Title: *Lowering barriers to engage in innovation*: evidence from the Spanish innovation survey

Primary sub-theme: S6: Enterprises and industrial development in a knowledge-based city or region: Small and medium-sized enterprises (SMEs) development

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1 Barriers to innovation: background discussion

Innovation has long been recognised as a vital contributor to firm economic performance and survival. Both the scientific literature and the policy agenda have consistently highlighted the importance of investment in innovative activities to reach further economic competitiveness and secure economic growth and higher living standards. Firms have extensively internalised this argument, with corporate strategies increasingly geared around innovation.

However, despite the ample support to the discourse in favour of innovation, many firms remain persistently detached from any deliberate effort towards innovation activities, and even further removed from any significant innovation achievement. For instance, drawing upon the Spanish Innovation Survey 2007, for the whole sample of *potentially innovative* firms, 30% did not conduct any innovation related activity in 2007. This phenomenon was not exclusive of firms in low-tech industries; among firms in high and medium technology manufacturing industries, about 16% of the potentially innovative firms did not invest any money in innovation-related activities. For knowledge intensive business services (KIBS), the corresponding percentage was 20%.

This is striking since our definition of innovation-related activities is quite broad, encompassing expenditures in tasks that range from "activities for the market preparation and introduction of new (or significantly improved) goods and services", "acquisition of machinery or equipment to produce new (or significantly improved) goods or services" and "internal or external training of personnel involved in development or introduction of innovations".

If a substantial portion of the potentially innovative firms do not invest in innovation-related activities, it is plausible to claim that the innovation system is suffering from systemic failures to innovation. Following Chaminade and Edquist (2006) and Chaminade et al. (2008), systemic failures to innovation include: a) the lack of private institutional support for innovation, as for instance the restricted availability of finance for activities that entail high levels of risk and uncertainty; b) the lack of information on technological and market opportunities for innovation, as a consequence, for instance, of a weak connectivity between organizations in the innovation system; c) the lack of an adequate scientific and research infrastructure, as for instance, the weakness in the supply of an adequate skill-base from secondary and tertiary education; and d) the characteristics associated with the market structure and the potential entry barriers from incumbents; among other factors.

This papers aims at improving our understanding of the factors attenuating obstacles to innovation by distinguishing between firms that face *deterring* barriers to innovation and firms that confront *revealed* barriers to innovation (D'Este et al., 2008). As discussed throughout the paper, making this distinction is crucial to help disentangling two essentially different mechanisms when referring to 'obstacles to innovation'. In the two sections below, we make a case for the distinction between barriers that are likely to impede firms from engaging in innovative activities versus barriers that are revealed throughout the innovation process; as well as, discussing the factors that attenuate these innovation barriers.

2 Deterring versus revealed barriers to innovation

In this section we argue that it is important to distinguish two mechanisms through which barriers to innovation operate. On the one hand, barriers operate by deterring firms from engaging in innovation activities. This happens when firms that would be willing to undertake innovative projects, choose not to become active in innovation-related activities. This decision is likely to be the result of the firm lacking access to finance for high-risk projects, lacking adequate channels to obtain information about markets or technologies, facing obstacles for the recruitment of high-skilled employees, or having difficulties in meeting adequate partners for innovation activities, among other reasons. In short, deterring barriers refer to obstacles that prevent or block firms from undertaking innovative activities. Baldwin and Lin (2002), for instance, examine this type of barriers when investigating the importance of impediments faced by firms with regards to the adoption of advanced technologies.

On the other hand, barriers operate by obstructing the activities of firms that do engage in innovation projects. These barriers may simply delay or slow down innovation projects, or they may represent a major determinant of the decision to abandon an innovation project. Nevertheless, in these cases barriers do not prevent firms from initiating an innovation-activity, but may impose a substantial obstacle to its completion. For this reason we categorize these barriers as "revealed" barriers, since these barriers are only observed once firms engage in innovation activities. In other words, revealed barriers refer to obstacles to innovation that are realised by firms alongside their innovation-related activities. This is the type of barriers addressed in the literature when looking at financing and the costs involved in bringing an innovation to market (e.g. Baldwin and Hanel, 2003).

It is also important to make a distinction between these two types of barriers from the point of view of innovation policy. If policy makers aim at addressing systemic failures in the innovation system, it is crucial to identify the extent of the problem (that is, the proportion of potential innovators that are detached from innovation activities) as well as to identify the main features of the actors deterred from engaging in innovation activities, in order to help design appropriate policies that confront systemic failures (Chaminade and Edquist, 2006). In other words, we need to gain a better understanding of the systemic factors that prevent firms from being innovation-active. Preliminary evidence in this sense has been provided by Mohnen and Roller (2005) who show that, when it comes to turn non-innovators into innovators, a system approach is needed that takes into account the complementarities between obstacles.

3 Attenuating barriers to innovation

The main objective of this study is to improve the understanding of the factors attenuating obstacles to innovation. In this study, we approach this objective by distinguishing between firms that face *deterring* barriers to innovation and firms that confront *revealed* barriers to innovation, since the dynamics at work might differ between these two groups of firms with regards to the lowering of barriers. Drawing upon the literature on innovation studies, we would expect the following factors to attenuate deterring and/or revealed barriers to innovation.

a) Firm size

We expect that the size of the firm should have an attenuating effect on both deterring and revealed barriers to innovation. This is because larger firms are more likely to draw on an internal pool of financial and knowledge-related resources, as well as benefitting from scale advantages to spread the fixed costs of innovation over a larger volume of sales. This makes larger firms less vulnerable to entry and revealed barriers to innovation (e.g. Schoonhoven et al., 1990; Cohen and Klepper, 1996; Katila and Shane, 2005). Additionally, we would also expect that the attenuating effect of size is likely to be stronger for deterring than for revealed barriers, since organizational complexity and routines can offset the advantages associated to size among firms already engaged in innovative activities (Tushman and Anderson, 1986; Christensen and Bower, 1996).

b) Being a start up

There are two conflicting arguments with regards to new firms: the creativity and entrepreneurial dynamism associated with start ups and the liability of newness. On the one hand, we would expect that recently established firms are more likely to participate in innovative activities than established firms, since new firms might be less constrained by the risks of cannibalising existing product portfolios or destabilizing core competencies (Tushman and Anderson, 1986; Henderson, 1993). However, on the other hand, start ups are comparatively more likely to confront barriers to innovation due to a lack of prior expertise, scarcity of financial resources or lack of complementary assets (Schoonhoven et al., 1990; Tripsas, 1997).

c) Human capital

The availability of highly skilled employees, and particularly of employees with a higher education degree, is expected to equip firms with an adaptable, responsive and pro-active workforce, softening the challenges imposed by changes in market conditions and the emergence of disruptive technologies (e.g. Gibbons and Johnston, 1974; Cohen and Levinthal, 1990; Baldwin and Lin, 2002). Building upon

this, we would expect that firms with a higher proportion of highly skilled employees would be better positioned to overcome both deterring and revealed obstacles to innovation.

In assessing the impact of the above factors, it is important to control for some important individual and environmental features that might affect the capacity of firms to face barriers to innovation. On one hand, the extent to which the firm has been systematically engaged in innovation-related activities in the past (or whether it has never been active in innovation activities before). On the other hand, we control for the extent to which the firm has been recipient of public financial support to innovation.

4 Data and Method

4.1 Data sources

The data set used in this paper contains firm level data from the Spanish Technological Innovation Panel (PITEC). The data is collected by a joint effort of the Spanish National Statistics Institute (INE), the Spanish Foundation for Science and Technology (FECYT), and the Foundation for Technical Innovation (COTEC). PITEC is organized as a panel data set, with a relatively consistent data collection methodology over a number of time periods (2003, 2004, 2005, 2006 and 2007). In this paper we use specifically the data from the period 2004-2007. In order to have a longitudinal dataset with a consistent number of firms in all years, we have excluded those for which we had missing values in some of the years of that period. The result was a sample of 6606 firms with non-missing values and with data for four waves of the Spanish innovation survey, embracing a wide sectoral coverage that includes both manufacturing and service sectors.

4.2 Filtering process of 'potential innovators'

In line with previous works (see D'Este et al., 2008; Monhen et al., 2008; Savignac, 2008), we filter out from our sample those firms that do not aim at innovating. This is done in order to correct for a sample selection bias problem, which emerges from asking all surveyed firms (irrespective of their willingness to engage in innovative activities) about obstacles to innovation.

As reported in many studies (Baldwin and Lin, 2002; Mohnen and Roller, 2005; Savignac, 2008), a positive correlation between the experience of barriers to innovation and the probability that a firm innovates or engages in innovative activities is found. As Savignac (2008) points out, this counterintuitive positive relationship is strongly dependent on the inclusion in the sample of firms that are not willing to innovate. Indeed, firms not aiming at innovating do not carry out innovation activities at all and, for this reason, are more likely to report obstacles to innovation as not important. The positive relationship between the extent of innovation activity and the assessment of innovation obstacles is thus only a spurious relationship.

In order to avoid biases resulting from the inclusion of firms that are not 'potentially innovative' firms (i.e. not willing to engage in innovative activities of any sort), it is necessary to distinguish between the following two types of firms: (i) firms not willing to innovate, i.e. those that do not carry out any innovation activity and, at the same time, do not experience any barriers to innovation and (ii) "potential innovators", i.e. firms either reporting themselves as innovation active or experiencing some sort of barriers to innovation.

In the setting of this study, we exclude from our sample those firms that are not oriented to innovation in 2007 (i.e. 704 firms, about 11% of our overall sample). In order to identify this group we used the information contained in the Spanish Innovation Survey. In particular, the survey includes two questions asking whether the firm has been engaged in innovation activities during the last three years (2005-2007) and whether it has experienced any barriers to innovation during that period. If the firm responds negatively to these questions, we classified the firm as non-innovation oriented. The underlying rationale is that firms that did not carry out innovation activities and did not experience any barrier to innovation are unlikely to have any aspiration to innovate. Indeed, about 54% of these companies also indicated that innovation was not necessary in their respective markets because of the lack of demand for innovations.

4.3 Measures

In order to obtain a measure of the assessment of innovation obstacles, we have drawn on the responses to the question, in the Spanish innovation survey, on factors hampering innovation. Table 1 shows how this question is displayed in the questionnaire. The question on barriers distinguishes between nine types of factors, grouped into three sets of barriers: a) cost factors; b) knowledge factors; and c) market factors. We have chosen not to investigate the nine barrier items individually, but the three sets of barriers mentioned above.

We have measured the extent to which firms assess barriers as important in two different ways. The first one is based on the construction of a dichotomous variable, indicating whether the firm assesses as important at least one barrier item (i.e. the variable takes the value 1 if the firm has assessed as highly important at least one barrier within each set, and takes the value 0 otherwise). The second one is based on the average assessment of all items in a particular barrier set – a variable that is bounded between 1 (if the firm assesses all barrier items as being of low importance) and 4 (if the firm assesses all barrier items as being highly important).

Table 1. Question on factors hampering innovation.

During the three-year period 2005-2007, how important were the following factors as constraints to your innovation activities or influencing a decision not to innovate?

			Degree of importance		
		Factor not experienced	Low	Medium	High
Cost Factors	Lack of available internal finance	☐	☐	☐	☐
	Lack of available finance from other organisations	☐	☐	☐	☐
	Direct innovation costs too high	☐	☐	☐	☐
Knowledge Factors	Lack of qualified personnel	☐	☐	☐	☐
	Lack of information on technology	☐	☐	☐	☐
	Lack of information on markets	☐	☐	☐	☐
	Difficulties to find appropriate innovation partners	☐	☐	☐	☐
Market Factors	Market dominated by established enterprises	☐	☐	☐	☐
	Uncertain demand for innovative goods or services	☐	☐	☐	☐

As we mentioned in Section 3, one of the main objectives of this study is to identify the factors that may influence or attenuate the assessment of barriers as highly important. Following that discussion, we have constructed the following three variables. First, a measure of firm size is included since previous research shows that larger firms are less vulnerable to entry and revealed barriers to innovation. This variable is measured as the natural logarithm of the total number of employees in 2006 (*Size*). Second, given that new firms could behave differently from established firms in terms of assessment of barriers, a variable that states whether or not the firm is a start-up is included (*Start up*). This variable takes the value 1 if the firm has been established after 1 January of 2002. Third, the proportion of the total employees with higher education degree is used as a proxy for the firm's human capital level. This variable is taken from the 2006 survey (*HumCap*).

We have also included, as control variables, three variables related to the extent to which the firm has been recipient of public financial support to innovation. These variables are taken from the 2006 survey and are dummy variables taking the value 1 if the firm indicates that it received public support from European (PubSupEur), National (PubSupNat) and regional/local governments (PubSupLoc) to support their innovative activities during the period 2004-2006. We also control for the firm's degree of engagement in innovative activities in the past. To this end, we include two variables taken from the 2006 survey: a) *InnInt* (innovation expenditures on total sales in 2006) and b) *Innexp* (this variable takes the value 1 if the firm has engaged in innovation activities during the period 2004-2006, and 0 otherwise). We also included a variable representing the market orientation of the firm (IntMkt), which is defined as a binary variable and takes the value 1 if the firm sells its goods or services in other countries. Finally, we have included a set of five variables to control for the effect of sectoral characteristics. The sectoral dummies have been defined taking into account the distinction between low (*IndMLT*), medium (*IndMMT*) and high technology (*IndMHT*) sectors in manufacturing (as defined by Eurostat/OECD classification) and the distinction between High-tech-Knowledge intensive service sector (*IndSHT*) and firms in other service sectors (*IndSLT*).

4.4 Examining differences in the assessment of barriers between matched groups of firms, using a propensity score matching procedure

As discussed in Section 3, our aim is to investigate how different firm characteristics contribute to lowering deterring and revealed barriers to innovation. To do that, we need to distinguish which type of firms are experiencing each type of barrier. While from a conceptual point of view the distinction between the two types of barriers might be clear-cut, its operasionalisation is much more difficult from an empirical viewpoint.

First, no question is available in the Spanish Innovation Survey that allows us to clearly distinguish whether a firm is experiencing either deterring or revealed barriers. Second, firms can actually face at the same time both kinds of barriers, rather than only one of the two: there might be a "grey zone" where firms are neither *strongly* engaged in innovative activities nor completely deterred from engaging in innovation activities. For this reason, it is necessary to provide a separation as clear-cut as possible between firms facing deterring and revealed barriers. Thus, the first step is to individuate those firms that face clearly either revealed barriers or deterring barriers to innovation.

Our approach to identify differences between the two groups of firms relies on a quasi-experimental procedure by comparing outcomes for a treated[1] group of firms and a control group. We use the propensity score matching technique to identify a control group *without* markedly differences compared to target firms, based on a set of observed characteristics. The procedure consists of matching firms with a similar (or identical) estimated probability of carrying out a "certain" number of innovative activities, based on a set of observable characteristics.[2] Once this propensity score is calculated, observations from target and non-target firms are matched – each target firm is associated with a control firm endowed with a similar propensity score.

Since our aim is to examine whether firms with different levels of engagement in innovation activities attach a different importance to barriers, we define different kinds of treatments according to the number of innovative activities that firms are carrying out (as reported in the Spanish Innovation Survey). For each treatment definition we estimate, as mentioned above, the probability of being treated, that is the probability that a firm carries out a certain number of innovative activities (according to the definition of treatment taken into account). We then find, for each treated unit, one or several non-treated units that have the same (or a sufficiently close) estimated probability of carrying out the same number of innovative activities.

We then compare these groups of firms in terms of the average assessment of barriers to innovation (our outcome variable) as reported by the firm in the survey, thus testing for differences in mean assessment rates of innovation barriers for treated and non-treated units. Not only this provides an estimate of the average effect of treatment on the treated, but we are also able to identify a pattern in the assessment of barriers to innovation along the extent of innovative activities carried out.

5. Findings

5.1. Revealed and deterring barriers to innovation: towards an operational distinction

By plotting the average assessment of barriers to innovation against the number of innovative activities (see Figure 1), we observe a U-shaped pattern. In particular, it seems that firms reporting a modest number of innovative activities (1 or 2) tend, on average, to report barriers to innovation as less

[1] In our case the treatment, or better the treatments, are defined as the specific numbers of innovative activities carried out by the firms belonging to a particular group.

[2] To obtain the propensity score, we estimate a logistic model where the dependent variable is a dummy variable taking value 1 if a 'selected' number of innovative activities are carried out and 0 otherwise. As explanatory variables, we make use of the most important factors stressed by the literature to explain firms' propensity to innovate: firm size, firm age, market power, as well as environmental characteristics (e.g. technological opportunities, demand pull, etc.).

important compared to other firms (those that do not carry out innovative activities at all and those that report a medium or high number of innovative activities).

This behaviour is consistent with our argument in favour of a differentiation between deterring and revealed barriers to innovation. Interestingly, the U-shaped pattern, that is valid for the overall assessment of barriers to innovation, seems to be driven mainly by knowledge and market barriers to innovation rather than cost barriers. In the latter case, the average assessment, although increasing for firms reporting a medium and high number of innovative activities, seems not to be different between firms reporting no innovative activities and those characterised by a modest number of them. Table 2 provides some descriptive statistics for all the firms contained in our sample and for three sub-groups of firms according to the number of innovative activities.

Figure 1: Curvilinear relationship between importance of barriers to innovation and number of innovative activities

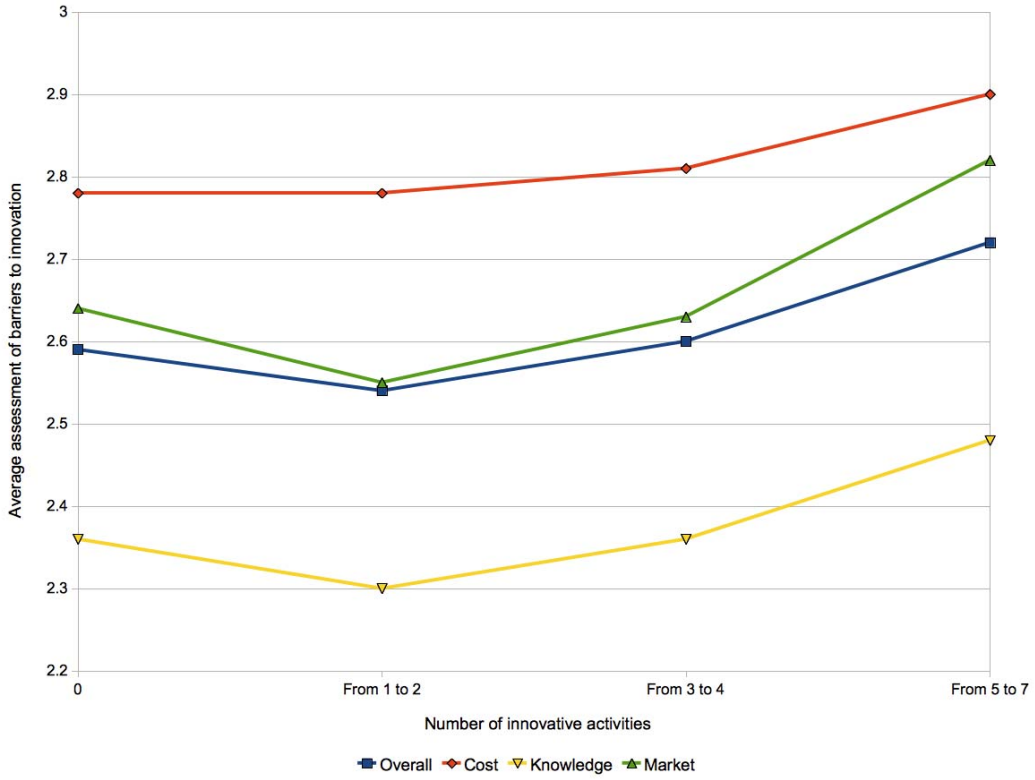

Table 2: Descriptive statistics by groups of firms according to the number of innovative activities

	All observations (N=5330)				Non innovators * (N=1300)				Modest innovators ** (N=2810)				Moderate and strong innovators *** (N=1220)			
	mean	Sd	min	max	Mean	Sd	min	Max	Mean	sd	min	max	mean	sd	min	max
ObsTot °	2.57	0.67	1	4	2.59	0.70	1	4	2.55	0.67	1	4	2.62	0.62	1	4
ObsCost °	2.78	0.94	1	4	2.80	0.96	1	4	2.79	0.94	1	4	2.83	0.9	1	4
ObsKnow°	2.32	0.8	1	4	2.35	0.86	1	4	2.28	0.79	1	4	2.37	0.74	1	4
ObsMkt °	2.79	0.95	1	4	2.82	0.96	1	4	2.74	0.96	1	4	2.85	0.90	1	4
Size	4.19	1.50	0	10.02	4.02	1.55	0	8.65	4.16	1.44	0	10.0	4.48	1.57	0.69	9.93
Startup	0.07	0.25	0	1	0.03	0.17	0	1	0.07	0.25	0	1	0.11	0.32	0	1
HumCap	26.44	27.42	0	100	17.3	23.8	0	100	28.0	27.7	0	100	32.56	28.02	0	100

Note: (*) “non-innovators”, firms reporting no innovative activities; (**) “modest innovators”, firms reporting 1 or 2 innovative activities; and (***) “moderate and strong innovators”, firms reporting 3 to 7 innovative activities. ° Average assessment of barrier items.

The descriptive statistics presented in Table 2 and the visual representation of Figure 1, are simply descriptive comparisons. We now turn to examine whether these differences still hold, once we explicitly consider all of the factors that may influence the probability of carrying out different levels of innovative activities. To do that, we rely on the propensity score matching procedure explained in Section 4.4. The main purpose is to compare the rate of barriers' assessment of firms carrying out a different number of innovative activities with those of an appropriate control group.

We do this by taking into consideration three treated groups: (i) "non-innovators" (firms reporting no innovative activities), (ii) "modest innovators" (firms reporting 1 or 2 innovative activities) and (iii) "moderate innovators" (those reporting 3 or 4 innovative activities). We compare each one of them with several control groups. For instance, for the "non-innovators", we compare how the average assessment of barriers to innovation differs from that of a control group composed by firms reporting more than one innovative activity (column 1 in Table 3); from that composed of modest innovators (column 2 in Table 3), from moderate innovators (column 3 in Table 33), and finally from strong innovators (column 4 in Table 3). We then compare the group of "modest innovators" with a group of controls drawn from moderate (column 5 in Table 33) and strong innovators (column 6 in Table 3). And finally, the last comparison is done between the group of moderate innovators and a control group containing strong innovators (column 7 in Table 3).[3]

Table 3 shows the difference between the average assessment of barriers to innovation of the treated and control groups that constitutes the Average effect of Treatment on the Treated (ATT) estimation procedure. A positive and significant difference is found between non-innovators and modest innovators while a negative and significant difference is present between modest innovators and groups of controls that are moderately and strongly innovative as well as between moderate and strong innovators. Interestingly, no significant difference is found between non-innovators and control groups containing firms carrying out more than 3 innovative activities.

The results from the propensity score matching confirm the outcome obtained via descriptive and visual inspections. In particular, we find that a non-innovator is likely to rate barriers to innovation as more important compared to modest innovators, while a modest innovator tends to rate barriers as less important compared to firms that are more strongly engaged in innovation activities. This confirms the U-shape pattern in the relationship between the number of innovative activities a firm carries out and its assessment of barriers. We moreover find that this overall pattern is actually driven by knowledge and market barriers, while we do not find such a pattern for cost barriers.

In short, the matching procedure helps us to conclude that, when compared with groups of firms of similar characteristics that engage only modestly in innovation activities, "non innovators" are experiencing significantly stronger barriers to innovation. Therefore, we can argue that "non-innovators" are likely to face deterring barriers: that is, barriers that prevent them from starting innovation activities. Moreover, there are other groups of firms (i.e. moderate and strong innovators) for which obstacles increase alongside their engagement in innovative activities. Thus, these firms are likely to be facing revealed barriers, in the sense that their awareness of factors hindering innovation does not prevent them from pursuing innovation-related activities. In between, there is a group of firms composed by modest innovators that are likely to be facing a mix of the two kinds of obstacles, making it difficult to unambiguously classify these firms as either experiencing deterring or revealed barriers to innovation.

[3] Strong innovators are defined as those firms that report a number of innovative activities between 5 and 7.

Table 3: Average effect of Treatment on the Treated (ATT): differences in the average assessment of barriers to innovation between treated and control groups

	Non-innovators vs innovators †	Non-innovators vs modest innovators†	Non-innovators vs moderate innovators†	Non-innovators vs strong innovators‡	Modest innovators vs moderate innovators†	Modest innovators vs strong innovators‡	Moderate innovators vs strong innovators‡
Overall							
ATT	0.045*	0.06*	-0.001	-0.084	-0.05*	-0.2**	-0.13**
SE	0.02	0.03	0.04	0.06	0.02	0.05	0.04
N treated	1300	1300	1300	1298	2810	2796	999
N controls	4030	2810	1002	3812	1002	2519	4283
Cost barriers							
ATT	0.013	0.03	-0.02	-0.09	-0.02	-0.17*	-0.12**
SE	0.03	0.04	0.05	0.1	0.03	0.06	0.05
N treated	1300	1300	1300	1298	2810	2796	999
N controls	4030	2810	1002	3812	1002	2519	4283
Knowledge barriers							
ATT	0.06*	0.07**	0.009	-0.02	-0.07*	-0.16**	-0.11*
SE	0.03	0.03	0.04	0.07	0.03	0.05	0.05
N treated	1300	1300	1300	1298	2810	2796	999
N controls	4030	2810	1002	3812	1002	2519	4283
Market barriers							
ATT	0.07*	0.1**	0.007	-0.16	-0.08**	-0.3**	-0.2**
SE	0.03	0.03	0.05	0.1	0.03	0.06	0.05
N treated	1300	1300	1300	1298	2810	2796	999
N controls	4030	2810	1002	3812	1002	2519	4283

† *ATT estimation with the kernel propensity score matching with bootstrapped standard errors (100 replications)*
‡ *ATT estimation with the stratification method*
* p<0.05, ** p<0.01

5.2. Factors attenuating the assessment of barriers to innovation: a comparison of revealed and deterring barriers

In this section we concentrate on the empirical test of the hypothesis proposed in Section 3 concerning factors that are likely to attenuate barriers to innovation. We conduct the analysis for two samples of firms: those confronting deterring barriers and those facing revealed barriers, as defined in the previous section.

The empirical analysis is based on a logistic model (where the dependent variables are dichotomous, indicating whether the firm assesses as highly important at least one barrier item), differentiating between knowledge and market obstacles. On the grounds of the findings obtained in Section 5.1, cost barriers are not taken into account in the estimation of factors attenuating the assessment of innovation obstacles, since no clear U-shaped relationship is found to hold in this case – and therefore, we are not able to differentiate between firms facing deterring or revealed barriers. The estimation is conducted on two related sub-samples.

On the one hand, firms facing deterring barriers to innovation: that is, the group of firms that have not been engaged in innovation activities. Since non-innovators report their assessment on how important knowledge and market obstacles are, we define two dependent variables: one related to knowledge barriers (KNOW_DET) and another one related to market barriers (MKT_DET).

On the other hand, we consider firms facing revealed barriers: that is, the group of firms that engage in 3 or more innovative activities (the moderate and strong innovators). As in the previous case, these firms report their assessments on both knowledge and market barriers, so we consider two dependent variables: one related to knowledge obstacles (KNOW_REV) and another one related to market obstacles (MKT_REV). The results are reported in Table 4.

Results from Table 4 show a negative and significant coefficient for firm size. In particular, other things being equal, being a larger firm decreases the probability of assessing barriers to innovation as highly important irrespective of facing revealed or deterring obstacles. It is worth stressing that this result is similar for knowledge and market barriers. However, contrary to the hypothesis proposed in Section 3, being a new firm does not seem to influence the probability of assessing barriers as important, with no notable difference between the group of firms facing deterring barriers and those confronting revealed ones.

Interestingly, human capital (i.e. the proportion of employees with a higher education degree) is found to be significant and negatively related to the assessment of the importance of barriers to innovation. In particular, this result is found to hold for those firms confronting deterring barriers to innovation (either knowledge or market related ones), but it is not found for firms confronting revealed barriers. This latter result is quite important because it clearly shows that firms with a higher proportion of highly skilled employees are better positioned to overcome deterring obstacles to innovation.

Table 4: Results of the logistic model

	Dependent variable: whether the firm assesses at least 1 barrier as highly important			
	KNOW_DET	KNOW_REV	MKT_DET	MKT_REV
Size	-0.184***	-0.329***	-0.257***	-0.161***
	(0.050)	(0.060)	(0.045)	(0.048)
StartUp	-0.214	-0.629	0.453	0.488
	(0.453)	(0.397)	(0.389)	(0.331)
HumCap	-0.010**	0.004	-0.006*	0.002
	(0.003)	(0.004)	(0.003)	(0.003)
PubSupLoc	0.533*	0.153	-0.045	-0.122
	(0.214)	(0.167)	(0.204)	(0.146)
PubSupNat	0.191	0.346*	0.322	-0.016
	(0.293)	(0.175)	(0.270)	(0.153)
PubSupEur	0.748	0.443	-0.740	0.211)
	(0.635)	(0.244)	(0.704)	(0.226)
IntMkt	-0.187	-0.060	0.059	0.292
	(0.141)	(0.206)	(0.128)	(0.186)
InnInt	-0.0009	-0.0002	0.0001	0.0002
	(0.003)	(0.001)	(0.001)	(0.001)
InnExp	-0.153	-0.016	0.148	-0.529
	(0.187)	(0.542)	(0.165)	(0.437)
IndMLT	-0.469	0.677*	-0.535	-0.059
	(0.381)	(0.277)	(0.344)	(0.224)
IndMMT	-0.113	0.566*	-0.271	-0.054
	(0.353)	(0.279)	(0.322)	(0.223)
IndSLT	0.049	0.241	0.161	0.269
	(0.425)	(0.316)	(0.384)	(0.264)
IndSHT	-0.080	0.033	-0.535	-0.639*
	(0.373)	(0.318)	(0.340)	(0.265)
Cons	-0.018	-0.733	0.863*	0.092
	(0.389)	(0.583)	(0.358)	(0.478)
Chi2	39.85	76.34	72.60	57.02
N	1300	1220	1300	1220
Log-likelihood	-704	-603	-817	-745

* p<0.05, ** p<0.01, *** p<0.001.

6. Discussion and conclusions

Despite the fact that innovation is often seen to be the key to a firm's economic success, not all firms willing to innovate engage in innovation activities. This raises the issue about why firms are deterred from innovation and what factors may attenuate the obstacles faced by firms to engage in innovation activities. These are the main questions addressed in this paper.

The paper contribution is threefold. First, our results show that there is a U-shaped relationship between the level of engagement in innovative activities and the assessment of barriers. This is important since it confirms that non-innovators are extremely sensitive to barriers to innovation: they actually assess barriers as significantly more important compared to firms involved modestly in innovation, and their assessments are similar to firms involved strongly in innovation related activities.

This curvilinear relationship highlights, first, that there are actually different groups of firms that perceive high "levels" of barriers to innovation; and second, that the barriers experienced by each group are likely to be of a different kind. While firms in one group (i.e. those firms not engaged in innovative activities) are likely to face obstacles that deter them from engaging in innovation activities, firms in the other group (i.e. those strongly involved in innovative activities) are likely to face obstacles that are revealed alongside their engagement in innovation-related activities.

Second, the paper shows that market and knowledge barriers are playing a much more important role than cost-barriers as deterring mechanisms to innovation activities. While financial constrains have often been the focus of most of the empirical literature on obstacles to innovation, our findings show that cost-related barriers are particularly strong among firms heavily engaged in innovation activities. In other words, firms seem to be more strongly deterred from innovation by factors such as market conditions (i.e. 'market dominated by established firms' or 'uncertain demand for innovative products') and knowledge (i.e. 'lack of qualified personnel' or 'lack of information on technology'), than by financial-related obstacles.

Without doubt, it would be important to replicate this study in different settings in order to check for the robustness of the findings. Nevertheless, these findings provide preliminary evidence that points towards policy measures to promote innovation that expand well-beyond the availability of finance and the response to imperfect financial markets. Instead, they point towards policies addressing systemic failures on innovation associated with the weaknesses of the research infrastructure, the lack of technological capabilities among firms, and the entry barriers emerging from highly concentrated markets.

Third, this research has also addressed the extent to which certain firm characteristics alleviate deterring and revealed obstacles to innovation. Small firms seem to be clearly disadvantaged to face both deterring and revealed barriers on innovation. As expected, large firms seem to benefit from economies of scale and scope that attenuate the importance of obstacles to innovation. In this sense, policy initiatives oriented to support risky projects by small firms should be welcomed.

We have not found support for the hypothesis that start-up firms are particularly sensitive to deterring barriers on innovation. Rather, being a new-established firm does not seem to imply either an advantage or a disadvantage to face deterring or revealed barriers. Additionally, our results do not support either that deterring barriers are particularly prevalent among firms in high-tech sectors.

Finally, our findings point out that firms with a highly educated workforce are better equipped to face deterring barriers on innovation, with regards to both knowledge and market barriers. This result points out the importance of a science and technology infrastructure (and of universities in particular) as suppliers of a talented workforce in order to avoid a shortage of skilled labour; but also highlights the importance of raising awareness among firms about the need to introduce the organisational changes required to continuously upgrading their skill-base.

This study has a number of limitations. Our sample of non-innovators is likely to be underrepresented and therefore we need to be cautious about making inferences to the whole population of firms, and particularly to "potential innovators" that do not carry out innovation activities. Moreover, we have not examined in detail the role of environmental factors in shaping firms' assessment of barriers. We plan to address this latter issue more explicitly in future work, as well as investigating whether there are

interaction effects between environmental and individual features with regards to the assessment of barriers.

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