068 (0.076)	1.068 (0.076)
<i>Foreign</i> _{<i>t</i>-1} (<i>dummy</i>)	1.289 (0.214)	1.292 (0.215)	1.292 (0.215)	1.289 (0.214)	1.289 (0.213)	1.289 (0.214)	1.289 (0.214)
<i>Technological dummies</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.171*** (0.067)	1.145*** (0.057)				
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.029* (0.015)	1.029* (0.015)				
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.947** (0.020)	0.947** (0.020)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.021*** (0.006)	1.019*** (0.005)		
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD</i> _{<i>t</i>-1}				1.000 (0.003)	1.000 (0.003)		
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD</i> _{<i>t</i>-1}				0.996 (0.004)	0.996 (0.004)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.958 (0.027)	0.971 (0.020)
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.022*** (0.006)	1.022*** (0.006)
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.973*** (0.007)	0.973*** (0.007)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.989 (0.013)	0.986 (0.019)
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.976*** (0.005)	0.976*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.025*** (0.005)	1.025*** (0.005)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.221*** (0.088)	1.197*** (0.081)
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.958** (0.020)	0.957** (0.020)
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.040 (0.033)	1.039 (0.033)
<i>GDP per capita</i>		0.984 (0.016)		0.976 (0.015)		1.020 (0.023)	
<i>Tertiari education</i>			0.991 (0.013)		0.982 (0.013)		1.005 (0.015)
<i>Constant</i>	0.013*** (0.004)	0.005*** (0.003)	0.004*** (0.002)	0.005*** (0.003)	0.005*** (0.003)	0.002*** (0.001)	0.002*** (0.001)

Continued

Table 4. *Continued*

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.568*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.568*** (0.102)	0.568*** (0.102)	0.567*** (0.102)	0.567*** (0.102)
<i>Variance (Region)</i>	0.103	0.078	0.079	0.073	0.068	0.023	0.028
<i>Variance (Firm – Region)</i>	4.138	4.132	4.133	4.133	4.134	4.134	4.133
<i>Observations</i>	24,174	24,174	24,174	24,174	24,174	24,174	24,174
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4943***	4925***	4925***	4880***	4888***	4759***	4767***
<i>Likelihood ratio test Region random intercept</i>	21.13***	15.89***	15.89***	14.06***	11.80***	1.520	2.508*
<i>Wald Test Mean values (Mundlak)</i>	949.3***	859.3***	865.9***	794.6***	794.6***	817.6***	817.9***
<i>Wald Test Time dummies</i>	798.1***	791.9***	813.8***	780.9***	807.8***	818.1***	809.1***

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 and Skrondal \(2012, pp. 88-89\)](#).

Appendix

Table A1. Technological classification of the manufacturing sectors

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	6,967	10,019	306.8	47,263	N 221
	Between		10,013	518.6	37,731	n 17
	Within		2,364	-1,768	16,524	T 13
Stock GERD business	Overall	3,662	5,923	37.28	25,866	N 221
	Between		5,925	92.93	20,245	n 17
	Within		1,374	-1,768	9,282	T 13
Stock GERD government	Overall	1,186	2,447	18.64	12,757	N 221
	Between		2,465	64.31	10,389	n 17
	Within		493.4	-796.8	3,553	T 13
Stock GERD HES	Overall	2,125	2,197	94.60	8,447	N 221
	Between		2,183	133.6	6,803	n 17
	Within		568.3	253.1	4,231	T 13
Stock Regional patents	Overall	633.5	1,120	6.42	5,880	N 221
	Between		1,108	40.07	4,469	n 17
	Within		303.9	-888.7	2,045	T 13
GDP per capita	Overall	24,272	4,861	14,182	35,607	N 221
	Between		4,749	16,446	32,846	n 17
	Within		1,518	20,478	27,429	T 13
Tertiary education	Overall	27.87	6.57	15.50	46	N 221
	Between		5.81	20.72	39.70	n 17
	Within		3.37	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	0.312	0.463	0	1	N 26,506
	Between		0.402	0	1	n 4,010
	Within		0.251	-0.622	1.245	T-bar 6.61
Outsourcing (dummy)	Overall	0.228	0.420	0	1	N 26,506
	Between		0.357	0	1	n 4,010
	Within		0.236	-0.705	1.162	T-bar 6.61
log (Internal R&D)	Overall	2.174	3.402	0	11.62	N 26,506
	Between		3.075	0	10.71	n 4,010
	Within		1.603	-6.660	10.72	T-bar 6.61
log (Size)	Overall	4.211	1.439	0.693	9.616	N 26,506
	Between		1.357	0.693	9.406	n 4,010
	Within		0.257	-0.822	6.562	T-bar 6.61
R&D Government (dummy)	Overall	0.067	0.250	0	1	N 26,506
	Between		0.190	0	1	n 4,010
	Within		0.165	-0.866	1	T-bar 6.61
Foreign (dummy)	Overall	0.162	0.368	0	1	N 26,506
	Between		0.338	0	1	n 4,010
	Within		0.123	-0.772	1.095	T-bar 6.61

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

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Cooperation (dummy)	1									
(2) Outsourcing (dummy)	0.604	1								
(3) log (Internal R&D)	0.709	0.575	1							
(4) log (Size)	0.497	0.439	0.482	1						
(5) R&D Government (dummy)	0.369	0.389	0.439	0.320	1					
(6) Foreign (dummy)	0.235	0.171	0.218	0.443	0.087	1				
(7) Stock of GERD	0.008	-0.003	0.057	0.005	-0.016	0.080	1			
(8) Stock of Regional patents	0.085	0.058	0.134	0.070	0.000	0.115	0.715	1		
(9) GDP per capita	0.071	0.064	0.126	0.076	0.061	0.132	0.750	0.582	1	
(10) Tertiary education	0.061	0.063	0.101	0.079	0.084	0.100	0.563	0.223	0.871	1

Table A5. Assuming missing at random

VARIABLES	(1) <i>NIP</i>	(2) <i>NIP</i>	(3) <i>NIP</i>	(4) <i>NIP</i>	(5) <i>NIP</i>	(6) <i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.309*** (0.062)	1.242*** (0.080)	1.242*** (0.080)	1.303*** (0.098)	1.304*** (0.098)	1.374*** (0.115)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.161** (0.083)	1.288*** (0.109)	1.288*** (0.109)	1.249** (0.127)	1.250** (0.127)	1.198 (0.168)
<i>Firm level controls</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.171*** (0.068)	1.145*** (0.057)			
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.029** (0.015)	1.029** (0.015)			
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.947** (0.020)	0.947** (0.020)			
<i>Stock GERD</i> _{<i>t</i>-1}				1.021*** (0.006)	1.019*** (0.005)	
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				1.000 (0.003)	1.000 (0.003)	
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.996 (0.004)	0.996 (0.004)	
<i>Stock GERD business</i> _{<i>t</i>-1}						0.971 (0.020)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.022*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.973*** (0.006)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.986 (0.019)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.976*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.025*** (0.005)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.198*** (0.081)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.958** (0.019)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.038 (0.033)
<i>GDP per capita</i>		0.984 (0.016)		0.976 (0.015)		
<i>Tertiari education</i>			0.991 (0.013)		0.982 (0.013)	1.005 (0.015)
<i>Constant</i>	0.015*** (0.005)	0.006*** (0.004)	0.005*** (0.003)	0.006*** (0.004)	0.006*** (0.004)	
<i>Random Part of the Model</i>						
<i>ln(alpha)</i>	0.567*** (0.103)	0.567*** (0.103)	0.567*** (0.103)	0.567*** (0.103)	0.567*** (0.103)	0.566*** (0.103)
<i>Variance (Region)</i>	0.104	0.078	0.079	0.073	0.069	0.029
<i>Variance (Firm – Region)</i>	4.138	4.133	4.133	4.133	4.134	4.133
<i>Observations</i>	24,174	24,174	24,174	24,174	24,174	24,174
<i>Number of groups</i>	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4945***	4928***	4928***	4883***	4891***	4770***
<i>Likelihood ratio test Region random intercept</i>	21.25***	16***	16***	14.16***	11.89***	2.548*
<i>Wald Test Mean values (Mundlak)</i>	886.9***	805***	812.5***	744.3***	746.5***	767.1***
<i>Wald Test Time dummies</i>	863.7***	856.3***	881.4***	842.5***	873.3***	872***

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 and Skrondal \(2012, pp. 88-89\)](#). We include a categorical variable (CAMBIO) 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; being the first category the reference one. Specification (6) is missing due to convergence problems with the model.

Table A6. Excluding enterprises moving among regions

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.323*** (0.064)	1.248*** (0.080)	1.248*** (0.080)	1.270*** (0.093)	1.271*** (0.092)	1.338*** (0.106)	1.341*** (0.105)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.155** (0.082)	1.273*** (0.118)	1.273*** (0.118)	1.246** (0.137)	1.247** (0.138)	1.185 (0.184)	1.185 (0.185)
<i>Firm level controls</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.168*** (0.066)	1.152*** (0.058)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.032*** (0.012)	1.032*** (0.012)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.951** (0.023)	0.951** (0.023)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.020*** (0.006)	1.018*** (0.005)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				1.002 (0.002)	1.002 (0.002)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.996 (0.004)	0.996 (0.004)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.948* (0.028)	0.970 (0.021)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.019*** (0.004)	1.019*** (0.004)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.975*** (0.007)	0.975*** (0.007)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.983 (0.014)	0.979 (0.021)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.986*** (0.003)	0.986*** (0.003)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.020*** (0.005)	1.019*** (0.005)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.249*** (0.097)	1.211*** (0.088)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.966** (0.015)	0.965** (0.014)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.039 (0.035)	1.039 (0.035)
<i>GDP per capita</i>		0.990 (0.019)		0.983 (0.020)		1.033 (0.028)	
<i>Tertiari education</i>			0.994 (0.016)		0.986 (0.016)		1.009 (0.018)
<i>Constant</i>	0.015*** (0.005)	0.004*** (0.003)	0.004*** (0.003)	0.005*** (0.003)	0.005*** (0.003)	0.001*** (0.001)	0.002*** (0.002)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.580*** (0.106)	0.579*** (0.106)	0.579*** (0.106)	0.580*** (0.106)	0.580*** (0.106)	0.579*** (0.106)	0.579*** (0.106)
<i>Variance (Region)</i>	0.120	0.090	0.091	0.086	0.082	0.020	0.030
<i>Variance (Firm – Region)</i>	4.161	4.157	4.157	4.157	4.158	4.159	4.157
<i>Observations</i>	22,648	22,648	22,648	22,648	22,648	22,648	22,648
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4595***	4577***	4578***	4540***	4545***	4412***	4426***
<i>Likelihood ratio test Region random intercept</i>	20.72***	15.18***	15.18***	14.02***	11.42***	0.908	2.125*
<i>Wald Test Mean values (Mundlak)</i>	974.5***	912.8***	909.4***	830.3***	828.4***	878.1***	870.5***
<i>Wald Test Time dummies</i>	1364***	1427***	1418***	1439***	1434***	1397***	1397***

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 and Skrondal \(2012, pp. 88-89\)](#).

Table A7. Main results for Small and medium-sized enterprises (SMEs)

VARIABLES	(1) <i>NIP</i>	(2) <i>NIP</i>	(3) <i>NIP</i>	(4) <i>NIP</i>	(5) <i>NIP</i>	(6) <i>NIP</i>	(7) <i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.214*** (0.082)	1.072 (0.106)	1.071 (0.105)	1.069 (0.128)	1.069 (0.127)	1.005 (0.172)	1.002 (0.170)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.215* (0.122)	1.359** (0.170)	1.359** (0.170)	1.239 (0.176)	1.239 (0.176)	1.203 (0.230)	1.209 (0.232)
<i>Firm level controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.197** (0.093)	1.175** (0.076)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.068** (0.028)	1.068** (0.028)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.944 (0.033)	0.944 (0.033)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.021** (0.010)	1.019** (0.008)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				1.007 (0.004)	1.007 (0.004)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.999 (0.006)	0.999 (0.006)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.920*** (0.023)	0.953** (0.021)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.007 (0.007)	1.008 (0.007)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.970*** (0.010)	0.971*** (0.010)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.970** (0.013)	0.956* (0.026)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.989* (0.006)	0.989** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.044*** (0.008)	1.044*** (0.009)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.334*** (0.093)	1.285*** (0.099)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.033 (0.035)	1.032 (0.035)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.043 (0.041)	1.040 (0.042)
<i>GDP per capita</i>		0.990 (0.024)		0.985 (0.026)		1.063** (0.028)	
<i>Tertiari education</i>			1.001 (0.020)		0.992 (0.022)		1.027 (0.021)
<i>Constant</i>	0.003*** (0.002)	0.001*** (0.001)	0.001*** (0.001)	0.001*** (0.001)	0.001*** (0.001)	0.000*** (0.000)	0.000*** (0.000)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.759*** (0.041)	0.758*** (0.130)	0.758*** (0.130)	0.758*** (0.130)	0.758*** (0.130)	0.756*** (0.130)	0.756*** (0.130)
<i>Variance (Region)</i>	0.194	0.148	0.155	0.146	0.148	5.22e-30	0.019
<i>Variance (Firm – Region)</i>	4.972	4.967	4.966	4.968	4.968	4.995	4.987
<i>Observations</i>	17,852	17,852	17,852	17,852	17,852	17,852	17,852
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	2857***	2857***	2857***	2835***	2844***	2730.48***	2730.06***
<i>Likelihood ratio test Region random intercept</i>	18.21***	14.07***	14.07***	13.91***	12.71***		0.55
<i>Wald Test Mean values (Mundlak)</i>	917.8***	1040***	1092***	983.8***	1025***	937.55***	978.16***
<i>Wald Test Time dummies</i>	20176***	20678***	20754***	18383***	18248***	12779***	12349***

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 and Skrondal \(2012, pp. 88-89\)](#).

Table A8. Main results for Large enterprises (LEs)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.491*** (0.143)	1.501*** (0.197)	1.500*** (0.196)	1.662*** (0.235)	1.660*** (0.234)	1.812*** (0.291)	1.812*** (0.291)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.101 (0.089)	1.220* (0.128)	1.222* (0.128)	1.211 (0.154)	1.216 (0.154)	1.139 (0.196)	1.145 (0.196)
<i>Firm level controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.115*** (0.035)	1.085*** (0.033)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.997 (0.033)	0.997 (0.033)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.946** (0.024)	0.945** (0.024)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.021*** (0.006)	1.018*** (0.005)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.992 (0.006)	0.992 (0.006)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.994 (0.004)	0.994 (0.004)		
<i>Stock GERD business</i> _{<i>t</i>-1}						1.002 (0.018)	0.998 (0.015)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.036*** (0.012)	1.036*** (0.012)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.969*** (0.006)	0.969*** (0.006)
<i>Stock GERD government</i> _{<i>t</i>-1}						1.018* (0.010)	1.033*** (0.011)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.941*** (0.005)	0.941*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.022*** (0.005)	1.022*** (0.005)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.087 (0.056)	1.069 (0.048)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.911* (0.046)	0.910* (0.046)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.052 (0.039)	1.050 (0.039)
<i>GDP per capita</i>		0.977* (0.012)		0.969** (0.014)		0.974 (0.017)	
<i>Tertiari education</i>			0.981*** (0.007)		0.973*** (0.005)		0.976*** (0.009)
<i>Constant</i>	3.561 (6.158)	2.404 (4.022)	2.391 (4.052)	2.320 (3.744)	2.486 (4.256)	1.716 (3.096)	1.807 (3.228)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.279*** (0.074)	0.279*** (0.074)	0.279*** (0.074)	0.278*** (0.074)	0.278*** (0.074)	0.277*** (0.074)	0.277*** (0.074)
<i>Variance (Region)</i>	1.62e-32	1.62e-32	3.62e-35	7.32e-33	1.80e-35	5.06e-34	4.44e-35
<i>Variance (Firm – Region)</i>	2.842	2.842	2.839	2.842	2.833	2.834	2.830
<i>Observations</i>	6,322	6,322	6,322	6,322	6,322	6,322	6,322
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	1748***	1719***	1720***	1679***	1677***	1661***	1661***
<i>Likelihood ratio test Region random intercept</i>	0.00374						
<i>Wald Test Mean values (Mundlak)</i>	314.2***	344.33***	365.37***	280.35***	357.75***	351.85***	400.65***
<i>Wald Test Time dummies</i>	1451***	1558***	1577***	1463***	1476***	1334***	1355***

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 and Skrondal \(2012, pp. 88-89\)](#).

Table A9. Excluding very large firms

VARIABLES	(1) <i>NIP</i>	(2) <i>NIP</i>	(3) <i>NIP</i>	(4) <i>NIP</i>	(5) <i>NIP</i>	(6) <i>NIP</i>	(7) <i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.295*** (0.050)	1.216*** (0.061)	1.216*** (0.061)	1.263*** (0.080)	1.264*** (0.079)	1.267*** (0.096)	1.267*** (0.094)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.190*** (0.078)	1.310*** (0.112)	1.310*** (0.112)	1.290*** (0.128)	1.291*** (0.128)	1.237* (0.159)	1.236 (0.159)
<i>Firm level controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.166** (0.071)	1.148** (0.062)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.036*** (0.012)	1.036*** (0.012)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.950** (0.021)	0.950** (0.021)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.021*** (0.006)	1.020*** (0.005)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				1.001 (0.003)	1.001 (0.003)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.995 (0.003)	0.995 (0.003)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.946* (0.029)	0.965 (0.021)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.014*** (0.005)	1.015*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.976*** (0.007)	0.976*** (0.007)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.990 (0.014)	0.983 (0.021)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.977*** (0.004)	0.977*** (0.004)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.018*** (0.004)	1.018*** (0.004)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.248*** (0.099)	1.218*** (0.092)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.989 (0.019)	0.988 (0.019)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.035 (0.029)	1.035 (0.029)
<i>GDP per capita</i>		0.989 (0.020)		0.981 (0.019)		1.032 (0.027)	
<i>Tertiari education</i>			0.995 (0.015)		0.985 (0.015)		1.012 (0.017)
<i>Constant</i>	0.009*** (0.004)	0.003*** (0.002)	0.002*** (0.002)	0.003*** (0.002)	0.003*** (0.002)	0.001*** (0.001)	0.001*** (0.001)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.620*** (0.097)	0.620*** (0.097)	0.620*** (0.097)	0.620*** (0.098)	0.620*** (0.098)	0.619*** (0.098)	0.619*** (0.098)
<i>Variance (Region)</i>	0.128	0.101	0.103	0.093	0.091	0.026	0.035
<i>Variance (Firm – Region)</i>	4.213	4.208	4.208	4.208	4.209	4.211	4.209
<i>Observations</i>	23,372	23,372	23,372	23,372	23,372	23,372	23,372
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4542***	4531***	4531***	4486***	4495***	4352***	4362***
<i>Likelihood ratio test Region random intercept</i>	23.81***	19.33***	19.33***	16.84***	15.07***	1.52	2.95**
<i>Wald Test Mean values (Mundlak)</i>	948.6***	880.77***	882.79***	820.77***	818.55***	833.64***	826.3***
<i>Wald Test Time dummies</i>	3567***	3587***	3518***	3728***	3667***	3489***	3414***

Robust SE in parent heses. *** 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 and Skrondal \(2012, pp. 88-89\)](#).

Table A10. Employment in high and medium-high technological manufacturing industries

VARIABLES	(1) <i>NIP</i>	(2) <i>NIP</i>
<i>Cooperation</i> _{t-1} (dummy)	1.121 (0.089)	1.122 (0.089)
<i>Outsourcing</i> _{t-1} (dummy)	1.440*** (0.183)	1.440*** (0.183)
<i>Firm level controls</i>	Yes	Yes
<i>High med – high tech employment</i> _{t-1}	1.010 (0.045)	1.024 (0.041)
<i>Cooperation</i> _{t-1} (dummy) * <i>High med – high tech employment</i> _{t-1}	1.028*** (0.011)	1.028*** (0.011)
<i>Outsourcing</i> _{t-1} (dummy) * <i>High med – high tech employment</i> _{t-1}	0.963** (0.018)	0.963** (0.018)
<i>GDP per capita</i>	1.002 (0.023)	
<i>Tertiari education</i>		0.993 (0.020)
<i>Constant</i>	0.003*** (0.002)	0.004*** (0.003)
<i>Random Part of the Model</i>		
<i>ln(alpha)</i>	0.568*** (0.029)	0.568*** (0.029)
<i>Variance (Region)</i>	0.105	0.104
<i>Variance (Firm – Region)</i>	4.132	4.132
<i>Observations</i>	24,174	24,174
<i>Number of groups</i>	17	17
<i>Likelihood ratio test Firm random intercept</i>	4935***	4942***
<i>Likelihood ratio test Region random intercept</i>	20.55***	20.03***
<i>Wald Test Mean values (Mundlak)</i>	934.2***	936***
<i>Wald Test Time dummies</i>	802.9***	824.1***

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 and Skrondal \(2012, pp. 88-89\)](#).

Table A11. Controlling by Total employment in R&D

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.305*** (0.060)	1.246*** (0.081)	1.246*** (0.081)	1.304*** (0.096)	1.306*** (0.096)	1.388*** (0.122)	1.390*** (0.121)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.163** (0.085)	1.288*** (0.110)	1.288*** (0.110)	1.250** (0.128)	1.251** (0.128)	1.198 (0.166)	1.198 (0.166)
<i>Total employment in R&D</i> _{<i>t</i>-1}	0.999 (0.001)	0.999 (0.001)	0.999 (0.001)	0.999 (0.001)	0.999 (0.001)	0.999 (0.001)	0.999 (0.001)
<i>Firm level controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.173*** (0.068)	1.146*** (0.058)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.026* (0.016)	1.026* (0.016)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.948** (0.020)	0.948** (0.020)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.022*** (0.005)	1.020*** (0.004)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				1.000 (0.003)	1.000 (0.003)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.996 (0.004)	0.996 (0.004)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.961 (0.028)	0.973 (0.021)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.022*** (0.005)	1.022*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.973*** (0.007)	0.973*** (0.007)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.991 (0.014)	0.989 (0.020)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.977*** (0.005)	0.977*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.025*** (0.005)	1.025*** (0.005)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.213** (0.092)	1.190** (0.083)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.953** (0.020)	0.953** (0.019)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.039 (0.032)	1.039 (0.033)
<i>GDP per capita</i>		0.982 (0.017)		0.975* (0.015)		1.015 (0.024)	
<i>Tertiari education</i>			0.990 (0.014)		0.980 (0.012)		1.002 (0.015)
<i>Constant</i>	0.015*** (0.004)	0.006*** (0.003)	0.005*** (0.003)	0.006*** (0.003)	0.006*** (0.003)	0.002*** (0.002)	0.003*** (0.002)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.571*** (0.101)	0.571*** (0.101)	0.571*** (0.101)	0.571*** (0.101)	0.571*** (0.101)	0.571*** (0.101)	0.571*** (0.101)
<i>Variance (Region)</i>	0.120	0.084	0.084	0.077	0.072	0.031	0.035
<i>Variance (Firm – Region)</i>	4.144	4.140	4.140	4.140	4.141	4.139	4.139
<i>Observations</i>	23,900	23,900	23,900	23,900	23,900	23,900	23,900
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4895***	4879***	4879***	4834***	4842***	4712***	4720***
<i>Likelihood ratio test Region random intercept</i>	21.68***	16.62***	16.62***	14.21***	11.84***	2.324*	3.193**
<i>Wald Test Mean values (Mundlak)</i>	762.2***	704.9***	710.4***	651***	653.2***	670.2***	670.6***
<i>Wald Test Time dummies</i>	890.1***	878.7***	903.6***	873.5***	904.2***	914***	908.8***

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 and Skrondal \(2012, pp. 88-89\)](#).

Table A12. Controlling by Employment in R&D with tertiary education

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.303*** (0.059)	1.236*** (0.079)	1.236*** (0.079)	1.292*** (0.096)	1.293*** (0.095)	1.366*** (0.117)	1.368*** (0.116)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.161** (0.085)	1.285*** (0.110)	1.285*** (0.110)	1.242** (0.129)	1.243** (0.129)	1.181 (0.164)	1.181 (0.164)
<i>Employment in R&D with tertiary education</i> _{<i>t</i>-1}	0.996 (0.002)	0.996 (0.002)	0.996 (0.002)	0.996 (0.002)	0.996 (0.002)	0.996 (0.002)	0.996 (0.002)
<i>Firm level controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.173*** (0.068)	1.148*** (0.058)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.030** (0.015)	1.030** (0.015)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.948** (0.020)	0.948** (0.020)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.022*** (0.006)	1.020*** (0.005)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				1.000 (0.003)	1.000 (0.003)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.996 (0.004)	0.996 (0.004)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.959 (0.027)	0.972 (0.020)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.022*** (0.005)	1.022*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.972*** (0.007)	0.972*** (0.007)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.990 (0.013)	0.987 (0.019)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.977*** (0.005)	0.977*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.026*** (0.005)	1.026*** (0.005)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.219*** (0.088)	1.195*** (0.081)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.957** (0.020)	0.957** (0.019)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.045 (0.033)	1.045 (0.033)
<i>GDP per capita</i>		0.984 (0.016)		0.976 (0.015)		1.020 (0.023)	
<i>Tertiari education</i>			0.992 (0.013)		0.982 (0.013)		1.005 (0.015)
<i>Constant</i>	0.015*** (0.004)	0.005*** (0.003)	0.005*** (0.003)	0.006*** (0.003)	0.006*** (0.003)	0.002*** (0.001)	0.003*** (0.002)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.569*** (0.101)	0.569*** (0.101)	0.569*** (0.101)	0.569*** (0.101)	0.569*** (0.101)	0.568*** (0.101)	0.568*** (0.101)
<i>Variance (Region)</i>	0.106	0.079	0.080	0.072	0.068	0.023	0.028
<i>Variance (Firm – Region)</i>	4.108	4.103	4.103	4.104	4.105	4.105	4.104
<i>Observations</i>	24,110	24,110	24,110	24,110	24,110	24,110	24,110
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4908***	4891***	4891***	4847***	4855***	4725***	4733***
<i>Likelihood ratio test Region random intercept</i>	21.73***	16.38***	16.38***	13.98***	11.78***	1.523	2.511*
<i>Wald Test Mean values (Mundlak)</i>	1067***	954.8***	967.6***	867.7***	870.9***	890.4***	895.3***
<i>Wald Test Time dummies</i>	764.4***	759.1***	777.5***	750.7***	772.5***	783.8***	776.1***

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 and Skrondal \(2012\)](#), pp. 88-89).

Table A13. Controlling by engineers/graduates with governmental/corporate experience in R&D

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>)	1.299*** (0.062)	1.229*** (0.080)	1.229*** (0.079)	1.293*** (0.099)	1.294*** (0.099)	1.356*** (0.115)	1.358*** (0.114)
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>)	1.159** (0.083)	1.287*** (0.111)	1.287*** (0.111)	1.246** (0.129)	1.247** (0.129)	1.190 (0.170)	1.190 (0.171)
<i>Hiring Personnel in R&D</i>	1.060 (0.043)	1.061 (0.043)	1.061 (0.043)	1.060 (0.043)	1.060 (0.043)	1.060 (0.042)	1.060 (0.042)
<i>Firm level controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.171*** (0.067)	1.146*** (0.057)				
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.031** (0.015)	1.031** (0.015)				
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.946** (0.021)	0.946** (0.021)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.021*** (0.006)	1.019*** (0.005)		
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD</i> _{<i>t</i>-1}				1.000 (0.003)	1.000 (0.003)		
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD</i> _{<i>t</i>-1}				0.996 (0.004)	0.996 (0.004)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.957 (0.027)	0.972 (0.020)
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.022*** (0.006)	1.022*** (0.006)
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.972*** (0.007)	0.972*** (0.007)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.986 (0.013)	0.983 (0.019)
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.974*** (0.005)	0.974*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.025*** (0.005)	1.025*** (0.005)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.225*** (0.088)	1.199*** (0.081)
<i>Cooperation</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.960* (0.021)	0.960* (0.020)
<i>Outsourcing</i> _{<i>t</i>-1} (<i>dummy</i>) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.042 (0.034)	1.041 (0.034)
<i>GDP per capita</i>		0.984 (0.016)		0.978 (0.015)		1.022 (0.023)	
<i>Tertiari education</i>			0.991 (0.013)		0.982 (0.013)		1.005 (0.015)
<i>Constant</i>	0.015*** (0.004)	0.005*** (0.003)	0.005*** (0.003)	0.006*** (0.003)	0.006*** (0.003)	0.002*** (0.001)	0.003*** (0.002)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.568*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.568*** (0.102)	0.568*** (0.102)	0.567*** (0.102)	0.567*** (0.102)
<i>Variance (Region)</i>	0.103	0.077	0.078	0.074	0.070	0.023	0.029
<i>Variance (Firm – Region)</i>	4.106	4.101	4.101	4.101	4.103	4.102	4.100
<i>Observations</i>	24,174	24,174	24,174	24,174	24,174	24,174	24,174
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4921***	4903***	4903***	4858***	4865***	4730***	4740***
<i>Likelihood ratio test Region random intercept</i>	21.81***	16.19***	16.19***	15.06***	12.48***	1.623	2.738**
<i>Wald Test Mean values (Mundlak)</i>	1697***	1693***	1717***	1585***	1575***	1691***	1668***
<i>Wald Test Time dummies</i>	743.7***	742***	761***	727.6***	751***	763***	754.5***

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 and Skrondal \(2012, pp. 88-89\)](#).

Table A14. Including sectoral fixed effects

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.309*** (0.063)	1.245*** (0.081)	1.245*** (0.080)	1.307*** (0.098)	1.308*** (0.098)	1.381*** (0.115)	1.381*** (0.113)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.158** (0.082)	1.282*** (0.114)	1.282*** (0.114)	1.242** (0.132)	1.243** (0.132)	1.183 (0.173)	1.183 (0.173)
<i>Firm level controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.181*** (0.070)	1.154*** (0.056)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.028* (0.015)	1.028** (0.014)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.948** (0.022)	0.948** (0.022)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.022*** (0.006)	1.019*** (0.005)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				1.000 (0.003)	1.000 (0.003)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.996 (0.004)	0.996 (0.004)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.964 (0.028)	0.974 (0.022)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.022*** (0.006)	1.022*** (0.006)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.973*** (0.007)	0.973*** (0.007)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.982 (0.015)	0.977 (0.022)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.975*** (0.005)	0.975*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.024*** (0.005)	1.024*** (0.005)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.215*** (0.088)	1.201** (0.086)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.957** (0.020)	0.957** (0.020)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.043 (0.034)	1.043 (0.035)
<i>GDP per capita</i>		0.985 (0.017)		0.979 (0.016)		1.019 (0.022)	
<i>Tertiari education</i>			0.995 (0.015)		0.986 (0.015)		1.009 (0.017)
<i>Constant</i>	0.011*** (0.005)	0.004*** (0.003)	0.003*** (0.002)	0.004*** (0.003)	0.004*** (0.003)	0.001*** (0.001)	0.002*** (0.001)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)
<i>Variance (Region)</i>	0.110	0.081	0.083	0.078	0.076	0.030	0.035
<i>Variance (Firm – Region)</i>	3.950	3.945	3.945	3.945	3.946	3.944	3.943
<i>Observations</i>	24,174	24,174	24,174	24,174	24,174	24,174	24,174
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4639***	4631***	4630***	4598***	4606***	4493***	4494***
<i>Likelihood ratio test Region random intercept</i>	21.52***	15.75***	15.75***	14.67***	12.64***	2.398*	3.428**
<i>Wald Test Mean values (Mundlak)</i>	952***	854***	864.3***	804.2***	809.9***	847.2***	849.8***
<i>Wald Test Time dummies</i>	805.5***	794***	814***	782.8***	805***	816.3***	806.6***

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 and Skrondal \(2012, pp. 88-89\)](#).

Table A15. Controlling for Firm's Age

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.305*** (0.061)	1.248*** (0.083)	1.248*** (0.082)	1.317*** (0.099)	1.318*** (0.099)	1.394*** (0.119)	1.396*** (0.118)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.158** (0.082)	1.278*** (0.108)	1.279*** (0.108)	1.247** (0.127)	1.248** (0.127)	1.205 (0.169)	1.206 (0.170)
<i>Firm's Age</i>	0.999 (0.004)	0.999 (0.004)	0.999 (0.004)	0.999 (0.004)	0.999 (0.004)	0.999 (0.004)	0.999 (0.004)
<i>Firm level controls</i>	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.177*** (0.069)	1.149*** (0.059)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.025 (0.016)	1.025 (0.016)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.949** (0.020)	0.949** (0.020)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.022*** (0.006)	1.020*** (0.004)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.999 (0.003)	0.999 (0.003)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.996 (0.004)	0.996 (0.004)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.961 (0.028)	0.973 (0.021)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.022*** (0.005)	1.022*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.976*** (0.007)	0.976*** (0.007)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.989 (0.013)	0.987 (0.019)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.974*** (0.005)	0.974*** (0.005)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.021*** (0.006)	1.021*** (0.006)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.218*** (0.091)	1.197*** (0.083)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.954** (0.020)	0.954** (0.019)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.032 (0.032)	1.031 (0.032)
<i>GDP per capita</i>		0.982 (0.016)		0.975* (0.015)		1.016 (0.023)	
<i>Tertiary education</i>			0.991 (0.013)		0.981 (0.012)		1.003 (0.015)
<i>Constant</i>	0.013*** (0.004)	0.005*** (0.003)	0.004*** (0.003)	0.006*** (0.003)	0.005*** (0.003)	0.002*** (0.001)	0.002*** (0.002)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.568*** (0.102)	0.568*** (0.102)	0.568*** (0.102)	0.568*** (0.102)	0.568*** (0.102)	0.567*** (0.102)	0.567*** (0.102)
<i>Variance (Region)</i>	0.108	0.080	0.081	0.076	0.071	0.029	0.033
<i>Variance (Firm – Region)</i>	4.136	4.131	4.132	4.130	4.131	4.129	4.128
<i>Observations</i>	23,907	23,907	23,907	23,907	23,907	23,907	23,907
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4897***	4875***	4875***	4830***	4838***	4712***	4717***
<i>Likelihood ratio test Region random intercept</i>	21.58***	15.89***	15.89***	14.40***	11.79***	2.104*	2.995**
<i>Wald Test Mean values (Mundlak)</i>	1030***	858.3***	871.5***	834.2***	838.7***	874.8***	881.2***
<i>Wald Test Time dummies</i>	1118***	1137***	1167***	1114***	1143***	1144***	1148***

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 and Skrondal (2012, pp. 88-89).

Table A16. Using a depreciation rate of 10% for the computation of stocks

VARIABLES	(1) <i>NIP</i>	(2) <i>NIP</i>	(3) <i>NIP</i>	(4) <i>NIP</i>	(5) <i>NIP</i>	(6) <i>NIP</i>	(7) <i>NIP</i>
<i>Cooperation</i> _{<i>t</i>-1} (dummy)	1.308*** (0.062)	1.241*** (0.082)	1.241*** (0.082)	1.298*** (0.100)	1.300*** (0.099)	1.368*** (0.114)	1.369*** (0.112)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy)	1.158** (0.083)	1.287*** (0.113)	1.287*** (0.113)	1.253** (0.132)	1.254** (0.132)	1.214 (0.175)	1.215 (0.175)
<i>Firm level controls</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Regional stock of patents</i> _{<i>t</i>-1}		1.262*** (0.108)	1.220*** (0.090)				
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		1.042* (0.023)	1.042* (0.023)				
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Regional stock of patents</i> _{<i>t</i>-1}		0.924** (0.029)	0.924** (0.029)				
<i>Stock GERD</i> _{<i>t</i>-1}				1.034*** (0.009)	1.030*** (0.007)		
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				1.001 (0.004)	1.001 (0.004)		
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD</i> _{<i>t</i>-1}				0.993 (0.006)	0.993 (0.006)		
<i>Stock GERD business</i> _{<i>t</i>-1}						0.936 (0.039)	0.956 (0.030)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						1.034*** (0.009)	1.034*** (0.009)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD business</i> _{<i>t</i>-1}						0.962*** (0.009)	0.962*** (0.009)
<i>Stock GERD government</i> _{<i>t</i>-1}						0.996 (0.024)	0.989 (0.033)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						0.956*** (0.009)	0.956*** (0.009)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD government</i> _{<i>t</i>-1}						1.044*** (0.009)	1.044*** (0.009)
<i>Stock GERD HES</i> _{<i>t</i>-1}						1.347*** (0.140)	1.310*** (0.131)
<i>Cooperation</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						0.940** (0.028)	0.939** (0.027)
<i>Outsourcing</i> _{<i>t</i>-1} (dummy) * <i>Stock GERD HES</i> _{<i>t</i>-1}						1.045 (0.047)	1.045 (0.048)
<i>GDP per capita</i>		0.983 (0.016)		0.975 (0.015)		1.020 (0.023)	
<i>Tertiari education</i>			0.991 (0.013)		0.982 (0.012)		1.006 (0.015)
<i>Constant</i>	0.013*** (0.004)	0.005*** (0.003)	0.004*** (0.002)	0.005*** (0.003)	0.005*** (0.003)	0.002*** (0.001)	0.002*** (0.001)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.568*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)
<i>Variance (Region)</i>	0.103	0.077	0.078	0.070	0.067	0.023	0.028
<i>Variance (Firm – Region)</i>	4.138	4.132	4.132	4.132	4.133	4.134	4.132
<i>Observations</i>	24,174	24,174	24,174	24,174	24,174	24,174	24,174
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4943***	4924***	4924***	4877***	4886***	4769***	4774***
<i>Likelihood ratio test Region random intercept</i>	21.13***	15.72***	15.72***	13.35***	11.60***	1.393	2.380*
<i>Wald Test Mean values (Mundlak)</i>	949.3***	857.4***	864***	792.8***	791.4***	807***	805.9***
<i>Wald Test Time dummies</i>	798.1***	790.9***	813.7***	780.9***	809***	819.4***	810.9***

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 and Skrondal \(2012, pp. 88-89\)](#).

Table A17. Including jointly both measures of regional knowledge endowment

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>	<i>NIP</i>
<i>Cooperation</i> _{t-1} (dummy)	1.308*** (0.062)	1.242*** (0.081)	1.242*** (0.081)	1.303*** (0.098)	1.303*** (0.098)	1.375*** (0.115)	1.374*** (0.114)
<i>Outsourcing</i> _{t-1} (dummy)	1.158** (0.083)	1.284*** (0.110)	1.284*** (0.110)	1.245** (0.128)	1.246** (0.128)	1.194 (0.169)	1.194 (0.169)
<i>Firm level controls</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Regional stock of patents</i> _{t-1}		1.084** (0.044)	1.050 (0.046)	1.081** (0.041)	1.046 (0.043)	1.141 (0.178)	1.209 (0.191)
<i>Cooperation</i> _{t-1} (dummy) * <i>Regional stock of patents</i> _{t-1}		1.029* (0.015)	1.029* (0.015)				
<i>Outsourcing</i> _{t-1} (dummy) * <i>Regional stock of patents</i> _{t-1}		0.947** (0.020)	0.947** (0.020)				
<i>Stock GERD</i> _{t-1}		1.014*** (0.005)	1.014*** (0.005)	1.015*** (0.005)	1.015*** (0.005)		
<i>Cooperation</i> _{t-1} (dummy) * <i>Stock GERD</i> _{t-1}				1.000 (0.003)	1.000 (0.003)		
<i>Outsourcing</i> _{t-1} (dummy) * <i>Stock GERD</i> _{t-1}				0.996 (0.004)	0.996 (0.004)		
<i>Stock GERD business</i> _{t-1}						0.924 (0.045)	0.921* (0.043)
<i>Cooperation</i> _{t-1} (dummy) * <i>Stock GERD business</i> _{t-1}						1.022*** (0.006)	1.022*** (0.006)
<i>Outsourcing</i> _{t-1} (dummy) * <i>Stock GERD business</i> _{t-1}						0.973*** (0.007)	0.973*** (0.007)
<i>Stock GERD government</i> _{t-1}						1.041 (0.070)	1.056 (0.068)
<i>Cooperation</i> _{t-1} (dummy) * <i>Stock GERD government</i> _{t-1}						0.976*** (0.005)	0.976*** (0.005)
<i>Outsourcing</i> _{t-1} (dummy) * <i>Stock GERD government</i> _{t-1}						1.025*** (0.005)	1.025*** (0.005)
<i>Stock GERD HES</i> _{t-1}						1.198** (0.095)	1.175** (0.082)
<i>Cooperation</i> _{t-1} (dummy) * <i>Stock GERD HES</i> _{t-1}						0.957** (0.020)	0.957** (0.019)
<i>Outsourcing</i> _{t-1} (dummy) * <i>Stock GERD HES</i> _{t-1}						1.039 (0.034)	1.039 (0.034)
<i>GDP per capita</i>		0.974* (0.015)		0.974* (0.015)		1.024 (0.023)	
<i>Tertiari education</i>			0.983 (0.013)		0.983 (0.013)		1.013 (0.014)
<i>Constant</i>	0.013*** (0.004)	0.006*** (0.003)	0.005*** (0.003)	0.006*** (0.003)	0.005*** (0.003)	0.002*** (0.001)	0.002*** (0.001)
<i>Random Part of the Model</i>							
<i>ln(alpha)</i>	0.568*** (0.102)	0.568*** (0.102)	0.568*** (0.102)	0.568*** (0.102)	0.567*** (0.102)	0.567*** (0.102)	0.567*** (0.102)
<i>Variance (Region)</i>	0.103	0.067	0.068	0.068	0.068	0.018	0.022
<i>Variance (Firm – Region)</i>	4.138	4.133	4.134	4.133	4.134	4.136	4.134
<i>Observations</i>	24,174	24,174	24,174	24,174	24,174	24,174	24,174
<i>Number of groups</i>	17	17	17	17	17	17	17
<i>Likelihood ratio test Firm random intercept</i>	4943***	4895***	4900***	4881***	4887***	4759***	4758***
<i>Likelihood ratio test Region random intercept</i>	21.13***	12.59***	12.59***	12.60***	11.90***	0.852	1.561
<i>Wald Test Mean values (Mundlak)</i>	949.3***	809.9***	810.3***	795.6***	795.7***	803.9***	817***
<i>Wald Test Time dummies</i>	798.1***	791.6***	819.1***	780.6***	808***	832***	817.9***

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 and Skrondal \(2012, pp. 88-89\)](#).

The logo for UBIREA, featuring the text 'UBIREA' in a bold, sans-serif font. The 'U' and 'B' are in a light blue color, while 'IREA' is in white. The text is set against a dark blue background that is part of a larger graphic element consisting of many thin, parallel lines forming a semi-circular shape in the upper left corner of the page.

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AQR

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