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Reviving demand-pull perspectives: The effect of uncertainty and lack of demand on R&D strategy

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Abstract

This paper looks at the effects of demand uncertainty and stagnancy on firms? decisions to engage in R&D activities and the amount of financial effort devoted to it. The paper contributes to the innovation literature in three respects: first, it adds to the revived debate on demand-pull perspectives in innovation studies, by looking at demand-related (lack of) incentives to invest in innovation. Also, it complements the emerging literature on barriers to innovation in a two-fold way: first, by focusing on demand-related obstacles rather than the more explored financial barriers; second, by analyzing whether experiencing demand-related obstacles is a sector-specific feature, namely whether firms active in high or low tech manufacturing or in knowledge intensive or low tech services are more or less dependent on demand conditions when deciding to perform R&D. We find that uncertain demand and lack of demand are perceived as two completely different barriers. While uncertainty on demand has a slightly positive and significant effect on R&D plans, the perception of lack of demand does strongly reduce not only the amount of investment in R&D but also the likelihood of firms to engage in R&D activities. We interpret this evidence in terms of the specific phase of the innovation cycle in which decisions to invest in R&D are formulated. Sectoral affiliation does not seem to matter when it relates to demand conditions, supporting the conjecture that positive expectations on market demand is a structural and necessary

condition to be fulfilled for all firms before deciding to invest

Jelcodes:O31,C23

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Abstract

This paper looks at the effects of demand uncertainty and stagnancy on firms' decisions to engage in R&D activities and the amount of financial effort devoted to it. The paper contributes to the innovation literature in three respects: first, it adds to the revived debate on demand-pull perspectives in innovation studies, by specifically looking at demand-related (lack of) incentives to invest in innovation. Also, importantly, it complements the emerging literature on barriers to innovation in a two-fold way: first, by focusing on demand-related obstacles rather than the more explored financial barriers; second, by analyzing in details whether experiencing demand-related obstacles is a sector-specific feature, namely whether firms active in high or low tech manufacturing or in knowledge intensive or low tech services are more or less dependent on demand conditions when deciding to perform R&D. We find that uncertain demand and lack of demand are perceived as two completely different barriers. While uncertainty on demand has a slightly positive and significant effect on R&D plans, the perception of lack of demand does strongly reduce not only the amount of investment in R&D but also the likelihood of firms to engage in R&D activities. We interpret this evidence in terms of the specific phase of the innovation cycle in which decisions to invest in R&D are formulated. Sectoral affiliation does not seem to matter when it relates to demand conditions, supporting the conjecture that positive expectations on market demand is a structural and necessary condition to be fulfilled for all firms before deciding to invest.

Keywords: Barriers to innovation, Demand uncertainty, Lack of demand, Innovative Inputs, Panel data
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1. Introduction

The intertwined influence of demand and technological opportunities on firms' strategic decisions to innovate and the aggregate outcomes of these decisions are age-old topics in innovation studies, sparked by the seminal contribution by Schmookler (1966) and followed up by a fierce debate (Mowery and Rosenberg, 1979). A recent contribution (Di Stefano et al., 2012) reviews this debate by looking at the evolution of the scholarship that has over time supported a technology-push or demand-pull source of innovation, or disentangled their relative importance in fostering innovation.

Interestingly, none of these contributions has looked at the demand-pull perspective from the viewpoint of barriers to innovation. As it is common within the innovation literature, analysis of the factors of success of innovation is proportionally larger than contributions on patterns of failure and the effect of the lack of incentives. Scholars of demand-pull perspectives seem therefore to have overlooked the lack of demand or demand uncertainty as factors hampering decisions to invest in innovation.

Similarly, the emerging literature on barriers to innovation has mostly dealt with the firms' characteristics affecting the perception of barriers to innovation or, when specifically looking at the actual hampering effect of perceived barriers, it has disproportionately focused on financial barriers and the limitations to the financial capacity of firms to invest in R&D (see D'Este et al., 2012 and Pellegrino and Savona, 2013 for a review of this literature). This unbalance toward financial obstacles might well reflect the relative "dominance" of technology-push perspectives over interest on demand-related incentives to innovate.

Rather than empirically contrasting the two perspectives, we aim to rebalance the picture by trying to disentangle the effects of lack of demand or perceived uncertainty about demand conditions on firms' decision to invest in R&D and amount of resources devoted to it. The paper contributes to the innovation literature in three respects: first, it adds to the revived debate on demand-pull perspectives in innovation studies, by specifically looking at demand-related (lack of) incentives to invest in innovation. Also, importantly, it complements the emerging literature on barriers to innovation in a two-fold way: first, by focusing on demand-related obstacles rather than the more explored financial barriers; second, by analyzing in details whether experiencing demand-related obstacles is a sector-specific feature, namely whether firms active in high or low tech manufacturing or in knowledge intensive or low tech services are more or less dependent on demand conditions when deciding to perform R&D.

We find that uncertain demand and lack of demand are two completely different barriers and we interpret this evidence in terms of the phase in which decisions to invest in R&D are formulated. While uncertainty on demand has a weak positive statistically significant effect on R&D plans, the perception of lack of demand does strongly reduce not only the amount of investment in R&D but also the likelihood of firms to engage in R&D activities. Sectoral affiliation does not seem to matter when it related to demand conditions, supporting the conjecture that positive expectations on market demand is a structural and necessary condition to be fulfilled for firms before deciding to invest. When considered from the perspective of barriers to innovation, demand-related incentives seem therefore to cut across sectoral specificities in technological opportunities.

Next section briefly reviews the two relevant branches of literature mentioned above: the demand-pull versus technology-push perspectives and the one on barriers to innovation. Section 3 describes the data employed in the empirical analysis, Section 4 illustrates te econometric strategy and the variables used for the estimations, while Section 5 discusses the results and answers the main research question. Section 6 concludes.

2. Background literature

2.1. Demand-pull perpectives revisited

Innovation literature has traditionally been rather ambivalent on the role of demand besides technical progress as an incentive to innovation. As suggested by Di Stefano et al., (2012) in a recent review, the debate between demand-pull and technology-push perspectives has gone through different phases, from a fierce counter-position between demand-pull supporters (Schmookler, 1962, 1966; Myers and Marquis, 1969; von Hippel, 1978, 1982) and demand-pull critics (Mowery and Rosenberg, 1979; Dosi, 1982; Kleinknecht and Verspagen, 1990) before settling more recently on a more balanced view that demand is a complementary (though not dominant) factor explaining innovation. This literature includes both conceptual and empirical contributions (Cainelli et al., 2006; Piva and Vivarelli, 2007; Fontana and Guerzoni, 2008) and both macro- and firm-level analyses.

For the purpose of our argument, it suffices here to recall the main terms of the debate, relate them to the most recent literature on barriers to innovation (Section 2.2) and put forward the conjectures (Section 2.3) that we empirically test in the remaining of the paper.

As Fontana and Guerzoni (2008) suggest, the intuition on the influence of demand on innovation sparked with the seminal contribution by Schmookler (1962; 1966) and Myers and Marquis (1969), who claimed that the introduction of new products and processes is conditioned to the presence of demand or even possibly a latent demand and, in general, on positive expectations on profitability from returns to innovation. In absence of these conditions, firms would simply not have any incentive to innovate. Further, the adoption and diffusion of (especially new) products is intrinsically subject to uncertainty, which would reduce incentives to innovate. Technology-push scholars’ argument touched upon various issues, going from the reverse causality of the empirical relationships estimated by

Schmookler (1966) and Meyers and Marquis (1969) to the difficulties of identifying the relevant demand affecting innovation incentives.

We would argue here, and reprise later, that market size – and therefore expectations on profitability – and demand uncertainty are very likely to refer to different levels of demand. First, positive expectations on profitability and therefore incentives to innovate, despite being intrinsically linked to the fate of the new product being launched, are predominantly affected by the macro-conditions of aggregate demand and market dynamism of the specific and related products. Even incremental product or process innovation woud be hard to implement, should forecast of sufficient sales and adequate returns to innovation be failing.

Second, while uncertainty might be linked to aggregate macro-conditions of demand, it is predominantly affected by the characteristics of the new products/services and the lack of information on users and their capabilities to adopt/benefit from the new product (see also von Tunzelmann and Wang, 2003 on user capabilities).

Of course, macro- and micro-demand conditions are likely to reinforce each other, though in the case of incrementally new product or process innovation aggregate stagnancy of demand might be more influent, whereas in the case of radically new product or services it is the uncertainty which is likely to play a major role in terms of incentives to innovate (see also Fontana and Guerzoni, 2008).

2.2 Demand as a barrier to innovation: stagnancy and uncertainty

Although the literature on barriers to innovation is relatively recent, compared to the age of innovation studies as a discipline, scholars have found substantial evidence on the presence and effects of perceived hindrances on propensity and intensity of engagement in innovation activities.

A large proportion of these studies have privileged the analysis of the effect of financing constraints on firms' cash flow sensitivity to afford R&D investments (for a review, see Schiantarelli, 1996 and Hall, 2002; see also Bond et al., 1999 and Hottenrott and Peters, 2012).

More at large, empirical evidence tends to confirm that encountering financial constraints significantly lowers the likelihood of firms to engage in innovative activities (Savignac, 2008), where this pattern is more pronounced in small firms and high-tech sectors (Canepa and Stoneman, 2007; Hall, 2008; Hottenrott and Peters, 2012).

The implicit assumption behind this preferred focus of analysis is that it is mainly access to finance, financial uncertainty and information asymmetries that reduce the financial returns of R&D investments and the ability to attract external funds, therefore reducing incentives to invest in R&D.

A few recent contributions have extended the analysis to non-financial obstacles to innovation, mainly drawing upon innovation surveys evidence, which allows looking into the effects of knowledge-related obstacles – i.e. lack of qualified employees, lack of information on technology and markets –market-related obstacles – lack of interest of customers in innovative products or market dominated by large incumbents and barriers due to the need to meet national and international regulation. Further, innovation surveys allow going beyond the mere decision to invest in R&D, and taking into account innovation outputs such as the introduction of a new (to the market or to the firm) good or service or a new process.

Even within the CIS-based literature, an overwhelming number of contributions focuses on financing constraints to innovation, treating the role of non-financial ones as a simple control factor (Tiwari et al., 2008; Mancusi and Vezzulli, 2010; Blanchard et al., 2013). Analyses of factors affecting the perception of all types of obstacles is offered by Iammarino et al., 2009 and D'Este et al., 2008 and 2012. Pellegrino and Savona (2013) look at the effect of all types of barriers on the likelihood of being a successful innovator, recognizing the fundamental – possibly exacerbating – role of other types of obstacles indirectly on the financing ones and directly on the innovation intensity of firms. All these contributions point to an equally important constraining effect of the lack of poor condition of access to finance and of the lack of market responses to innovation.

2.3 Main conjectures

Overall, the implicit assumption behind the "technology-push" perspectives' bias within the innovation literature is that firms plan their innovation investments in a context that is structurally and indefinitely able to absorb the outcomes of innovation, much in line to a blind trust in a sort of Say's Law[1] for innovative products. This would apply both at the general macro-economic level - that is a general state of dynamism of aggregate consumption – and at the micro-level of analysis – that is for the specific product/service/sector that has been introduced onto the market.

Without the ambition of empirically testing technology-push and demand-pull hypotheses here, we contest this assumption and claim that - if easy access to finance and funds availability are important conditions to implements plans of innovation investments – trust and positive expectations on the state of demand are a necessary condition for firms to even start plans of innovation investments.

[1] In simple terms, Jean Baptiste Say claimed that "supply always creates its own demand" – i.e. markets are able to infinitely absorb any quantity of production. The Keynesian framework overall rejected Say's Law. Here we might stretch the argument and argue that in the case of innovative products, the uncertainty of whether the launch of new products or services is going to be adopted by consumers and diffused in the markets is even higher.

Rather than market structure issues or "lack of interest of customers" we focus on firms' perception of the state of demand, in terms of both lack of demand tout court and market uncertainty.

As far as this latter is concerned, we are aware that some scholars (see for instance Czarnitzki and Toole, 2011 and 2013) have analysed the effect of market uncertainty on R&D investment behaviour from a real option theory perspective, finding that uncertainty causes falls in R&D investments, though mitigated by patent protection (Czarnitzki and Toole, 2011) and firms' size and market concentration (Czarnitzki and Toole, 2013).

Here we make use of more of an heuristic approach to uncertainty, certainly more data driven, with the aim of testing whether firms' self-reported perception of market uncertainty[2] affect their investing behaviour. In particular, we look at whether decisions to invest in R&D and amount of investments in R&D are affected by the perceptions of both demand-related obstacles as increasingly relevant over time and we empirically test this in a panel econometrics framework, as detailed in next section.

Further, an important added value of this paper is the analysis of the possible sectoral differences in the way demand affects firms' propensity to invest in R&D[3]. Our conjecture is that service firms are substantially more sensitive to the state of demand when planning their innovative strategies. This is in line with much of the literature on innovation in services (for a review, see Gallouj and Savona, 2009), which claims that the importance of customers and user-producer interactions in services is sensibly higher than in manufacturing sectors.

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[2] As detailed in Section 3, the information on market uncertainty is drawn upon a specific question formulated in terms of "Uncertain demand for innovative goods or services" as a perceived barrier to innovation. We are convinced that despite the self-reported and qualitative nature of the information that this question provides (common to all CIS-based evidence), it nevertheless allows to draw a plausible picture of firms' response to increasing levels of (perceived) uncertainty.

[3] In the best tradition of innovation studies, this allows us to control for the role of different technological opportunities at the sectoral level, and therefore implicitly accounting for the "technology-push" argument.

Accordingly, we empirically test the conjectures above for both the whole sample of firms and for sub-samples of different macro-sectors, as explained in detail below.

3. Data

We draw on firm level data from the Spanish Technological Innovation Panel (PITEC). PITEC represents the results of the joint effort of the Spanish National Statistics Institute (INE), the Spanish Foundation for Science and Technology (FECYT), and the Foundation for Technical Innovation (COTEC). The data are collected following the Oslo Manual's guidelines (OECD, 1997) and can be therefore considered like as a Community Innovation Survey (CIS) –type dataset. Accordingly, along with a set of firm's general information (main industry of affiliation, turnover, employment, founding year), PITEC includes also a (much larger) set of innovation variables measuring the firms' engagement in innovation activity, economic and non-economic measures of the effects of innovation, self-reported evaluations of factors hampering or fostering innovation, participation in cooperative innovation activities and some complementary innovation activities such as organisational change and marketing.

An important feature that distinguishes PITEC from the majority of the European CIS-type dataset is its longitudinal nature. Since 2003 a systematic data collection methodology has allowed a consistent representativeness of the population of manufacturing and service Spanish firms over a number of time periods.

In this work we use the data referring to the period 2004-2011 and select the working database starting from the initial sample (100,016 year observations); we first drop those firms operating in the primary (1,628 observations), construction (3,914 observations), utilities (720 observations), sewage/refuse disposal (318 observations) sectors and those firms which experienced process of M&A (8,543 observations)[4]. In line with our previous contributions (D'Este et al., 2008 and 2012; Pellegrino and Savona, 2013), we select a relevant sample. Accordingly, we exclude 6,114 observations referred to what we called "Not innovation oriented firms", that is firms that did not introduce any type of innovation (goods, services and processes) and that at the same time did not experienced any barriers to innovation during the three year period, so by inference not interested in innovating. The resulting sample of 78,779-year observations, is further reduced by excluding all the missing values referring to the variables used for the empirical analysis (24,315 observations), and 354 firms observed for just one year.

Table 1 reports the composition of the final dataset obtained after this cleaning procedure. As can be seen, half of the 9,132 firms (54,110 observations) included in the final sample are observed for all the 8 periods (2004-2011); about 23% are observed for 7 periods while only a negligible percentage of firms (around 10%) are observed for less than 5 years. These figures allow us to safely confirm the suitability of this dataset to perform dynamic analysis.

< INSERT TABLE 1 >

4. Econometric strategy and variables

As mentioned in the introduction, the main aim of this paper is to empirically assess whether and how demand-related obstacles to innovation affect two important firm's innovative decisions: the propensity to engage in R&D and, conditional on that, the level of

[4] It is common practice in the innovation literature to focus on private manufacturing and services and exclude public utilities and primary activities, due to differences in the regulatory framework they operate in. As for M&A, firms were eliminated from the sample in the years following the merger or acquisition.

investment in R&D. As stressed by a consolidate stream of literature, innovation and in particular R&D activities are processes that present high degrees of cumulativeness and irreversibility and, as a result, are characterised by a higher level of persistence (see Atkinson and Stiglitz, 1960; David, 1985; Dosi, 1988; Cefis and Orsenigo, 2001). This evidence is fully supported by our data. Indeed, looking at the transition probabilities of engaging in R&D activities (see table 2) it emerges that almost 86% of R&D performers in one year persisted in the same status the subsequent year, this percentage increasing up to 91% in the case of non R&D performers that did not change their status into the next period.

< INSERT TABLE 2>

This evidence suggests that the use of an autoregressive specification for both firm' decisions related to R&D activities is the most appropriate one. Accordingly, our empirical strategy will be based on the estimation of the following two equations:

$$y^*_{1it} = \varphi_1 y_{1i,t-1} + \beta_1' x_{it} + c_{1i} + v_{1it} \quad (1)$$

$$y^*_{2it} = \varphi_2 y_{2i,t-1} + \beta_2' x_{it} + c_{2i} + v_{2it} \quad (2)$$

Where y^*_{1it} and y^*_{2it} denote the two latent dependent variables representing respectively the firm's i propensity at period t (i = 1,…N; t = 1,….T) to engage in R&D (expressed as a binary variable), and the firm's i decision regarding the level of investment in R&D activity (the natural logarithm of R&D expenditure). For each firm i, $y_{1i,t-1}$ and $y_{2i,t-1}$ represent the one period lagged of the y^*_{1it} and y^*_{2it} dependent variables, while x is a vector of explanatory variables that has been chosen taking into account both the characteristics of the dataset at our disposal and the main insights provided by the literature on the subject.

More in detail, we first consider a binary indicator of international competition, which equals to 1 if a firm's most significant destination market is international and to 0 otherwise. In this respect, on the ground that international markets are characterized by a higher level of competition, this variable should exert a positive effect on the firm's propensity to innovate (e.g. Archibugi and Iammarino, 1999; Narula and Zanfei, 2003; Cassiman et al., 2010). However, some authors (see, for example, Clerides et al., 1998) warn about the existence of a possible reverse causation: most innovative firms are more likely to penetrate foreign markets and self-select themselves so as to engage in tougher foreign competition. In order to deal with this endogeneity issue we consider the one period lagged value of this variable.

Reverse causation has also been observed in the relationship between public subsidies and innovation activity. Most of the literature on the subject provides empirical support of the positive impact of incentive schemes on the firm's propensity to both engage in and realize R&D (see for example Callejon and García-Quevedo, 2005; González et al., 2005 for the Spanish case). However, other contributions cast doubts on the reliability of such a relationship because of the potential endogeneity of public funding (see, for example, Wallsten, 2000). Accordingly, the t-1 value of an indicator of whether the firm has received public support for innovation is included.

A one period lagged value has also been considered for two indicators of whether the firm makes use respectively of patents and informal methods (registration of design, trademarks, copyrights) to protect its innovations[5]. In this case, the rationale is that the mechanisms of appropriability used by the firms take time to show their positive impact.

[5] Previous studies generally show a clear-cut positive link between these factors and firms' innovative activity (see Levin et al., 1987; Salomon and Shaver, 2005; Liu and Buck, 2007).

We also use a variable recording firm's age to control for age related effects. Theoretical and empirical literatures provide mixed evidence about the possible effect of age on the engagement in/realization of innovation activities. Keppler (1996) puts forward a theoretical model that points to a negative relationship between the firm's age and its probability of innovating. However, as Galande and De la Fuente (2003) pointed out, firm's age can also be seen as a proxy of the firm' knowledge and experience accumulated over time and consequently it should be positively related to innovation.

Moreover, in line with some studies that underline the expected innovative benefits for a firm that is member of an industrial group (see Mairesse and Mohnen, 2002), such as easier access to finance and positive intra-group knowledge spillovers, we include a dummy variable identifying this firm' characteristic.

Another important factor that can influence the firm's R&D decision is the business cycle. In order to control for this aspect, in line with some recent contributions (see Aghion et al., 2012; Lopez Garcia et al., 2013), we use a micro-level perspective to identify idiosyncratic shock to firms by considering *firm's sales growth*.

Finally, following the Schumpeterian tradition, we consider a variable reporting the log of the total number of employees as a measure of firm size and a set of industry dummies variables (based on the 2-digit CNAE codes[6]).

Turning to the demand-related obstacles, and in line with the background in Section 2 and the rationale behind it, we singled out two different binary variables identifying an increase (on a yearly base) in the degree of importance (irrelevant, low, medium, high) that the firms have assigned to the barriers labelled as "uncertain demand for innovative goods

[6] To a large extent the Spanish industrial classification codes (CNAE) correspond to the European NACE taxonomy.

and services” and “lack of demand for innovation”[7]. Finally we control for possible additional negative effects of other obstacles to innovation, including a dicotomic variable recording an yearly increase in the importance of the firm’s level of perception of the remaining obstacles categories (cost and knowledge related obstacles, market dominated by established firms). Table A1 in the Appendix shows the list of variables, their acronyms and a detailed description.

As far as the econometric methodology is concerned, in order to estimate equations (1) and (2), we applied a method put forward by Wooldridge (2005) based on a conditional maximum likelihood estimator. The author proposes a simple solution in order to address the two well-known problems that might bias the results in a dynamic random effect probit/tobit context: the initial condition problem and the correlation between the individual error term and the explanatory variables. More in detail, Wooldridge suggests to model the firm-specific error term as follow:

$$c_{ji} = \alpha_{j0} + \alpha_{j1} y_{ji0} + \alpha_{j2} \bar{x}_i + a_{ji} \qquad (3)$$

Where $\bar{x}_i$ refers to the within mean of the x_{it} vector of explanatory variables and embodies the elements that are correlated with x_{it}, while y_{ji0} (with j = 1,2) are the initial conditions of the dependent variables that are supposed to be correlated with the individual error term.

The new equations (1) and (2), obtained by replacing the individual error terms c_{ji} (with j= 1,2) in the right hand side of equation 3, will be estimated by using standard random-effects probit (equation (1)) and tobit (eqation (2), due to the censored nature of R&D expenditure) software.

[7] We decided to use such constructed variables in light of the high within-variation of the obstacles factors variables.

5. Empirical evidence

5.1. Descriptive statistics

One of the conjectures in this paper is that firm sectoral affiliation is an important determinant of the nature and dimension of the effects of demand obstacles on firms' innovative behavior. Following the classification proposed by Eurostat and based on an aggregation of NACE manufacturing and service sectors, we identify four macro categories: high/medium-high tech manufacturing industries (HMHt), low/medium-low tech manufacturing industries (LMLt), knowledge intensive services sectors (KIS) and less knowledge intensive services sectors (LKIS). Table 3 depicts the sectoral (2 digit) composition and the distribution of these 4 macro categories and reports the mean of the two demand obstacles variables Lack of demand and Uncertainty for each sector. In terms of sectoral composition, there is a slight prevalence of LMLt firms, almost 35% of the total observations, while the remaining 65% of the observations are roughly equally distributed among the three other sectoral categories (HMHt, KIS and LKIS). Looking at the highest sectoral frequencies by macro-categories it emerges that about 22% of LMLt firms operates in the food, beverage tobacco sectors; around 29% of HMHt companies is active in the chemical sectors; 35% of KIS firms carry out computer programming activities and finally 36% of the LKIS are active in the trade sector. Among these four macro-sectors, almost 20% of firms have experienced an increase in the degree of importance assigned to uncertainty of demand, while a lower percentage (around 16%) experienced an increase in the degree of importance of the lack of demand as a perceived obstacles. Turning to the sectoral categories, no striking differences can be found, with a percentage range going from 13.54 (HMHt) to 17.90 (LKIS) for the variable Uncertainty and from 17.39 (HMHt) to 22.26 (LKIS) for the variable Lack of demand. In general, these figures show a quite high firm's responsiveness to changes in the demand condition that can hinder their innovation activities. This evidence is further corroborated by the figures in table 4, which report the mean values (in percentage) of the two demand related obstacles variables by year and sectoral categories. As emerged, though, the percentage of firms that perceived as more important the demand obstacles factors decreases over time, still these variables show a considerable within variation.

< INSERT TABLE 3 AND 4>

Turning to possible sectoral specificities in terms of firm' characteristics, table 5 shows the summary statistics (mean and standard deviation) for the variables presented in the previous section. Some of the differences that emerge are quite in line with the expectations. In particular: 1) HMHt and KIS firms appear to be more prone to engage in R&D, invest more in R&D and have a higher probability to receive subsidies for their innovation activity (in line with the discussion previously pointed out) than the other two categories; 2) firms in the manufacturing sectors show a much higher propensity to export than those active in the services sectors; 3) while no striking sectoral differences are detected with respect to the firm's propensity to use informal methods of protection (with, as expected, the lowest percentage for LKIS category), HMHt firms are much more oriented to protect the results of their innovation activity by means of patents than firms operating in the other sectors (with only the 5% of LKIS firms making use of this type of appropriability method). Looking at the remaining variables, on average 37% of the observations refers to firms that are part of a group, this percentage ranging from 34% for the LMLt category to 42% for the MHMt one. Finally, turning to the variable ln(Size) and ln(Age), on average, firms acting in the KIS sectors appears to be younger and smaller than the firms in the remaining sectoral categories.

< INSERT TABLE 5>

Table 6 report the mean values of the variables for four different types of firms that have been identified by taking into account their "demand obstacles status". More in detail we distinguish firms that did not experienced an increase in the degree of relevance assigned to any of the two obstacles, from those that report an increase in the degree of importance of: only lack of demand obstacle; only uncertainty demand obstacle; both types of demand obstacles. We find that firms that belong to the first category appear to have quite different characteristics from any of the remaining groups. In particular, firms that did not report any increase in the degree of relevance assigned to any of the two obstacles present, with the exception of the variables other obstacles and sales growth, higher values for all the variables considered. Instead, as expected, firms with positive values for the demand obstacles variables appear to be less R&D oriented (both in terms of probability and level of investment) than their counterparts, and this is particularly true for those firms that have reported an increase in the level of importance of the obstacle "lack of demand". This evidence is largely robust across the 4 sectoral categories. Despite at a descriptive level, this evidence seems to suggest that, regardless the sector, demand conditions play an important role in affecting innovative firms' decisions. We test this in an econometric framework in the next section.

< INSERT TABLE 6 and 6.1 >

5.2. Econometric results

The estimation results for the propensity to engage in R&D (probit estimations) and the expenditure in R&D (tobit estimations) for the whole sample are reported in Table 7. The table shows the estimated parameters of the main variables of interest, the demand obstacles, and the control variables.

Before discussing the core results for the demand obstacles we first look at the results for the control variables, which show the expected signs and significance. First, both firms' R&D decisions (whether or not, and how much to invest) appear to be highly persistent over time as the parameters for the initial value and the lagged dependent variables are positive and highly significant. Second, in both estimations, the traditional firms' characteristics affecting R&D expenditures' decisions have the expected sign. Larger and internationalised firms are more likely to carry out R&D activities and to devote more resources to them. Moreover, although the literature is not unanimous, our results suggest that there is a negative and significant relationship between age and R&D, so that younger firms are more likely to carry out R&D activities. Third, other variables that characterise the innovation behaviour of firms such as the use of IPR and receiving public subsidies also positively affect R&D investments. Finally, while firms with higher level of sales growth have more chances to engage and invest more in R&D, the increase in the percepction of other obstacles to innovation exerts, as expected, a negative and highly significant effect on both firm' decisions.

The results of the estimations (Tables 9 and 10) are consistent with most of the previous results regarding the effect and significance of the control variables across the four groups of sectors. The parameters for the initial conditions and the lagged dependent variables are positive and significant showing that the likelihood of carrying out R&D and R&D investment are highly persistent across different sectors. In addition, as in the estimation on the full sample, size and participation in foreign markets have a positive relationship with the decision to engage in R&D and the level of investment. Public subsidies also show positive and significant parameters across the four groups of sectors. On the other hand, age is only significant in the less knowledge intensive services, showing a negative link as in the full-sample estimation. Finally, the negative effect of the variable controlling for other obstacles is particularly important in high and medium-high technology manufacturing sectors and in knowledge intensive sectors

5.2.1 Uncertainty, lack of demand and R&D strategies

Turning to our main variables of interest, we find that an increase in the level of uncertainty for the demand for innovative goods or services as perceived by firms does not affect their R&D decisions or is weakly positively related to the amount of R&D invested. In particular, in the sectoral estimations the parameter is not significant and therefore an increase in uncertainty neither affects the likelihood of engaging in R&D nor the amount invested in these activities.

As mentioned in Section 2, the theoretical literature on the relationship between uncertainty and R&D does not offer a conclusive answer. The few empirical studies in this field seem to support a negative relationship (Czarnitzki and Toole, 2011 & 2013), while in some recent works (Stein and Stone, 2013) a positive relationship between uncertainty and R&D investment is found, which seems to be (weakly) supported by our full-sample estimations. Our results suggest that there might be a defensive strategy as a reaction to an increase in the perceived demand uncertainty in terms of firms' increasing their decision to invest or the budget devoted to R&D.

The weakly positive relation between uncertainty and R&D behaviour might be explained by a "caution-effect" that leads to a reduction of the responsiveness of R&D to changes in business conditions when uncertainty is higher (Bloom, 2007). Overall, our findings support the (robust) evidence on the persistence over time of R&D activities (see also Cefis and Orsenigo, 2001): decisions to invest in R&D seem therefore to belong to structural, long-term firms' strategies. After all, especially when spending in basic research and in the first phases of applied research, returns to R&D are themselves almost by definition highly uncertain and in most of the cases highly risky. Part of the demand uncertainty might therefore be already "incorporated" in the strategic horizon of firms' decisions and even be considered an incentive to face uncertainty by competing on product quality.

In contrast with this result, and very interestingly for the purpose of our analysis, the perception by firms of an increase in the deterioration of the conditions of the demand has a strong and significant negative effect on R&D strategy. Falling or lack of demand for goods and services not only has a negative effect on the amount invested in R&D but also reduces the likelihood of engaging in R&D altogether. Although a general stagnation of demand may affect prices and therefore lead to a net increase of demand for cheaper innovative products (OECD, 2012), our results show that the negative effect is clearly dominant, suggesting that rather than uncertainty on a single product or a specific portfolio of products' demand, it is the general macro-economic condition and therefore expectations on the aggregate state of the economy that affect firms' R&D strategies. This confirms our conjecture that, especially in time of crisis, demand-pull perspectives on innovation should be revisited and made better use of for (macro) policy purposes. We will reprise these considerations in the concluding section.

< INSERT TABLE 7 >

5.2.2 Uncertainty, lack of demand and R&D strategies – sectoral specificities

The estimations carried out for the four groups of sectors (Tables 9 and 10), distinguishing between manufacturing and service sectors as well as their technological content show that the effect of demand obstacles on R&D investments are homogenous across sectors. Results are therefore robust, confirming that demand conditions affect R&D

behaviour in all type of firms, regardless their sectoral affiliation. High demand uncertainty neither affects the likelihood of performing R&D nor the amount invested in it, in any of the four sectors. On the contrary, a deterioration of general demand conditions has a negative effect across all four sectors. However, the magnitude of these effects is not homogeneous across all sectors. In particular, the reduction of the demand has more intense effect on the expenditure in R&D in the less knowledge intensive services.

< INSERT TABLE 8 AND 9 >

6. Concluding remarks

This paper has reprised demand-pull perspectives from the point of view of barriers to innovation and investigated whether the perception of lack of demand and demand uncertainty negatively affects decisions to invest in R&D and amount of financial effort devoted to R&D.

Our main conjecture is that the size of demand and expectations on profitability, and therefore the perceived lack of demand and of market dynamism are likely to have different effects than the perceived uncertainty on demand on the propensity to engage in R&D and the amount of financial resources devoted to R&D.

While the former reflects a general trust in the state of the economy and more of a macro-condition for firms to be verified, the latter is rather more of a micro-condition related to the specific characteristics of the product and therefore to the specific user needs that this is supposed to meet. We claim, and find empirical support to, that lack of trust in macro-condition and a dynamic demand would be more of a deterrent for firms to even engage in innovative activities, whereas the uncertainty on the specific demand and user needs would still be a deterrent but are likely to be incorporated in the specific R&D plans.

We found support to this conjecture: from our analysis it emerges that while the perception of increasing lack of demand has a significant, strong and negative effect on both decisions to invest and amount of investments in R&D, increasing demand uncertainty do not seem to have any significant effect or have a weakly significant positive effect (Stein and Stone, 2013). Part of the demand uncertainty might therefore be already "incorporated" in the strategic horizon of firms' decisions when they engage in an intrinsically risky and uncertain activity such as R&D.

These findings contribute to the debate on demand-pull and technology-push approaches in innovation studies from a radically novel perspective, the one on barriers to innovation.

The literature on barriers is increasing in importance due to its obvious policy relevance. However, much of the scholarship produced so far, a part few exceptions, has focused on financial barriers, overlooking other importance hindrances that firms might face when deciding to innovate. Overlooking demand-related obstacles – we have claimed here – reflects the dominance of technology-push perspectives and the way the debate between demand-pull and technology-push has "settled" over time (see Di Stefano et al., 2012 for a recent review).

A thorough reflections on the policy implications of these findings goes beyond the scope of the paper. However, our results confirm the importance of demand as a strong incentive to innovate. We support the need to foster demand-side innovation policies in the innovation policy agenda. Although the role of demand is still incipient in innovation policies (Edler and Georghiu, 2007), recent trends show an increase and a growing emphasis in the use of demand-side innovation measures (OECD, 2011; Edler, 2013). These measures may help guaranteeing markets for new goods and services and complement supply-side innovation policy tools to promote innovation efforts and performance.

Finally, our results show that the lack of demand affects negatively the decision to invest in R&D for the four groups of sectors considered. Although sectors differ in terms of the dynamics of innovation, these results suggest that demand-oriented innovation policies may stimulate R&D in all type of industries. Nevertheless, further research is needed to analyse in more detail the reaction of the individual industries to the lack of demand and the convenience to target different policy tools to different sectors.

References

Aghion, P., Askenazy, P., Berman, N., Cette, G., Eymard, L., 2012. Credit Constraints and the Cyclicality of R&d Investment: Evidence from France. Journal of the European Economic Association 10, 1001–1024.

Archibugi, D., Filippetti, A., 2011. Innovation and Economic Crisis: Lessons and Prospects from the Economic Downturn. Routledge.

Archibugi, D., Iammarino, S., 1999. The Policy Implications of the Globalisation of Innovation. Research Policy 28, 317–336.

Atkinson, A.B., Stiglitz, J.E., 1969. A New View of Technological Change. The Economic Journal 79, 573–578.

Blanchard, P., Huiban, J.-P., Musolesi, A., Sevestre, P., 2012. Where There Is a Will, There Is a Way? Assessing the Impact of Obstacles to Innovation. Industrial and Corporate Change 22, 679–710.

Bloom, N., 2007. Uncertainty and the Dynamics of R&D. American Economic Review 97, 250–255.

Bloom, N., Bond, S., Reenen, J.V., 2007. Uncertainty and Investment Dynamics. Review of Economic Studies 74, 391–415.

Bond, S., Harhoff, D., Harho, D., Reenen, J.V., 1999. Investment, R&D and Financial Constraints in Britain and Germany. Institute for Fiscal Studies.

Cainelli, G., Evangelista, R., Savona, M., 2006. Innovation and economic performance in services: a firm-level analysis, Cambridge Journal of Economics, 30, 435–58.

Callejon, M., García-Quevedo, J., 2005. Public Subsidies to Business R&D: Do they Stimulate Private Expenditures? Environment and Planning C: Government and Policy 23, 279–293.

Canepa, A., Stoneman, P., 2008. Financial Constraints to Innovation in the UK: Evidence from CIS2 and CIS3. Oxford Economic Papers 60, 711–730.

Cassiman, B., Golovko, E., Martínez-Ros, E., 2010. Innovation, Exports and Productivity. International Journal of Industrial Organization 28, 372–376.

Cefis, E., Orsenigo, L., 2001. The persistence of innovative activities: A cross-countries and cross-sectors comparative analysis. Research Policy 30, 1139–1158.

Cohen, W.M., 2010. Fifty Years of Empirical Studies of Innovative Activity and Performance, in: Bronwyn H. Hall and Nathan Rosenberg (Ed.), Handbook of the Economics of Innovation, Handbook of The Economics of Innovation, Vol. 1. North-Holland, pp. 129–213.

Czarnitzki, D., Toole, A.A., 2011. Patent Protection, Market Uncertainty, and R&D Investment. Review of Economics and Statistics 93, 147–159.

Czarnitzki, D., Toole, A.A., 2013. The R&D Investment–Uncertainty Relationship: Do Strategic Rivalry and Firm Size Matter? Managerial and Decision Economics 34, 15–28.

D'Este, P., Iammarino, S., Savona, M., von Tunzelmann, N., 2008. What Hampers Innovation? Evidence from UK CIS4 SPRU Electronic Working Paper Series (SEWPS), no. 168 (February).

D'Este, P., Iammarino, S., Savona, M., von Tunzelmann, N., 2012. What Hampers Innovation? Revealed Barriers Versus Deterring Barriers. Research Policy 41, 482–488.

David, P.A., 1985. Clio and the Economics of QWERTY. The American Economic Review 75, 332–337.

Di Stefano, G., Gambardella, A., Verona, G., 2012. Technology push and demand pull perspectives in innovation studies: Current findings and future research directions. Research Policy 41, 1283–1295.

Dosi, G., 1982. Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. Research Policy 11, 147–162.

Dosi, G., 1988. Sources, Procedures, and Microeconomic Effects of Innovation. Journal of Economic Literature 26, 1120–1171.

Edler, J., 2013. Review of Policy Measures to Stimulate Private Demand for Innovation. Concepts and Effects, Manchester Institute of Innovation Research, University of Manchester, January 2013 (http://research.mbs,ac.uk/innovation/).

Edler, J., Georghiu, L. 2007. Public procurement and innovation. Resurrecting the demand side. Research Policy 36, 949-963.

Fontana, R., Guerzoni, M., 2008. Incentives and uncertainty: an empirical analysis of the impact of demand on innovation. Cambridge Journal of Economics 32, 927–946.

Galende, J., de la Fuente, J.M., 2003. Internal Factors Determining a Firm's Innovative Behaviour. Research Policy 32, 715–736.

Galia, F., Legros, D., 2004. Complementarities between Obstacles to Innovation: Evidence from France. Research Policy 33, 1185–1199.

Gallouj, F., Savona, M., 2009. Innovation in services: a review of the debate and a research agenda. Journal of Evolutionary Economics 19, 149–172.

González, X., Jaumandreu, J., Pazó, C., 2005. Barriers to Innovation and Subsidy Effectiveness. The RAND Journal of Economics 36, 930–950.

Hall, B.H., 2002. The Financing of Research and Development. Oxford Review of Economic Policy 18, 35–51.

Hottenrott, H., Peters, B., 2011. Innovative Capability and Financing Constraints for Innovation: More Money, More Innovation? Review of Economics and Statistics 94, 1126–1142.

Iammarino, S., Sanna-Randaccio, R., Savona, M., 2009. The Perception of Obstacles to Innovation. Foreign Multinationals and Domestic Firms in Italy. Revue d'économie industrielle 125, 75–104.

Kleinknecht, A., Verspagen, B., 1990. Demand and Innovation: Schmookler Re-examined. Research Policy 19, 387–394.

Klepper, S., 1996. Entry, Exit, Growth, and Innovation over the Product Life Cycle. The American Economic Review 86, 562–583.

Levin, R.C., Klevorick, A.K., Nelson, R.R., Winter, S.G., Gilbert, R., 1987. Appropriating the Returns from Industrial Research and Development. Brookings Papers on Economic Activity 3, 783–831.

Liu, X., Buck, T., 2007. Innovation Performance and Channels for International Technology Spillovers: Evidence from Chinese High-tech Industries. Research Policy 36, 355–366.

López-García, P., Montero, J.M., Moral-Benito, E., 2013. Business Cycles and Investment in Productivity-Enhancing Activities: Evidence from Spanish Firms. Industry & Innovation 20, 611–636.

Mairesse, J., Mohnen, P., 2002. Accounting for Innovation and Measuring Innovativeness: An Illustrative Framework and an Application. The American Economic Review 92, 226–230.

Mancusi, M.L., Vezzulli, A., 2010. R&D, Innovation, and Liquidity Constraints. KITeS Working Papers 30/2010, Bocconi University.

Meyers, S., Marquis, D.G., 1969. Successful industrial innovation: critical factors for the 1990s. National Science Foundation, Washington, DC.

Mowery, D., Rosenberg, N., 1979. The Influence of Market Demand Upon Innovation: a Critical Review of some Recent Empirical Studies. Research Policy 8, 102–153.

Mundlak, Y., 1978. On the Pooling of Time Series and Cross Section Data. Econometrica 46, 69–85.

Narula, R., Zanfei, A., 2003. The International Dimension of Innovation, in: Fagerberg, J., Mowery, D.C., Nelson, R.R. (Eds.), The Oxford Handbook of Innovation. Oxford University Press, Oxford, pp. 318–345.

OECD, 2011. Demand-side Innovation Policies. Organisation for Economic Co-operation and Development.

OECD, 2012. Innovation in the crisis and beyond, in: OECD Science, Technology and Industry Outlook. Organisation for Economic Co-operation and Development.

Pellegrino, G., Savona, M., 2013. Is money all? Financing versus knowledge and demand constraints to innovation. UNU-MERIT Working Paper Series 029.

Piva, M., Vivarelli, M., 2007. Is Demand-pulled Innovation Equally Important in Different Groups of Firms? Cambridge Journal of Economics 31, 691–710.

Salomon, R.M., Shaver, J.M., 2005. Learning by Exporting: New Insights from Examining Firm Innovation. Journal of Economics & Management Strategy 14, 431–460.

Savignac, F., 2008. Impact of Financial Constraints on Innovation: What Can Be Learned from a Direct Measure? Economics of Innovation and New Technology 17, 553–569.

Schiantarelli, F., 1996. Financial Constraints and Investment: Methodological Issues and International Evidence. Oxford Review of Economic Policy 12, 70–89.

Schmookler, J., 1962. Economic Sources of Inventive Activity. The Journal of Economic History 22, 1–20.

Schmookler, J., 1966. Invention and Economic Growth. Harvard University Press, MA.

Stein, L., Stone, E. 2013. The effect of uncertainty on investment, hiring and R&D: Causal evidence from equity options, mineo.

Tiwari, A., Mohnen, P., Palm, F., Schim van der Loeff, S., 2008. Financial Constraint and R&D Investment: Evidence from CIS, in: Determinants of Innovative Behaviours: A Firm's Internal Practice and Its External Environments. London, pp. 217–242.

Von Hippel, E., 1978. Successful Industrial Products from Customer Ideas. Journal of Marketing 42, 39.

Von Hippel, E., 1982. Appropriability of innovation benefit as a predictor of the source of innovation. Research Policy 11, 95–115.

Von Tunzelmann, N., Wang, Q., 2003. An Evolutionary View of Dynamic Capabilities. Structural Change and Economic Dynamics 6, 33–64.

Wallsten, S.J., 2000. The Effects of Government-Industry R&D Programs on Private R&D: The Case of the Small Business Innovation Research Program. The RAND Journal of Economics 31, 82–100.

Wooldridge, J.M., 2005. Simple Solutions to the Initial Conditions Problem in Dynamic, Nonlinear Panel Data Models with Unobserved Heterogeneity. Journal of Applied Econometrics 20, 39–54.

Table 1. Composition of the panel

Time obs.	N° of firms	%	%Cum	N° of obs.
2	384	4.26	4.26	768
3	511	5.55	9.81	1,533
4	647	7.08	16.89	2,588
5	893	9.85	26.74	4,465
6	2,123	23.25	49.99	12,738
7	4,574	50.01	100.00	32,018
Total	9,132	100		54,110

Note: the final sample only comprises firms for which a lag of the dependent variable is available. This implies that t=2 refers to firms that are observed for at least three periods, t=3 corresponds to firms that are observed for four periods and so on.

Table 2. Transition probabilities: R&D performers

		Performer in t	
		R&D	
		0	1
Performer in t-1	0	90.95	9.05
	1	14.15	85.85
	Total	43.98	56.02

Table 3. Sectoral composition for macro categories (relative frequencies) and percentage of firms that experienced an increase in the degree of importance of the demand (uncertainty and lack) related obstacles

	Freq. For category	% over category	% over total	Incr. in lack of demand	Incr. in uncertainty demand
Low/Med-Low	18,730	100.00	34.61	16.27	19.87
Petroleum	39	0.21	0.07	10.26	20.51
Food products beverages, tobaco	4,109	21.94	7.59	16.50	19.96
Textiles	1,180	6.30	2.18	13.90	16.86
Wearing apparel	370	1.98	0.68	14.32	24.32
Leather -products, footwear	359	1.91	0.66	19.50	18.38
Wood-products, cork	599	3.20	1.11	20.03	24.71
Pulp/paper-products	546	2.92	1.01	13.00	16.12
Rubber and plastics	1,981	10.57	3.66	14.89	19.59
Mineral products (no mettalic)	1,736	9.27	3.21	17.40	20.68
Basic metals	955	5.10	1.76	16.65	20.52
Fabricated metal products	3,464	18.49	6.40	17.26	20.84
Furniture	1,119	5.98	2.07	18.77	21.00
Other manufacturing n.e.c.	1,835	9.80	3.39	14.39	18.37
Repair of fabricated metal products	438	2.34	0.81	13.47	19.86
High/Med-High	11,736	100.00	21.69	13.54	17.39
Chemicals	3,364	28.67	6.22	12.90	16.59
Pharmaceutical	909	7.75	1.68	10.34	16.50
Electronic, optical, computer products	1,049	8.94	1.94	12.96	17.35
Electrical equipment	1,265	10.77	2.34	13.20	18.02
Other machinery	3,540	30.17	6.54	15.31	17.91
Motor vehicles	1,274	10.86	2.35	13.19	18.29
Aerospace	143	1.21	0.26	13.29	15.38
Other transport equipment	192	1.64	0.35	15.10	17.71
KIS	11,942	100.00	22.07	15.26	19.58
Telecommunications	312	2.61	0.58	13.46	22.12
Computer programming activities	4,207	35.24	7.77	15.43	20.25
Other inform. and communication serv.	951	7.96	1.76	18.30	22.08
Financial intermediation, insurance	1,086	9.09	2.01	15.29	17.03
Research and development services	1,678	14.05	3.10	11.98	17.10
Other activities*	3,505	29.34	6.48	19.60	19.80
Education	203	1.70	0.38	15.76	20.20
LKIS	11,702	100.00	21.63	17.90	22.26
Trade	4,236	36.20	7.83	16.34	20.87
Passenger transport, warehousing	1,153	9.86	2.13	20.29	23.42
Hotels and Restaurants	708	6.04	1.31	17.37	23.73
Real Estate	317	2.71	0.59	19.87	22.71
Public amministration and auxiliary serv.	3,186	27.22	5.89	17.92	23.07
Other service activities**	2,102	17.97	3.88	8.52	22.65
TOTAL	54,110		100.00	15.81	19.78

* Legal activities; Activities of head offices; Architectural activities; Advertising agencies; Specialised design activities; Veterinary activities.

** Washing and (dry-)cleaning of textile and fur products; Repair of computers and peripheral equipment.

Table 4. Percentage of firms that report an increase in the degree of importance of the demand (uncertainty and lack) related obstacles. (by year and sectoral categories)

	2005		2006		2007		2008		2009		2010		2011	
	Un. Dem.	Lack Dem.	Un. Dem.	Lack Dem.	Un. Dem.	Lack Dem.	Un. Dem.	Lack Dem.	Un. Dem.	Lack Dem.	Un. Dem.	Lack Dem.	Un. Dem.	Lack Dem.
Low/Med-Low	24.07	18.80	19.92	16.80	19.14	13.91	20.50	17.25	19.15	15.33	18.58	16.73	17.98	15.44
High/Med-High	20.00	16.91	17.69	13.32	17.00	11.98	18.07	14.23	16.90	11.54	16.79	13.88	15.25	13.38
KIS	24.37	17.76	20.86	15.47	19.17	14.59	19.96	16.27	17.74	15.45	17.36	14.23	18.38	13.27
LKIS	26.57	20.28	23.52	20.57	20.37	15.28	25.11	18.16	20.36	17.86	19.87	16.54	20.43	16.88
Total	23.73	18.47	20.40	16.54	18.95	13.94	20.87	16.59	18.61	15.09	18.21	15.51	18.03	14.84
Observations	6,616		8,524		8,439		8,229		7,931		7,459		6,912	

Table 5. Descriptive statistics: mean and standard deviation of the variables; all firms and 4 sectoral categories

	All firms		Low/Med-low		High/Med-high		Kis		Lkis	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
ln(R&D)	7.20	6.21	6.92	6.05	9.62	5.52	8.43	6.17	3.95	5.67
R&D dummy	0.58	0.49	0.58	0.49	0.77	0.42	0.66	0.47	0.33	0.47
R&D dummy t-1	0.63	0.48	0.63	0.48	0.80	0.40	0.70	0.46	0.37	0.48
Lack of demand	0.16	0.36	0.16	0.37	0.14	0.34	0.15	0.36	0.18	0.38
Uncertainty	0.20	0.40	0.20	0.40	0.17	0.38	0.20	0.40	0.22	0.42
ln(Age)	3.06	0.65	3.19	0.62	3.20	0.63	2.77	0.66	3.02	0.61
Exporter dummy t-1	0.63	0.48	0.77	0.42	0.85	0.36	0.43	0.50	0.37	0.48
Industrial group	0.37	0.48	0.34	0.47	0.42	0.49	0.35	0.48	0.39	0.49
Patent dummy t-1	0.13	0.33	0.13	0.33	0.20	0.40	0.13	0.33	0.05	0.22
Informal protection dummy t-1	0.24	0.43	0.25	0.44	0.27	0.44	0.26	0.44	0.18	0.38
ln(Size)	4.10	1.56	4.05	1.29	4.08	1.34	3.66	1.67	4.65	1.87
Subsidy dummy t-1	0.37	0.48	0.35	0.48	0.42	0.49	0.48	0.50	0.22	0.42
Sales growth	0.00	0.59	-0.01	0.42	0.00	0.51	0.02	0.78	0.00	0.66
Other obstacles	0.47	0.50	0.48	0.50	0.45	0.50	0.47	0.50	0.46	0.50
Observation	54,110		18,730		11,736		11,942		11,702	

Table 6. Descriptive statistics: mean of the variables by sectoral categories and by obstacles variables status (whole sample, LMLt, HMHt)

	All the sample				Low/Med-low				High/Med-high			
	No-obst.	Uncer. Dem.	Lack of Dem.	Both Obst	No-obst.	Uncer. Dem.	Lack of Dem.	Both Obst	No-obst.	Uncer. Dem.	Lack of Dem.	Both Obst
ln(R&D)	7.65	6.87	5.34	5.57	7.36	6.70	5.11	5.37	10.01	9.35	7.43	8.15
R&D dummy	0.62	0.56	0.44	0.46	0.61	0.55	0.43	0.46	0.79	0.74	0.61	0.67
R&D dummy t-1	0.65	0.58	0.56	0.54	0.65	0.58	0.57	0.55	0.82	0.77	0.73	0.73
ln(Age)	3.08	3.01	3.01	3.04	3.20	3.14	3.14	3.18	3.22	3.16	3.16	3.14
Lack of demand	0	0	1	1	0	0	1	1	0	0	1	1
Uncertainty	0	1	0	1	0	1	0	1	0	1	0	1
Exporter dummy t-1	0.65	0.59	0.58	0.56	0.78	0.74	0.73	0.70	0.86	0.83	0.82	0.78
Industrial group	0.38	0.35	0.33	0.35	0.35	0.33	0.28	0.31	0.43	0.41	0.36	0.39
Patent dummy t-1	0.13	0.11	0.11	0.10	0.13	0.12	0.11	0.10	0.20	0.17	0.17	0.17
Informal protection dummy t-1	0.25	0.22	0.22	0.20	0.26	0.24	0.23	0.22	0.28	0.25	0.23	0.24
ln(Size)	4.14	4.05	3.94	4.06	4.10	3.99	3.81	3.96	4.12	4.07	3.87	3.91
Subsidy dummy t-1	0.38	0.35	0.33	0.32	0.36	0.33	0.32	0.33	0.42	0.42	0.37	0.37
Sales growth	0.00	0.01	-0.03	-0.01	-0.01	-0.01	-0.05	0.00	0.01	0.01	-0.02	-0.03
Other obstacles	0.40	0.60	0.74	0.54	0.41	0.61	0.74	0.54	0.39	0.64	0.73	0.51
Observation	38,244	7,313	5,161	3,392	13,198	2,485	1,811	1,236	8,733	1,414	962	627
%	70.68	13.52	9.54	6.27	70.46	13.27	9.67	6.60	74.41	12.05	8.20	5.34

Table 6 Descriptive statistics: mean of the variables by sectoral categories and by obstacles variables status (Kis and LKIS) (continuation)

	Kis				Lkis			
	No-obst.	Uncer. Dem.	Lack of Dem.	Both Obst	No-obst.	Uncer. Dem.	Lack of Dem.	Both Obst
ln(R&D)	8.77	8.40	6.84	6.94	4.31	3.75	2.80	2.73
R&D dummy	0.69	0.67	0.55	0.55	0.36	0.31	0.24	0.24
R&D dummy t-1	0.72	0.70	0.65	0.62	0.39	0.32	0.35	0.33
ln(Age)	2.80	2.70	2.70	2.78	3.04	2.99	2.99	2.97
Lack of demand	0	0	1	1	0	0	1	1
Uncertainty	0	1	0	1	0	1	0	1
Exporter dummy t-1	0.45	0.41	0.39	0.38	0.39	0.34	0.34	0.34
Industrial group	0.35	0.33	0.33	0.36	0.39	0.37	0.38	0.38
Patent dummy t-1	0.13	0.13	0.11	0.10	0.06	0.05	0.05	0.03
Informal protection dummy t-1	0.26	0.25	0.24	0.20	0.19	0.15	0.17	0.15
ln(Size)	3.71	3.53	3.50	3.67	4.67	4.62	4.56	4.65
Subsidy dummy t-1	0.49	0.48	0.43	0.39	0.23	0.21	0.20	0.19
Sales growth	0.02	0.04	-0.01	-0.05	0.00	0.01	-0.05	0.02
Other obstacles	0.40	0.64	0.74	0.59	0.40	0.50	0.75	0.52
Observation	8,491	1,629	1,113	709	7,822	1,785	1,275	820
%	71.1	13.64	9.32	5.94	66.84	15.25	10.9	7.01

Table 7. Dynamic RE probit and tobit estimations for the whole sample

	(1) R&D Dummy	(2) Ln (R&D)	(3) R&D Dummy	(4) Ln (R&D)
R&D Dummy t-1	0.263*** (0.005)		0.268*** (0.005)	
R&D Dummy t_0	0.229*** (0.008)		0.219*** (0.008)	
Ln (R&D) t-1		0.696*** (0.010)		0.701*** (0.010)
Ln (R&D) t_0		0.469*** (0.013)		0.458*** (0.013)
Uncertainty	0.002 (0.004)	0.146* (0.066)		
Lack of demand			-0.070*** (0.004)	-1.256*** (0.074)
ln(Age)	-0.003 (0.004)	-0.169* (0.078)	-0.003 (0.004)	-0.173** (0.077)
Exporter dummy t-1	0.061*** (0.005)	0.984*** (0.086)	0.060*** (0.005)	0.967*** (0.085)
Industrial group	0.013** (0.005)	0.118 (0.090)	0.013** (0.005)	0.124 (0.089)
Patent dummy t-1	0.039*** (0.007)	0.228* (0.095)	0.039*** (0.007)	0.225** (0.094)
Informal protection dummy t-1	0.033*** (0.005)	0.478*** (0.073)	0.031*** (0.005)	0.463*** (0.073)
ln(Size)	0.036*** (0.002)	0.575*** (0.036)	0.034*** (0.002)	0.558*** (0.036)
Subsidy dummy t-1	0.053*** (0.004)	0.569*** (0.069)	0.052*** (0.004)	0.562*** (0.068)
Sales growth	0.019*** (0.003)	0.315*** (0.044)	0.018*** (0.003)	0.305*** (0.044)
Other obstacles	-0.024*** (0.003)	-0.260*** (0.054)	-0.017*** (0.003)	-0.143*** (0.054)
Constant		-8.560*** (0.350)		-8.156*** (0.345)
N° of observations	54,110	54,110	54,110	54,110
Log likelihood	-18,349.36	-110,152.19	-18,230.76	-115,420.97
σ_u	0.829*** (0.025)	3.286*** (0.063)	0.804*** (0.025)	7.466*** (0.080)
ρ	0.407***	0.311***	0.393***	0.700***
LR test for Rho	741.549	2,759.567	676.358	8,805.801
p-value	0.000	0.000	0.000	0.000

Notes; ***, ** and * indicate significance on a 1%, 5% and 10% level, respectively. Standard errors in brackets. Time and industry dummies are included. Columns 1-3 report marginal effects.

Table 8. Dynamic RE probit and tobit estimations for Manufacturing sectors (Low/medium tech and High/medium sectors)

	Low/medium-low tech Sectors				High/medium-high tech Sectors			
	(1) R&D Dummy	(2) Ln (R&D)	(3) R&D Dummy	(4) Ln (R&D)	(5) R&D Dummy	(6) Ln (R&D)	(7) R&D Dummy	(8) Ln (R&D)
R&D Dummy t-1	0.299***		0.303***		0.215***		0.220***	
	(0.009)		(0.009)		(0.012)		(0.012)	
R&D Dummy t_0	0.236***		0.225***		0.183***		0.174***	
	(0.015)		(0.015)		(0.017)		(0.017)	
Ln (R&D) t-1		0.723***		0.729***		0.652***		0.657***
		(0.017)		(0.018)		(0.018)		(0.018)
Ln (R&D) t_0		0.425***		0.414***		0.301***		0.292***
		(0.022)		(0.022)		(0.023)		(0.023)
Uncertainty	0.001	0.184			0.001	0.084		
	(0.007)	(0.118)			(0.007)	(0.105)		
Lack of demand			-0.082***	-1.401***			-0.060***	-1.038***
			(0.008)	(0.133)			(0.008)	(0.120)
ln(Age)	0.000	-0.052	0.001	-0.047	0.001	-0.093	0.001	-0.093
	(0.008)	(0.131)	(0.007)	(0.129)	(0.008)	(0.114)	(0.008)	(0.112)
Exporter dummy t-1	0.083***	1.544***	0.080***	1.525***	0.058***	1.004***	0.056***	0.980***
	(0.009)	(0.166)	(0.009)	(0.165)	(0.010)	(0.162)	(0.010)	(0.160)
Industrial group	0.032**	0.403*	0.031**	0.405*	-0.014	-0.270	-0.014	-0.261
	(0.010)	(0.163)	(0.010)	(0.161)	(0.010)	(0.143)	(0.010)	(0.142)
Patent dummy t-1	0.051***	0.429*	0.049***	0.413*	0.025*	0.111	0.026*	0.120
	(0.012)	(0.170)	(0.012)	(0.169)	(0.011)	(0.128)	(0.011)	(0.127)
Informal protection dummy t-1	0.035***	0.503***	0.033***	0.484***	0.037***	0.453***	0.036***	0.442***
	(0.009)	(0.133)	(0.009)	(0.132)	(0.009)	(0.112)	(0.009)	(0.112)
ln(Size)	0.064***	1.025***	0.062***	0.993***	0.049***	0.697***	0.047***	0.676***
	(0.005)	(0.075)	(0.004)	(0.074)	(0.005)	(0.068)	(0.005)	(0.067)
Subsidy dummy t-1	0.043***	0.460***	0.043***	0.461***	0.034***	0.264**	0.034***	0.264**
	(0.007)	(0.118)	(0.007)	(0.118)	(0.008)	(0.102)	(0.007)	(0.101)
Sales growth	0.020**	0.369**	0.019**	0.359**	0.013*	0.260**	0.012*	0.244**
	(0.007)	(0.115)	(0.007)	(0.114)	(0.005)	(0.079)	(0.005)	(0.079)
Other obstacles	-0.013*	-0.080	-0.006	0.045	-0.042***	-0.442***	-0.037***	-0.363***
	(0.006)	(0.097)	(0.006)	(0.097)	(0.006)	(0.084)	(0.006)	(0.083)
Constant		-10.892***		-10.493***		-4.502***		-4.175***
		(0.703)		(0.691)		(0.673)		(0.662)
N° of observations	18,730	18,730	18,730	18,730	11,736	11,736	11,736	11,736
Log likelihood	-6,962.85	-38,630.89	-6,906.97	-38,575.79	-3,444.10	-27,914.75	-3,414.47	-27,877.33
σ_u	0.813***	3.398***	0.783***	3.318***	0.896***	2.375***	0.857***	2.318***
	(0.039)	(0.111)	(0.039)	(0.112)	(0.061)	(0.097)	(0.061)	(0.097)
ρ	0.398***	0.297***	0.380***	0.288***	0.446***	0.278***	0.423***	0.268***
LR test for Rho	279.950	935.581	250.348	885.615	148.184	604.328	129.396	566.990
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes; ***, ** and * indicate significance on a 1%, 5% and 10% level, respectively. Standard errors in bracketsTime and industry dummies are included. Columns 1-3-5-7 report marginal effects.

Table 9. Dynamic RE probit and tobit estimations for services sectors (KIS and LKIS)

	KIS				LKIS			
	(1) R&D Dummy	(2) Ln (R&D)	(3) R&D Dummy	(4) Ln (R&D)	(5) R&D Dummy	(6) Ln (R&D)	(7) R&D Dummy	(8) Ln (R&D)
R&D Dummy $t-1$	0.275***		0.278***		0.233***		0.237***	
	(0.011)		(0.011)		(0.010)		(0.010)	
R&D Dummy t_0	0.175***		0.168***		0.244***		0.234***	
	(0.017)		(0.017)		(0.016)		(0.016)	
Ln (R&D) t-1		0.715***		0.717***		0.773***		0.782***
		(0.020)		(0.020)		(0.032)		(0.032)
Ln (R&D) t_0		0.336***		0.330***		0.804***		0.784***
		(0.024)		(0.024)		(0.044)		(0.043)
Uncertainty	0.002	0.077			0.006	0.327		
	(0.008)	(0.125)			(0.008)	(0.229)		
Lack of demand			-0.050***	-0.790***			-0.074***	-2.215***
			(0.009)	(0.143)			(0.009)	(0.262)
ln(Age)	-0.008	-0.210	-0.009	-0.222	-0.026**	-0.968***	-0.027**	-0.979***
	(0.009)	(0.156)	(0.009)	(0.155)	(0.009)	(0.280)	(0.008)	(0.275)
Exporter dummy t-1	0.032***	0.309*	0.031***	0.300*	0.049***	1.154***	0.048***	1.133***
	(0.009)	(0.136)	(0.009)	(0.135)	(0.009)	(0.283)	(0.009)	(0.280)
Industrial group	-0.023*	-0.403*	-0.022*	-0.396*	0.018	0.541	0.018	0.548
	(0.011)	(0.168)	(0.011)	(0.167)	(0.010)	(0.305)	(0.010)	(0.301)
Patent dummy t-1	0.011	-0.094	0.012	-0.088	0.065***	1.051*	0.063***	1.018*
	(0.014)	(0.187)	(0.014)	(0.186)	(0.017)	(0.419)	(0.017)	(0.416)
Informal protection	0.028**	0.354**	0.027**	0.341*	0.024*	0.540*	0.023*	0.526
dummy t-1	(0.009)	(0.134)	(0.009)	(0.134)	(0.010)	(0.275)	(0.010)	(0.273)
ln(Size)	0.034***	0.555***	0.033***	0.549***	0.019***	0.528***	0.018***	0.515***
	(0.004)	(0.065)	(0.004)	(0.065)	(0.003)	(0.101)	(0.003)	(0.100)
Subsidy dummy t-1	0.066***	0.744***	0.065***	0.731***	0.068***	1.368***	0.067***	1.348***
	(0.008)	(0.137)	(0.008)	(0.137)	(0.009)	(0.263)	(0.009)	(0.261)
Sales growth	0.022***	0.339***	0.021***	0.332***	0.013*	0.317*	0.012*	0.314*
	(0.004)	(0.065)	(0.004)	(0.065)	(0.005)	(0.131)	(0.005)	(0.131)
Other obstacles	-0.031***	-0.346***	-0.025***	-0.260*	-0.014*	-0.195	-0.006	0.039
	(0.007)	(0.104)	(0.007)	(0.104)	(0.007)	(0.196)	(0.007)	(0.197)
Constant		-5.819***		-5.608***		-11.614***		-10.979***
		(0.770)		(0.763)		(0.996)		(0.977)
N° of observations	11,942	11,942	11,942	11,942	11,702	11,702	11,702	11,702
Log likelihood	-3,990.23	-26,751.98	-3,973.86	-26,736.80	-3,806.35	-15,858.81	-3,770.68	-15,823.30
σ_u	0.758***	2.808***	0.734***	2.769***	0.806***	5.131***	0.778***	5.005***
	(0.052)	(0.120)	(0.052)	(0.121)	(0.053)	(0.235)	(0.053)	(0.234)
ρ	0.365***	0.267***	0.350***	0.262***	0.394***	0.365***	0.377***	0.355***
LR test for Rho	126.762	546.201	114.697	525.103	152.728	478.487	137.003	457.777
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes; ***, ** and * indicate significance on a 1%, 5% and 10% level, respectively. Standard errors in bracketsTime and industry dummies are included. Columns 1-3-5-7 report marginal effects.

APPENDIX

Table A1. The variables: acronyms and definitions.

Dependent variables (Innovative Inputs)	
R&D dummy	Dummy =1 if firm's R&D (both internal and external) expenditures are positive
ln(R&D)	Natural log of the total firm's expenditures in R&D (both internal and external)
Independent variables (control variables)	
ln(Age)	Natural log of the firms's age (calculated as years elapsed since founding)
Exporter dummy	Dummy =1 if the firm have traded in an international market during the three year period; 0 otherwise
Industrial group	Dummy =1 if the firm is part of an industrial group, 0 otherwise
Patent dummy	Dummy=1 if the firm uses patents; 0 otherwise
Informal protection dummy	Dummy=1 if the firm adopts others instruments of protection than patents; 0 otherwise
ln(Size)	Log of the total number of firm's employees
Subsidy dummy	Dummy = 1 if the firm has received public support for innovation; 0 otherwise
Sales growth	Growth rates of sales (calculated by taking logarithmic differences of sales levels)
Other obstacles	Dummy=1 if the firm reports an higher degree of importance (from period t to period t+1) for at least one of the remaining obstacles variables; 0 otherwise
Independent variables (Obstacles demand variables)	
Lack of demand	Dummy=1 if the firm reports an higher degree of importance (from period t to period t+1) for the obstacles variables "it was not necessary to innovate due to the Lack of demand for innovation"; 0 otherwise
Uncertainty	Dummy=1 if the firm reports an higher degree of importance (from period t to period t+1) for the obstacles variables "Uncertain demand for innovative goods or services"; 0 otherwise