Corporate Basic Research and First-movers

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[PRELIMINARY VERSION]

Abstract

Rosemberg (1990) stresses the importance attached to basic research as a driving force of first-mover advantages. The aim of this paper is to evaluate to what extent conducting in-house basic research and the experience gained performing this activity helps firms to bring new products into the market ahead of competitors. The analysis is performed on a sample of manufacturing Spanish firms over the period 2006-2011. We find that conducting in-house basic research and performing this activity continuously affects firm's propensity to introduce market novelties in low-tech and high-tech sectors. In contrast, basic research has no effect on the propensity to imitate, and in the case of high-tech sectors the impact may be significantly negative.

Key words: basic research, pioneer, imitation, R&D.
JEL classification: D22, L21, O32.

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1. Introduction

Literature shows that despite the appropriability problems related to basic research, there are rational reasons for firms to conduct internal basic research activities[1]. Rosemberg (1990) argues that one of the important benefits associated to basic research is the possibility to confer the firm with first-mover advantages. These advantages may be the result from being the first to possess new knowledge resulting from basic research, or from the development of new product or processes which, brought to the market ahead of competitors, may confer them a temporary monopolistic position. The importance of developing and bringing to market innovative products ahead of competitors and the benefits for the firm pursuing this strategy are well recognized (Lieberman and Montgomery, 1988). However, there is a lack of empirical evidence on how internal basic research may contribute to help firms to be pioneers and therefore be able to enjoy first-mover advantages.

Despite the extensive literature focusing on the role of R&D, the literature on firm's basic research activities has been relatively scarce. Notable exceptions, however, highlight the benefits from private basic research. These include, amongst others, improvement in innovation performance (Gambardella, 1992), in productivity (Mansfield, 1980; Griliches, 1986) or in the development of firm's absorptive capacity (Cockburn and Henderson, 1998). This paper contributes to expand this strand of the literature by analyzing the role of corporate basic research in shaping firm's innovation choice, and in particular in determining the chances to be pioneer.

The academic literature has also embraced the concept of learning-by-doing, i.e. learning effects through the continuous engagement in an activity (Wright, 1936; Arrow, 1962). In the innovation literature, learning, experience and accumulation of knowledge are important sources of the innovation process. Rosenberg (1990, p.173) stresses that for basic research to be successful it "requires the making of stable, long-term commitments". On that basis, we also test to what extent experience in conducting basic research influences the chances of being a pioneer.

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[1] According to the Frascati Manual (2002: 30) "*basic research is experimental or theoretical work undertaken primarily to acquire new knowledge …, without any particular application or use in view*".

More specifically, this paper aims to analyse the impact of performing in-house basic research and doing it continuously upon the choice of firms' innovative strategies, distinguishing between: (i) abstaining from innovation, (ii) introducing products that are known to the market but new to the firm (imitation) and, (iii) introducing original innovative products to the market (pioneering). To do so, we take advantage of a panel database for Spanish firms that follows the recommendations of the Frascati and Olso Manuals (OCDE, 2002; 2005), and provides detailed information about firms' R&D activities, allowing for differentiation between basic and applied research and development expenditures, as well as distinguishing innovations due to new products which were new to the market from those that were just new to the firm but known to the market (which we refer to as imitation).

We find that firms performing basic research are more likely to introduce market novelties ahead of competitors in low and high-tech sectors. In contrast, basic research has no effect on the propensity to imitate, and in the case of high-tech sectors results from a multinomial model show that the impact may be significantly negative. In addition, accumulated experience in basic research may be a key driver of first-movers in low-tech sectors. With respect to other determinants of firm's innovation choices we find that total R&D, cooperation in innovation, access to government funding, human capital and market size affect positively the likelihood of being a market pioneer.

The rest of the paper is structured as follows. The next section provides an overview of the literature on the potential private benefits from basic research. Section 3 presents the data and the empirical model. The empirical results are discussed in section four, and the final section concludes.

2. Related Literature

Despite the extensive literature focusing on the role of R&D, the literature on firm's basic research activities has been relatively scarce. Existing studies on basic research have been either theoretical or have focused their attention onto academic/scientific research as the source of basic research, overlooking the importance of corporate basic research. Notable exceptions, however, highlight the benefits from private basic research. These include, amongst others, improvement in innovation performance (e.g. Gambardella, 1992), in productivity (Griliches, 1986) or in the development of firm's absorptive capacity, which allows firms to better screen and absorb external information (Cockburn and Henderson, 1998).

The empirical studies by Gambardella (1992) and Fabrizio (2009) show that firms engaging in basic research activities obtain advantages in the innovation outcome, in terms of number, quality and timing. In contrast, Lim (2004) finds no significant effect of internal basic research on the patenting performance of pharmaceutical firms, while a negative effect is found for firms in the semiconductor industry. Findings from Mansfield (1980), Griliches (1986), and more recently, from Czarnitzki and Thoorwarth (2012) show that not only basic research is an important determinant of firm's productivity but also exhibits a premium with respect to other types of R&D, particularly in high-tech sectors. In addition, Cassiman et al. (2002) find that basic research enhances applied research productivity and argue that it allows firms to develop their absorptive capacity, an idea previously embraced by Rosemberg (1990) and supported also by Cockburn and Henderson (1998). Complementarity effects between basic and applied research are additionally found in Henard and McFadyen (2005). Moreover, Stern (2004) show that a focus on basic research may lead to labor cost reductions, as researchers may be willing to accept lower salaries in exchange of permission to keep up with scientific research.

From a more theoretical point of view, basic research has been linked to the generation of pioneering and revolutionary ideas, as well as breakthrough applications, even in the short term (Pavitt, 1991). Basic or fundamental research has the potential to enable significant commercial opportunities through facilitating entirely new product areas rather than just incremental changes. Many important and commercially viable products have been developed based on breakthroughs made by basic research. Examples are the birth of radio astronomy at Bell Laboratories, and the discovery of high temperature superconductivity at IBM research labs.

Breakthrough innovations are not the only economic benefits of basic research for industrial innovation. Additionally, scientific knowledge, resulting from basic research activities, helps firms to gain a better understanding of the technological landscape in which they search for new inventions, informs them about the most profitable directions for applied research, avoiding wasteful experimentation, and helps them to better interpret findings of applied research (Rosenberg, 1990; Fleming and Sorenson, 2004; Kelchtermans et al. 2013). Internal basic research capabilities also allow firms to expand firm's absorptive capacity, by allowing to better monitor, interpret and absorb scientific knowledge that is conducted externally to firms (Cohen and Levinthal, 1990; Cockburn and Henderson, 1998).

As Rosenberg (1990) claims, firms that perform basic research may benefit from 'first-mover advantages'. These advantages may be the result from being the first to possess the new knowledge resulting from basic research, or from the development of new product or processes which, brought to the market ahead of competitors, may confer them a temporary monopolistic position (Lieberman and Montgomery, 1988; Kelchtermans et al. 2013). On this basis, and despite the risks attached to basic research we argue that in-house basic research activities may enhance the likelihood of being a market leader and confer the firm with first-mover advantages.

3. Data and Model

3.1. Data sources

The data used in this paper are drawn from a yearly survey called *The Technological Innovation Panel* (PITEC)[2]. The survey is conducted by the Spanish National Institute of Statistics and contains questions characterizing the innovative activities of Spanish firms since 2003 in all sectors of the economy. In this study, we use information from the PITEC survey for the period 2006 to 2010[3]. The survey provides detailed information on firms' innovation strategies, which allows us to distinguish between: (i) firms that do not imitate/innovate (i.e. firms that do not introduce any new or improved product or services); (ii) imitators (i.e. firms that report having exclusively introduced a product/services new to the firm but known to the market); and (iii)

[2] Details on the survey can be found at http://icono.fecyt.es/pitec/Paginas/por_que.aspx.

[3] We use the anonymized data set (López, 2011). Due to the enlargement of the survey suffered in 2003 and 2004, we start the analysis in 2006, although we may use data for 2003-2005 as some variables are defined as lags.

pioneers (i.e. firms having introduced new products/services to the market). The dataset has been organised in such a way that the three strategies are exclusive to each other[4].

The survey also gathers information on the three types of intramural R&D: basic research, applied research, and experimental development. This information allows us to know whether the firm invested in basic research, and whether she did it in a continuous basis. Additionally, the database contains other information about the firm such as capital investment, number of employees, ownership or sector of activity. Following Cuneo and Mairesse (1984), among others, the number of R&D employees by the firm is used as a proxy for the R&D stock. As suggested by Schankerman (1981) the number of employees is corrected for double counting by subtracting R&D employment from total employment. All variables in monetary units are measured in prices of the year 2005. We use the industrial price index deflator for price adjustment.

The analysis is conducted for firms in the manufacturing sector. We exclude from the sample public firms and research associations as well as merged or acquired firms; and to control for possible outliers firms with turnover above or below the 1% and 99% tails of the distribution are also excluded. We also eliminate data with missing values in variables of interest. Our final sample is an unbalanced panel of 5738 firms, which are at least observed for three consecutive periods.

[Insert Figure 1 around here]

Figure 1 depicts innovation strategies by technological sector. Overall 38% of firms refrain from innovating[5], while 27% and 35% imitate and are pioneers respectively. In the low-tech sector the proportion of firms not innovating increases significantly up to 46%. In the case of high tech sectors, 43% of firms lead innovation, 30% imitate and 27% abstain from innovation/imitation.

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[4] Other studies that have used this variable are Vinding (2006), Vega-Jurado et al. (2008) and Slivko (2012).

[5] This does not mean that these firms abstain from other types of innovation, such as process or organizational innovation, which are not considered in the present study.

Table 1 shows the importance of basic research activities by innovation strategy. The first evidence to notice is that the percentage of firms doing basic research is very low. Just about 6% of firms in the Spanish manufacturing industry invest in basic research. However, there are interesting differences across the three types of strategies, with the percentage of firms involved in basic research increasing as we move from not doing innovation (2%) to imitate (6%) and to be pioneer (10%). These percentages increase for the three strategies in the high tech sector. Differences are also observed for the number of years continuously doing basic research, which increases as we move from abstention to being pioneer. However, there are no major differences in terms of the percentage of total R&D invested in basic research across the three strategies.

[Insert Table 1 around here]

3.2. Model specification

The aim of the study is to gauge the importance of basic research in determining the firm's choice on the innovation strategy. To do so, the model takes into account that the innovation choices firm faces are threefold: abstention from innovation, imitation and pioneering innovation. Due to the categorical nature of the dependent variable, a discrete choice model offers the best approach to assessing the determinants, including basic research, of the observed innovation choices, at firm level.

Previous studies have used different model specifications to analyse the determinants that govern the choice of innovation strategies. On the one hand, Vinding (2006) suggests the existence of a natural ordering of the dependent variable according to the degree of innovativeness and used an econometric specification based on an *ordered logit model (OLM)*. On the other hand, Vega-Jurado et al. (2008) propose a *multinomial logit model* (MNLM), in which categories are assumed unordered. Finally Slivko (2012) uses a *stereotype logistic regression model (SLM)* developed by Anderson (1984), which imposes ordering constraints on the multinomial model and can be regarded as a compromise between the OLM and the MNLM. Unlike the OLM, the SLM does not impose the proportional-odds assumption, and it can be more parsimonious than the MNLM (Agresti, 2010). In our model, the proportional-odds assumption is not fulfilled; therefore the OLM is not applied in the present analysis. We will present, therefore, results both from the MNLM and from the SLM.

In the multinomial logistic model (MNLM), *K–1* parameter vectors β_k, $k = 1, ..., K-1$, are estimated. The SLM imposes restrictions on the MNLM by estimating d parameter vectors, where $1 < d < min(K\text{-}1, p)$, and p is the number of covariates. The relationship between the coefficients of the SLM, β_j, and the MNLM coefficients is: $\beta_k = -\sum_{j=1}^{d} \phi_{jk}\beta_j$; where the ϕs are scale parameters to be estimated along with the $\beta_j s$. Thus, assuming that there are K outcomes, x is a vector of covariates and θ_d are unrestricted constant terms for each equation, the SLM in its complete form is represented by[6],

$$\Pr(y = k \setminus x) = \frac{\exp(\theta_k + \sum_{j=1}^{d} \phi_{jk} x \beta_j)}{\sum_{l=1}^{m-1} \exp(\theta_l + \sum_{j=1}^{d} \phi_{jl} x \beta_j)} \qquad (1)$$

where $\phi_{jj} = 1$ and $\phi_{jk} = 0$ for $j \neq k$ are imposed to identify the model.

The above equation will indicate the implied probability that observed alternative innovation strategy k is observed, where the choice set K = 0, 1, 2 represents when the firm chooses not to innovate, to imitate, or to be pioneer respectively.

Our interest lies in explaining the role of basic research in determining the choice of firm's innovation strategy. To this end, we assume that the vector x in equation (1) contains proxies for internal knowledge, including in-house basic research, as well as a set of other control variables, which have been previously shown to affect innovation choices at firm level. As proxies for internal knowledge we use the number of employees in R&D (*lprd*), a dummy for firms conducting basic research (*dbasic*), the firm's experience conducting basic research (*cont_br*), and a proxy for human capital (hc), measured by the share of qualified personnel (Freel and Robson, 2004). Among the rest of variables assumed to influence the innovation choices we

[6] The original version of the SLM by Anderson (1984) reports a minus sign in front of ϕs, which makes the interpretation confusing. Therefore, the model here is written with a plus sign in front of ϕs. The sign of the estimated βs are reversed correspondingly (see Slivko, 2012).

use firm size (*lsize*). The literature suggests that large established firms engage more in improving existing products (i.e. imitate), while new and small firms invest more I original innovations (Acs and Audretsch, 1988; Akcigit and Kerr, 2010). Furthermore, the firm's investment in tangibles is added to the model (lk). We control also for group membership (*group*), in order to allow for the possibility of intra-firm spillovers, for whether the firm is foreign-owned (*foreign*) and the market size to which firms have access (geo). We also allow for whether the firm has contracted R&D externally (*drd_ext*), has received any government funding for its innovation activity (*gvt_funding*), and for whether the firm has cooperated in the innovation process (*coopera*). Finally, sector dummies are also included to capture different technological opportunities and other unobserved factors varying across industries; and a set of time dummies capturing business cycle effects. To deal with the potential endogeneity of some of the internal factors determining innovation choices, R&D, basic research, size and tangible assets enter with one lag in the model specification. A detailed description of the variables is provided in Table 2.

[Insert Table 2 around here]

Table 3 presents the descriptive statistics of the empirical variables used to estimate the choice of innovation strategy. Statistics are presented for the total sample and for low and high-tech sectors. Some interesting features may be pointed out. Pioneer firms invest more in R&D than imitators and non-innovators. As previously seen, there is also a larger percentage of pioneer firms conducting basic research, and they also have greater experience in conducting these activities, in both low and high-tech sectors. Pioneering firms also seem to be larger and invest more in both physical and human capital assets.

[Insert Table 3 around here]

4. Empirical Results

We start this section with the multinomial logit model (MLNM) analysis for the choice of innovation strategy. Table 4a presents the coefficients and Table 4b the average marginal effects (AME) for the total sample, and distinguishing between high-tech and low-tech sectors, respectively. The dependent variable has three different outcomes: abstaining from innovation, being and imitator and being a pioneer. The coefficients in Table 4a are a comparison of the imitator and pioneer category with the base category (i.e. abstaining from innovation). They show us that doing basic research increases the likelihood of being an imitator and a pioneer vis-à-vis refraining from innovation. This result holds both for the total sample and low-tech sectors; while for high-tech sectors doing basic research only increases the probability of being a pioneer.

Since our interest lies in explaining the determinants of firm's choices in innovation strategies, we will mostly base the discussion of the results on the estimated average marginal effects, as they are a more direct interpretation of the effects of explanatory variables on the probability of choosing a particular innovation strategy. The average marginal effects in table 4b show that basic research has a positive effect on the possibility of becoming market leader and in discriminating between different strategies; with firms conducting basic research being more likely to be pioneers in the total sample and in low-tech sectors. Interestingly, in high-tech sectors, basic research constitute a key element in helping firms to become pioneer, and it makes it less likely that a firm will be imitator only. Additionally, experience in basic research is also important in determining the propensity to become pioneer; in both low and high-tech sectors, and in the case of high-tech it makes it less likely that a firm will be imitator only.

Holding everything else constant, the probability of innovating, either by imitation or by introducing market novelties, is higher when firms invest in R&D. Additionally, human capital, cooperation and government funding seem to have similar results to those obtained for basic research, in that they boost the likelihood of being a market pioneer. However, imitation strategies are discouraged by cooperation in R&D in low-tech sectors, by human capital in high-tech sectors, and by government funding in both technological sectors. In contrast, size has no effect in distinguishing between different innovation strategy choices; this is not entirely surprising as it probably affects the extent of innovation rather than its likelihood. Foreignness and investment in physical capital encourage firms to introduce market innovations do not either help in high-tech sectors. Geographical market size has the expected sign, with larger markets favouring novel innovation strategies.

Table 5a and 5b provide estimates of the coefficients and AME of the stereotype logistic regression (SLM). For purposes of identification, category j = 0 ("non-innovator") is treated as the baseline category and therefore the corner constrains are $\phi_1 = 1$ and $\phi_0 = 0$. The estimated ϕ parameters indicate the distance between the different innovation choices, and one can appreciate that are monotonically increasing with respect to j, satisfying the condition $\phi_2 > \phi_1 = 1 > \phi_0 = 0$. This supports the appropriateness for the ordered dependent variable. For the three samples we observe that the effect of the independent variables on firm' innovation strategy choice varies among adjacent categories, suggesting that these variables have stronger impact on the odds of a firm's choice between imitation and non-innovation ($\hat{\phi}_1 - \hat{\phi}_0 = 1$) than on the odds of the choice between being pioneer and imitator ($\hat{\phi}_2 - \hat{\phi}_1$). Additionally, the hypothesis that all ϕ parameters are equal is rejected, suggesting that the categories of the dependent variable are distinguishable.

Regarding the determinants of firm's choices in innovation strategies, we will mostly base the discussion of the results on the estimated average marginal effects, as in the case of the MNLM. The estimates of the SLM compare closely to the estimates of the MNLM discussed previously. In particular, doing basic research enhances the probability of being an innovation leader in both high and low-tech sectors, and reduces the chance of not innovating. However, it has no significant effect on the probability of imitating. Regarding the effect of experience in basic research, results show that experience boost the probability of being pioneer in low-tech sectors, but is has no significant effect on high-tech sectors. In high-tech sectors what matters is doing basic research independently of the accumulated experience in these activities. Total in-house R&D is also an important determinant of the innovation choice, increasing the likelihood of being pioneer in both low and high tech, and in high-tech sectors also decreases the chances of being an imitator.

In addition to internal R&D activities, results show that cooperation in innovation activities, human capital, contracting R&D externally, government funding and market size influence the innovation strategy choice. The impact of these variables has the same significance and direction, i.e. enhancing the probability of the pioneer strategy choice and reducing the likelihood of not innovating. However, except for the total sample, they show no significant effect on the probability of imitation. Finally, belonging to a group has different effect on the innovation strategy choice in high and low-tech sectors. While in low-tech sectors, belonging to a group enhances the probability of being pioneer, the chance of being pioneer decreases in high tech sectors (similar result is obtained in the MNLM).

Major differences between the stereotype and the multinomial logit model are found in the determinants of the probability of imitation. Except for in-house total R&D, the rest of variables appear not to have a statistical significance in determining the probability of being innovator in the SLM. This is not the case in the MNLM. Regarding our variables of interest, we find that doing basic research and experience in basic research have no significant effect in the probability of choosing an imitation strategy in low-tech in both estimation models; but has a significant negative effect in high-tech sectors only in the multinomial model but insignificant in the stereotype logistic model.

5. Conclusion

This paper examined the effects of doing internal basic research and the experience gained in basic research activities on the firm's innovation strategy choice. For a sample of Spanish manufacturing firms we find that firms conducting basic research are more likely to introduce market novelties ahead of competitors in low and high-tech sectors. In contrast, basic research has no effect on the propensity to imitate, and in the case of high-tech sectors results from a multinomial model show that the impact may be significantly negative. In addition, accumulated experience in basic research may be a key driver of first-movers in low-tech sectors. With respect to other determinants of firm's innovation choices we find that cooperation in innovation, access to government funding and human capital affect the likelihood of being a market pioneer.

These results may have important policy and management implications. From the policy point of view, we argue that it is important to consider the heterogeneous nature of R&D activities when providing innovation incentives. Incentives to invest in corporate basic research may have the potential to enable significant commercial opportunities through facilitating entirely new product areas rather than just incremental change. From the managerial point of view, our result suggest that performing basic research activities are important drivers for a market leader strategy, which may award the firm with first-mover advantages. However, although the term "first mover advantage" suggests that early entry is desirable, market pioneering is a high-risk strategy. In some instances an imitation strategy may be more appropriate. Future research will be addressed to evaluate whether basic research may help firms to materialize the first-mover advantages.

References

Anderson, J.A. (1984). Regression and Ordered Categorical Variables. *Journal of the Royal Statistical Society Series B*, 46(1): 1-30.

Arrow, K. (1962). The Economic Implications of Learning-by-Doing. *Review of Economic Studies*, 29(3): 155-173.

Cassiman, B., Perez-Castrillo, D., and Veugelers, R. (2002). Endogenizing Know-How Flows through the Nature of R&D Investments. *International Journal of Industrial Organization,* 20(6): 775–799.

Cockburn, I., and Henderson, R. (1998). Absorptive Capacity, Coauthoring Behavior, and the Organization of Research in Drug Discovery. *Journal of Industrial Economics*,46(2): 157–182.

Cohen W. and Levinthal D. (1990). Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly, 35: 128-152.

Czarnitzki, D., and Thorwarth, S. (2012), Productivity Effects of Basic Research in Low-Tech and High-Tech Industries, *Research Policy, 41*: 1555-1564.

Fabrizio K.R. (2009). Absorptive capacity and the search for innovation. *Research Policy*, 38(2): 255-267.

Gambardella, A. (1992). Competitive advantage from in-house scientific research: the US pharmaceutical industry in the 1980s. *Research Policy*, 21: 391–407.

Griliches, Z. (1986). Productivity, R&D, and Basic Research at the Firm Level in the 1970s. *American Economic Review*, 76(1): 141–154.

Henard, D.H. and M. Ann McFadyen (2005), The Complementary Roles of Applied and Basic Research: A Knowledge-based Perspective, *Journal of Product Innovation Management*, 22(6): 503-14.

Kelchtermans, S., B. Leten, and R. Belderbos (2013). “Do firms benefit from investing in basic scientific research? An empirical investigation for pharmaceutical firms." In F. de Beule and Nauwelaerts (eds.) *Innovation and Creativity: Pillars of the Future Global Economy*, Edward Elgar Publishing, 155-172.

Lieberman, M. B. and D. B. Montgomery (1988). First-Mover Advantages, *Strategic Management Journal* 9(S1): 41-58.

Lim K. (2004). The relationship between research and innovation in the semiconductor and pharmaceutical industries (1981-1997). *Research Policy*, 33: 287-321.

Mansfield, E. (1980). Basic Research and Productivity Increase in Manufacturing. *American Economic Review*, 70(5): 863–873.

OECD (1992): Oslo Manual: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data. Paris

Pavitt, K. (1991), What makes basic research economically useful?, *Research Policy* 20: 109-119.

Rosenberg, N. (1990). Why do firms do basic research (with their own money)? *Research Policy,* 19:165–174.

Slivko, O. (2012). "Innovation strategies of German firms: The effect of competition and intellectual property protection," ZEW Discussion Papers 12-089, ZEW.

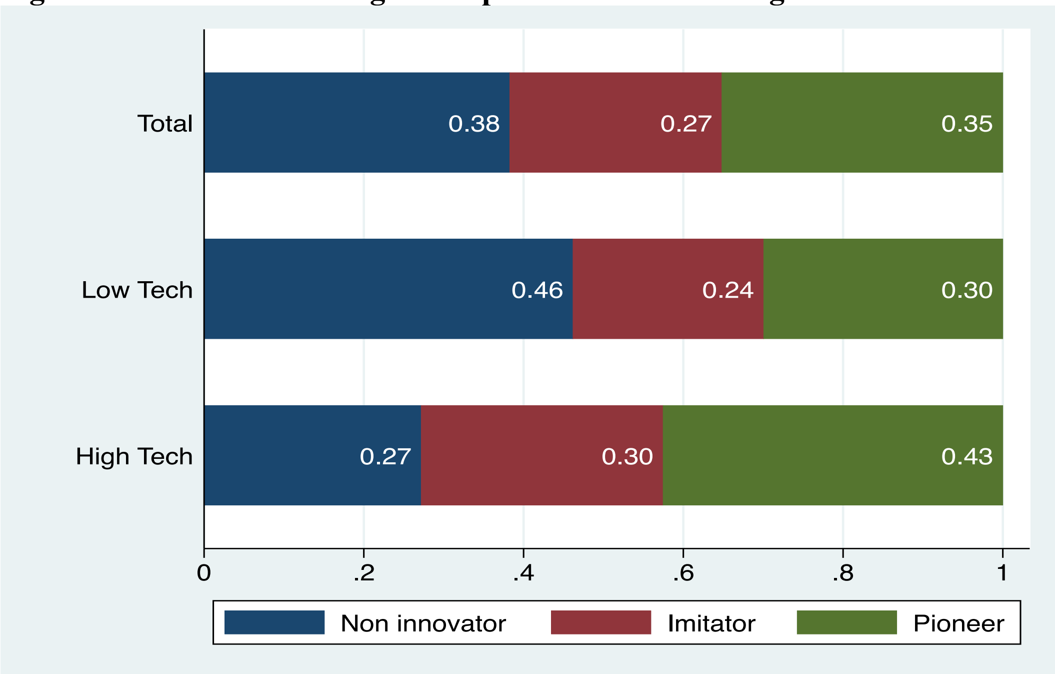
Stern S. (2004). Do Scientists Pay to Be Scientists?, *Management Science*, 50(6): 835-853.

Vega-Jurado, J., Gutierrez-Gracia, A., Fernández-de-Lucio, I., and Manjarrés-Henríquez, L. (2008). The effect of external and internal factors on firms' product innovation. *Research Policy*, 37: 616-632.

Vinding, A.L. (2006). Absorptive capacity and innovative performance: A human capital approach, Economics of Innovation and New Technology, 15(4): 507 – 517.

Wright, T. P. (1936). Factors Affecting the Cost of Airplanes, *Journal of the Aeronautical Sciences,* 3: 122-128.

Figure 1: Innovation strategies in Spanish manufacturing firms



Source: PITEC

Table 1: The importance of basic research on firms' innovation strategy

	Total Sample			Low Tech			High Tech		
Innovation strategy	Firms doing BR	BR/R&D	BR experience	Firms doing BR	BR/R&D	BR experience	Firms doing BR	BR/R&D	BR experience
No innovation/imitation	0.023	0.020	0.046	0.015	0.016	0.026	0.041	0.026	0.092
Imitator	0.060	0.020	0.125	0.053	0.020	0.105	0.069	0.020	0.146
Pioneer	0.096	0.026	0.226	0.084	0.026	0.197	0.108	0.026	0.255
Total	0.058	0.023	0.130	0.045	0.022	0.096	0.078	0.024	0.178

Note: BR stands for basic research
Source: PITEC

Table 2: Description of Variables

Variable	Description
Innovation Strategy	Categorical variable that takes the values: 0: The firm did not introduce any new or improved product or service. 1: The firm only introduced products or services that were new to the firm 2: The firm introduced new products/services ahead of competitors.
lag_prd	Knowledge stock measured as R&D employment in logs (lagged one period).
lag_dbasic	Dummy that takes value 1 if the firm conducts basic research in t-1, 0 otherwise
contBR	Number of years continuously doing basic research
lag_lk	Capital investment in logs (lagged one period)
lag_lsize	Number of employees in logs in t-1
foreign	Dummy that takes value 1 if the firm is foreign-owned, 0 otherwise
coopera	Dummy that takes value 1 if the firm reports having engaged in cooperation in innovation activities, 0 otherwise.
group	Dummy that takes value 1 if the firm belongs to a group of firms, 0 otherwise
hc	Firm's human capital measured as the percentage of employees with a degree over total employment
drd_ext	Dummy that takes value 1 if the firm has contracted R&D externally, 0 otherwise
gvt_funding	Dummy that takes value 1 if the firm has received government funding for its R&D activities, 0 otherwise
geo	Geographical size of the market in which the firm competes. Takes the following values: 1=local or regional market; 2=national market; 3=EU market, EFTA countries and EU candidates; 4=worldwide market

Table 3: Descriptive statistics

	Total Sample			Low Tech			High tech		
	Non Innovator	Imitator	Pioneer	Non Innovator	Imitator	Pioneer	Non Innovator	Imitator	Pioneer
lag_lprd	1.336 (0.952)	1.616 (1.017)	1.875 (1.094)	1.249 (0.912)	1.459 (0.942)	1.674 (1.062)	1.477 (0.997)	1.756 (1.060)	2.053 (1.090)
lag_dbasic	0.0292 (0.168)	0.076 (0.264)	0.110 (0.313)	0.0217 (0.146)	0.069 (0.253)	0.096 (0.295)	0.047 (0.212)	0.083 (0.276)	0.124 (0.330)
contBR	0.0458 (0.386)	0.125 (0.621)	0.226 (0.870)	0.0265 (0.271)	0.105 (0.549)	0.197 (0.813)	0.092 (0.571)	0.146 (0.690)	0.255 (0.921)
lag_lk	14.07 (2.177)	14.50 (2.061)	14.60 (2.070)	14.18 (2.165)	14.80 (2.014)	14.91 (2.024)	13.82 (2.183)	14.17 (2.062)	14.30 (2.068)
lag_lsize	3.787 (1.358)	4.004 (1.307)	4.062 (1.455)	3.850 (1.348)	4.114 (1.274)	4.213 (1.403)	3.636 (1.371)	3.881 (1.331)	3.912 (1.490)
foreign	0.105 (0.306)	0.124 (0.329)	0.143 (0.350)	0.082 (0.274)	0.090 (0.286)	0.125 (0.330)	0.159 (0.365)	0.161 (0.368)	0.162 (0.368)
coopera	0.215 (0.411)	0.298 (0.457)	0.409 (0.492)	0.214 (0.410)	0.277 (0.448)	0.399 (0.490)	0.217 (0.412)	0.321 (0.467)	0.420 (0.494)
group	0.322 (0.467)	0.390 (0.488)	0.429 (0.495)	0.302 (0.459)	0.361 (0.480)	0.429 (0.495)	0.371 (0.483)	0.422 (0.494)	0.429 (0.495)
hc	0.138 (0.171)	0.171 (0.170)	0.206 (0.201)	0.115 (0.151)	0.135 (0.141)	0.155 (0.168)	0.194 (0.201)	0.211 (0.189)	0.257 (0.217)
drd_ext	0.143 (0.350)	0.304 (0.460)	0.396 (0.489)	0.126 (0.332)	0.272 (0.445)	0.362 (0.481)	0.184 (0.387)	0.339 (0.474)	0.429 (0.495)
gvt_funding	0.176 (0.380)	0.355 (0.479)	0.468 (0.499)	0.166 (0.372)	0.333 (0.471)	0.443 (0.497)	0.198 (0.398)	0.380 (0.485)	0.492 (0.500)
geo	2.088 (1.005)	2.469 (0.832)	2.540 (0.789)	2.032 (1.022)	2.377 (0.873)	2.454 (0.842)	2.222 (0.951)	2.570 (0.772)	2.626 (0.722)

Note: Mean values and standard deviation in parenthesis.
Source: PITEC

Table 4a. Multinomial Logit: total sample, high & low-tech (coefficients)

	All sample		Low Tech		High Tech	
	b	se	b	se	b	se
Imitator						
lag_prd	0.031***	(0.005)	0.039***	(0.008)	0.027***	(0.007)
lag_dbasic	0.288***	(0.090)	0.404***	(0.123)	0.138	(0.132)
contBR	-0.014	(0.046)	0.142*	(0.076)	-0.110*	(0.057)
lag_lk	0.022*	(0.013)	0.041**	(0.016)	-0.009	(0.021)
lag_lsize	0.016	(0.021)	0.027	(0.027)	-0.008	(0.035)
foreign	-0.177***	(0.064)	-0.208**	(0.091)	-0.169*	(0.093)
coopera	0.291***	(0.046)	0.202***	(0.058)	0.426***	(0.077)
grupo	-0.034	(0.048)	-0.060	(0.060)	-0.049	(0.078)
hkap	-0.085	(0.127)	0.190	(0.178)	-0.345*	(0.185)
drd_ext	0.077*	(0.046)	0.056	(0.060)	0.096	(0.074)
gvt_funding	0.073	(0.044)	0.061	(0.057)	0.081	(0.071)
geo	0.126***	(0.023)	0.087***	(0.028)	0.198***	(0.038)
constant	-1.172***	(0.172)	-1.386***	(0.214)	-0.135	(0.271)
Innovator						
lag_prd	0.037***	(0.005)	0.048***	(0.008)	0.031***	(0.007)
lag_dbasic	0.480***	(0.086)	0.489***	(0.120)	0.410***	(0.124)
contBR	0.088**	(0.044)	0.238***	(0.077)	-0.003	(0.050)
lag_lk	0.018	(0.012)	0.015	(0.016)	0.015	(0.020)
lag_lsize	0.007	(0.021)	0.018	(0.026)	-0.019	(0.034)
foreign	-0.006	(0.061)	0.152*	(0.083)	-0.106	(0.090)
coopera	0.562***	(0.044)	0.543***	(0.055)	0.630***	(0.073)
grupo	-0.017	(0.046)	0.103*	(0.058)	-0.208***	(0.076)
hkap	0.646***	(0.120)	0.584***	(0.170)	0.610***	(0.176)
drd_ext	0.214***	(0.044)	0.201***	(0.058)	0.231***	(0.071)
gvt_funding	0.289***	(0.043)	0.289***	(0.055)	0.279***	(0.069)
geo	0.162***	(0.022)	0.111***	(0.028)	0.247***	(0.037)
constant	-1.413***	(0.169)	-1.398***	(0.208)	-0.824***	(0.268)
N	21603		11941		9662	
chi2	1877.8***		870.7***		710.3***	
LL	-22073.37		-12463.75		-9544.564	

Note 1: Reference group: Abstain from innovation.
Note 2: All the estimations include time and industry dummies.
Note 3: Significance level: ***p<0.01, **p<0.05, *p<0.1. Robust standard errors in parenthesis

Table 4.b *Average Marginal effects from Multinomial*

	Full Sample			Low Tech			High Tech		
	Non-innovator	Imitator	Pioneer	Non-innovator	Imitator	Pioneer	Non-innovator	Imitator	Pioneer
	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)
lag_prd	-0.006***	0.002***	0.004***	-0.009***	0.003***	0.006***	-0.004***	0.001**	0.003***
	(0.001)	(0.000)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
lag_dbasic*	-0.070***	-0.001	0.071***	-0.092***	0.030	0.062***	-0.042**	-0.033*	0.075***
	(0.014)	(0.014)	(0.014)	(0.023)	(0.020)	(0.020)	(0.017)	(0.020)	(0.020)
contBR	-0.007	-0.014**	0.022***	-0.040***	0.003	0.036***	0.007	-0.024***	0.016**
	(0.008)	(0.006)	(0.006)	(0.015)	(0.010)	(0.010)	(0.007)	(0.008)	(0.008)
lag_lk	-0.004*	0.002	0.001	-0.006**	0.007**	-0.001	-0.001	-0.004	0.005
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
lag_lsize	-0.002	0.003	-0.001	-0.005	0.004	0.001	0.002	0.001	-0.003
	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
Foreign*	0.015	-0.037***	0.022**	0.004	-0.060***	0.056***	0.019	-0.021	0.001
	(0.010)	(0.011)	(0.011)	(0.016)	(0.016)	(0.015)	(0.012)	(0.015)	(0.015)
Coopera*	-0.078***	-0.011	0.089***	-0.078***	-0.018*	0.096***	-0.078***	-0.004	0.082***
	(0.007)	(0.007)	(0.007)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)	(0.012)
Group*	0.004	-0.005	0.001	-0.005	-0.024**	0.029***	0.020*	0.021*	-0.041***
	(0.007)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)	(0.010)	(0.012)	(0.013)
Hc	-0.055***	-0.102***	0.157***	-0.082***	-0.025	0.106***	-0.027	-0.169***	0.196***
	(0.020)	(0.021)	(0.021)	(0.031)	(0.031)	(0.031)	(0.024)	(0.028)	(0.029)
drd_ext*	-0.027***	-0.012	0.038***	-0.027**	-0.011	0.038***	-0.025**	-0.015	0.039***
	(0.007)	(0.008)	(0.008)	(0.011)	(0.010)	(0.010)	(0.010)	(0.011)	(0.012)
gvt_funding*	-0.034***	-0.022***	0.056***	-0.037***	-0.019*	0.056***	-0.028***	-0.025**	0.053***
	(0.007)	(0.007)	(0.007)	(0.010)	(0.010)	(0.010)	(0.009)	(0.011)	(0.011)
geo	-0.026***	0.006	0.020***	-0.020***	0.006	0.015***	-0.033***	0.005	0.027***
	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)
N	21603	21603	21603	11941	11941	11941	9662	9662	9662
Predicted	26.4%	31.5%	42.1%	32.4%	30.0%	37.6%	19.1%	33.3%	47.6%
Prob	(0.126)	(0.054)	(0.131)	(0.118)	(0.514)	(0.128)	(0.099)	(0.061)	(0.122)

Note 1: (*) dy/dx is for discrete change of dummy variable from 0 to 1.
Note 2: All the estimations include time and industry dummies.
Note 3: Significance level: ***p<0.01, **p<0.05, *p<0.1. Robust standard errors in parenthesis

Table 5a. Stereotype Logit (SLM). Coefficients

	All sample		Low Tech		High Tech	
	b	se	b	se	b	se
lag_prd	-0.021***	(0.004)	-0.024***	(0.006)	-0.015***	(0.004)
lag_dbasic	-0.333***	(0.060)	-0.293***	(0.073)	-0.289***	(0.083)
contBR	-0.083***	(0.032)	-0.133***	(0.046)	-0.028	(0.037)
lag_lk	-0.014*	(0.008)	-0.011	(0.010)	-0.012	(0.013)
lag_lsize	-0.008	(0.014)	-0.013	(0.016)	0.008	(0.022)
foreign	0.015	(0.042)	-0.086*	(0.052)	0.057	(0.058)
coopera	-0.389***	(0.031)	-0.331***	(0.038)	-0.403***	(0.056)
group	0.010	(0.031)	-0.059*	(0.035)	0.135***	(0.048)
hc	-0.448***	(0.084)	-0.350***	(0.104)	-0.503***	(0.117)
drd_ext	-0.151***	(0.030)	-0.127***	(0.035)	-0.155***	(0.046)
gvt_funding	-0.202***	(0.029)	-0.180***	(0.033)	-0.197***	(0.044)
geo	-0.113***	(0.015)	-0.071***	(0.017)	-0.158***	(0.027)
($\phi_0 = 0, \phi_1 = 1$) ϕ_2	1.469***	(0.054)	1.670***	(0.131)	1.569***	(0.109)
($\theta_0 = 0$) θ_1	-1.065***	(0.121)	-0.974***	(0.151)	-0.532***	(0.171)
θ_2	-1.475***	(0.168)	-1.463***	(0.210)	-0.914***	(0.269)
N	21603		11941		9662	
chi2	752.28***		273.29***		237.80***	
LL	-22199.33		-12536.59		-9611.27	

Table 5b: AMEs for SLGIT

	All			Low-tech			High-tech		
	Non-innovator	Imitator	Pioneer	Non-innovator	Imitator	Pioneer	Non-innovator	Imitator	Pioneer
	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)	dy/dx (s.e.)
lag_prd	-0.005***	0.000**	0.004***	-0.007***	0.001	0.006***	-0.003***	-0.000**	0.003***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
lag_dbasic	-0.075***	0.007***	0.068***	-0.081***	0.007	0.075***	-0.055***	-0.007	0.062***
	(0.013)	(0.003)	(0.012)	(0.019)	(0.005)	(0.018)	(0.016)	(0.005)	(0.018)
contBR	-0.018***	0.002*	0.017***	-0.037***	0.003	0.034***	-0.005	-0.001	0.006
	(0.007)	(0.001)	(0.006)	(0.012)	(0.003)	(0.010)	(0.007)	(0.001)	(0.008)
lag_lk	-0.003*	0.000	0.003*	-0.003	0.0003	0.003	-0.002	-0.000	0.003
	(0.002)	(0.000)	(0.002)	(0.003)	(0.000)	(0.002)	(0.002)	(0.000)	(0.003)
lag_lsize	-0.002	0.000	0.002	-0.004	0.0003	0.003	0.001	0.000	-0.002
	(0.003)	(0.000)	(0.003)	(0.004)	(0.000)	(0.004)	(0.004)	(0.001)	(0.005)
foreign	0.003	-0.000	-0.003	-0.024	0.002	0.022	0.011	0.001	-0.012
	(0.009)	(0.001)	(0.009)	(0.015)	(0.002)	(0.014)	(0.011)	(0.001)	(0.012)
coopera	-0.087***	0.008***	0.079***	-0.092***	0.008	0.084***	-0.077***	-0.010	0.086***
	(0.007)	(0.003)	(0.007)	(0.009)	(0.005)	(0.010)	(0.009)	(0.006)	(0.010)
grupo	0.002	-0.000	-0.002	-0.016*	0.001	0.015*	0.026***	0.003	-0.029***
	(0.007)	(0.001)	(0.006)	(0.010)	(0.001)	(0.009)	(0.009)	(0.002)	(0.010)
hkap	-0.100***	0.009***	0.091***	-0.097***	0.008	0.089***	-0.096***	-0.012	0.108***
	(0.019)	(0.003)	(0.018)	(0.029)	(0.006)	(0.027)	(0.024)	(0.009)	(0.030)
drd_ext	-0.034***	0.003***	0.031***	-0.035***	0.003	0.032***	-0.030***	-0.004	0.033***
	(0.007)	(0.001)	(0.006)	(0.010)	(0.002)	(0.009)	(0.009)	(0.003)	(0.010)
gvt_funding	-0.045***	0.004***	0.041***	-0.050***	0.004	0.046***	-0.038***	-0.005	0.042***
	(0.007)	(0.001)	(0.006)	(0.009)	(0.003)	(0.009)	(0.008)	(0.003)	(0.010)
geo	-0.025***	0.002***	0.023***	-0.020***	0.002	0.018***	-0.030***	-0.004	0.034***
	(0.003)	(0.001)	(0.003)	(0.005)	(0.001)	(0.004)	(0.005)	(0.002)	(0.005)
N	21603	21603	21603	11941	11941	11941	9662	9662	9662
Predicted	0.264	0.315	0.421	0.324	0.300	0.376	0.191	0.333	0.476
Prob.	(0.125)	(0.028)	(0.126)	(0.117)	(0.027)	(0.123)	(0.096)	(0.032)	(0.116)

Note 1: (*) dy/dx is for discrete change of dummy variable from 0 to 1.
Note 2: All the estimations include industry dummies.
Note 3: Significance level: ***p<0.01, **p<0.05, *p<0.1.