FINANCIAL CONSTRAINTS AND PERSISTENCE IN INNOVATION

PhD student at the University of Barcelona
Research assistant at the Barcelona Institute of Economics
Correspoding e-mail: pere_arque@ub.edu

January 2008

Preliminary Draft

Abstract:

Recent papers provide evidence that firms which perform R&D in one period tend to perform R&D in succeeding periods too. A stream of the literature considers that this persistence is partly due to true state dependence. This means that performing R&D in one period has a positive causal effect on the probability to perform R&D in subsequent periods. However, in a context characterized by the presence of financial constraints, the relevance of the state dependence phenomenon may differ for firms with different degrees of financial autonomy. In such a context, firms with enough internal funds will possibly be able to conduct R&D persistently, whereas firms with low internal funds could have to innovate intermittently or even rule out R&D. To verify this hypothesis I test whether the magnitude of state dependence is higher for firms that are financially autonomous to innovate. To carry out the analysis I use a panel data set of Spanish manufacturing firms (Survey on Firm Strategies) for the period 1998-2002. In a first step I discriminate between firms that can afford their R&D expenditures and firms that can not. Next, I study the sources of persistence for autonomous and non autonomous firms with discrete dynamic models. The results show that state dependence both exists and is higher for firms that are financially self-sufficient to perform R&D.

Key Words: Innovation; Financial constraints; Persistence; State dependence
JEL codes: O30

1. INTRODUCTION

The objective of this paper is twofold. Firstly, it aims to study whether firms' decision to innovate is subject to financial constraints. Secondly, it evaluates the eventual effects of financial constraints on the competitive advantages derived from innovating persistently.

Recent papers provide evidence that firms which innovate in one period tend to innovate in succeeding periods too (Malerba and Orsenigo, 1999 or Cefis, 2002). A stream of the literature considers that this persistence is partly due to true state dependence (Peters, 2006). This means that innovating in one period has a positive causal effect on the probability to innovate in subsequent periods. However, in a context characterized by the presence of financial constraints, the relevance of the state dependence phenomenon may differ for firms with different degrees of financial autonomy. Firms with enough internal funds will possibly be able to innovate persistently whereas firms with low internal funds could have to innovate intermittently or even rule out innovation. Consequently, the synergies derived from past experience in innovation may vanish for firms with low internal funds, reducing even more their chances to innovate.

This study may result interesting in terms of economic policy. First of all, if financial constraints are detected, policies aiming at rising firms' availability of funds will spur innovation. In the second place, if real state dependence exists, innovation-stimulating policies will eventually not only have a positive impact on present innovation but are also likely to have long-lasting effects (Peters, 2006). Finally, if real state dependence only operates, as suspected, in firms with high internal flows, then government support programs will have a higher impact on them.

To carry out the analysis, I use a panel data set of Spanish manufacturing firms for the 1998-2002 period. First, I discriminate between firms that can afford their R&D expenditure and firms that cannot. I consider that a firm is financially autonomous to innovate if it can afford R&D expenditures with its internal funds. That is, if its cash-flow totally covers the minimum required R&D expenditures necessary to obtain profits from innovation. In order to compute such thresholds, I replicate González et al. (2005). Finally, I study the sources of persistence for autonomous and non autonomous firms with two econometric models: a random effects dynamic probit and a pooled probit. To obtain a magnitude of the real state dependence, the average partial effects are calculated. They reveal that state dependence both exists and is higher for firms that are financially self-sufficient to perform R&D. Relative to autonomous firms, about 37% of the persistence in innovation can be traced back to real state dependence. In contrast, real state dependence accounts for only 20.2% of the persistence showed by non autonomous firms

The paper is organized as follows. Section 2 analyses the implications that financial autonomy may have on state dependence and formulates some hypotheses to be tested. Section 3 describes the data and checks whether the hypotheses formulated in section 2 are in agreement with the data. Section 4 introduces the econometric models. Section 5 presents the empirical specifications. Section 6 reports the results. Section 7 concludes.

2. FNANCIAL AUTONOMY AND STATE DEPENDENCE

2.1 Identification of financially autonomous firms

The belief that R&D must be mainly financed with internal funds is based on the existence of adverse selection problems between firms and potential creditors (Stiglitz and Weiss, 1981 and Myers and Majluf, 1984). The uncertain nature of innovative output raises monitoring costs leading to a wedge between internal and external costs.

Many attempts have been made to examine empirically whether firms that perform R&D are financially constrained. A classical methodology consists in estimating R&D investment equations and testing for the presence of excess sensitivity to cash-flow shocks. A finding that investment is sensitive to cash-flow shocks that are not signals of future demand increases would reject the hypothesis that the cost of external funds is the same as the cost of internal funds (Hall, 2002) [1]. However, this approach has proved to be controversial. Firstly, Kaplan and Zingales (1997) argue that it is not necessarily true that the magnitude of the sensitivity increases in the degree of financing constraints. Besides, R&D expenditures, because of their strategic features, are often planned in advance and may not respond to temporary changes in cash-flow. Yet the last studies point that cash flow is more likely to affect the decision to undertake R&D than the level of expenditures in R&D (Bond, Harhoff and Van Reenen, 2003).

Furthermore, if one is interested in a measure of firms' financial autonomy to innovate, the cash flow itself may not be representative since different firms may need to incur different levels of R&D expenditures to obtain profits[2]. In particular, González, et al. (2005) define a framework characterized by firms competing in prices in a product-differentiated industry where demand can be shifted by enhancing product quality and quality can be improved by incurring R&D expenditures. To surpass the current industry standard quality, firms must incur some set-up costs per period. Below this level of R&D expenditure, performing R&D activities yields losses. Therefore, firms willing to innovate will demand funding only above a certain threshold[3]. I consider that a firm is self-sufficient to undertake R&D if its cash flow covers the totality of its

[1] Hall (2002) conducts an exhaustive review of the literature concerning the financing of R&D.

[2] The R&D related literature has long considered that innovative activities are subject to the indivisibility of some resources. This idea appears in Arrow (1962) or Sutton (1992).

[3] González et al. (2005) use the threshold to evaluate subsidy effectiveness for Spanish manufacturing firms.

profitability threshold. The following dummy variable can then be considered as a valid indicator of financial autonomy:

$$COVERAGE = \begin{cases} 1 \quad if \quad \dfrac{cash\ \ flow}{threshold} \cdot 100 > 100 \\ \\ 0 \qquad\quad otherwise \end{cases}$$

2.2. State dependence in innovation: theoretical foundations and some evidence

Economic theory provides some explanations of why state dependence may exist. Peters (2006) offers an exhaustive and structured outline of these reasons to which I am going to refer. First, knowledge accumulates over time through learning-by-doing and learning-to-learn, providing innovation with an accumulative nature where new knowledge draws on old knowledge. Thus, knowledge stock determines the technological progress of the firm and current innovations depend on past experience (Cefis, 2002). The second potential explanation is the hypothesis of "success breeds success". For instance, a firm achieving successful innovations that make a difference in the market can increase its market share. And a higher market share can in turn, spur innovation. At last, sunk costs (Sutton, 1991) can also be seen as an argument in favour of state dependence. Engaging into innovative activities often involves incurring important start-up costs like building an R&D department, hiring researchers and training them. These costs tend to be non recoverable and may act as a barrier to both entry and exit from innovation.

The empirical articles that study the state dependence phenomenon can be divided in two groups according to the variable they use to identify firms' innovation status. The first group studies persistence by focusing on firm's registered patents (an output measure of innovation). This is the case of Cefis and Orsenigo (2001) who study persistence in innovation across countries, sectors and firms. Their results inform us that both innovators and non innovators show a strong tendency to remain in the same state. The second group refers to an innovator as a firm which has some expenditure in R&D (an input measure of innovation). Two good examples are Mañez Castillejo et al. (2004) and Peters (2006). The former article analyses a panel data set of Spanish manufacturing firms during the 1990-2000 period and finds that past experience in R&D has a positive impact on the decision to persist in innovation. The latter uses a panel data set of German manufacturing and service firms for the 1994-2002 period. It finds that state dependence exists and is more relevant for manufacturing firms.

2.3. Financial autonomy and persistence in innovation: hypotheses to verify

I consider a framework similar to that of González et al. (2005) in that firms can only obtain profits from R&D if they invest above a profitability threshold. Firms are free to choose between innovating and remaining in innovative inaction. Nevertheless, profits arising from innovation are higher than those of inaction if the expenditure in R&D exceeds the previously mentioned threshold. Consequently, in the absence of financial constraints all firms could finance the threshold and would always choose to innovate. I further assume that non R&D performers have free access to financial markets at a non significant cost while R&D performers' access to external funding is systematically denied (or external funds are too expensive)[4]. In this context, firms can only finance R&D with their own cash flow. Thus, the interaction between cash flow and thresholds determines a firm's capacity to decide over its innovative activities. Relating this framework characterized by the presence of financial constraints with the existence of state dependence, it is possible to define three different effects on innovative trajectories:

[4] The framework described is extreme, but not too far away from reality. The 2005 Survey of Technological Innovation conducted by the Spanish Institute of Statistics reveals that 50% of Spanish manufacturing firms regard the cost of financing as the major obstacle to innovate.

1. ***True state dependence effect:*** true state dependence implies that innovating in one period enhances the probability to innovate in the subsequent period. Therefore, all firms will exhibit a certain degree of persistence in their R&D status provided state dependence exists. That is, firms that perform R&D in one period will exhibit a positive probability of performing R&D the next period..
2. ***Financial autonomy effect:*** firms which are never covered (COVERAGE=0) will have more difficulties to persist in innovative activities given their inability to finance the profitability threshold. Therefore they are expected to exhibit a lower degree of persistence as well as a higher probability to exit R&D activities. The opposite happens with always covered firms (COVERAGE=1).
3. ***Effect of financial autonomy on true state dependence:*** a firm that is already innovating and is always covered (COVERAGE=1) has no reason to abandon R&D. This stability guarantees that the forces that drive state dependence operate freely (i.e. positive innovations can positively affect the conditions for future innovations or knowledge can accumulate over time). If firms are never covered (COVERAGE=1), these forces are interrupted and the synergies derived from past experience in innovation vanish. As a result, I expect real state dependence to be higher for financially autonomous firms.

Three hypotheses to be tested can be derived from these three effects: i) state dependence exists; ii) the probability to persist and enter into innovation is higher (lower) for always (never) covered firms. The verification of this event could be understood as a proof that innovative firms are subject to financial constraints; iii) state dependence varies depending on the financial autonomy of firms. If state dependence was found to be sensitive to financial autonomy then it would imply that financial constraints not only deter current innovation but also mitigate the synergies inherent to past innovative experience.

3. DATA AND STYLIZED FACTS

3.1. Data

To study the presence and impact of financial constraints on the decision to perform R&D I use the "Encuesta Sobre Estrategias Empresariales" (from now on ESEE)[5]. The ESEE gathers information on manufacturing firms of more than 9 employees that operate in Spain. It is conducted on a yearly basis across twenty different sectors.

The initial sampling of the survey differentiated firms according to their size. Whereas all firms with more than 200 workers where required to participate, firms whose number of workers was between 10 and 200 were selected by stratified sampling (stratification across the twenty sectors of activity and four size intervals). Afterwards, all newly created firms above 200 employees as well as a randomly selected sample of new firms having between 10 and 200 workers have been gradually incorporated.

I refer in this study to the waves comprised between 1998 and 2002 (the last usable wave of the survey) both included. The survey provides information about approximately 2,000 firms each year and the original sample counts 9,325 observations. Nevertheless, for analysing the dynamics in firms' innovation behaviour it is necessary to observe the entire sequence of innovating decisions throughout the whole period under study. Consequently, I drop all the firms that fail to answer consecutively, being left with a balanced panel of 3,660 observations (732 firms for 5 years). The reduction with respect to the original data set is significant, fact that can reduce its representativeness. To evaluate eventual effects of the diminution of the sample on its

[5] The "Encuesta Sobre Estrategias Empresariales" (Survey on Firm Strategies) has been conducted since 1990 by the "Fundación SEPI" under the sponsorship of the Spanish Ministry of Industry.

representativenes, tables 1.A and 2.A of appendix.A compare the distribution of firms by size and innovation status in the total sample and the balanced panel.

Table1.A shows that small firms are slightly overrepresented in the selected panel. Their sales are relatively higher and their R&D expenditures almost double their weight relative to the overall sample. Focusing on the innovative status of the firms, table 2.A shows that the proportion of non R&D performers among small firms is lower in my sample. Their sales and number of employees also account for a smaller share of the total. The contrary is observed when focusing on large firms. Large R&D performers are clearly overrepresented in the balanced panel although their share of sales and employees adopt values similar to those of the overall sample. Thus, the balanced panel contains a higher proportion of small firms as well as of large firms that perform R&D. Nonetheless, tables 1.A and 2.A testify that the distribution of the balanced panel still exhibits grate similarities with the overall sample and can therefore be considered representative.

3.2. Stylized facts: transition probabilities by coverage length

To gain some intuition on whether the data is in agreement with the three hypotheses previously formulated, I construct the variable COVERAGE (defined in section 2.1) [6] and split the sample in three groups. The first group is labelled "always" and only considers firms that are always covered (COVERAGE=1). The second group in labelled "sometimes" and includes firms which switch from COVERAGE=1 to COVERAGE=0 during the sample period. Finally, the third group is labelled "never" and contains those firms that are never covered (COVERAGE=0) during the sample period. One might be suspicious of the validity of COVERAGE as a good indicator of financial autonomy. For instance, if the thresholds showed little variation and were almost the same for all

[6] To estimate the thresholds I replicate González et al. (2005). Details of the estimation are reported in Appendix B, where I also report a brief summary of González et al. (2005) to specify which the parts I have replicated exactly are.

firms COVERAGE would be nothing but a division between firms with high and low cash flow. To alleviate concerns, Chart 1.A of appendix A reports the distribution of cash flow and thresholds by coverage (always, sometimes and never). It turns out that thresholds do matter in determining the group firms belong to. As an example, 30% of the firms belonging to "always" have a cash flow-sales ratio in the lowest decile and are nevertheless considered autonomous to innovate.

Chart1 depicts the transition probabilities distinguishing between the three groups[7]. The first visible result is that the probability of persisting in a given state is high while the probability of observing transitions is low for all groups of firms as expected if state dependence exists. Despite these common features, probabilities differ according to the financial autonomy of the firm. The shapes of the curves give a hint that financial constraints may exist. Two main trends are observed.

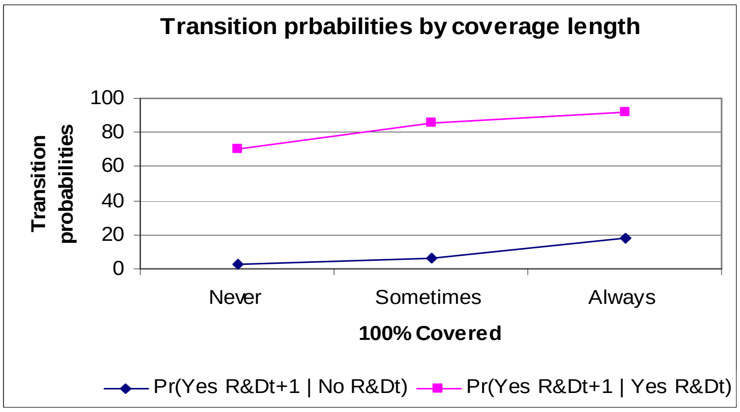
Firstly, the probability of both persisting in innovation and entering into innovation increases with coverage length. Never covered firms exhibit a probability of performing R&D at period t of only the 2.34% if they did not perform R&D at period t-1. This probability increases up to the 18.22% when firms are always covered. Similarly, never covered firms show a probability of persisting in innovation of 70%, whereas always covered firms' probability to persist innovating is nearly 92%.

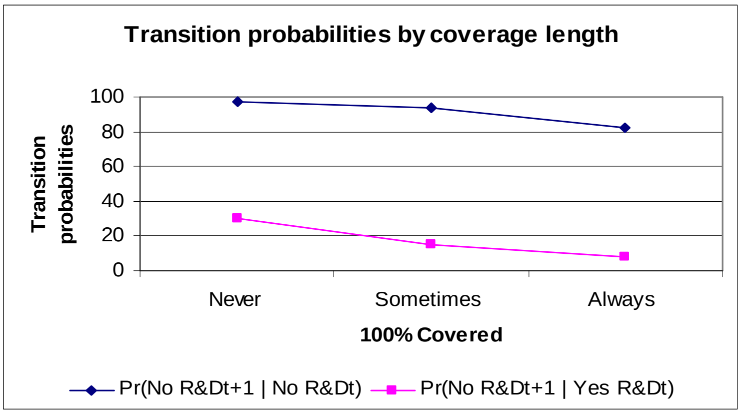
Secondly, the probability of R&D inaction as well as the probability of exiting R&D declines when firms move from never to always covered. The probability of never covered firms to keep on inaction is about 100%. This probability drops noticeably to 81% when firms are always covered. Likewise, the probability of exiting innovation is 22% lower for always covered firms relative to never covered firms. Finally, the state

[7] Table 3 of appendix A reports the transition probabilities in numbers.

dependence measure stemming from transition probabilities is higher for always financed firms (73.71%) than for never covered firms (61.66%).

Chart1. Transition probabilities by coverage length





These results seem to be in accord with the hypotheses formulated in the previous section and can therefore be understood as evidence that innovators are financially constrained and rely on their own funds to innovate. As predicted, additionally, state dependence is greater for always covered firms (see table 3.A of the appendix). Nevertheless, transition probabilities neglect an important part of the factors that cause persistence –such as observable and unobservable characteristics of the firms-. To find a more reliable measure of state dependence it is convenient to carry out a more formal approach.

4. ECONOMETRIC ANALYSIS

4.1. Random effects dynamic probit

The first approach considered to model the dynamic behaviour of innovative activity is a random effects dynamic probit. This model permits isolating true state dependence from persistence arising from individual heterogeneity –either observable or unobservable to the econometrician-. Let's start assuming that a firm $i = 1 \ldots N$ will perform R&D in period $t = 1 \ldots T$ if the expected present value of the profits associated to the investment in R&D, y_{it}^{*} are positive. As a result, if y_{it}^{*} is bigger than zero, we observe that firm i engages in R&D:

$$y_{it} = 1\{\gamma y_{it-1} + z_{it}\beta + c_i + e_{it} > 0\} \qquad (1)$$

where $1\{\cdot\}$ is the indicator function. From expression (1), expected profits depend on the R&D status of the previous period $y_{i,t-1}$. In this context, the parameter γ should be seen as a valid measure of the true state dependence. Moreover, (1) depends on some observable characteristics of the individual captured by the vector of exogenous variables z_{it} and on two unobservable terms c_i and e_{it}. The first one, c_i, embodies the determinants of R&D that are unobservable over time (in the sense that they do not vary during the sample period) such as workers' creativity, the degree of risk aversion of the managers or the commitment of the personnel with firms' goals. The residual variation e_{it} is idiosyncratic and is assumed to follow a standard normal distribution $e_{it} \sim N(0,1)$. Two issues need to be tackled when modelling c_i. Firstly, unobservable factors are likely to be correlated with observed exogenous variables z_{it}. For instance, the degree of risk aversion of the managers is probably related with the property structure of the firm. Similarly, one may expect worker's creativity to be linked with their level of education. Secondly, y_{i0}, that is, firm's R&D status in the initial period, is also likely to be correlated with the factors captured by c_i: a low proportion of skilled workers can induce a firm not to innovate at $t = 0$. These two issues can be addressed by modelling the individual term as

$$c_i = \alpha_0 + \alpha_1 y_{i0} + \alpha_2 \bar{z}_i + a_i \qquad (2)$$

where $\bar{z}_i = T^{-1} \sum_{t=1}^{T} z_{it}$ denotes the temporal average of the observed variables z_{it} and $a_i \sim N(0, \sigma_a^i)$. As Peters (2006) points out, having specified the distribution of c_i in this fashion, Wooldridge (2005) shows that the probability of being an innovator is given by:

$$P(y_{it} = 1 \mid y_{i0}, \ldots, y_{i,t-1}, z_i, \bar{z}_i, a_i) = \Phi(\gamma y_{i,t-1} + z_{it}\beta + \alpha_0 + \alpha_1 y_{i0} + \bar{z}_i \alpha_2 + a_i) \qquad (3)$$

Integrating a_i out of this expression, a maximum likelihood function with the same structure as that of the standard random effects probit is obtained[8]. Nevertheless, to estimate the model by conditional maximum likelihood, the strict exogeneity assumption must hold (Biewen, 2004): there must be no feedback effects from R&D status at period t, y_{it}, to future realizations of the explanatory variables. This assumption is likely to fail in the given context where some of the regressors (i.e. exports over sales, market share or concentrated market dummy, not to mention the financial autonomy of the firm) may be sensitive to the innovative status of the firm. As a preventive measure, I will lag all these variables that are expected to violate the strict exogeneity assumption.

4.2. Pooled probit

Additionally, a simple alternative suggested by Wooldridge (2002) is to use the pooled probit, consistent even in the presence of feedback effects, as an estimator of the true state dependence parameter. Reporting the pooled probit estimates is a common practice

---

[8] This allows carrying out the estimate by STATA.

in many applications[9]. It is useful in that it allows comparing the results of the random effects dynamic probit to its robust counterpart.

The procedure is analogous to that shown above. It is nevertheless necessary to emphasize that estimates of the pooled model yielded by standard software can be seen as those of the random effects model multiplied by $(1+\sigma_a^2)^{-1/2}$. Therefore, to make the results from both models comparable, the parameters of the random effects model need to be normalized by this quantity[10].

A final remark needs to be made regarding the properties of both methods. Whereas the random effects dynamic probit is efficient (given that it takes into account the unobservable heterogeneity of the firms) but inconsistent when feedback effects exist, the pooled probit is consistent but inefficient[11].

4.3. Average Partial Effects (APE)

The two models introduced so far allow stating whether true state dependence exists by referring to the significance level of γ but are not informative of the importance of this phenomenon. Peters (2006) suggests estimating the partial effect after averaging the individual heterogeneity across firms[12]. The average partial effect for the lagged endogenous is:

[9] Hyslop (1999), Biewen (2004) or Peters (2006) are three good examples.

[10] This is due to the fact that the pooled model does not differentiate between the cross and the time dimension of the panel. A detailed explanation can be found in Biewen (2004).

[11] Wooldridge (2000) suggests an extension of the random effects dynamic probit that accounts for the endogeneity of the regressors. This method allows obtaining both efficient and consistent estimates. Nevertheless it is not available in standard software and Biewen (2004) and Blindum (2003) are up to now the only two papers that have implemented it empirically (to study state dependence in individuals' poverty and in unemployment respectively).

[12] Wooldridge (2002) and Wooldridge (2005) already suggest a method to calculate the APE for a specific point in time. Peters (2006) extends this method to calculate the average APE over the whole period of the panel.

$$APE = \frac{1}{N}\frac{1}{T}\sum_{i=1}^{N}\sum_{t=1}^{T}\Phi\left[\hat{\gamma}^{a} + z^{o}\hat{\beta}^{a} + \hat{\alpha}_{0}^{a} + \hat{\alpha}_{1}^{a} y_{i0} + \bar{z}_{i}\hat{\alpha}_{2}^{a}\right] - \frac{1}{N}\frac{1}{T}\sum_{i=1}^{N}\sum_{t=1}^{T}\Phi\left[z^{o}\hat{\beta}^{a} + \hat{\alpha}_{0}^{a} + \hat{\alpha}_{1}^{a} y_{i0} + \bar{z}_{i}\hat{\alpha}_{2}^{a}\right] \quad (4)$$

Where the superscript a denotes the original parameters multiplied by $(1+\sigma_{a}^{2})^{-1/2}$ and z^{o} and y^{o} are fixed values obtained after averaging z_{it} and y_{it} across i and t. The APE is of interest since it will offer the magnitude of the state dependence after discounting the observed and the unobserved heterogeneity.

5. EMPIRICAL SPECIFICATION

To be consistent with the theoretical framework adopted from González et al. (2005), the variables I include in the regression are mainly the same used to estimate the thresholds[13]. The endogenous variable is a dummy variable with value one if the firm performs R&D. With respect to the explanatory variables, these can be divided in five main types: 1) variables that inform of the financial situation of the firm; 2) indicators of the internationalization of the firm; 3) indicators of market power and competition conditions; 4) variables that reflect the elasticity of demand with respect to product quality and the elasticity of product quality with respect to R&D expenditures; 5) variables that capture some set-up costs. Next I describe in depth all these variables as well as the reasons of their inclusion.

With the purpose to control for factors that may alter the financial state of the firm I include in the regressions a measure of the subsidy firms expect to receive from public agencies (ESUBSIDY). This variable has been computed following González et al. (2005). Appendix B reports all the details concerning its estimation in addition to the results of the estimates (table B.1 of appendix B).

[13] That is, the same variables that Gonzálezet al. (2005) include in the equation of R&D decision.

The degree of internationalization is measured with EXPORT $_{t-1}$, a dummy variable that takes value one if the firm has exported during the year. The justification of its inclusion is that exporting firms may have a higher need for innovating to face the challenging competition of international markets.

As indicators of market power and competition conditions I use the market share reported by the firm (MSHARE $_{t-1}$) and a dummy variable which takes the value one if the firm's main market has less than 10 competitors (CMARKET $_{t-1}$). The effects of competition on innovation remain unclear. While standard IO literature associates innovation to monopolistic structures, recent empirical work suggests that competitive markets favour innovation (Blundell et al. 1999). Aghion et al. (2005) find that the relationship between product market competition and innovation is an inverted U-shape.

The elasticity of demand with respect to product quality is considered by two variables. The first of them is QUALITY, a dummy variable with value one if the firm reports that quality is an important feature of the product. In this case firms could find an incentive to innovate given that improvements in their products are appreciated by the customers. The second one is ADVERTISING $_{t-1}$ and the reason it may have and impact on the decision to innovate is similar to the one exposed immediately above: through advertisement, innovations expand to customers having a highest impact on firm's demand. A set of four variables is used as a measure of the elasticity of product quality with respect to R&D. One of them is the average industry patents excluding the patents of the firm (AVPATENTS) and is meant to measure technological opportunities. The other one is AGE, and tries to capture the technological cycle of the firm. A dummy variable taking value one if the firm has highly qualified workers (SKILLED) is also included to provide a measure of the easiness in which research translates into tangible results. Finally, TSOF stands for the degree of technological sophistication of the firm.

It is a dummy variable which takes value one if the firm reports using automatic machines or robots or CAD/CAM and has engineers or graduates.

Finally, following González et al., I include a set of variables to account for set-up costs: a dummy variable with value one if the firm has foreign capital (FOREIGNK); a dummy variable with value one if the firm is allocated in the autonomous communities of Catalonia, Madrid or Valencia (GEOG.OPP.); a dummy variable with value one if the firm reported that its main market was in recession (RECESSIVE $_{t}$-1) and a variable indicating the growth of firms' capital in equipment goods and machinery (KGROWTH). I also include 5 time dummies and 17 sector dummies[14].

6. RESULTS

With respect to the econometric analysis I initially split the balanced panel in two sub samples -one joining firms that are always covered and the other joining firms that are sometimes or never covered[15]- and run the random effects dynamic probit and the pooled probit on each sub sample. Next, I calculate the average partial effects (APE) of the different estimates to obtain a measure of true state dependence.

The pooled and the random effects estimates of each sub sample are reported in Table 5.A and 6.A of appendix A. The lag of the dependent variable as well as all variables described in the previous section -and its respective time averages- are included in the regression. There are nevertheless four variables showing almost no time variation which time average is excluded.

The first main result is the significance of the state dependence parameter in both the pooled and the random effects model. However, the parameter of the pooled model

[14] Descriptive statistics of all the variables are reported in table 4.A of appendix A divided by coverage length (always, sometimes, never).

[15] I do not split the sample in three as I have done with the transition probabilities to make sure that the econometric estimates are made over a reasonable number of observations.

adopts higher values. This is an important but expected discrepancy given that in the pooled model, the parameter of the lagged endogenous picks up part of the persistence caused by unobservable variation. Actually, the value $\rho = \sigma_a^2 /(1+\sigma_a^2)$ proves the importance of unobservable heterogeneity in explaining the R&D status of the firm. It rationalizes 30% of the dependent variable variation.

Besides previous experience in R&D and unobservable heterogeneity, none of the explanatory variables of the structural equation is significant. This is probably a consequence of having introduced most of the variables with a lag. Indeed, I have traded off some explanatory power for the certainty that the strict exogeneity assumption holds.

The significance of ESUBSIDY reveals that firms which consider having a high probability of being granted are more likely to undertake R&D. This result supports the belief that funding is one of innovators' major concerns. Technological opportunities also seem to play an important role in the decision to innovate as derived from the significance of AVPATENTS. Firms with qualified workers (SKILLED) are also more prone to undertake innovative activities. Finally, the fact that the main market of the firm is in recession precludes firms from innovating. It seems, thus, that R&D is, to some extent, pro-cyclical.

Table7 reports the APE obtained from all the different estimates. The magnitudes are as expected always lower than those of the transition probabilities given that firms' heterogeneity is now taken into account. As predicted in section 2, the probability of remaining in R&D activities (Pr (R&D t+1/No R&D t)) is higher for always covered firms. Indeed, its magnitude doubles the probability of never/sometimes covered firms. Similarly, the probability of entering R&D (Pr (R&D t+1/No R&D t)) is also higher for always covered firms and more than doubles the probability exhibited by never/sometimes covered firms. Finally, the APE is also higher for always covered firms revealing that true state dependence is more acute for firms that can self-finance their R&D expenditures. For this group, between 37% (RE dynamic model) and 42% (pooled model) of the innovation persistence can be attributed to true state dependence. For the group of never/sometimes covered firms, only 20% of innovation persistence is due to true state dependence.

TABLE7. Measure of real state dependence in the different samples

		Pr(R&D t+1/ R&D t)	Pr(R&D t+1/No R&D t)	APE
Always covered	RE dynamic probit	0.668	0.297	0.371
	Pooled	0.664	0.241	0.422
Sometimes / never covered	RE dynamic probit	0.329	0.126	0.203
	Pooled	0.331	0.099	0.231

Notes: APE denotes the average partial effects for the lagged dependent variable and is calculated as:
$APE = P(y_{i,t+1} = 1 \mid y_{i,t} = 1, z_i, c_i) - P(y_{i,t+1} = 1 \mid y_{i,t} = 0, z_i, c_i)$

7. CONCLUSIONS

In this paper I have studied the presence and impact of financial constraints on the dynamic behaviour of innovative firms. Special emphasis has been placed on analysing whether true state dependence exists and whether it varies with firms' degree of financial autonomy. The investigation has been carried out over a balanced panel data set of 732 Spanish manufacturing firms during the period 1998-2002.

A first analysis with transition probabilities reveals that firms tend to persist in their R&D status. That is, firms that innovate (do not innovate) in one period show a high probability to innovate (not innovate) in subsequent periods and transitions from one state to the other are not common. However, different trends are observed for firms with different degrees of financial autonomy: firms that are always able to finance their R&D expenditures with their internal funds show a higher probability of both persisting in innovation and entering into innovation.

The econometric analysis has shown that state dependence exists and differs for firms with different degrees of financial autonomy. The average partial effects have been calculated to measure its importance. Relative to firms that are always covered, about 37% to 42% of the persistence in innovation can be traced back to real state dependence. In contrast, real state dependence accounts for only 20.2% of the persistence showed by firms that are never covered. A possible interpretation of these results is that always covered firms can innovate with fewer interruptions, enjoying the advantages arising from previous experience in R&D.

These findings may have several important implications in terms of economic policy. Firstly, since true state dependence exists, innovation-stimulating policy measures will have a long-lasting effect in favour of innovation. Secondly, in the event of financial constraints, this effect will be even deeper and longer for firms that are always financially autonomous. Thus, it may result particularly effective to induce financially autonomous firms to perform R&D.

REFERENCES

Aghion, P., Bloom, R., Blundell, R. Griffith, R. and Howitt, P.(2005), "Competition and Innovation: An Inverted-U relationship", The *Quarterly Journal of Economics*, vol. 120, 701-728.

Arrow, K, (1962), "Economic Welfare and the Allocation of Resources for Inventions", Ed. R. Nelson. , The Rate and Direction of Inventive Activity, Princeton University Press.

Biewen, M. (2004), "Measuring State Dependence in Individual Poverty Status: Are There Feedback Effects to Employment Decisions and Household Composition?", IZA, Discussion Paper No. 1138.

Blindum, W., S. (2003), "Relaxing the Granger Noncausality Assumption in a Random Dynamic Probit Model and the Question of State Dependence", CAM, Working Paper.

Blundell, R., Griffith, R. and Van Reenen, J. (1999), "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms", *Review of Economic Studies*, vol. 66, 529-554

Bond, S., Harhoff, D. and Van Reenen, J. (1999), "Investment, R&D, and Financial Constraints in Britain and Germany", London, Institute of Fiscal Studies Working Paper No. 99/5.

Cefis, E. (2002), "Is there Persistence in Innovative Activities?", *International Journal of Industrial Organization* 21, 489-515

Cefis, E. y Orsenigo, L. (2001), "The Persistence of Innovative Activities, A Cross-Countries and Cross-Sectors Comparative Analysis", *Research Policy* 30, 1139-1158.

González, X., Jaumandreu, J. and Pazó, C. (2005), "Barriers to Innovation and Subsidy Effectiveness", *The Rand Journal of Economics*, vol. 36 (4) pp. 930-949.

Hall, B.H. (1992), "The Financing of Research and Development", *Oxford Review of Economic Policy*, vol. 18, 1.

Kaplan, S. and Zingales, L. (1997), "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?", The Quarterly Journal of Economics, Vol. 112, pp. 169-215.

Hyslop, R. (1999), "State Dependence, Serial Correlation and Heterogeneity in Intertemporal Labor Force Participation of Married Woman", *Econometrica*, Vol. 67, No. 6, pp. 1255-1294.

Malerba, F. and Orsinego, L. (1999), "Technological Entry, Exit and Survival: An Empirical Analysis of Patent Data", *Research Policy* 28, 643-660.

Mañez Castillejo, J. A., Rochina Barrachina, M. E., Sanchis Llopis, A. and Sanchis Llopis, J. (2004), "A Dynamic Aproach to the Decision to Invest in R&D: The Role of Sunk Costs", mimeo.

Myers, S.C. and Majluff, N. S., (1984), "Corporate financing and investment decisions when firms have information that investors do not have", *Journal of Financial Economics*, 13, 187-221.

Peters, B. (2006), "Persistence of Innovation: Stylised Facts and Panel Data Evidence", ZEW Discussion Paper, No. 05-81.

Stiglitz, J.E. and Weiss, A. (1981), "Credit Rationing in Markets With Imperfect Information", *American Economic Review*, 71, 393-410.

Sutton, J. (1991), "Sunk Costs and Market Structure", Cambridge, Mass.

Wooldridge, J. M. (2000), "A framework for estimating dynamic, unobserved effects panel data with possible feedback to future explanatory variables", *Economics Letters* 68, 245-250.

Wooldridge, J. (2002), "Econometric Analysis of Cross Section and Panel Data", Cambridge, Mass.

Wooldridge, J. (2005), "Simple Solutions to the Initial Conditions Problem in Dynamic Nonlinear Panel Data Models with Unobserved Heterogeneity", *Journal of Applied Econometrics* 20(1), 39-54.

APPENDIX A

TABLE1.A Representativeness of the sample by size (only for year 1998)

	Overall sample		Selected balanced panel	
	Small firms	Large firms	Small firms	Large firms
Number of firms	1256	560	529	203
% of firms	69.16	30.84	72.27	27.73
% sales	8.46	91.54	12.95	87.05
% expenditure in R&D	3.62	96.38	6.40	93.60
% employees	13.62	86.38	16.49	83.51

Note: firms are considered large if they have more than 200 employees and small otherwise.

TABLE 2.A Representativeness of the sample by R&D status (only for year 1998)

	Overall sample		Selected balanced panel	
	Do not perform R&D	Do perform R&D	Do not perform R&D	Do perform R&D
Small firms				
Number of firms	965	291	418	111
% firms	76.83	23.17	79.02	20.98
% sales	55.76	44.24	58.46	41.54
% employees	63.27	36.73	79.02	20.98
Large firms				
Number of firms	180	380	46	157
% firms	32.14	67.86	22.66	77.34
% sales	18.55	81.45	17.49	82.51
% employees	20.50	79.50	17.04	82.96

Note: firms are considered large if they have more than 200 employees and small otherwise.

Chart 1.A. Distribution of thresholds and cash flows by coverage lenght

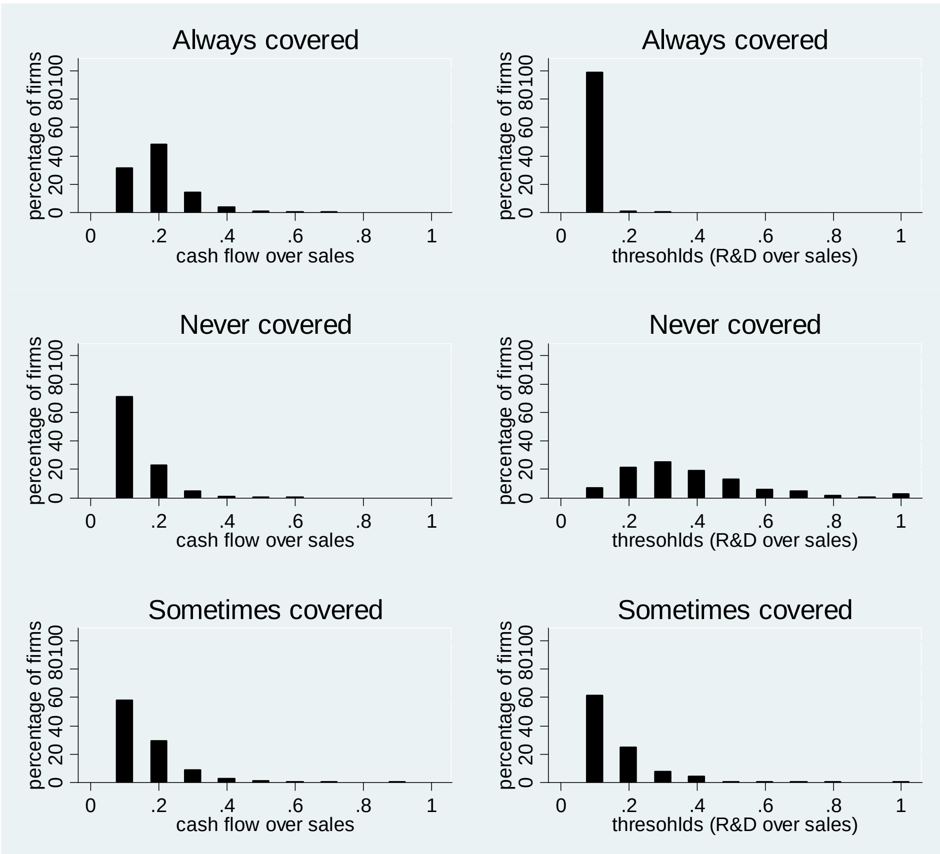


TABLE 4.A Descriptive Statistics

Variable	Always covered						Never Covered						Sometimes covered					
	Mean	Std. Dev. overall	Std. Dev. between	Std. Dev. within	Min	Max	Mean	Std. Dev. overall	Std. Dev. between	Std. Dev. within	Min	Max	Mean	Std. Dev. overall	Std. Dev. between	Std. Dev. within	Min	Max
Dummy R&D $_{t}$	0.66	0.47	0.40	0.26	0	1	0.06	0.25	0.20	0.14	0	1	0.28	0.45	0.39	0.22	0	1
Dummy R&D $_{t-1}$	0.66	0.47	0.40	0.25	0	1	0.07	0.25	0.20	0.14	0	1	0.28	0.45	0.40	0.21	0	1
Log Expected Subsidy	0.06	0.13	0.09	0.10	0.00	2.30	0.01	0.04	0.03	0.02	0.00	0.59	0.03	0.09	0.05	0.07	0.00	2.30
Cash flow/sales ratio	0.15	0.09	0.07	0.05	0.00	0.67	0.05	0.14	0.10	0.10	-1.89	0.55	0.09	0.12	0.07	0.09	-1.04	0.80
Threshold	0.01	0.02	0.02	0.01	0.00	0.20	0.33	0.21	0.19	0.09	0.00	1.72	0.10	0.11	0.10	0.05	0.00	0.93
Coverage	80.09	82.95	73.98	37.77	1	615	-6.50	69.80	55.87	42.02	-1390	1	10.82	52.08	27.79	44.07	-562	803
Never does R&D	0.17	0.37	0.38	0.00	0	1	0.85	0.35	0.36	0.00	0	1	0.54	0.50	0.50	0.00	0	1
Occasionally does R&D	0.40	0.49	0.49	0.00	0	1	0.13	0.33	0.33	0.00	0	1	0.29	0.45	0.45	0.00	0	1
Always does R&D	0.43	0.50	0.50	0.00	0	1	0.02	0.15	0.15	0.00	0	1	0.17	0.38	0.38	0.00	0	1
Skilled Labour	0.96	0.21	0.19	0.09	0	1	0.16	0.37	0.34	0.14	0	1	0.65	0.48	0.45	0.17	0	1
Market Share $_{t-1}$	0.19	0.22	0.20	0.09	0	1	0.03	0.11	0.09	0.07	0	1	0.11	0.18	0.15	0.10	0	1
Concentrated Market $_{t-1}$	0.69	0.46	0.39	0.24	0	1	0.30	0.46	0.36	0.28	0	1	0.52	0.50	0.41	0.29	0	1
Advertising Sales Ratio $_{t-1}$	0.02	0.04	0.04	0.01	0.00	0.28	0.01	0.01	0.01	0.01	0.00	0.14	0.01	0.03	0.03	0.01	0.00	0.47
Average Ind. Patents	0.21	0.29	0.17	0.23	0.00	3.96	0.17	0.34	0.19	0.28	0.00	3.96	0.24	0.46	0.26	0.38	0.00	3.96
Negative Cash Flow	0.01	0.07	0.03	0.07	0	1	0.17	0.38	0.24	0.29	0	1	0.14	0.35	0.17	0.31	0	1
Foreign Capital	0.40	0.49	0.47	0.13	0	1	0.01	0.10	0.08	0.05	0	1	0.15	0.36	0.35	0.10	0	1
Geographical Opportunities	0.54	0.50	0.50	0.06	0	1	0.52	0.50	0.50	0.04	0	1	0.51	0.50	0.50	0.06	0	1
Capital Growth $_{t-1}$	0.39	0.69	0.08	0.68	-1.19	3.26	0.38	0.75	0.12	0.74	-2.93	4.43	0.39	0.71	0.14	0.70	-5.07	3.42
Recessive Market $_{t-1}$	0.12	0.32	0.19	0.27	0	1	0.16	0.37	0.23	0.29	0	1	0.14	0.34	0.20	0.28	0	1
Quality Control	0.72	0.45	0.39	0.22	0	1	0.10	0.31	0.28	0.12	0	1	0.44	0.50	0.44	0.23	0	1
Size	341.60	394.10	383.81	92.21	9	4016	42.68	164.45	163.33	22.10	3	2012	151.62	490.17	479.97	102.63	3	7931
Observations			1494						1098						1800			
Firms			249						183						300			

TABLE 5.A Dynamic probits when firms are ALWAYS COVERED

	Pooled probit		RE dynamic probit	
Structural equation				
R&D $_{t-1}$	1.70***	(0.13)	1.08***	(0.16)
ESUBSIDY	-0.24	(0.82)	-0.09	(0.90)
EXPORT $_{t-1}$	-0.09	(0.41)	-0.11	(0.44)
MSHARE $_{t-1}$	1.08	(0.69)	1.19	(0.78)
CMARKET $_{t-1}$	-0.13	(0.22)	-0.08	(0.25)
ADVERISING $_{t-1}$	-7.81	(4.89)	-6.25	(5.44)
AVPATENTS	0.17	(0.25)	0.14	(0.29)
FOREIGNK	0.10	(0.39)	0.06	(0.42)
GEOG.OPP.	-0.49	(1.05)	-0.72	(1.20)
KGROWTH	0.18	(0.27)	0.13	(0.31)
RECESSIVE $_{t-1}$	-0.15	(0.22)	-0.13	(0.24)
Initial condition				
R&D $_{1997}$	0.65***	(0.15)	1.06***	(0.23)
Variables with no time variation				
QUALITY	0.22*	(0.13)	0.24*	(0.17)
SKILLED	0.79**	(0.31)	0.87**	(0.42)
TSOF	0.40	(1.03)	0.47	(1.41)
AGE	0.01*	(0.00)	0.00*	(0.00)
Random effects (within firms mean)				
ESUBSIDY	3.52***	(1.22)	3.15**	(1.57)
EXPORT $_{t-1}$	0.16	(0.45)	0.21	(0.52)
MSHARE $_{t-1}$	-0.40	(0.76)	-0.38	(0.91)
CMARKET $_{t-1}$	-0.18	(0.28)	-0.32	(0.35)
ADVERISING	6.70	(5.39)	4.66	(6.29)
AVPATENTS	1.83**	(0.80)	2.29**	(1.16)
FOREIGNK	-0.23	(0.43)	-0.20	(0.50)
GEOG.OPP.	0.49	(1.06)	0.71	(1.21)
KGROWTH	1.77**	(0.71)	2.21***	(1.01)
RECESSIVE $_{t-1}$	-0.16	(0.37)	-0.18	(0.50)
σ_a	-		0.66	(0.08)
ρ	-		0.31	(0.05)
LR			0.0000	
Ln L	-366.81		-359.50	
Pseudo R^2	0.533		-	
Observations	1245			
Firms	249			

Notes: ***, ** and * indicate significance on a 1%, 5% and 10% level respectively. Standard errors are shown in parenthesis. A constant (significant at the 1% level) and three sets of dummy variables (of size, sector and time) have been included.

[a] All the coefficients of the RE dynamic probit have been multiplied by $(1+\hat{\sigma}_a^2)^{-1/2}$ to make them comparable to the coefficients of the pooled probit.

TABLE 6.A Dynamic probits when firms are SOMETIMES or NEVER COVERED

	Pooled probit		RE dynamic probit	
Structural equation				
R&D $_{t-1}$	1.92***	(0.12)	1.22***	(0.15)
ESUBSIDY	-0.82	(0.91)	-0.10	(1.14)
EXPORT $_{t-1}$	-0.19	(0.21)	-0.15	(0.23)
MSHARE $_{t-1}$	0.11	(0.54)	0.13	(0.59)
CMARKET $_{t-1}$	0.01	(0.17)	0.02	(0.18)
ADVERISING $_{t-1}$	0.09	(4.57)	-0.69	(4.93)
AVPATENTS	0.21	(0.14)	0.20	(0.16)
FOREIGNK	-0.28	(0.55)	-0.15	(0.57)
GEOG.OPP.	-0.85	(0.73)	-0.87	(0.84)
KGROWTH	0.06	(0.14)	0.05	(0.16)
RECESSIVE $_{t-1}$	0.17	(0.17)	0.11	(0.18)
Initial conition				
R&D $_{1997}$	0.69***	(0.14)	1.08***	(0.21)
Variables with no time variation				
QUALITY	0.13	(0.11)	0.16	(0.14)
SKILLED	0.18	(0.13)	0.22	(0.17)
TSOF	-0.74	(1.34)	-0.76	(1.78)
AGE	0.00	(0.00)	0.00	(0.00)
ESUBSIDY	6.18***	(1.81)	6.32***	(2.37)
EXPORT $_{t-1}$	0.38	(0.25)	0.35	(0.29)
MSHARE $_{t-1}$	-0.33	(0.66)	-0.24	(0.79)
CMARKET $_{t-1}$	0.21	(0.21)	0.20	(0.25)
ADVERISING $_{t-1}$	2.96	(4.70)	4.19	(5.27)
AVPATENTS	0.54	(0.74)	0.88	(0.96)
FOREIGNK	0.53	(0.59)	0.39	(0.64)
GEOG.OPP.	0.92	(0.74)	0.96	(0.85)
KGROWTH	0.03	(0.38)	0.07	(0.51)
RECESSIVE $_{t-1}$	-0.51**	(0.28)	-0.41	(0.36)
σ_a	-		0.66	(0.08)
ρ	-		0.31	(0.05)
LR	-		0.00	
Ln L	-460.64		-359.51	
Pseudo R^2	0.62		-	
Observations	2,415			
Firms	483			

Notes: ***, ** and * indicate significance on a 1%, 5% and 10% level respectively. Standard errors are shown in parenthesis. A constant (significant at the 1% level) and three sets of dummy variables (of size, sector and time) have been included.

[a] All the coefficients of the RE dynamic probit have been multiplied by $(1+\hat{\sigma}_a^2)^{-1/2}$ to make them comparable to the coefficients of the pooled probit.

APPENIX B: Estimation of the profitability thresholds [16]

Let e^* and $\bar{e}$ be the logs of optimal effort and the profitability thresholds respectively.

$$e^* = \beta \ln(1-\rho^e) + z_1\beta_1 + w \quad (1)$$

$$\bar{e} = z\beta_2 + u_2 \quad (2)$$

$$\rho^e = E(\rho \mid z_\rho) = g(z_\rho, \lambda) \quad (3)$$

Were e^* is only observed when $e^* - \bar{e} > 0$, ρ^e is the expectation about ρ, fraction of (the innovative expenditures that is subsidized) and w represents an error. In their article, González et al. (2005) develop four econometric models. “Model I” assumes the disturbance of (3) not to be autocorrelated, while the other three models do assume autocorrelation. The authors explicitly warn that neglecting the autocorrelated nature of the disturbances may cause simultaneity bias to “Model I” estimates. Nevertheless, “Model I” is comparatively much easier to implement and it is model I base my estimates on under the risk of obtaining less precise estimates. To estimate the expected subsidies, equation (3) is decomposed as follows

$$\rho^e = E(\rho \mid z_\rho) = P(\rho > 0 \mid z_\rho) E(\rho \mid z_\rho, \rho > 0)$$

Where $P(\rho > 0 \mid z_\rho)$ is the conditional expectation of getting a grant and $E(\rho \mid z_\rho, \rho > 0)$ is the expected value of the subsidy conditional on z_ρ and its granting. The authors specify $P(\rho > 0 \mid z_\rho)$ by means of a probit of parameters λ_1 and assume $\ln \rho \mid (z_\rho, \rho > 0) \sim N(z_\rho \lambda_2 \sigma^2)$ to estimate $E(\rho \mid z_\rho, \rho > 0)$. Substituting $\hat{\rho}^e$ for ρ^e in the total effort equation, the Tobit model can be estimated. Moreover, one of the identification conditions for the thresholds is the availability of at least one variable that enters the equation for the censored variable but can be excluded on theoretical grounds of the threshold equation (Amemiya, 1985). This condition holds here given that expected subsidies can be excluded from the determinants of the thresholds.

Regarding the estimates of the thresholds, I estimate a Tobit model by means of a Heckman two steps procedure. In the first step I estimate by maximum likelihood the probit model

$$I = \begin{cases} 1 \quad if \quad \gamma \ln(1-\rho^e) + z\gamma_\beta' > \dfrac{w}{\sigma} \\ 0 \qquad\qquad oterwise \end{cases}$$

That will permit to obtain

$$\gamma = \frac{\beta}{\sigma} \quad (4)$$

$$\gamma_\beta = \frac{\beta_1 - \beta_2}{\sigma} \quad (5)$$

and the inverse Mills ratio.

[16] To estimate the profitability thresholds I replicate the methodology used at González, Jaumandreu and Pazó (2005). Next I report the results obtained with my data.

$$\lambda = \frac{\phi(w\gamma)}{\Phi(w\gamma)}$$

where w is the vector of explanatory variables and γ is the vector of parameters obtained with the probit model. Now it is possible to rewrite he optimal effort equation as follows

$$e^* = -\beta \ln(1-\rho^e) + z_1\beta_1 + \beta_\lambda \lambda(w\gamma) + \xi .$$

The estimation of this model yields $\hat{\beta}$ and $\hat{\beta}_1$, which combined with the vector of parameters γ from the probit model facilitate the estimation of $\hat{\sigma}$, and therefore of equation (2) parameters. Thus, from the relationships described in equations (4) and (5) it is now possible to obtain

$$\hat{\sigma} = \frac{\hat{\beta}}{\hat{\gamma}}$$

$$\hat{\beta}_2 = \hat{\beta}_1 - \hat{\sigma}\,\hat{\gamma}_\beta$$

Knowing $\hat{\beta}_2$, the estimation of the thresholds is straightforward: $Threshold = \exp(\hat{\beta}_2 z_1)$ [17]. Table 1.B and 2.B report the results of the estimations.

Table 1.B Estimates of probability and subsidy equations. Dependent variable: indicator function and log of expected subsidy

	Probability equation		Subsidy equation	
Constant	-2.44	(-13.43)	-1.19	(-3.18)
Abnormal subsidy dummies	-0.15	(-0.78)	2.42	(14.82)
Received subsidy at t-1	2.04	(25.33)		
Log of the subsidy at t-1			0.34	(6.84)
No subsidy at t-1			-0.50	(-4.37)
Size t-1	0.01	(2.41)	0.00	(-0.45)
Age	0.01	(3.10)	-0.01	(-3.03)
Technological sophistication	2.24	(6.42)	-0.33	(-0.51)
Capital growth	0.21	(3.84)	-0.19	(-1.15)
Domestic exporter dummy	0.42	(6.28)	0.13	(1.10)
Foreign capital dummy	0.26	(3.63)	-0.09	(-0.74)
Firm with market power dummy	0.13	(2.17)	-0.08	(-0.84)
Industry, region and time dummies[1]	included		included	
Estimation method	Probit		OLS	
Number of firms	1484		268	
Number of observations	7031		1455.264	
Correctly predicted observations:				
zeroes	0.80			
ones	0.84			
R^2			0.45	

Notes: t-ratios in parenthesis (computed from errors robust to heteroskedasticity and serial autocorrelation). [1] 17 industry dummies, two particular region dummies (Navarre and Basque Country) and yearly dummies for periods 1998-2000)

[17] Where the exponential operator undoes the logarithmic transformation previously imposed on the endogenous variable.

Table 2.B Estimate of the thresholds

	R&D effort		R&D decision		Threshold
Constant[1]	-3.93***	(0.24)	-1.78***	(0.10)	-1.29
Expected subsidy	0.19	(0.23)	4.14***	(0.31)	
Market share t-1	-0.28**	(0.14)	0.37**	(0.10)	-0.84
Concentrated market dummy t-1	-0.27***	(0.06)	0.10**	(0.04)	-0.41
Advertising/sales ratio t-1	2.81***	(0.87)	4.46***	(0.64)	-3.80
Average industry patents	-0.06	(0.10)	0.13**	(0.06)	-0.26
Negative cash flow dummy	0.10	(0.11)	-0.25***	(0.06)	0.47
Foreign capital dummy			0.08	(0.05)	-0.11
Geographical opp. dummy			0.07*	(0.04)	-0.10
Capital growth t-1			0.01	(0.02)	-0.01
Recessive market dummy t-1			-0.09	(0.06)	0.13
Quality controls dummy			0.48***	(0.04)	-0.72
Skilled labour dummy			0.68***	(0.05)	-1.01
21-50 workers	-0.45***	(0.12)	0.22***	(0.06)	-0.78
101-200 workers	-0.70***	(0.12)	0.44***	(0.06)	-1.35
201-500 workers	-0.93***	(0.13)	0.95***	(0.06)	-2.33
>500 workers	-1.12***	(0.14)	1.25***	(0.08)	-2.97
Industry dummies	included		included		included
ρ	-0.59				
σ	1.49				
Mills Ratio	-0.88	(0.12)			

Notes: standard errors in parenthesis. First columns estimates refer to parameters β_1, the second to parameters γ_β and the third to parameters β_2. Third columns estimates are based on $\beta_2 = \beta_1 - \sigma\gamma_\beta$.

[1] Firm with less than 20 workers, eighteenth industry.