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A double–hurdle model for innovative performance: the role of university-industry collaborations

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ABSTRACT: In the last few decades, university-industry collaborations have attracted considerable attention. A large body of literature has pointed to the importance of scientific research for technological change, innovation and economic performance. This paper identifies the effect of collaborations with public research organizations on firms' innovative performance. Using the French Community Innovation Survey, we present evidence that collaborating with universities and other public research organizations increases firm's innovative performance.

KEYWORDS: Innovation, public research organizations, double-hurdle model, French Community Survey.

1 INTRODUCTION

In the last few decades, the link between collaborations with public research organizations (PROs) and innovative performance has been well documented. Universities are no longer simply considered as ivory towers that perform research for the own sake of knowledge, but as real actors in the knowledge-based economy [1]. In addition to their traditional roles (i.e. education and research), universities are now playing a third role which is the diffusion of knowledge and techniques that may contribute to industrial innovation [2].

Many empirical studies find support for the idea that interactions with PROs positively influence firms' innovative performance. For instance, cooperation with universities is shown to be positively associated with innovative sales in Netherlands, Germany and Sweden [3], [4], [5]. In contrast, Meda and *al*. [6] and Eom and Lee [7] found that collaboration with PROs does not yield benefits in Italy and Korea, respectively. In France, few studies have evaluated the effect of collaborations with public research organizations on innovative performance [8]. Consequently, empirical evidence is yet to be found confirming whether collaborations with PROS could significantly improve firms' innovative performance.

France is the second most important country in the European Union (EU) with regards to gross domestic expenditure on research and development (R&D)[9]. However, the percentage of higher education expenditure on R&D financed by industry is among the lowest rates in the EU: 2,57 percent in France against 6,57 in the EU in 2011[10]. France is considered as an innovation follower because of its low ability to transform innovation inputs into innovation outputs [11]. Since 1983, companies that pursue innovation activities are granted a tax cut to encourage them to innovate. This is relatively late compared to countries such as Canada and United States where this measure was applied since 1960 and 1979, respectively. Still, firms can be offered a research tax credit if they engage in R&D activities which is very important especially for small and medium enterprises and very small enterprises.

In order to improve its innovation efforts, a number of actions have been taken. For instance, an evaluation agency of research and higher education (AERES) was implemented in 2007 whose aim is to make the French academic system closer to international standards. Moreover, several clusters were created in different regions so that universities and public research organizations can easily collaborate with firms in strategic sectors. Many technology Transfer Offices were also created within and outside campuses.

Our paper contributes to this growing empirical literature. We examine the relationship between knowledge emanating from PROs through formal collaborations and firms' innovative performance in France. We distinguish between collaborations with universities or establishments of higher education and those with public or non-profit research organizations. Our paper also achieves some methodological improvement since we propose to use a double hurdle model [12]. Our main result suggests that collaborations with PROs have a recent positive effect on firm's innovative intensity.

The remainder of the paper is organized as follows. Section 2 introduces our data and shows the main descriptive statistics. It is followed by the econometric modeling and the results in section 3. Finally, our conclusions are presented in section 4. An appendix is presented in section 5.

2 INNOVATIVE PERFORMANCE AND UNIVERSITY-INDUSTRY RELATIONSHIPS

2.1 DATA AND VARIABLES

The data used are taken from the fifth French Community Innovation Survey (CIS 2006). It was undertaken in 2007, covers the period 2004-2006 and collects information on the innovative behavior of manufacturing firms with more than 19 employees. To consider the impact of academic partnerships on innovative performance across time, we also use the previous survey (CIS 4) which was undertaken in 2005 and covers the period 2002-2004.The surveys had 7009 and 4900 participating firms in 2005 and 2007, respectively.

The CIS questionnaire contains some filtering questions which creates selection problems. Firms are first asked some general questions such as their turnover, their industry, their size, their export activity and whether they are part of a group. Then, they answer questions that determine if they are innovators. The following questions relate mainly to innovating firms, which describe in more details their innovative activities. Non innovating firms have only to answer questions about obstacles to innovation and intellectual property rights.

Theoretical foundations of academic interactions with firms are well defined. Innovation is the result of a process that requires a variety of resources which can be brought through collaboration with science ([13], [14]). The Triple Helix model also emphasized the role of university-industry interactions in improving the commercialization of knowledge [15]. CIS provides information on firms' interactions in their innovative activities; including links with PROs. Firms are first asked whether they have cooperated with partners for innovation. If yes, they then have to specify with whom they have collaborate.

The main input of innovation is R&D activity. The survey provides information about R&D intensity measured as the amount spent on R&D in euro on total sales. Two types of R&D intensity are considered: internal R&D, defined as investment in in-house R&D, and external R&D which is bought-in from outside the firm. Prior knowledge enables firms to increase their absorptive capacity so that they can identify opportunities for successful innovations [16]. We include another variable of investment in R&D which is whether the firm is continuously doing R&D activities.

Other explanatory variables are chosen on the basis of previous empirical literature. The survey gives information about the demand pull and technology push hypotheses. The first approach, which is attributed to Schmookler, implies that innovation is a function of the market demand [17]. Firms innovate to meet the unsatisfied needs of consumers. In order to control for this feature, a binary variable is used describing if the firm aimed to break into new markets and/or to increase its market share. We also consider a binary variable which identify firms who faced obstacles linked to the market[1] that have hampered their innovation activities. In contrast to the demand pull approach, the technology push view, which is ascribed to Schumpeter, supports the idea that innovation is driven by research and technological capabilities [18]. Making commercial use of new knowledge is here the main objective no matter if a demand already exists or not. We capture the technological opportunity using 11 industry dummies whose description is presented in Appendix A. We rely on previous academic

[1] *Firms were asked whether they faced obstacles to innovation such as competition and uncertainty of demand.*

evidence to separate between high-tech industries (Vehicles, Chemicals, Electric and Machinery) and low-tech industries (Food, Textile, Wood, Plastic-rubber, Non-metallic, Metallic and NEC[2]) [19].

Obstacles to innovation are important factors that may affect innovation performance, especially the cost of innovation [20]. We use a dummy variable which explains whether the cost of innovation hindered firms' activities of innovation. We expect that the cost of innovation will have a negative effect on the extent to which sales are generated from innovation.

Another Schumpeterian hypothesis argues that competition between firms drives innovation [18]. Firms operating in foreign markets may be more exposed to competition which may affect their innovation activities [21]. Aschhloff and Schmidt [4] point out that international competition could encourage firms to improve product quality and to create more new products. They also consider that exporters have access to a larger market to sell their products than non-exporters. Therefore, we include a binary variable which identify whether a firm exports or not.

A last hypothesis, also developed by Schumpeter, argues that large firms have the resources that enable them to address the risks associated with innovation activities [18]. Thus, we control for firm's size measured as the logarithm of the number of employees. Finally, previous studies found that the exchange of knowledge between firms which are part of the same internal network may enhance innovation [22], [23]. We use a binary variable coded 1 if the firm belongs to a company group and coded 0 if it does not.

2.2 INNOVATIVE PERFORMANCE

The survey first asks firms whether they have introduced at least one product innovation. It distinguishes between products that are only new to the firm and those that are new to the market. The former can be considered as a simple imitation of products that are already available in the market, whereas the latter are true innovations. Then, CIS asks innovative firms to estimate the percent of turnover related to the introduction of new products, which can be considered as a measure of innovative performance. We choose to restrict our analysis to the share of sales related to products that are new to the market.

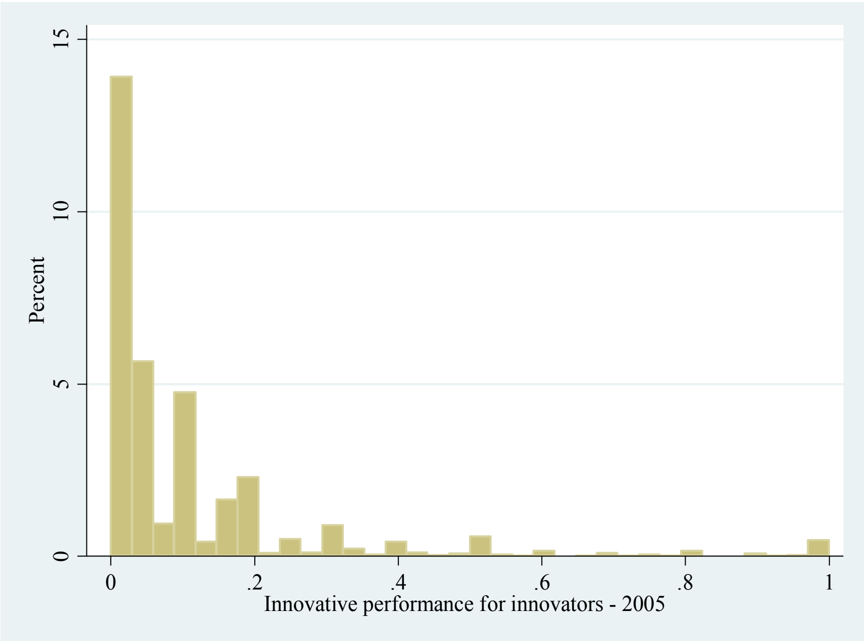

Figure 1: Innovative performance for innovators - 2005

[2] Not Elsewhere Classified.

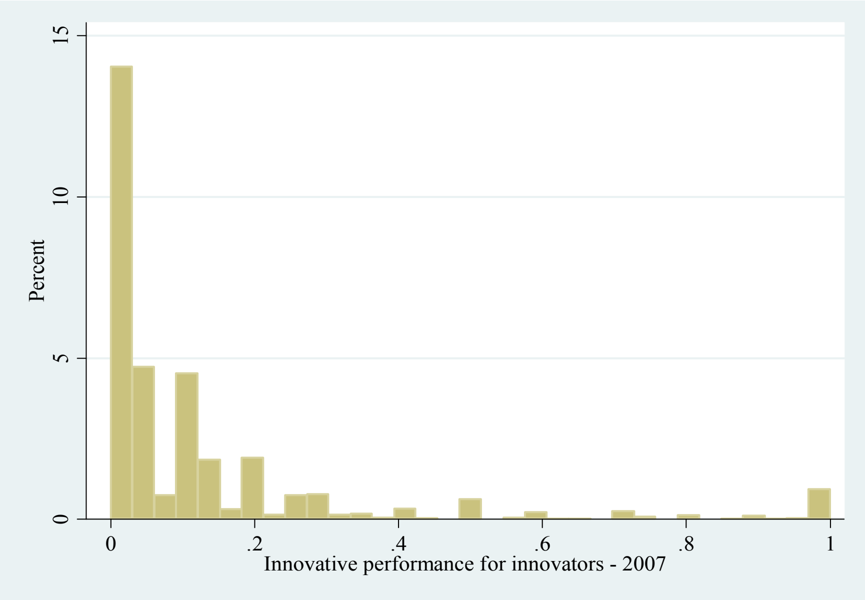

Figure 2: Innovative performance for innovators - 2007

A quick overview of Fig. 1 and 2 above provides interesting insights of the distribution of innovative performance for both surveys. The majority of innovative firms have an innovation intensity which is below 20%. About 30 % percent of these firms report a zero innovative intensity even if they introduced a new product into markets. Also, for some firms, their total turnover comes from sales of products new to market.

2.3 COLLABORATING VS. NON-COLLABORATING FIRMS

Tab.1 thereafter gives the mean of the variables used in our analysis, separately for firms who cooperate with academia and those that do not[3]. The former seem to have a higher innovative performance than the later. Internal R&D investment of collaborating firms is twice that of non-collaborating firms in 2007, whereas the difference is not significant in 2005. The link is almost the same for external R&D, however it is only significant in 2005. Furthermore, firms having partnerships with PROs are more likely to have continuous investment on R&D activities than those that do not. Noticeably, firms who engage in academic partnerships have a higher average size, most often belong to a group and are nearly all export-oriented. Moreover, most collaborating firms want to increase their market share or to break into new markets but they are more likely to face barriers to innovation. Finally, it appears that there are some differences between collaborating and non-collaborating firms with regard to technological opportunity. Collaborating firms are more likely to operate in Chemical and Electric industries while non-collaborating firms are more likely to be in Wood, Textile or Food industries.

Overall, this statistical analysis shows that there is a difference between collaborating and non-collaborating firms, especially with regard to innovative performance which is larger for the former. This effect appears to be statistically significant in the two surveys and this is the hypothesis that is examined in the following econometric analysis.

[3] *At this stage, we still do not separate between the two types of academic collaborations previously mentioned.*

Table 1: A comparison between collaborating and non-collaborating firms

	2005			2007		
Variables	Collaborating firms (N=168)	Non-collaborating firms (N=2673)	Significance	Collaborating firms (N=570)	Non - collaborating firms(N=1602)	Significance
Innovative performance	0.146	0.108	***	0.144	0.120	**
Internal R&D	0.073	0.054	ns	0.040	0.021	***
External R&D	0.020	0.003	***	0.005	0.003	ns
Continuous R&D	0.952	0.621	***	0.868	0.638	***
Increasing market share	0.964	0.924	*	0.921	0.873	***
Market obstacles	0.935	0.850	***	0.877	0.785	***
Cost of innovation	0.911	0.825	***	0.877	0.767	***
Firm's size	6.679	4.898	***	5.952	5.081	***
Belonging to a group	0.935	0.734	***	0.865	0.712	***
Exporting	1.000	0.854	***	0.939	0.851	***
Vehicles	0.119	0,086	ns	0,082	0,101	ns
Chemicals	0,232	0,104	***	0,189	0,093	***
Electric	0,274	0,145	***	0,198	0,164	*
Machinery	0,107	0,098	ns	0,118	0,092	*
Food	0,054	0,165	***	0,111	0,144	*
Textile	0,006	0,077	***	0,042	0,074	***
Wood	0.030	0.080	**	0.044	0.082	***
Plastic Rubber	0.065	0.061	ns	0.049	0.071	*
Non-metallic	0.018	0.045	*	0.042	0.050	ns
Basic metal	0.083	0.094	ns	0.104	0.087	ns
NEC	0.012	0.046	*	0.021	0.043	**

***, ** and * represent 1%, 5% and 10% levels of significance, respectively ns : non significant

3 MODELING INNOVATIVE PERFORMANCE

Because only firms that have introduced a new product have to complete the question about innovative performance, CIS data can be subject to a selection problem**.** It is also likely that the decision to innovate and innovative performance may be explained by different independent variables. To take account of these two features, most studies use a Heckman selectivity model consisting of two equations where the first is a probit equation which indicates if a firm innovates or not, and the second equation explains the extent of innovative performance [24]. Using CIS data for France, Robin and Schubert [8] estimated a Heckit model (see [25]) which is an extension of the Heckman model that allows some explanatory variables to be endogenous. In fact, they consider that collaborations are endogenous independent variables since collaboration variables and innovative performance may be determined by the same unobserved variables. While they focus on the potential endogeneity of academic collaborations, it seems that their model does not fully takes into account the selection problem[4]. Indeed, the authors include some independent variables in the probit part of their model (the decision to innovate) which are not observed for all firms, namely, collaborations with non-academic partners and an indicator of openness (which indicates if an external source of knowledge is used). Our paper builds upon this recent work but differs from it in different respects.

First of all, using the Heckman model requires that innovative performance must be positive for all innovating firms. Still, the distribution of innovative performance reported in Fig. 1 and 2 shows opposite conclusion. In fact, even after controlling the innovating activity, some zero innovative intensity is still likely. Indeed, about 30% of the innovating firms in 2005 and 2007 report zero innovative intensity. This leads us to consider a double hurdle model, where a positive dependent variable

[4] Robin et Schubert include some independent variables in the probit part of their model (the decision to innovate) which are not observed for all firms, namely, collaborations with non-academic partners and an indicator of openness (which indicates if an external source of knowledge is used).

is observed if two hurdles are crossed [12]. The first hurdle is related to the decision to innovate and the second hurdle is to have an innovation intensity larger than zero. The double hurdle model can be represented by the following functions [26]:

$$y_i = \begin{cases} y_i^* \ if \ \ y_i^* > 0 \ \ and \ \ D_i > 0 \\ 0 \ \ otherwise \end{cases} \tag{1}$$

where the latent dependent variable is described by the regression equation:

$$y_i^* = x_i^* \beta + e_i \tag{2}$$

with, $e_i \sim N(0, \sigma_e^2)$, and D_i is a latent variable describing the decision to innovate:

$$D_i = z_i \theta + w_i \tag{3}$$

with $w_i \sim N(0,1)$.

The equation of the decision to innovate only contains explanatory variables observed for all firms, irrespective of whether they are innovators.

Thus, under the assumption of the independence between the two stochastic errors, the likelihood function of the double hurdle model is:

$$\ln L = \sum_0 \ln\left(1 - \Phi\left(x_i.\frac{\beta}{\sigma_e}\right)\Phi(z_i.\theta)\right) + \sum_1 \left(-\ln\sigma_e + \log\varphi(\frac{y_i - x_i.\beta}{\sigma_e}) + \ln\Phi(z_i.\theta)\right) \tag{4}$$

where $\Phi(.)$ and $\varphi(.)$ are the standard normal cumulative and density functions respectively. The Stata program used to estimate the model described in this paper is presented in Appendix B.

Moreover, most studies do not control for the possible endogeneity of collaboration in the innovative performance equation [5], [7], [20], [27]. In addition, no endogeneity could be found in studies that have tested the potential endogenous character of collaborations [4], [28]. Because our purpose is to carry out a model that best suits the data, testing endogeneity is left to other future studies.

Finally, although the literature does not specify whether to use exclusion restrictions in double hurdle models, many empirical analyses include them. This restriction means that a variable should appear among the explanatory variables of the decision equation without being included in the explanatory variables of the outcome equation. As an exclusion variable, we use the variable representing obstacles to innovation which are linked to the market.

Tab.2 below shows the results for the two surveys. We distinguish in the outcome equation between exports to European markets and exports to other international markets. The machinery industry serves as the reference category. For each survey, we examine three models: the first only takes account of collaborations with universities or establishment of higher education, the second only introduces collaborations with public or non-profit research organizations and the third model includes all cooperation variables (including cooperation with non-academic institutions[5]). The first part of each model presents the decision equation of the double hurdle model (columns 1, 3, 5, 7, 9 and 11) while the second column is the outcome equation (columns 2, 4, 6, 8, 10 and 12).

We find that collaboration with PROs positively affects the enterprise's revenues from product innovation in 2007, while the relationship is insignificant in 2005. When all forms of collaboration are included in the regression (columns 6 and 12), academic collaborations turn to be insignificant. This suggests the existence of a multicolinearity problem which is mainly related to data structure. As a consequence, we prefer to present the collaboration variables one by one.

Besides our main finding, our results also indicate that internal R&D investments are positively associated with innovative performance. Doing R&D on a continuous basis has also a similar effect. In contrast, the amount an enterprise invests in external R&D seems not to have any effect on innovative intensity.

[5] *Such as others firms of the group, suppliers, customers, competitors and consultants.*

Regarding the Schmooklerian hypothesis, which states that innovation depends on market demand, there is a strong association between increased innovation performance and the willingness of firms to increase their market share and/or to break into new markets. It also appears that firms that face barriers to innovation related to market demand such as competition and demand uncertainty are more likely to innovate. Turning to the technology push hypothesis, the results do not allow us to conclude that innovation is more important in the high-tech sectors. There are some sectoral differences but this Schumpeterian hypothesis is not clearly confirmed.

As expected, the cost of innovation reduces sales from product innovation. Firm's size appears to be positively associated with the decision to innovate but influences negatively sales from innovation. Being part of a group has only a positive impact on the probability to innovate in 2005. Finally, the export activity only determines the decision to innovate but does not affect significantly the intensity of innovation.

4 CONCLUSION

This paper has investigated the effect of collaboration with public research organizations on innovative performance through an estimation of a double hurdle model. Our findings show evidence that collaboration with public research organizations increases innovative performance. While this effect is significant in 2007, it turns out be insignificant in 2005, which may reflect an evolution of the role of science-industrie links in France.

Our econometric analysis was done under the assumptions of independent, homoskedastic and normally distributed error terms. If these assumptions are not true, coefficients estimates are inconsistent [26]. Yet, Smith [29] found that the dependent double hurdle model is statistically deficient since the correlation parameter is poorly identified. He argues that this is why most studies were unable to support the existence of dependent parameter. Consequently, assuming this parameter is zero allows a better estimation of all parameters.

For future research, additional empirical work is needed to improve the robustness of these results, especially with regard to normality and homoskedasticity assumptions as well as endogeneity problems.

Table 2: Double hurdle estimation for innovative performance

Variables	2005 (N=7009)											
	1		2		3		4		5		6	
Firm's size	0.352***	(0.030)	-0.013***	(0.004)	0.352***	(0.030)	-0.013***	(0.004)	0.353***	(0.030)	-0.014***	(0.004)
Belonging to a group	0.317***	(0.073)	-0.010***	(0.012)	0.317***	(0.073)	-0.010***	(0.012)	0.317***	(0.073)	-0.010***	(0.012)
Exporting	0.699***	(0.070)			0.699***	(0.070)			0.700***	(0.070)		
Exporting_Europe			-0.010	(0.016)			-0.010	(0.016)			-0.010	(0.016)
Exporting_ Others			0.006	(0.012)			0.007	(0.012)			0.006	(0.012)
Increasing market share			0.255***	(0.021)			0.254***	(0.021)			0.254***	(0.021)
Market obstacles	0.875***	(0.069)			0.875***	(0.069)			0.875***	(0.069)		
Cost of innovation			-0.025**	(0.012)			-0.025**	(0.012)			-0.026**	(0.012)
Internal R&D			0.012***	(0.003)			0.012***	(0.003)			0.012***	(0.003)
External R&D			0.309*	(0.184)			0.308*	(0.183)			0.294	(0.184)
Continuous R&D			0.063***	(0.011)			0.064***	(0.011)			0.063***	(0.011)
Coop_univ			0.021	(0.020)							0.009	(0.023)
Coop_other PROs							0.030	(0.023)			0.022	(0.028)
Coop_non academic											0.006	(0.011)
Vehicles	-0.260	(0.176)	0.023	(0.021)	-0.260	(0.176)	0.024	(0.021)	-0.260	(0.176)	0.023	(0.021)
Chemicals	0.056	(0.201)	-0.020	(0.020)	0.054	(0.201)	-0.020	(0.020)	0.056	(0.201)	-0.020	(0.02)
Electric	-0.010	(0.171)	0.017	(0.018)	-0.010	(0.171)	0.017	(0.018)	-0.010	(0.171)	0.017	(0.018)
Food	-0.400**	(0.158)	-0.060***	(0.019)	-0.400**	(0.158)	-0.050***	(0.019)	-0.400**	(0.158)	-0.060***	(0.019)
Textile	-0.710***	(0.161)	0.037	(0.022)	-0.710***	(0.161)	0.037*	(0.022)	-0.710***	(0.161)	0.037*	(0.022)
Wood	-0.790***	(0.165)	-0.040	(0.023)	-0.790***	(0.165)	-0.040	(0.023)	-0.790***	(0.165)	-0.040	(0.023)
Plastic Rubber	-0.220	(0.203)	0.026	(0.023)	-0.220	(0.203)	0.027	(0.023)	-0.220	(0.203)	0.026	(0.023)
Non metalic	-0.350*	(0.211)	-0.080***	(0.026)	-0.350*	(0.211)	-0.080***	(0.026)	-0.350*	(0.211)	-0.080***	(0.026)
Basic metal	-0.560***	(0.164)	0.013	(0.020)	-0.560***	(0.164)	0.014	(0.02)	-0.560***	0.164	0.013	(0.020)
NEC	-0.440**	(0.191)	0.114***	(0.026)	-0.440**	(0.191)	0.114***	(0.026)	-0.440**	(0.191)	0.114***	(0.026)
Constant	-2.309***	(0.183)	-0.059*	(0.032)	-2.309***	(0.182)	-0.059*	(0.032)	-2.312***	(0.183)	-0.055*	(0.033)
Sigma	0.201***(0.004)				0.200***(0.004)				0.200***(0.004)			
Wald test (prob>chi2)	304.060(0.000)				304.730(0.000)				305.010(0.000)			

Variables	2007 (N=4900)											
	7		8		9		10		11		12	
Firm's size	0.502***	(0.045)	-0.014**	(0.006)	0.502***	(0.045)	-0.014**	(0.006)	0.506***	(0.045)	-0.017***	(0.006)
Belonging to a group	0.024	(0.093)	0.004	(0.017)	0.022	(0.093)	0.006	(0.017)	0.023	(0.094)	0.002	(0.017)
Exporting	0.885***	(0.087)			0.883***	(0.087)			0.886***	(0.088)		
Exporting_Europe			-0.046**	(0.023)			-0.044*	(0.023)			-0.043*	(0.023)
Exporting_ Others			0.029	(0.018)			0.029	(0.018)			0.031*	(0.018)
Increasing market share			0.232***	(0.025)			0.232***	(0.025)			0.232***	(0.025)
Market obstacles	0.720***	(0.084)			0.720***	(0.084)			0.723***	(0.085)		
Cost of innovation			-0.004	(0.016)			-0.006	(0.016)			-0.008	(0.016)
Internal R&D			0.255**	(0.114)			0.261**	(0.114)			0.252**	(0.115)
External R&D			-0.192	(0.413)			-0.228	(0.412)			-0.223	(0.413)
Continuous R&D			0.072***	(0.016)			0.073***	(0.016)			0.070***	(0.016)
Coop_universities			0.032**	(0.016)							0.000	(0.02)
Coop_other PROs							0.040**	(0.018)			0.022	(0.022)
Coop_non academic											0.049***	(0.015)
Vehicles	-0.400	(0.252)	0.044	(0.028)	-0.400	(0.251)	0.043	(0.028)	-0.400	(0.254)	0.044	(0.028)
Chimicals	-0.240	(0.274)	0.007	(0.027)	-0.240	(0.274)	0.008	(0.027)	-0.230	(0.278)	0.003	(0.027)
Electric	-0.190	(0.241)	0.003	(0.025)	-0.180	(0.24)	0.003	(0.025)	-0.180	(0.243)	0 .000	(0.025)
Food	-0.910***	(0.231)	-0.010	(0.027)	-0.910***	(0.231)	-0.020	(0.027)	-0.910***	(0.234)	-0.010	(0.027)
Textile	-0.830	(0.235)	0.176	(0.032)	-0.830	(0.235)	0.176	(0.032)	-0.820	(0.238)	0.170	(0.033)
Wood	-1.340***	(0.234)	0.062***	(0.034)	-1.340***	(0.234)	0.062***	(0.034)	-1.350***	(0.237)	0.062***	(0.034)
Plastic Rubber	-0.250	(0.291)	0.083***	(0.031)	-0.250	(0.291)	0.084***	(0.031)	-0.250	(0.295)	0.079**	(0.031)
Non metalic	-0.610**	(0.272)	0.032	(0.036)	-0.610**	(0.272)	0.030	(0.036)	-0.610**	(0.275)	0.031	(0.036)
Basic metal	-0.990***	(0.237)	0.043	(0.029)	-0.990***	(0.237)	0.044	(0.029)	-0.990***	(0.24)	0.041	(0.029)
NEC	-0.350	(0.306)	0.014	(0.039)	-0.350	(0.306)	0.012	(0.039)	-0.340	(0.311)	0.008	(0.039)
Constant	-2.624***	(0.281)	-0.077*	(0.045)	-2.625***	(0.281)	-0.080*	(0.045)	-2.633***	(0.284)	-0.077	(0.045)
Variance	0.247***(0.005)				0.247***(0.005)				0.247***(0.005)			
Wald test (prob>chi2)	174.01(0.000)				175.16(0.000)				182.90(0.000)			

Standard errors are between brackets

***, ** and * represent 1%, 5% and 10% levels of significance, respectively

5 Appendix

Appendix A: Industrial sectors based on Nace code

Industries	Nace	Definitions
Food	15-16	Manufacture of food, beverage and tobacco
Textile	17-19	Manufacture of textiles ; Manufacture of wearing apparel; dressing and dyeing of fur ; Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
Wood	20-22	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials ; Manufacture of pulp, paper and paper products
Chemicals	23-24	Manufacture of coke, refined petroleum products and nuclear fuel ; Manufacture of chemicals and chemical products ; Publishing, printing and reproduction of recorded media
Plastic Rubber	25	Manufacture of rubber and plastic products
Non-metallic	26	Manufacture of other non-metallic mineral products
Metallic	27-28	Manufacture of basic metals ; Manufacture of fabricated metal products, except machinery and equipment
Machinery	29	Manufacture of machinery and equipment n.e.c
Electrical	30-33	Manufacture of office machinery and computers ; Manufacture of electrical machinery and apparatus n.e.c.; Manufacture of radio, television and communication equipment and apparatus ; Manufacture of medical, precision and optical instruments, watches and clocks
Vehicles	34-35	Manufacture of motor vehicles, trailers and semi-trailers ; Manufacture of other transport equipment
NEC	36	Manufacture of furniture; manufacturing n.e.c.

Appendix B: Stata code for estimation of the double hurdle model

```
capture program drop myhurdle5
program define myhurdle5
args lnf xb s1 zc
quietly replace `lnf'=ln(1-normprob(`xb')* normprob(`zc')) if $ML_y2==0
quietly replace `lnf'=-ln(`s1'*sqrt(2*_pi))-0.5*(($ML_y1-`xb')/`s1')*(($ML_y1-`xb')/`s1')+ ln( normprob(`zc')) if $ML_y2==1
end
```

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