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Ownership structure and innovation:

Is there a real link?

Raquel Ortega-Argilés*
Rosina Moreno
Jordi Suriñach Caralt

Regional Quantitative Analysis Research Group (AQR)
Department of Econometrics, Statistics and the Spanish Economy
(University of Barcelona)

Corresponding Author
Av. Diagonal 690
08034 Barcelona (Spain)
Phone: +34 93 402 10 10
Fax Number: + 34 93 402 18 21
E-mail: r.ortega@ub.edu

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Abstract: This work focuses on the study of the relationship between ownership and control structure of the company and its innovative activity. Its aim consists of analysing the role that may be played by determinants within the company related to ownership structure when the decision to incur research and development activities is taken as well as on the output of this innovative process. Among these determinants we may think of issues such as who owns the firm and how the control of decision-making is distributed, the nature of this control and the level of concentration of ownership, among others. The study is carried out for the year 2001 using a representative sample of Spanish manufacturing industries.

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Resumen: Este trabajo se centra en el estudio de la relación entre la estructura de propiedad y control de la empresa y la actividad innovadora de la misma. Se pretende analizar el papel que pueden desempeñar ciertos determinantes internos a la empresa relacionados con la estructura de propiedad tanto en la decisión de incurrir en gastos de I+D como en el resultado innovador obtenido por la empresa. Del análisis realizado se podrán extraer conclusiones sobre el efecto que ciertos mecanismos adoptados para paliar los problemas de agencia surgidos por la no identidad entre propiedad y control en puestos de toma de decisiones tienen en la gestión de actividades innovadoras en la empresa. El estudio se realiza para el año 2001 tomando una muestra representativa de las industrias manufactureras españolas.

1. INTRODUCTION

In recent years, companies have become aware of their need to encourage their capacity for innovation. This has reached the point where it has come to be understood as a continuous process that is not formulated in order to attain a specific objective, but instead one that is included in the company's strategy, becoming institutional. Companies feel that they are safer from possible competition by formalising their own innovations in the patents and trademarks register. All types of activities are involved in obtaining this objective - scientific, technological, organisational, financial and commercial.

There is a great deal of recent literature which studies the determinants in innovation. These studies may be categorised as macroeconomic, which try to explain the potentialities in various geographical units in the field of innovation, and microeconomic studies, which analyse the internal determinants within the company to explain innovative efforts and results. Some questions such as the effect of the company's size, its age, its degree of co-operation with other companies or financing, both internal and external, have been analysed in detail in the microeconomic studies. However, there have been few studies which have tried to explain the effect of variables such as the decision-making structure or ownership on the decisions to invest in the company.

A company's ability to innovate depends on a series of factors, in such a way that whether or not they are present has a favourable or unfavourable influence on the innovation process. These factors may be placed in the following groups:

1. The existence of favourable conditions in the demand structure or in the market size, in the life cycle of the products it manufactures, or in the evolution of scientific and technical means that it may use.
2. The resources that the company allocates to engineering, design, research and marketing.

Moreover, the favourable conditions mentioned above and the company's technical capacity must be integrated in the framework of an innovative strategy, and then the following factors become involved:

3. The company's management and organisation.
4. Its desire to differentiate its products or processes from those of its competitors.

Considering the possible significance of the company's management and organisation

with regard to its innovative activity, the third point above, we feel that there is a need to analyse the characteristics of the ownership structure of the company - who owns it and how the control of decision-making is distributed, the nature of this control, the percentage of its capital owned by managers[1] and the level of concentration of ownership, among other issues. The characteristics that may lead to good management of the company's resources, both financial and physical, are innumerable. This will be determinant in the achievement of good results in the company's innovative process, which will determine its growth and its future.

While there are many studies that contain models analysing the determinants of companies in the decision to invest in R&D (Geroski and Pomroy, 1990; Busom, 1993; Gumbau, 1994, 1997; Crépon et al., 1996; Love et al., 1996; Dixon and Seddighi, 1996; Galende and Suárez, 1996; Beneito, 2003, among others), there are very few that include any type of ownership structure variable in their study. Some works analyse what the determinants are in the creation of the company's value, introducing variables which include the structure of capital and control of the company into their analysis (Jensen, 1986; Himmelberg et al., 1999; Hermanlin and Weisbach, 1991; and Kole, 1995; among others), but in most cases they do not analyse the process of innovation, due to a lack of information.

Thus, our work focuses on the study of the relationship between company ownership and control structure and the R&D input and output. Its aim, based on the literature both in the field of ownership structure and in the field of innovation, is to analyse the role that may be played by internal determinants in the company related to its ownership and control structure on the innovative activity of the company.

The article is structured in five parts. After the short introduction, which we have used as a guide to identify the determinants to be considered in our study, and the presentation of our objective, we briefly summarise the empirical literature in the field of the impact of ownership structure in company's results. The third section describes the characteristics of the sample and the methodology followed. In the same section, all the variables considered in our analyses are discussed. The fourth section shows the results obtained in the empirical research. Finally, the main conclusions drawn from our analysis are presented.

[1] In this study, we will use the terms "manager" and "director" indiscriminately to designate workers in decision-making positions.

2. THE RELATIONSHIP BETWEEN OWNERSHIP STRUCTURE AND INNOVATION. WORKING HYPOTHESIS.

In order to draw conclusions regarding the role of organisational strategy in business decisions in general, and in investment decisions in particular, it is necessary to consider the literature concerning capital structure in depth. The literature analysing the subject of ownership and control has provided interesting articles with the objective of studying how companies' capital and financial structure determines their opportunities for growth. These have tried to explain companies' results taking the structure of the company's share capital, the concentration of ownership and the type of main investor as explanatory variables.

Among the works analysing the relationship between capital structure and opportunities for growth are those by Smith and Watts (1992) and Lasfer (1995). The first analyses how financing decisions, on the one hand, and management remuneration policy, on the other, may influence the company's investments and opportunities for growth, with a negative relationship obtained between opportunities for growth and debt, something which provides the opportunity to regulate the agency conflicts affecting them. Lasfer's work confirms the positive influence of "leverage"[2] on those cases in which the company does not have valuable opportunities for growth, as proposed by Jensen (1986) and Stulz (1990). Himmelberg et al. (1999) also analyses the determinants of company value by applying panel data, arguing that the heterogeneity that is not observed generates a spurious correlation between ownership and opportunities for growth.

By carrying out a short review of the literature which relates Tobin's Q ratio[3] with the "managerial ownership"[4] variable, it can be seen that the creation of value has no relationship of a lineal nature with ownership, as the value of the company increases and decreases for various proportions of ownership in the hands of its directors. Among the studies analysing this area are several that obtain an inverted U-shaped relationship (McConnell and Servaes, 1990; Mørck et al., 1988; Holderness et al., 1999). The study by Kole (1995) examines the differences in the works mentioned above and concludes

[2] "Leverage" is understood to be the effect that occurs on risk and the level of variability in a company's results due to the effect of having increased external financing.
[3] Tobin's Q ratio is a proxy valuable in the creation of value. One of the most often used ratios is the quotient between the value of shares and the sum of the company's debt in the financial market and the cost of repositioning its real assets.
[4] We understand "managerial ownership" to be an aspect showing the percentage of shares or ownership in the hands of managers or directors.

that differences in business size may lead to differences in the conclusions drawn by this type of work. Moreover, they do not take into account the problem of endogeneity involved in the use of the variable "managerial ownership" as an explanatory variable, as noted by Jensen and Warner (1988).

Leech and Leahy (1991) carry out a study using data from British companies, with the aim of describing the ownership structure of a sample of large companies and carrying out an econometric analysis of its causes and consequences in terms of control and incentives. They feel that the ownership structure and its level of concentration have an important role in the growth of the company. Using the regression model including variables related to the utility functions of the directors, shareholders and owners, they conclude that the company's opportunity for growth depends on the concentration of ownership and the directors' control.

In Spain, Galve and Salas (1993) carried out an empirical study with the aim of analysing the shareholding composition of Spanish companies and to check whether there were differences in the financial results that were attributable to the type of the owner group controlling the company. They gave details of the mechanism by which the ownership-control influences results, with a positive relation shown between concentration of ownership and the results obtained by the company, as well as family ownership type. In the work by Andrés et al. (2000), which aimed to study the impact of the decision to become indebted and contractual structure on the market value of companies, the conclusion is drawn that concentration of ownership is a harmful influence in the presence of opportunities for growth. A positive relationship between directors' shareholdings and the creation of value in the absence of opportunities is not proved.

Literature concerning ownership structure and its effect on the growth of companies has been analysed up to this point. However, as far as we know, there are hardly any works concerning the role that may be played by a company's ownership structure and the way in which it is constituted and administered on decisions as important as the innovative strategy to be adopted. Some aspects related to ownership structure, among other questions, are only analysed in the works by Love et al. (1996), Dixon and Seddighi (1996), Acs and Isberg (1991) and Francis and Smith (1995). In the first of these, a sample of Scottish companies is analysed, with the conclusion that foreign ownership has a positive effect on the probability of a company located in Scotland obtaining product innovations. In the work by Dixon and Seddighi, carried out with a

sample of English companies, the effect of the type of ownership (domestic or foreign) is analysed. In this work, as well as that by Acs and Isberg, it is independent of the innovation carried out by the company. Finally, the work by Francis and Smith, examines the empirical relation between corporate ownership structure and innovation. They test the hypothesis that diffusely-held firms are less innovative than firms with either a high concentration of management ownership or a significant equity block held by an outside investor. Their results are consistent with the conjecture that concentrated ownership and shareholder monitoring are effective at alleviating the high agency and contracting costs associated with innovation.

For the Spanish case Galende and De la Fuente (1999) have developed an econometric analysis to a sample of Spanish innovative companies. Investigating the determinant factors in the organisation of a firm's innovative activities, their empirical findings confirm the existence of interesting relations between internal factors and the innovative process. The significant effect of the financing mechanism (the use of debt) indicates that high financial debt in the company has an impact in the sense that more incremental innovations are generated than radical ones.

Taking into account the previous literature, we have some a priori ideas on which can be the impact of some variables reflecting the ownership and control structure of firms on their R&D activity. With regards to the level of concentration of the firm's ownership, we expect that the diffusely-held companies will have more probability to undertake R&D costs because of the major mobility of actions of their managers. On the other hand, the incorporation of owners into the firm decisions acts as a direct control of the manager decisions so we expect that due to the lack of specialisation, their effect on the R&D activities will be negative. Finally, despite of the ambiguity of the debt mechanism on the firm investment explained in the literature, we consider that the empirical evidence that points to the negative influence of debt financing on innovation activities should be taken into account.

3. METHODOLOGY AND DATA

3.1. METHODOLOGY

Our objective is to analyse the impact of several aspects related to ownership structure and management/control of the company on the decision to innovate, the

innovative effort and the innovative output, so that the treatment of the data will be different in each case. We will need therefore to develop different models to measure each of these aspects.

3.1.1. The decision to undertake R&D expenses

Our first model will be focussed on the yes/no decision to carry out R&D expenses, so that we estimate a logistic cross-sectional model[5] which relates internal and external structure of the firm and innovation.

As a result, given the binary nature of the endogenous variable for analysis, the decision whether or not to invest in innovation, specifying a discreet choice model is considered appropriate, selecting the logistic model estimated using the maximum likelihood method. Due to the fact that in this type of model the first order conditions are not lineal, the estimated parameters are obtained using iterative procedures. While the parameters are not easy to interpret, their sign shows us the direction of the effect caused by the explanatory variables on the endogenous variable[6]. In this type of model, the quotients between the estimated values of two parameters measure the relative importance of the effects that the explanatory variables associated with these parameters have on the probability of selecting the Y_i=1 alternative. Because of this property, while the coefficients of a logit model are not directly interpretable, their relative values are.

The logistic model can be rewritten in terms of the odds that a particular event will occur. The odds are the ratio between the probability that an event will happen (in this case, that the firm will carry out R&D expenses over the year) and the probability that it will not happen. Thus, Exp (β_i) is the incremental odds ratio corresponding to an increase of one unit in an independent variable, assuming that the values of all other variables remain unchanged. If the value is greater than one the odds increase, and if the value is less than one they decrease.

Taking into account the hypothesis that we aim to test, the model we will estimate follows the next expression:

[5] Like several authors Busom, 1993; Gumbau, 1994; Dixon and Seddighi, 1996; Gumbau, 1997; Galende and Suárez, 1999; Beneito, 2003

[6] For a more detailed explanation of the logit model, see Econometrics manuals such as the one by Greene (2003).

$$INNOV_i = \beta_0 + \beta_1 SIZE_i + \beta_2 AGE_i + \beta_3 OWN_i + \beta_4 STOCK_i + \beta_5 SHARE_i + \beta_6 DEBT_i + \beta_7 HIGH_i + \beta_8 LOW_i + \beta_9 REG_i + \beta_{10} MARKET_i + u_i$$

(Model 1)

As a dependent variable, the innovation input variable INNOV is a dichotomous variable that takes the value of 1 if the company has incurred some R&D expense over the year, and a null value if not.

Considering the objectives stated in the previous section and the ideas expressed in the second section in order to analyse the impact that the various ownership structure and control of the company variables may have on the company's innovative activity, our study includes the following variables.

The variable OWN is the percentage of owners or family members in management positions in the company's total staff as of 31st December in the year analysed. The variable explains the application of the incorporation of owners into decisions posts in the firm to alleviate the ownership and management separation of functions. This separation of functions implies a series of advantages, mainly of specialisation, which businesses cannot ignore. In their study in 1976, Jensen and Meckling noted that there was a problem of free-riding, according to which given the information that investors have on the company's activities is usually limited or not precise, they may have the incentive to involve the company in growth rates above optimal levels instead of trying to maximise its market value. When directors are the people controlling this type of resource, there is the risk of an unproductive or inappropriate use of resources. The solution to this type of conflict may involve providing managers with the incentive to distribute these resources as against investing them in projects with a negative net current value. To ensure this type of conduct, the management team has two basic tools at its disposition. Firstly, an increase in financing in the form of debt, which obliges the manager to release the free resources that the company has generated. Secondly, greater control by investors by means of a concentration of ownership (an instrument used in Spanish industry, as we will see) which acts as a supervision mechanism for the poor use that management may make of these resources. In this latter case, managers' shareholding in the company may also contribute to putting a stop to sub-optimal investment policies.

The variable DEBT, includes the percentage of external financing compared to the total financing. Some authors argue that financing with debt has an ambiguous effect as a mechanism for mitigating agency problems (Hall, 1992; Chiao, 2002). From a

theoretical point of view, transaction cost theory and the agency theory argue that debt financing can discourage innovative activities. The first one analyses the high specificity and intangibility of technological investments. This increases transaction costs and seems to dissuade debt financing. The second theory shows the high risk of these activities and the existing information asymmetries, which cause problems with debt financing (in Galende and De la Fuente, 2003). An increase in the level of indebtedness may lead to increased conflict between shareholders and bondholders. However, this increase may mitigate the divergences of interests between internal and external shareholders and management, as well as providing valuable information regarding business perspectives. Jensen and Meckling (1976) argue that financing in the form of debt leads to the adoption of investment projects with excessive risk. According to them, the contribution made by shareholders to the company has limited responsibility, so that shareholders prefer management to adopt risky investment projects which offer the opportunity to obtain higher profits and in which the increased probability of loss only affects the holder of the debt. However, the latter prefer less risky project enabling surer recovery of the value of their contribution.

The variable SHARE includes information regarding the level of concentration of ownership, showing the percentage of the company's share capital that is in the hands of the main shareholder. This higher concentration may be acting as a mechanism to relieve agency problems arising from the lack of identity between ownership and control. The direct control of the shareholders to the management can reduce the risky investments of the firm. This mechanism has a range of associated disadvantages, related to the increased risk borne by the owners, less liquidity in markets and fewer opportunities for negotiation of the company’s values.

Finally, we include also the variable dichotomous variable STOCK, which takes the value of the unit when the company is quoted on the Stock Exchange, and a null value when it is not.

Furthermore, a range of variables regarding the company's internal structure is considered to check the effect that its general characteristics may have on its innovation. These aspects have been widely analysed in the literature. Problems of bias are thereby avoided in the coefficients of the variables related to the company's ownership structure, which are the main focus of this study.

As far as the company's internal structure variables are concerned, the variable SIZE, a variable showing the size of the business, includes the total personnel numbers

as of 31st December. The variable AGE, the variable showing the company's age or maturity, shows how many years have passed since the company was founded. With regard to the size variable, the study by Schumpeter (1942) suggested the influence of size on this type of analysis. There are theoretical works which argue that larger companies have potentialities such as obtaining economies of scale, decreased risk, a larger market and greater opportunities for appropriation (Fernández, 1996). Despite the unanimity of the theoretical works, from the empirical point of view there is a great deal of disparity in results. There are both studies with a positive result in the relationship between size and innovation (Scherer, 1992; Scherer and Ross, 1990; Love et al., 1990; Cohen and Kleeper, 1996; among others), and others that have not been able to confirm this positive influence of size (Mansfield, 1964; Acs and Audretsch, 1991; among others). The age variable has also been one of the determinants most checked by the literature. The age of the firm is a possible measure of its organisational resources. It represents the experience and knowledge accumulated throughout its history and is related to a better management of communication and of necessary creativity to innovate, and to a more effective capacity of absorption (Galende and De la Fuente, 2003). It is a variable commonly used to measure the experience and the learning of the firms, factors that are organisational resources.

Concerning the information regarding its business sector we have classified the firms into different categories depending on the technological opportunity of their sector. The technological opportunity is considered to be determined by characteristics of the specific industrial sector to which a particular firm belongs. This kind of variables may be capturing various technology dimensions such as technological opportunity, appropriability regimes, dynamic aspects as cumulativeness or the emergence of dominant designs along the technology life cycle, the necessity for complementary and specialized assets, when implementing innovations. Following Lafuente et al. (1985), the industrial sectors of the ESEE can be classified as sectors of high, medium and low technological opportunities[7]. In order to avoid perfect multicollinearity we have eliminated the medium category. Therefore, the variable HIGH is a dichotomous variable which takes the value of the unit when the company belongs to a high

[7] The following have been classified as high technological opportunity sectors: office machinery, computer, processing, optical and similar equipment; chemical products; machinery and mechanical equipment; electrical and electronic machinery and material; motors and autos; other transport material, publishing and graphic arts. As medium technological opportunity sectors: the meat industry; food and tobacco products; beverages; rubber and plastics; non-metallic mineral products; Metallurgy; metal products. And as low technological opportunity sectors: Textiles and clothing, leather and footwear, wood; Paper; Furniture and other manufacturing industries.

technological opportunity sector of activity, and a null value when it is not and the variable LOW is a dichotomous variable which takes the value of the unit when the company belongs to a low technological opportunity sector of activity, and a null value when it is not. We expect that the companies belonging to high opportunity sectors have a more important R&D activity than the companies from low opportunity sectors.

In order to include the effect of the structure of the market in which the company works, the variable MARKET has been included, which provides information regarding the geographical extent of the main market. It is a dichotomous variable that classifies companies according to whether their market is higher or equal to national extent and takes the null value when it is lower than national geographical extent. This variable shows the effect that the company deciding to expand its market to a wider geographical extent may have on R&D activities. This variable also explains the effect of demand on the R&D company decisions and the different kinds of competition whether the geographical extent is higher than national or not. The empirical literature shows a positive relationship between exports and R&D and innovation investments.

Finally, concerning the region where the company is situated, we have constructed the variable REG. The ESEE is not representative at a regional geographical extent, so we constructed the variable REG with the macroeconomic information of The National Statistical Institute (INE). The dichotomous variable REG classifies firms into two categories, firms that are situated in a region with higher technological opportunities than the medium of Spanish regions take the value one, and a null value when their region has a low value of R&D effort with respect to the medium value of the total amount of regions[8]. We expect that the firms situated in a region with high technological opportunities have more possibilities to undertake R&D expenses and to obtain R&D output.

3.1.2. The R&D effort.

The second model explains the R&D effort per employee, which is measured as the R&D expenses per employee. Due to the fact that the dependent variable is a continuous and truncated variable we choose the Tobit model based on the following function:

$$y = \beta' x_i + \varepsilon_i, \varepsilon_i \approx N[0, \sigma^2]$$

The most familiar case of this model, which is typical for expenditures, is the case in which the observed data contain a cluster of zeros, and the observed dependent variable is described with the following structure:

$$y_i^* \begin{cases} 0 \quad \text{when } y_i^* \le 0 \\ y_i^* \quad \text{when } y_i^* > 0 \end{cases}$$

Taking into account the hypothesis that we want to analyse, we develop the following tobit model, which has as a dependent continuous variable the innovation input variable EFFORT, a variable showing the R&D expense per employee over the year:

$$EFFORT_i = \beta_0 + \beta_1 SIZE_i + \beta_2 AGE_i + \beta_3 OWN_i + \beta_4 STOCK_i + \beta_5 SHARE_i + \beta_6 DEBT_i + \beta_7 HIGH_i + \beta_8 LOW_i + \beta_9 REG_i + \beta_{10} MARKET_i + \beta_{11}\lambda_i + u_i$$

(Model 2)

Following the work of other authors that use the Tobit model to analyse the R&D expenses of the firm (Cohen, Levin and Mowery, 1987; Cohen and Klepper, 1996; González and Jaumandreu, 1998; Beneito, 2003), we will include the inverse Mills ratio (λ_i) computed from the previous estimation of the discrete choice model with the aim to control the selection bias. The signification of this parameter explains the importance of the selection bias and the necessity to control the different characteristics of the two groups of firms, the firms that undertake R&D expenses over the year and the firms that do not by means of the discrete choice methods.

3.1.3. The probability to obtain an R&D output

We develop different models to explain the effect of several aspects internal to the firm on the R&D output. In a first step we estimate a model that explains the determinants of the probability to award R&D output (model 3). There are authors that develop a discrete choice model to measure the effect of different variable on the probability of awarding patents or other R&D result (Love et al., 1996; Coronado and Acosta, 1999).

As a result, given the binary nature of the endogenous variable and the hypothesis that we want to estimate, we develop the following logistic model:

$$RESULT_i = \beta_0 + \beta_1 EFFORT + \beta_2 AGE + \beta_3 OWN + \beta_4 STOCK + \beta_5 SHARE + \beta_6 DEBT + \beta_7 HIGH + \beta_8 LOW + \beta_9 REG + \beta_{10} MARKET + u_i$$

(Model 3)

[8] The high technological regions, which take the unit value, are Catalonia, Madrid, Navarre and the Basque Country.

The model has as a dependent variable, the dichotomous variable RESULT, that takes the unit value when the firm award national or foreigner patents and/or models of use, and the null value otherwise. The set of explanatory variables are the same as the ones used in the previous models.

3.1.4. The innovative result

Finally, the fourth model is focussed on the analysis of the R&D output based on the Griliches' work. The Knowledge Production Function framework was originally developed by Griliches (Griliches 1979, 1986) and is conceptualised as a Cobb-Douglas-type function that includes several factors of knowledge production such as the R&D expenditures carried out by the firm (Pakes and Griliches, 1984; Hausman, Hall and Griliches, 1984; Acs and Audretsch, 1988; Crépon and Duguet, 1997; Blundell, Griffith and Van Reenen, 1995).

Specifically, the basic model we consider relates the innovative output in a firm, measured through the number of patents and models of use, to research and development inputs in the same firm through a knowledge production function. We slightly modify this production function so that the increment of the innovative output depends upon a number of further factors related to the internal characteristics of the firms among which some issues related to ownership structure are included.

In order to assess the impact of these determinants on the number of patents and models of use awarded by the firm, the discreteness of the latter variable has to be taken into account. For instance, because of difficulties and uncertainty inherent to R&D activities, firms do not always apply for patents and hence a zero value is a natural outcome of this variable. Because of this property, the use of conventional linear regression models may be inappropriate. The reasons are that some basic assumptions such as the normality of residuals or the linear adjustment of data are no longer fulfilled. The usual way to deal with the discrete non-negative nature of the patent dependent variable is to consider a count data model. (in Cincera, 1997)

One of the most common count data model is the Poisson regression model, the number of events, given a set of regressors X, has a Poisson distribution with density function:

$$f(y_i|x_i) = \frac{e^{-\mu}\mu_i^{y_i}}{y_i!}, y_i = 0,1,2,...$$

The conditional mean depends on the individual characteristics reflected in the regressors, in others words:

$$\mu_i = E(y_i|x_i) = \exp(x_i\beta)$$

The likelihood function, given the independence of the observations, is:

$$L(\beta|y,X) = \prod_{i=1}^{N} Pr(y_i|\mu_i) = \prod_{i=1}^{N} \frac{\exp(-\mu_i)\mu_i^{y_i}}{y_i!}$$

And the logarithmic likelihood function is:

$$\ln L(\beta|y,X) = \sum_{y=1}^{N} [y_i x_i\beta - \exp(x_i\beta) - \ln y_i!]$$

The estimators of the Poisson model would be given by the solution of the first order conditions:

$$\sum_{i=1}^{N} [y_i - \exp(x_i\beta)]x_i = 0$$

The standard procedure for computing the estimators is the Newton-Raphson iterative method. Convergence is ensured because the logarithmic likelihood function is globally concave.

The application of the Poisson model requires equality of means and variance, a requirement that cannot always be met in practice. If the data show overdispersion, the standard errors of the Poisson model will be biased to the low end, giving spurious high values for the t statistics (Cameron and Trivedi, 1986, 1990). The most common formulation for taking into account the overdispersion of data is the negative binomial model. This assumes that the variance is a quadratic function of the mean. We also incorporated like other authors (Coronado and Acosta, 2003) the estimation of the negative binomial model for a more comprehensive evaluation of the hypothesis.

$$PAT_i = \beta_0 + \beta_1 EFFORT + \beta_2 AGE + \beta_3 OWN + \beta_4 STOCK + \beta_5 SHARE + \beta_6 DEBT + \beta_7 HIGH + \beta_8 LOW + \beta_9 REG + \beta_{10} MARKET + u_i$$

(Model 4)

3.2. DATABASE[9]

The database used is the Survey of Entrepreneurial Strategies (*Encuesta sobre Estrategias Empresariales*, henceforth ESEE) produced by the "Public Enterprise Foundation" of Spain for what is today the Ministry of Science and Technology (previously the Ministry of Industry and Energy). The Public Enterprise Foundation's Economic Research Programme designed the survey, supervises its annual production and maintains the database. The ESEE is a statistical research project that surveys a panel of companies representing manufacturing industries in Spain on an annual basis. Its design is relatively flexible and it is suitable for two types of potential use. On the one hand, it provides in-depth knowledge and analysis of the industrial sector's evolution over time by means of multiple data concerning the business and decisions of companies in the sector. The ESEE is also designed to generate micro-economic information that enables econometric models to be specified and tested.

As far as its coverage is concerned, the reference population of the ESEE is companies with 10 or more workers in what is usually known as manufacturing industry. The geographical area of reference is Spain, and the variables have a timescale of one year. One of the most outstanding characteristics of the ESEE is its representativeness. The initial selection of companies took place by combining thoroughness criteria and a random sample. Companies with more than 200 workers were included in the first group, which were requested to participate thoroughly. Companies with less than 200 employees formed the second group, which was selected by stratification sampling, proportional with restrictions and systematic with a random start-up. This is a random sample of the crosses of the 21 CNAE manufacturing activities to two digits and for employment intervals: 2-10, 21-50, 51-100 and 100-200 workers.

As Beneito (2003) points out, the possibility offered by the ESEE of considering not only patents, but also models of use, is particularly important in a sample where the number of SMEs, as we will see later, is considerable. A great portion of innovations in SMEs are incremental innovations and thus are not susceptible to be reflected in patents. The consideration of models of use, as long as they are means of protecting incremental innovations, may come to compensate for this flaw of the patents measure.

[9] For more information concerning the database, see Fariñas and Huergo (1999), Fariñas and Jaumandreu (1994, 1999).

Since the variables have already been presented, in order to place the information within the framework that we are going to use in our study we considered it useful to give a descriptive analysis regarding the variables that will be used in the year under consideration (Tables 1, 2 and 3).

Table 1 shows some statistics describing the quantitative variables in the study for the year 2001. It can be seen that the average concentration of capital in the hands of the main shareholder (SHARE) has a high mean close to 100 per cent. It is worth to emphasize that the median is 100 per cent. It can be concluded that there are a high number of companies that decide to use the concentration of the capital as a possible control mechanism in the face of agency problems between ownership and control. As regards the variable OWN, the variable which considers the rate of owners in management positions in the company's total staff has a low mean and a null value. Finally, the variable DEBT, which includes the percentage of external financing compared to the total financing, seems to present a high mean and a higher medium to respect the others. The higher debt ratio in Europe have been noted by various authors (Prowse, 1990; Bhagat and Welch, 1995). Some of the causes can perhaps be attributed to the less severe conflicts of interest between the stockholders and bondholders in this European countries (France, Germany and Holland), compared to the US. The ownership and governance structures perhaps help mitigate stockholder-bondholder conflicts of interest.

As far as the average SIZE and AGE of the companies considered is concerned, these are medium-sized companies (with an average of 240 workers), which have been stable with the passing of time, and which have an average age of 24 years. With respect the R&D input and output (EFFORT and PAT), the percentages of the median are null in the two cases.

As far as variables of a qualitative nature are concerned, as a prior analysis to the estimation of the model, tables 2 and 3 are added, which show the percentages of companies that state they have invested in R&D in each category and have awarded patents and/or models of use in the current year. The results clearly show on a general scale that companies that do invest in R&D and have an innovative output are a small percentage of the total number of companies.

With regard to the variable which tells us whether or not the company is quoted on the Stock Exchange (STOCK), it is significant that practically all the companies quoted on the Stock Exchange invest in innovation. Moreover, companies quoted on the Stock

Exchange have a higher percentage of awarding some R&D output than the companies that do not quoted on the Stock Exchange.

As anticipated, for the technological opportunity variables, the category showing the highest percentage of investment in R&D and innovative output (national, foreigner patents and models of use) is the category "high technological opportunity" (HIGH), with half the companies in this category having R&D costs. The analysis for the geographical extent of the main market (MARKET), it can be seen that if the extent of the geographical market is higher or equal to the national level, the percentage of companies making an investment in innovation is more important. The same conclusion is obtained in relation to the innovative output, since the companies with their geographical extent of the main market higher or equal to national level have more patents and models of use than the companies with lower markets. Finally, the table shows the influence of the situation of the firm in a region with high technological opportunities (REG), showing approximately half the companies in this category having R&D expenses and also awarding R&D output.

Finally, Table 4 shows the correlation matrix between the variables considered in our model for the year analysed, with the lack of problems of high collinearity between them clearly visible.

4. RESULTS

4.1. The decision to undertake R&D expenses

Table 5 shows the results from the estimation of the logistical model, which explains the determinants in the decision to incur R&D costs for the year 2001. The main factor is the important explanatory role of the variables of ownership structure and control type in companies' innovative activity.

All the variables that we have defined as variables in the company's internal structure are significant[10] for the current year. As was to be expected, both size (SIZE) and age (AGE) presented a positive parameter, leading to the conclusion that the bigger and older the company is, the more likely it is to incur R&D costs. Many authors obtain these results. With regard to the size variable, our results show the influence pointed by

[10] The significance is tested with the use of the Wald statistic, which allow us to check the null hypothesis that each coefficient is 0.

Schumpeter (1942), and some others studies with a positive result in the relationship between size and innovation (Scherer, 1992; Scherer and Ross, 1990; Love et al., 1990; Cohen and Kleeper, 1996; among others). For the case of Spain, there are many studies that have aimed to confirm the effect of the size variable on innovation (Busom, 1993; Labeaga and Martinez-Ros, 1994; Gumbau, 1994, 1997; Molero and Buesa, 1996; Fariñas and Huergo, 1999; Beneito, 2002, 2003; among others) which have reached the same conclusion as Schumpeter, especially in the industrial sector. The age variable (AGE) has also been one of the most checked determinants by the literature, with the conclusion drawn by us reached on most occasions. It is a variable commonly used to measure the experience and the learning of the firms, factors that are organisational resources and the experience and knowledge accumulated. There are some authors who verify a positive impact of age on innovative activity for the Spanish case (Busom, 1993; Molero and Buesa, 1993; Gumbau, 1997, and others). However, there exists a work by Molero and Buesa (1996) which shows that young companies dedicated more resources to innovation.

As far as the variables of ownership structure and control are concerned, the variable showing identity between ownership and control (OWN) tells us that the greater the percentage of owners or relatives in management positions with regard to the total number of employees, the lower the probability of R&D being incurred. This is showing us that the fact that there is an identity between ownership and control makes the probability of incurring R&D costs decline. As pointed out by Rodríguez (1996), the separation between the functions of ownership and management, as well as the appearance of widely diffuse ownership structures (the introduction of other businesses in the company's shareholding) are phenomena that are easy to prove in the vast majority of companies at present (as in the limited company legal status mentioned previously). This separation of functions implies a series of advantages, mainly of specialisation, which businesses cannot ignore.

The variable showing ownership concentration (SHARE) is significant and has a negative parameter, meaning that the greater the concentration of capital in the hands of few people, the lower probability of incurring R&D costs. The relation between the ownership concentration and the innovation has been pointed by different authors (Galve and Salas, 1993; Leech and Leahy, 1991). We consider that companies in a position of effective control (when the largest homogenous group of shareholders possesses at least 50% of shares) have a lower probability of carrying out investment in

R&D. This is a result that may corroborate some studies for the Spanish case (Andrés et al., 2000), which attempts to measure the effect of concentration of ownership of Spanish companies on their results. The utilisation of this mechanism seems to act as a brake on business growth and in our study, it seems to be also a break for the innovative effort.

The variable for measuring the effect of the financing mechanism in the form of debt used to control investment activities carried out by the manager (DEBT) has a significant negative parameter, showing that the probability of incurring in R&D costs is lower with high debt ratios. Our results are in agreement with the theory, which predicts that firms with high debt ratios tend to decrease their R&D expenditures, because R&D expenditures can evaporate in financial distress. There are empirical evidence that find this negative influence (Hall, 1990; Giudici and Paleari, 2000). Among the works dealing with the Spanish situation, that by Azofra et al. (1995) obtains a negative relationship between indebtedness and the valuation ratio. It can be seen in this study how those companies with intangible assets or good opportunities for growth, and as a consequence, higher valuation ratios, tend to resort to debt to a lesser extent. It can also be seen how a positive valuation by the market is synonymous with a high capacity of internal resources that therefore enables external financing to be dispensed with.

Looking at the variable which states whether or not the company is quoted on the Stock Exchange (STOCK), it can be seen that this is not significant in 2001.

With regard to the variables concerning technological opportunity in the sector, it can be seen how those companies with a high technological opportunity (HIGH) have a higher probability of carrying out R&D expenses. Many authors have also obtained the same conclusions, in the sense that belonging to a business sector with a high level of technological complexity is a determinant when innovating (for example, Coronado and Acosta, 1999; Gumbau, 1994, 1997; Scherer, 1965; Cohen and Levin, 1989; Paricio, 1993; Kraft, 1989).

The variable dealing with the geographical extent of the main market in which the company operates (MARKET) shows the effect that the company deciding to expand its market to a wider region may have. This variable includes various issues. Firstly, there is the fact that companies that are classified in the category of the widest geographical extent (Spain and abroad) are in principle larger and more mature companies. This variable also shows the effect of demand on the decision to invest in improving the

product, so that product innovations are determinant in this situation[11]. In this field, an important role is played by dealing with a wider geographical area. International competition is more diverse and more intense than competition in smaller geographical areas, meaning that internal capabilities must be improved by more risky advertising or innovation expenses in order to obtain a safe market share. We can see that this is a significant variable in the year studied, with the estimated parameter positive. This result corroborates the one obtained in other studies, such as those by Gumbau (1997), Geroski (1990), Dixon and Seddighi (1995), Love et al. (1996) and Mansfield (1981,1986).

Finally, with respect to the technological level of the region (REG), the probability of a firm choosing to incur in R&D expenses also seems to increase if the firm is situated in a high technological region than if not, as we expected.

An additional comment in this type of models is their high predictive potential. The prediction potential of a model estimated with logistical methodology is carried out by means of what is known as "classification table", which compares the observed responses with the predicted responses in the implemented model. There is a high percentage of correct classification in the estimated models, being close to 74%.

4.2. The R&D effort

Table 6 reports the estimation results for the tobit model, which explains the determinants of the innovative effort. The first interesting result is that the significance of the variables is equal than the significance of the variables in the probabilistic model of R&D input (Model 1).

As can be deduced from the obtained results, the firm's size (SIZE) seems to have a positive effect on the R&D effort. As size increases, the proportion of R&D expenditures per employee increases (Gumbau, 1997; González and Jaumandreu, 1998). The age of the firms (AGE) seems to have a positive influence on their innovative effort, a results in agreement with some other authors (Busom, 1993; Galende and De la Fuente, 2003).

The results regarding the firm's ownership structure deserve some additional comments. As we obtained in the decision model, the variable showing identity between

[11] This aspect is included in the study by González and Jaumandreu (1998), who study the decision to carry out product innovations for a sample of Spanish companies.

ownership and control (OWN) has a negative and significant parameter, because of the reduction of unproductive or inappropriate use of resources, so that the more owners in decision positions the less R&D effort. Also, the mechanism of ownership concentration (SHARE) and the financing mechanism (DEBT) seems to have the same negative effect on the R&D effort. In a work by Myers (1977) the debt ratio seems to be significantly and negatively correlated with current R&D expenditures, because of financial distress costs, firm with considerable growth opportunities (and, correspondingly, firms that have significant R&D opportunities) are unlikely to issue much debt. However, the variable which states whether or not the company is quoted on the Stock Exchange (STOCK) seems not to have any effect on the R&D effort per employee.

In relation with the technological opportunity of the sector of activity, as we expected, the two variables have significant parameters. Firms that are belonging to a high opportunity sector (HIGH) have more R&D expenditures per employee than companies from low or medium opportunity sectors of activity. The results are similar to other authors for the Spanish case (Busom, 1993; Gumbau, 1997).

The variable REG, indicative of the technological opportunity of the region where the company is situated, has a positive and significant parameter. Therefore, the location of the firm is important for explaining the expense in R&D, explains the importance of the region resources in the firm R&D effort. The effect of geographical opportunities in Spain has been analysed by González and Jaumandreu (1998) with similar conclusions.

Finally, the influence of the geographical extent of their main market (MARKET) has a positive influence of the innovative effort per employee like in the González and Jaumandreu's work (1998). Companies that have a market higher or equal to national have more R&D expenses per employee than companies that have a geographical extent lower than national. The conclusion is that competition has a positive effect on the R&D firm effort.

As regards the Mills ratio, it has a positive and significant effect denoting that the selectivity bias is relevant so it is determinant to control the different answer between the groups of firms (firms that undertaking R&D expenses and firms that do not) as we have made in the previous section.

4.3. The probability to obtain an R&D output.

Table 7 shows the results of the discrete choice model of R&D output (model 3), with quite different conclusions if compared with the results obtained in the R&D input models.

As we expected, the variable that explains de R&D effort per employee (EFFORT) has a positive and significant parameter on the probability to obtain an R&D output, a result which was obtained by other authors (Love et al, 1996, Beneito, 2003; among others). As we expected, the two internal variables that explain the size (SIZE) and the age effect (AGE) on the probability of awarding some R&D output are also positive and significant, denoting the same conclusions that we obtained in the input model. The elder the company is the more probability to obtain R&D output.

Concerning the mechanisms to alleviate the agency problem, only the variable that explains the effect of quoting in the Stock Exchange (STOCK) seems to have a significant effect on the probability to award patents or models of use. If a company is quoted on the Stock Exchange, the probability to obtain an R&D output is higher than if not. This could be related to the idea that the patenting could be used as a signal for the shareholders to increase their shares in the company or even for potential shareholders to take part on the company.

Furthermore, the fact that the company has a geographical extent of their market (MARKET) higher or equal to the national level seems to have a positive and significant effect on the probability to obtain an R&D output. The fact that the market size increases the probability of generating innovation a similar result than in Beneito (2003). Finally, the effect of the sector of activity (HIGH, LOW) and also the region (REG) seems not to be determinant to have an R&D output. This result is contrary to the one by Coronado and Acosta (1999), which finds that the probability to obtain a R&D output is higher in high technological opportunity sectors of activity. Moreover, the Coronado and Acosta work found that if the region where the firm is located is a high technological region the firm has a higher probability to innovate.

In order to evaluate the suitability of the model estimated, we compute a statistic to verify the null hypothesis consisting of the coefficients of the variables being equal to zero. It shows the difference between the logarithm of likelihood for the full model and for the model that only has the constant term. As it can be observed, the log-likelihood ratio test produced a χ^2 value of 70.299 with 11 degrees of freedom. Its significance (*p*

= 0.0000) indicates that these variables are useful for classifying the firms and the model has a high explanatory power. Finally, the predictive efficacy of the model presented is measured in the "classification table". It can be concluded that 93% of the firms are correctly classified with the estimated equation.

4.4. The innovative result

Tables 8 and 9 summarise the results of the count data models (model 4) estimated by the Poisson and the Negative Binomial methods respectively. The equation explains the influence of the variable on the innovative output of the firm. The dependent variable of interest is the total number of patents (national and foreigner) and/or models of use over the year. In general, the results are encouraging since all the coefficients have the expected signs.

Firstly, the results of the Poisson model (table 8) show that the effect of R&D effort (EFFORT) on the R&D output is positive, as we expected. Also, the effect of the internal aspects of the firm (size and age) have the expected signs. The size (SIZE) and the age (AGE) have significant and positive effect on the achievement of obtaining R&D output.

With regards to the analyses concerning the effect of the control mechanisms on the awarded patents in the year several comments are in order. First, there are two mechanisms that seem to have some effect on the R&D output: the identity of the ownership and management (OWN) and the ownership concentration (SHARE), but the effect of the latter is in the opposite direction. Therefore, the results provide evidence that ownership concentration has a different effect in their ability to alleviate agency costs (and thus reducing R&D expenses) and to improve the innovate results of the firms. The identity of the functions of the ownership and management (OWN) has a negative effect on the receive patents and/or models of use. However, the ownership concentration has a positive effect, since closely-held are more innovative than diffusely-held firms. The results provide evidence that ownership concentration (SHARE) has a different effect in their ability to alleviate agency costs and to improve the innovative results of the firms. The application of this mechanism favours to achieve R&D output. This result is found in the empirical literature, which shows favourable results when carrying out projects of a high risk nature like the case of the R&D activities (Rodríguez, 1996; Galve and Salas, 1993; Leech and Leahy, 1991). Finally,

the financing mechanism (DEBT) and the fact that firms are quoted on the Stock Exchange (STOCK) seem not to have a significant effect on the R&D output. The fact that the financing effect has no significant parameter follows the results obtaining in Link (1982), a possible explanation being that R&D activities tend to be financed with internal funds.

As regards the other included variables, the variable that explains the fact of pertaining to a innovative region (REG) and having a geographical extent of the main market (MARKET) higher or equal than the national level seems to be determinant to achieve a good R&D result.

With regard to the Negative Binomial model results (table 9), we can find that only the R&D effort per employee (EFFORT) and the geographical extent of the main market (MARKET) have a positive and significant effect on the R&D output of the firm. Finally, the coefficient of overdispersion on the Negative binomial model is statistically significant showing the adequacy of this type of model.

5. CONCLUSIONS

This study has tried to analyse the effect that various questions related with ownership structure and control of companies have on their R&D activity. It also comes up with conclusions regarding the effect that certain control mechanisms used to alleviate possible agency problems arising from the separation between ownership and control may have on the R&D firm activities.

As shown in the data and as noted by various authors (Rodríguez et al., 1994; Alonso and Andrés, 2002) the ownership structure of Spanish companies does not meet the standards of separation between ownership and control and the existence of a large number of small investors, as is the case in the United States. The Spanish case is included within the European or continental model, in which the concentration of ownership as a mechanism for reducing agency problems predominates.

In view of the results obtained, we can draw some conclusions regarding the use of control mechanisms in resolving agency problems in the administration of business decisions. While this type of mechanism leads to the reduction of agency problems in moral risk arising in informational asymmetries between administrators and shareholders, they may have a number of disadvantages associated with the reduction in action on the part of the administrators.

With regard to the mechanism based on the concentration of capital in a small number of owners, it can be seen that it is the most important mechanisms applied by the company. This mechanism has a range of associated disadvantages, related to the increased risk borne by the owners (due to the reduction in their number to obtain greater control levels), less liquidity in markets and fewer opportunities for negotiation of the company's values. As can be seen in our study, it is a mechanism that does not favour carrying out investments in innovation, due to the higher levels of supervision of administrators' work. However, the application of this mechanism favours to achieve R&D output (patents and/or models of use). This result is in agreement with the empirical literature which found favourable results when carrying out projects of a high risk nature like the case of the R&D activities (Rodríguez, 1996; Galve and Salas, 1993; Leech and Leahy, 1991). Greater control over administrators leads to an increase in business profitability, since it leads to a behaviour that is closer to the maximisation of profits.

The second control mechanism that the study considers is the effect of the inclusion of owners in management and administration tasks. This is a mechanism that aims to alleviate the informational asymmetries that may arise due to the separation between control and administration, with owners assuming administrators' or managers' decision-making tasks. This mechanism moves the company away from the benefits of specialisation. If we therefore consider the importance of specialisation in the context of specific risk of investments in innovation, it can be seen that this mechanism is not the most opportune. Specialisation is on many occasions necessary, in order to have directors with the ability to administer complex organisational structures, diversify risk among shareholders and obtain large volumes of funds to acquire specific assets, as noted by Berle and Means (1932). Decreasing the divergences of interests because of an increase in the number of owners in management positions will make agency costs lower, but risky projects will not be adopted due to the failure to take advantage of specialisation or because there is a high degree of concentration of risk in the hands of a few owners. As can be seen in our results, an increase in the participation of owners in management positions will lower the probability and the intensity both of adopting R&D projects and as well as formalising the result of innovation in the Register of patents and models of use.

As regards the third and final mechanism, financing in the form of debt, it can be seen that although around half of the company financing is made up of external funding,

it is not a significant variable in the achievement to award R&D output, but it seems determinant and with negative effect in the probability and intensity to carry out investment in R&D. Our result is in agreement with the theories and the empirical literature that focus on the influence of debt on the decisions made by managers on the investments policy (Myers, 1977; Hall, 1992; among others).

Finally, with regard to the variables that we introduced in our analysis that show the characteristics of the company's internal structure, the anticipated results are obtained. The effect of the size, maturity, technological opportunity in the business sector to which the company belongs is positively related to the R&D activity, a result in line with the literature. Finally, the market structure and geographical variables are important in the analysis, with the influence of competition in business decisions related to the innovative process especially so.

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TABLE 1. Descriptive Statistics

Variable	Alls sizes					Lab≤200					Lab>200				
	Min.	Max.	Mean	Median	Stand. Dev.	Min.	Max.	Mean	Median	Stand. Dev.	Min.	Max.	Mean	Median	Stand. Dev.
Size	3	14419	239.61	51	642.90	3	200	48	29	47	203	14419	692	395	1143
Age	1	166	24.01	18	20.82	1	161	20	15	17	2	166	34	31	24
Own	0.00	0.30	0.02	0.00	0.05	0.00	0.30	0.03	0.00	0.05	0.00	0.02	0.00	0.00	0.00
Share	1.00	100.00	91.43	100.00	21.30	1.00	100.00	93.32	100.00	19.31	2.00	100.00	87.11	100.00	24.78
Debt	0.00	0.99	0.57	0.58	0.23	0.00	0.99	0.58	0.59	0.23	0.02	0.99	0.54	0.56	0.21
Effort	0.00	9122.75	186.09	0.00	560.62	0.00	5208.23	95.55	0.00	375.89	0.00	9122.75	388.99	102.45	802.06
Pat	0	56	0.36	0	2.34	0	25	0	0	1	0	56	1	0	4

TABLE 2. Share of firms undertaking R&D per category

VARIABLE	CATEGORIES	%
QUOTED ON THE STOCK MARKET (STOCK)	• No	35.0%
	• Yes	74.4%
HIGH LEVEL OF TECHNOLOGICAL OPPORTUNITY (HIGH)	• No	28.5%
	• Yes	49.2%
LOW LEVEL OF TECHNOLOGICAL OPPORTUNITY (LOW)	• No	39.6%
	• Yes	25.1%
GEOGRAPHICAL LIMIT OF THE MAIN MARKET (MARKET)	• Lower than National	12.1%
	• Higher or equal to National	44.6%
TECHNOLOGICAL LEVEL OF THE REGION (REG)	• High technological region	42.1%
	• Low technological region	29.0%

TABLE 3. Share of firms awarding Patents and/or Models of use per category

VARIABLE	CATEGORIES	%
QUOTED ON THE STOCK MARKET (STOCK)	• No	6.8%
	• Yes	20.5%
HIGH LEVEL OF TECHNOLOGICAL OPPORTUNITY (HIGH)	• No	6.4%
	• Yes	8.4%
LOW LEVEL OF TECHNOLOGICAL OPPORTUNITY (LOW)	• No	7.5%
	• Yes	6.2%

GEOGRAPHICAL LIMIT OF THE MAIN MARKET (MARKET)	•	Lower than National	2.3%
	•	Higher or equal to National	8.9%
TECHNOLOGICAL LEVEL OF THE REGION (REG)	•	High technological region	9.2%
	•	Low technological region	5.9%

TABLE 4. Correlation Matrix

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	SIZE	AGE	OWN	STOCK	SHARE	DEBT	HIGH	REG	MARKET	EFFORT	PAT
SIZE	1										
AGE	0.188	1									
OWN	-0.176	-0.150	1								
STOCK	0.141	0.142	-0.085	1							
SHARE	-0.039	-0.059	0.149	-0.174	1						
DEBT	-0.023	-0.256	0.064	-0.075	0.043	1					
HIGH	0.136	0.121	-0.150	0.027	-0.042	0.012	1				
REG	0.099	0.098	-0.034	0.032	-0.034	-0.046	0.045	1			
MARKET	0.166	0.172	-0.203	0.091	-0.095	-0.019	0.119	0.075	1		
EFFORT	0.231	0.147	-0.103	0.067	-0.094	-0.070	0.234	0.049	0.147	1	
PAT	0.179	0.112	-0.050	0.028	-0.018	-0.023	-0.065	-0.046	-0.079	0.030	1

TABLE 5. Model 1: DECISION EQUATION. LOGIT MODEL.

VARIABLE	ODDS-RATIO	COEFFIC.	STANDARD ERROR	Z=b/s.e.
SIZE	1.0023	0.0023	0.0003	7.352***
AGE	1.0078	0.0078	0.0033	2.351**
OWN	0.0008	-7.1745	2.1304	-3.368***
STOCK	1.2163	0.1958	0.4482	0.437
SHARE	0.9908	-0.0092	0.0029	-3.214***
DEBT	0.5568	-0.5856	0.3009	-1.946*
HIGH	1.6183	0.4814	0.1512	3.184***
LOW	0.9252	-0.0777	0.1707	-0.456
REG	1.3016	0.2636	0.1324	1.990**
MARKET	3.3508	1.2092	0.1802	6.710***
Intercept	0.3004	-1.2026	0.3705	-3.246***

***significant at the 0.01 confidence level
** significant at the 0.05 confidence level
* significant at the 0.1 confidence level
Maximum Likelihood Estimates
Dependent variable: INNOV. Year 2001
χ^2= 404.7566 (0.000)
R^2= 34.2%
N = 1414 observations

Classification Table

Observed		Predicted		
		Undertaking R&D		Correct share
		No	Yes	
Undertaking R&D	No	782	120	86.7
	Yes	242	270	52.7
Global share				74.4 %

TABLE 6. Model 2: EFFORT EQUATION. TOBIT MODEL.

VARIABLE	COEFFIC.	STANDARD ERROR	Z=b/s.e.
SIZE	0.2684	0.0441	6.090***
AGE	5.1221	1.5749	3.252***
OWN	-3689.6	1033.6	-3.570***
STOCK	108.05	178.59	0.605
SHARE	-5.2875	1.4354	-3.684***
DEBT	-385.35	157.48	-2.447**
HIGH	409.92	77.196	5.310***
LOW	-134.55	91.315	-1.490
REG	165.20	68.425	2.414**
MARKET	650.47	93.270	6.974***
Intercept	-641.29	188.65	-3.399***
λ	982.42	32.699	30.044***

***significant at the 0.01 confidence level
** significant at the 0.05 confidence level
* significant at the 0.1 confidence level
Maximum Likelihood Estimates
Dependent variable: EFFORT (R&D Expenses/ Employment). Year 2001
Log likelihood function: -4616.510
N = 1414 observations

TABLE 7. Model 3: INNOVATE RESULT. LOGIT MODEL.

VARIABLE	ODDS-RATIO	COEFFIC.	STANDARD ERROR	Z=b/s.e.
EFFORT	1.0006	0.0006	0.0001	4.322***
SIZE	1.0002	0.0002	0.0001	2.085**
AGE	1.0088	0.0088	0.0047	1.881**
OWN	0.0464	-3.0708	3.3806	-0.908
STOCK	2.2319	0.8028	0.4598	1.746*
SHARE	1.0024	0.0024	0.0051	0.466
DEBT	0.9854	-0.0147	0.5161	-0.028
HIGH	0.7934	-0.2314	0.2652	-0.873
LOW	0.9976	-0.0023	0.2892	-0.008
REG	1.0991	0.0945	0.2287	0.413
MARKET	2.7541	1.0131	0.3670	2.761***
Intercept	0.0168	-4.0884	0.6832	-5.984***

***significant at the 0.01 confidence level
** significant at the 0.05 confidence level
* significant at the 0.1 confidence level
Maximum Likelihood Estimates
Dependent variable: INNOV. Year 2001
χ^2= 68.6856 (0.0000)
N = 1414 observations

Classification Table				
Observed		Predicted		
		Awarding R&D output		Correct share
		No	Yes	
Awarding R&D output	No	1312	3	4.04
	Yes	95	4	99.77
Global share				93.07%

TABLE 8. Model 4: INNOVATION EQUATION. POISSON MODEL.

VARIABLE	COEFFIC.	STANDARD ERROR	Z=b/s.e.
EFFORT	0.6357E-03	0.2836E-04	22.411***
SIZE	0.1461E-03	0.1789E-04	8.165***
AGE	0.0116	0.0019	6.177***
OWN	-6.3877	1.8086	-3.532***
STOCK	-0.0541	0.2027	-0.267
SHARE	0.0270	0.0029	9.377***
DEBT	0.0564	0.2265	-0.249
HIGH	-0.0063	0.1180	-0.054
LOW	0.2083	0.1361	1.530
REG	0.4318	0.1056	4.089***
MARKET	1.5650	0.2215	7.066***
Intercept	-5.8615	0.4067	-14.411***

***significant at the 0.01 confidence level
** significant at the 0.05 confidence level
* significant at the 0.1 confidence level
Maximum Likelihood Estimates
Dependent variable: PAT. Year 2001
Log likelihood function: -1353.380
X^2 = 925.3222 (0.0000)
N = 1414 observations

TABLE 9. Model 4: INNOVATION EQUATION. NEGATIVE BINOMIAL MODEL.

VARIABLE	COEFFIC.	STANDARD ERROR	Z=b/s.e.
EFFORT	0.1282E-02	0.6301E-03	2.035**
SIZE	0.8634E-03	0.5312E-03	1.625
AGE	0.0135	0.0148	0.912
OWN	0.9479	3.1911	0.297
STOCK	-0.2065	1.7556	-0.118
SHARE	0.0119	0.0124	0.965
DEBT	0.5547	1.0067	0.551
HIGH	-0.5799	0.5598	-1.036
LOW	0.2313	0.3997	0.579
REG	0.2308	0.3783	0.610
MARKET	1.3423	0.3931	3.415***
Intercept	-4.9190	1.5974	-3.079***
λ	22.7700	3.3140	6.871***

***significant at the 0.01 confidence level
** significant at the 0.05 confidence level
* significant at the 0.1 confidence level
Maximum Likelihood Estimates
Dependent variable: PAT. Year 2001
Log likelihood function: -563.2185
X^2 =1580.323 (0.0000)
N = 1414 observations