INTERDEPENDENCE AND SPILLOVERS: IS FIRM PERFORMANCE AFFECTED BY OTHERS' INNOVATION ACTIVITIES?

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Abstract

We investigate the existence of performance spillovers associated with innovation activities by quantifying the innovation produced in surrounding firms and controlling for the fact that a firm is itself an innovation producer. We use two measures of innovation: engagement and expenditures in innovation activities. To tackle the endogeneity of the innovation variables on the firm production decision, we resort to the firm intellectual property protection methods as an instrument. We found a positive spillover of innovation on firm value added.

Keywords – Innovation; Performance; Spillovers; Community Innovation Survey

1. Introduction

R&D and innovation have characteristics of public goods, since the investments and results achieved by one agent can produce knowledge that is available, almost freely, to other agents. This process is possible when the reproduction costs for information are low, allowing the diffusion of knowledge to actors that did not invest in its production. As described by Adams and Jaffe (1996), knowledge production processes have two different types of effects: one direct, to the firm enroled in the knowledge production activity, and one indirect, to other firms that benefit from the public availability of some of the knowledge.

As for the direct effect, it is broadly accepted that R&D and innovation are essential to the evolution of the performance of firms (Griliches, 1986; Hall and Mairesse, 1995). As pointed out by Nadiri (1993), there is a positive and strong relationship between R&D expenditures and both growth of output and total factor productivity. As for the indirect effect, the creation of new knowledge is a case in which agents' behaviour can affect the performance of other actors positively, given that new knowledge creates positive externalities in the market. These externalities are reflected in the positive differences between social and private internal rates of return on R&D investments (Mansfield et al., 1977). As noted by Nadiri (1993), the social rates of return on R&D (spillovers) are on average close to 50%, varying considerably across industries (in industries with well-defined products and strong patents, such as pharmaceuticals, firms are more successful in capturing the research results and the social rates of return are lower).

Despite the fact that this availability of knowledge could be a hampering factor for investment in knowledge production, the existence of these positive externalities –

knowledge spillovers – can also generate a feedback mechanism that increases the overall returns on the initial investment in research and innovation and that can benefit both producers and non-producers of knowledge.

On one hand, spillovers are important for innovative firms, since knowledge production activities are associated with high levels of uncertainty and the existence of a local innovative culture allows agents to share similar experiences and ease the exploitation of new solutions to problems (Feldman, 1993). If a firm masters its absorptive capacity, it can take advantage, not only of its own innovative efforts, but also of others' investment. The right absorptive skills can enable a firm to manage the external information flows in order to maximise the incoming spillovers from other firms and, at the same time, control the spillovers to those firms (Cohen and Levinthal 1989; 1990). The technology developed by innovation projects of one firm is useful to others as well, and can contribute to other firms' productivity (Geroski, 1995; Jaffe, 1986). In other words, the production of knowledge by other firms cannot be merely analysed as a process by which competitors increase their knowledge, since innovation activities developed in other firms can produce positive spillovers that are absorbed by firms through several means: publications, reverse engineering, trade of goods, exchange of scientists, and collaborations.

On the other hand, spillovers are also important to non-innovative firms, because these firms can absorb knowledge through the implementation of incremental modifications on production (products and/or processes). These effects are not usually identified by the firm as innovative efforts or adoption of organizational innovations and therefore are not captured by technological innovation surveys.

In this context, our analysis seeks to identify the existence of knowledge spillovers that spring from innovation activities and have an impact on the performance of innovative and non-innovative firms. We use data from an innovation survey that measures innovation in a broad way, not reducing it to R&D and patents, which departs from previous literature on spillovers. This perspective allows us to enquire if the existence of non-radical and non-science based innovation activities of firms have an impact on the performance of surrounding firms from the same industry. Moreover, firm performance is directly measured by its value added and not by alternative measures such as turnover, which is a rough proxy of performance.

Since we include variables that measure the innovation performance of firms and the dependent variable is value added, we face an endogeneity problem. To tackle this issue, we had to instrument the innovation variable by resorting to instrumental variable estimators. The firm engagement in intellectual property protection methods is the instrument used, as there is information on this firm decision for both innovative and non-innovative firms. The main difficulty in innovation surveys like the one used in this paper is that most variables are only obtained for firms reporting innovation activities. Fortunately, the information on intellectual property was gathered for all firms.

The results drove us to two main conclusions: the performance of a firm is affected by the fact that other firms innovate and the effect is positive. In other words, firm level innovation not only contributes to the performance of the investing firm, but also can produce knowledge that positively affects the performance of other firms. The results also show that process innovation spillovers are more prevalent than product innovation spillovers.

The remainder of the paper is divided into four sections. Section 2 develops the hypotheses after building a conceptual framework. Section 3 describes the data and presents the model specification. In Section 4 the main results are presented and discussed. Finally, Section 5 concludes and draws some policy implications.

2. Conceptual framework and hypotheses development

The innovation capacity of firms and the diffusion, imitation and adoption of innovations have gained increasing importance in the analysis of economic performance of firms, and, in particular, in explaining the differences between the rates of growth of different regions (Solow, 1956; Romer, 1990; Griliches, 1992; Aghion, and Howitt, 1992). In particular, the existence of knowledge spillovers is a central concept of the theory of new growth economics (Romer, 1986; Aghion and Howitt, 1992), which stresses the cumulative nature of invention at the industry and geographical level.

Romer (1986), Krugman (1991), Grossman and Helpman (1991) and Audretsch and Feldman (1996), amongst others, have focused on the role that spillovers of economic knowledge across agents and firms play in creating increasing returns and economic growth. Knowledge spillovers can generate virtuous cycles by attracting additional labour and other inputs, further facilitating the exchange of ideas.

Following these works several empirical analyses of R&D and productivity have recognised the importance of spillovers. As referred to by Meagher and Rogers (2004), these works found that spillovers between firms are important in explaining productivity growth by comparing the roles of own research efforts against research efforts of other firms (pool of external knowledge available to a firm). In their research, Meagher and Rogers (2004) simulate a network of 100 firms in order to test the assumption that spillover intensity is heterogeneous across firms. They find that the long-run relationship between spillovers and aggregate innovation is S-shaped, and that there are significant network density effects on overall innovativeness, but no industry size effects.

The regional dimension of spillovers is also the subject of several works. Audretsch and Feldman (2004) explore the role of geographic proximity in the diffusion of knowledge. They find that spillovers are associated with geographic proximity since tacit knowledge is inherently non-rival in nature. They state that an increased concentration of a particular industry within a specific geographic region facilitates knowledge spillovers across firms. The best example of this process and its economic importance is the difference in the innovative and economic performance of two different regions of the USA: Silicon Valley and Boston’s Route 128. The performance of the California cluster is higher because the proximity and interdependence of the different actors is also higher (Audretsch and Feldman 2003).

In line with this work, Baptista and Swan (1998) and Jaffe et al. (1993) focus their analysis on the clustering process and find that spillovers associated with R&D activity are geographically localised. The concentration of technologically similar firms can produce several types of economies for firms and attracts additional entrants (Aharonson, et al., 2007; Fritsch and Franke, 2004). Hale and Long (2006) also analyse the spillovers at the regional level but with a focus on the differences between the effect of domestic and foreign firms. They find that, in the Chinese context, the main spillover process is the movement of highly-skilled workers from international firms to domestic firms.

The management of spillovers is also a subject of research. Using the Belgium Second Community Innovation Survey (CIS II) database, Cassiman and Veugelers (2002) explore the effects of knowledge flows on R&D cooperation, focussing on the distinction between incoming spillovers (measured by the importance of publicly available information for the innovation process of the firm) and appropriability. They consider that the ability to absorb incoming spillovers from other firms or institutions is linked to the innovation activities of the firm (own R&D, for example), participation in cooperative agreements, and the technological opportunities in the industry. They also find that the level of knowledge of in- and outflows is not exogenous to the firm since firms, through their innovation activities, can model their incoming spillovers and appropriation capabilities. Also using the Community Innovation Survey database, Crespi et al. (2007) analyse, in the UK context, the effect of knowledge flows on the productivity of firms and conclude that most relevant spillovers are associated with competitors and that multinational presence may be an important source of these spillovers.

Our analysis follows the works described above that seek to identify the existence of knowledge spillovers that spring from innovation activities and have an impact on the performance of the firm. More precisely, we will address the following research questions:

1) Is the performance of a firm affected by the fact that other firms located in the same region and from the same industry innovate (radically or not)?

2) If yes, is this effect positive or negative?

Our goal is to add new evidence to the knowledge spillovers literature, where nearly every study considers only spillovers associated with R&D and patenting activities (Bottazzi and Peri, 2003; Aharonson et al., 2007; Alcácer and Chung, 2007). In most regions and industries R&D and patenting are not activities widely implemented by the majority of firms. So, if we want to study the spillovers that occur in an economy that is not on the technological cutting edge and where most firms are technology adopters and not radical innovators, we cannot focus our analysis on R&D and patents.

Following this perspective, we measure innovation in a broader way than the radical innovation or scientific-based innovation, a standpoint that fits countries like Portugal.[1] We will enquire if firms are affected not only by the R&D and radical innovation but also from small product and process innovation increments developed by other firms within the same region and industry. In other words, we seek to identify a possible effect of being included in an environment where firms strive to evolve technologically even if not contributing with new knowledge to society.

To attain this goal we use the Portuguese Third Community Innovation Survey (CIS III) database, which provides information on the innovative performance of manufacturing and service firms, as well as their overall performance. Drawing on the information about the innovative behaviour of firms, we built a variable that summarises the innovative performance of firms from the same region, industry and size of a firm.[2]

We consider a production function with value added as the independent variable and with the variable measuring the innovation of other firms as a regressor to measure the indirect effect of innovation on performance of firms of the same industry and region. In other words, we assess regional horizontal spillovers, and do not consider vertical spillovers. By incorporating a measure of "borrowed" innovation into a production function, and following the influential work of Griliches (1979), which first added data

[1] Portugal has 4.8 patent applications to the EPO per million inhabitants and 0.8 % of GDP dedicated to R&D - Source: Eurostat (2007): Europe in figures - Eurostat Yearbook 2006-07.

[2] We measure spillovers controlling for the factors that Griliches (1992) considered important: relative position in the value chain; technological intensity; and geographic distance. Following this statement, Kafouros (2006) found that, even though all firms benefited (in terms of productivity) from their own R&D, only small firms and firms from high tech sectors benefited from the innovation activities undertaken by other firms of the same or other industries.

on R&D to the list of inputs entering the production function, we verify whether spillovers play an important role in enhancing firm performance.

3. Data and model specification

This section describes the data used to address the research questions. In addition, it presents the model specification and the methodological issues associated with it.

Data

Testing if the knowledge produced by firms' innovation activities spills over to other firms requires micro-level data with matching firm-level information on innovation and production levels. This information can be found in the Portuguese Community Innovation Survey (CIS) database. The CIS, executed under the supervision of the European Community (EU), is focused on the observation and collection of quantitative data on technological innovation. The dataset is representative of the population of the manufacturing sector and also of five selected service sectors (only firms with more than 10 employees were considered). The usual consistency and logical tests, as well as corrections for possible bias associated with non-responses, were performed for each country at the firm level.

Developed under the guiding principles of the Oslo Innovation Manual (OECD, 1992), the survey aims at collecting data on innovation understood from a broad firm perspective, rather than examining just the invention process. Thus, the CIS captures a larger variety of innovation activities than just R&D expenditures, including the acquisition of patents and licenses, product design, personnel training, trial production, and market analysis and innovative output that is not reflected in the submission of patent filings, including the introduction of innovative production processes and organizational changes. The importance of the CIS data is attested by a number of recent works that draw on this survey. Results obtained by Cassiman and Veugelers (2002) and Mohnen and Dagenais (2002) are good examples of the growing use of the CIS data to further our understanding of innovation at the micro level.

The survey enquires if firms have introduced at least one innovation in the period from 1998 to 2000. Specifically, the innovation question is asked as a binary query: has your firm incorporated any innovation in the last three years? This query was complemented by a validation question, which asked firms to describe the innovations. If the answer to this question was no, it asked if the firm had tried to innovate. To the firm that either introduced or attempted to introduce an innovation, a number of questions associated with the innovation process followed. In addition, the survey also collects information on the expenditures on innovation activities, such as intramural and extramural R&D, acquisition of machinery or other external knowledge, training, market introduction of innovation, design or other types of preparations for the production or distribution of innovation.

These two variables - engagement in innovation activities and expenditures in innovation - are the critical indicators of innovative activity considered in this paper. Using these variables provides a number of advantages. Firstly, we look at innovation in general, not only at the adoption of a specific technological innovation (such as computers). Secondly, it provides information about innovations beyond that linked to patent applications. As mentioned above, this helps to understand the innovation process in countries where patents are not common, or that are far from the technological frontier, such as Portugal. Finally, we can investigate differences between product and process innovation, in order to enquire if demand enhancing and cost reducing innovations have different effects on firms' performance, as stated in several studies (Leiponen, 2000; Rouvinen, 2002).

Table 1 presents the mean and standard deviation of the variables used in this study. The survey provides matching data on firm's value added, capital, number of employees and their schooling levels, if the firm belongs to a national or multinational group, the exports weight on turnover, and the above measures of innovation activities.[3] As can be seen from Table 1, 44% of the firms that answered the survey reported some kind of innovation activities. The innovation activities can be separated between process and product innovation, where the percentages are 30% and 35%, respectively. Concerning the workforce structure, on average, employees with higher education are a minority in the firms of this sample. In addition, there is a greater variance in the number of employees with higher education than in the number of employees without this kind of education, given an indication that there are significant differences between firms regarding absorptive capacity. Finally, only 19% and 11% of the firms are part of a national and multinational group, respectively; only 37% export more than ten percent of their turnover; and the majority are not engaged in any intellectual property protection method (69%).

(Insert Table 1)

[3] The survey does not provide information on the book values of capital stock for equipment and structures. Therefore, we had to resort to the closest variables available: the value of gross investment in tangible goods and an indicator of capital use calculated by the difference between turnover and value added. We assume that the sum of these two variables reflects the relative levels of capital stock employed by firms.

Model

To examine the possible effect of innovation activities performed by surrounding firms on the performance of a firm, we estimate a production function in which the percentage of innovative firms by industry, sector and size serve as inputs. By quantifying the innovation produced in surrounding firms and controlling for the fact that a firm is itself an innovation producer, we investigate the existence of knowledge spillovers associated with innovation activities. We considered a value-added[4] Cobb-Douglas production function for firm *i* with the following specification:

$$Y_i = A_i L_{Hi}^{\beta_1} L_{NHi}^{\beta_2} K_i^{\beta_3} e^{u_i} \qquad (1)$$

where L_H and L_{NH} are the number of employees with higher education (college or higher) and without higher education, respectively, in order to control for the qualifications of the workforce and measure the absorptive capacity of the firm; K is capital; and u is a stochastic disturbance. The total factor productivity parameter (A) is assumed to be driven by exports, inclusion in a group (national or multinational), industry and region characteristics, and the innovation activities of the firm and surrounding firms. We define A as

$$A_i = \exp\left(\theta_1 I_i + \theta_2 S_i + \sum_k \delta_k D_k + \sum_h \lambda_h R_h + \sum_j \gamma_j G_j \right) \qquad (2)$$

[4] Value added is used instead of productivity because the use of productivity implies a restriction of the coefficients and constant returns to scale. The variable value added is specific to the Portuguese CIS, implying that this test cannot be enroled using data from other countries.

where I and S are indicators of innovation activities of the firm and the surrounding firms, respectively. The industry (D) and region (R) dummies capture differences in market and technological opportunities across industries and regions. The dummies for differences in internal organization and firm performance (G) are defined as firm belonging to a national group and/or a multinational group, and firm exports are higher than 10% of its turnover. Taking logarithms, the production function becomes,

$$y_i = \beta_0 + \beta_1 l_{Hi} + \beta_2 l_{NHi} + \beta_3 k_i + \theta_1 I_i + \theta_2 S_i + \sum_k \delta_k D_k + \sum_h \lambda_h R_h + \sum_j \gamma_j G_j + u_i \qquad (3)$$

where the lowercase letters denote logs.

Two variables were used to measure the firm own innovation: a dummy variable indicating if a firm is engaged in innovation activities and the logarithm of expenditures in innovation activities. To capture the effect of innovative performance of surrounding firms – the spillover – we use, separately, three different variables measured by industry, sector and firm size[5]: percentage of innovative firms; percentage of product innovative firms; and percentage of process innovative firms. Our choice of defining these variables restricting by location, sector and size is based on the assumption, described by Griliches (1992) and more recently by Aharonson et al. (2007), that firms can more easily capture spillovers from firms located in the same region, sector and with a similar dimension. The path dependence of most of the technological knowledge and of its market applications makes the significance of potential spillovers greater within rather than across sectors, since, in order to take advantage of spillovers, firms

[5] Industry measured by NACE sections; region by NUTS 2 level; and size was controlled by dividing firms into two groups: small (fewer than 50 employees) and medium / large firms (more than 50 employees).

have to share a technological knowledge base. Following Acs et al. (1994) who state that small and large firms have different innovation production functions, Aharonson et al., (2007) assert that small firms are more likely to capture knowledge from firms of the same dimension and located in the same region. The distinction between process and product spillovers is founded in the idea that, although both can contribute to an increase in the output of the firm, the magnitude and pervasiveness of spillovers for product and process R&D are likely to be different (Ornaghi 2006).[6]

The inclusion of firm innovation amongst the determinants of productivity raises a possible endogeneity problem as this variable is potentially correlated with the error term in equation (3).[7] In this context, using OLS does not guarantee the consistency of the estimators. The solution adopted was to implement an instrumental variable (IV) approach.[8] The success of this estimation depends on finding effective instruments that lead to the correct identification of all model parameters. The instrument chosen was a dummy variable that identifies if firms are engaged in any intellectual property protection method (registration of design, trademarks, patents, confidentiality agreements, copyright, secrecy, complexity of design and lead-time advantage on

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[6] Several studies are focused on the spillovers associated with R&D activities, a measure of the innovative input. Our study uses measures of innovation output – engagement in innovation activities and expenditures on innovation activities – that, in our opinion, give a more trustful assessment of the real impact of innovation on the performance of firms.

[7] Moreover, the sample probably has a higher incidence of innovative firms given that the survey had explicitly the objective of measuring innovation activities.

[8] As stressed by Angrist and Krueger (2001), using a linear regression for the first-stage estimates generates consistent second-stage estimates even with a dummy or censored endogenous variable (which are the cases of our innovation indicators). Wooldridge (2002) corroborates this statement stressing that discrete and endogenous variables can be used in instrumental variables, without any additional assumptions.

competitors). This variable is correlated to the innovative performance even after partialing out all the explanatory variables, and there is no apparent reason to be correlated with unobserved heterogeneity in equation (3).

4. Results and Discussion

We report the results of the estimation in the following tables with the OLS and IV estimates. Table 2 shows the results of the specifications where the innovation variable was measured by the dummy variable "engagement in innovation activities" and Table 3 introduces the results of the specifications where the innovation variable was measured by the variable "expenditures in innovation activities".

All tables report three different specifications of the model estimated by OLS and IV: the first includes capital, human capital, innovation, spillover variables, the industry and region dummy variables and the controls for being part of a group and for international exposure; the second and third specifications are similar to the first specification differing only in the spillover variable: the second includes the product innovation variable and the third the process innovation variable.[9] To save space, we do not report the estimated coefficients for industry and region dummy variables.

(Insert Table 2 and Table 3)

The estimation results do not vary substantially across specifications. Furthermore, it does not make a difference for the effect of the remaining variables whether innovation

[9] As most innovative firms report product and process innovations, the two indicators of innovation activities (product and process) are highly collinear. The solution was to run two separate specifications.

is included as a dummy or as expenditures. The comparison between the OLS and IV estimations shows that the differences are substantial at the values obtained for the estimated coefficients on innovation. The effect of innovation dummy increases from 0.198 in the OLS estimation (specification (1) in Table 2) to 0.523 in the IV estimation (specification (4) in Table 2). The corresponding effects of the innovation expenditures are 0.041 and 0.109, respectively in specification (1) and (4) Table 2. The positive and significant effect of the spillover - the percentage of surrounding firms with innovation activities - is maintained with the IV method.[10]

The main result that should be highlighted is that the variables measuring innovation and spillovers are significant and positively correlated to the value added. In other words, value added is affected by innovation activities in two different ways: not only when the innovation is developed by the firm but also when the firm is located in an innovative environment. The difference between process innovation and product innovation spillovers, despite being small, is also observed in the two tables. Firms capture more knowledge from process innovation than from product innovation. A possible explanation for this finding is that technological innovations are more easily implemented by firms and have a deeper impact on the performance of firms

As expected, the coefficients on capital and human capital are significant and positive. In addition to the expected link between firm performance and size, from this finding we can infer that the qualification of the human resources is associated with the value added. The fact that the coefficient of the variable “employees without higher education” is higher than the coefficient of the variable “employees with higher

[10] Note that the chosen instrument – dummy for engagement in intellectual property protection – proved to be a strong instrument, as its estimation coefficient has the expected sign (positive) and was significant at the 1% level in the linear projection of innovation (dummy or expenditures) onto all the exogenous variables. Moreover, the partial R-squared was 8%.

education” is explained by the economic structure of Portugal: labour-intensive sectors have more economic weight than knowledge-intensive sectors. In traditional and labour-intensive sectors the structure of the firm is based on non-qualified personnel and the role of qualified employees may be limited. The existence of more qualified human resources could not imply an increase in value added, and adding an employee without qualifications may be more valuable. In addition, the role of the qualification of the workforce is also captured by the innovation variable.

The controls for being part of a group also have a positive effect on value added. In addition, the inclusion of these variables increases the magnitude and significance of the innovation variable. Unexpectedly, the variable that controls for the exports attitude of the firm is not significant in any specification. This finding can be explained by the fact that larger firms are more export intensive and thus the effect of exports is absorbed by the variables that measure capital (human and tangible) and that are proxies of size.

5. Conclusions and Policy Implications

This paper contains several contributions to the literature on innovation spillovers. We measured firm performance directly by resorting to the value added of each firm. The innovation variable comprises a broader definition than the usual stricter one. In other words, we do not confine our analysis to R&D-based innovations or patent analysis, since we use a broader variable that detects incremental innovation activities. The information pertaining to innovation was further differentiated into product and process innovation. Furthermore, the firm engagement in intellectual property protection methods was used as an instrument for innovation to solve the endogeneity of innovation on the firm production function.

A main conclusion can be drawn from the findings: innovation activity produces knowledge spillovers that be can observed in the performance of firms. Accordingly, we can obtain clear answers to the research questions stated in the introduction: the performance of a firm is affected by the fact that other firms innovate and this effect is positive. These results contribute to the idea that the effects of innovative activities are visible in firms that are not directly involved in them. Controlling for firm innovation activities and for industry and region specificities, we found a positive effect of innovation activities on value added of surrounding firms.[11] Another feature that is visible in this analysis is the role of the workforce qualification: firms with a high level of employees with higher education have a better performance and are more able to absorb the knowledge spillovers.

Using firm level data on innovation that covers not only radical and patentable innovation, but also incremental and firm level innovations, this study contributes to the understanding of innovation at the level below the technological frontier. Most of the Portuguese economy is far from this frontier and it is important to understand how firms absorb new knowledge that, despite not being new to the economy, is new to its context. Policy implications can be drawn from our findings: policy makers, when promoting local development through innovation activities, must take into account possible positive effects of these activities on the performance of other firms. In other words, policies aimed at fostering economic development at the regional level should stimulate synergies between firms, in order to maximise the rates on return of innovation and R&D investments. Examples of such policies are the creation of technology and industrial parks, where the proximity between firms is supported by an integrated

[11] Surrounding firms meaning: firms belonging to the same industry, in the same region and with similar size (an industry-region-firm size cell).

management of common infrastructures; or, when deciding on incentives to direct foreign investment, the government has to take into account the possible knowledge spillovers, in addition to the effects on the employment creation or direct technology transfers between firms.

In the Portuguese context, these are very important results, given that they stress the role of two priority issues for the country: education and institutional trust – an essential condition for the creation of cooperation arrangements that facilitate knowledge creation and spillovers.

Acknowledgments: The research reported in this paper was partially supported by *Gabinete de Planeamento, Estratégia, Avaliação e Relações Internacionais* (GPEARI) [Statistical Office of the Ministry for Science and Higher Education, Portugal] and by the project PTDC/ESC/67665/2006 of the Portuguese Foundation for Science and Technology (FCT). Pedro Faria is grateful to the Portuguese Foundation for Science and Technology (FCT) – POS_C Programme – for its financial support.

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Table 1 – Descriptive statistics

Variable	Mean	Std. Dev.
Value Added (log)	6.69	2.24
Engagement in innovation activities (dummy)	0.44	0.50
Expenditures in innovation activities (log)	2.13	2.76
Capital (log)	7.81	1.89
no. of employees with higher education (log)	1.18	1.40
no. of employees without higher education (log)	3.89	1.27
Part of a National Group (dummy)	0.19	0.39
Part of a Multinational Group (dummy)	0.11	0.31
Exports Dummy (> 10%)	0.37	0.48
% innovative firms by industry, region and size	43.89	17.09
% product innovative firms by industry, region and size	29.81	14.02
% process innovative firms by industry, region and size	34.03	16.09
Engagement in any intellectual property protection method	0.31	0.46

Table 2 – Production function OLS and IV estimations with "engagement in innovation activities" as innovation variable

	(1)	(2)	(3)	(4)	(5)	(6)
	Value Added (log)					
		OLS			IV	
Engagement in innovation activities (dummy)	0.198**	0.212**	0.206**	0.523*	0.528*	0.520*
	(0.099)	(0.099)	(0.098)	(0.306)	(0.306)	(0.306)
Capital (log)	0.175***	0.177***	0.177***	0.160***	0.161***	0.162***
	(0.051)	(0.050)	(0.051)	(0.053)	(0.052)	(0.053)
no. of employees with higher education (log)	0.256***	0.257***	0.253***	0.234***	0.236***	0.232***
	(0.062)	(0.063)	(0.063)	(0.064)	(0.065)	(0.064)
no. of employees without higher education (log)	0.543***	0.563***	0.548***	0.552***	0.569***	0.554***
	(0.084)	(0.087)	(0.080)	(0.084)	(0.087)	(0.080)
Part of a National Group (dummy)	0.309**	0.310**	0.312**	0.300**	0.301**	0.303**
	(0.128)	(0.128)	(0.128)	(0.126)	(0.127)	(0.126)
Part of a Multinational Group (dummy)	0.373**	0.371**	0.372**	0.404**	0.401**	0.402**
	(0.158)	(0.158)	(0.158)	(0.159)	(0.159)	(0.159)
Exports Dummy (> 10%)	0.142	0.154	0.150	0.152	0.162	0.158
	(0.102)	(0.102)	(0.102)	(0.101)	(0.101)	(0.101)
% innovative firms by industry, region and size	0.012***			0.010**		
	(0.004)			(0.005)		
% product innovative firms by industry, region and size		0.010*			0.009	
		(0.006)			(0.006)	
% process innovative firms by industry, region and size			0.012***			0.010**
			(0.004)			(0.005)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1396	1396	1396	1396	1396	1396
Adjusted R-squared	0.48	0.48	0.48	0.47	0.47	0.47
F statistic	56.94	56.88	56.83	57.36	57.31	57.22

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3 – Production function OLS and IV estimations with "expenditures in innovation activities" as innovation variable

	(1)	(2)	(3)	(4)	(5)	(6)
			Value Added (log)			
		OLS			IV	
Expenditures in innovation activities (log)	0.041**	0.043**	0.043**	0.109*	0.110*	0.108*
	(0.021)	(0.021)	(0.021)	(0.064)	(0.063)	(0.063)
Capital (log)	0.171***	0.172***	0.172***	0.148***	0.149***	0.150***
	(0.050)	(0.050)	(0.051)	(0.055)	(0.055)	(0.056)
no. of employees with higher education (log)	0.246***	0.248***	0.243***	0.209***	0.211***	0.207***
	(0.065)	(0.065)	(0.065)	(0.071)	(0.071)	(0.071)
no. of employees without higher education (log)	0.531***	0.550***	0.534***	0.518***	0.536***	0.519***
	(0.082)	(0.085)	(0.079)	(0.083)	(0.086)	(0.080)
Part of a National Group (dummy)	0.306**	0.307**	0.309**	0.292**	0.292**	0.295**
	(0.128)	(0.128)	(0.128)	(0.125)	(0.126)	(0.125)
Part of a Multinational Group (dummy)	0.382**	0.379**	0.381**	0.426***	0.423***	0.424***
	(0.158)	(0.158)	(0.158)	(0.163)	(0.163)	(0.163)
Exports Dummy (> 10%)	0.145	0.157	0.153	0.161	0.171*	0.166*
	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)	(0.101)
% innovative firms by industry, region and size	0.012***			0.011**		
	(0.004)			(0.004)		
% product innovative firms by industry, region and size		0.011*			0.010*	
		(0.006)			(0.006)	
% process innovative firms by industry, region and size			0.012***			0.012***
			(0.004)			(0.004)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Region Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1396	1396	1396	1396	1396	1396
Adjusted R-squared	0.48	0.48	0.48	0.47	0.47	0.47
F statistic	57.72	57.56	57.67	57.60	57.40	57.56

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%