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FIRM COMPETITIVE STRATEGIES AND THE LIKELIHOOD OF SURVIVAL. THE SPANISH CASE

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Abstract: This paper analyses the impact that some managerial competitive strategies followed by a firm may have on its survival. We have not only considered the classic strategies related to the *passive learning process* defined by Jovanovic (e.g., R&D or advertisement expenses), but we have also taken into account *the active learning process* ideas given by Ericson and Pakes. This way, we study the effect of product and process innovative strategies, with a detailed desegregation of their functions, on firm's survival likelihood. Several non-parametric, semi-parametric and parametric techniques are computed to check the effect of the active learning theory on business survival in a set of Spanish manufacturing firms (1990-2001).

Keywords: *firm survival, active learning theory, duration analysis.*

JEL classification: L11, M13, 031

1. INTRODUCTION

The basic precept underlying the various theories of industrial dynamics concerns the capacity of firms within the same industry, and operating within the same market, to become more efficient than their competitors in a situation of equal opportunities. Among the models

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based on industrial dynamics, probably the most influential has been developed by Jovanovic (1982) in which he concludes that the longer a firm operates within a market, that is, the more experience it acquires, the more efficient it becomes. The moment the firm ceases to be efficient, its competitors will step in and occupy its position in the market. Jovanovic's model is a model of *passive learning,* since the firms concentrate their efforts on making themselves more efficient solely by modifying their behaviour, but without taking into consideration high risks. Other authors, such as Klepper (1993, 1996a and 1996b) have introduced the concept of *capacity* to industrial dynamics, that is, the capacity of the entrepreneurs to adopt innovations in their methods of operating so as to make them much more competitive than their competitors. This is a type of learning similar to that formulated by Ericson and Pakes (1995), known as *active learning*, and it is based on the capacity of firms to become more competitive thanks to the adoption of innovations both in their products (Jovanovic and McDonald, 1994) and in their methods of production and organisation (Klepper, 1993).

In the growth process of the firm, this shift from *passive learning* to *active learning* makes the decisions adopted by the management crucial as they will determine the firm's behaviour. This behaviour is based on the adoption of techniques until then learnt from the other agents working in the industry in which the firm operates (passive learning). Techniques of this type are mainly short-term investments which tend to be modified as other new ones appear among the leading incumbents in the industry. Another way of operation is based on the adoption of new competitive strategies that allow the firm to act more rapidly in the race to make itself competitive (active learning). They comprise investments of a long-term nature vision in which it will become evident whether their adoption, and subsequent materialisation, has resulted in an increase in competitiveness or not.

The decisions taken by the firms during their lifetime will determine their efficiency and, in turn, their survival. The main ones are related to prices and production levels and the investments the firm chooses to make which can be modified in the short term; however, the decisions regarding investments can only be modified in the long term and require a period of time and of adaptation to see what their actual result will be. Among the latter, we find investments related to a firm's expansion into new markets or industries (diversification), financial investments and investments related to an improvement in the competitiveness of its product vis-à-vis those of its competitors (product differentiation), including technological differentiation (investment in innovation and development) and specific differentiation (investments in advertising).

Aspects related to the capacity of a firm to become more competitive in the market where it operates are mainly based on product and process innovations strategies. On the one hand, the product innovation strategy is based on the introduction in the market of new products or the modification of the existing ones. These would even include the firm's capacity to diversify itself, in other words, to operate in different markets or different industries. This strategy is more common in industries that are in the early stages of the life cycle of their product. Given that the amounts of investment requirements are not as important as in the process innovations, it is more associated with a lower scale of operation of the production activity. Changes in product are generally focussed on the differentiation versus its direct competitors with the aim of finding its own market share. The most important product differentiation strategies are related with the introduction of new products or new ways of presenting them like new design, materials, functions or new components.

On the other hand, the strategy based on process innovation is related to the implementation of new behaviours in the production process. The new production behaviour concerns the introduction of new processes in the production techniques or the implementation of new organization in the methods of operating. The improvements to the processes are linked with the capacity of the firm to reduce costs and to increase productivity, which would make a firm more efficient and which would translate into a reduction in prices. Process innovation are more usual in industries situated in mature stages of their life cycle, since this kind of innovation requires a high initial investment and is more related with sunk cost and long-term investments. When focussed in the implementations of new organization, the process innovation include factors related to the management, ownership and capacity of the firm to expand the number of establishments.

In this article we seek to analyse how the competitive behaviour adopted by the entrepreneur influences the survival of the firm. In addition to the factors that have already been studied in the literature (factors most closely related with Jovanovic's vision of passive learning), such as advertising or innovation costs, we also analyse aspects related to the type of innovation undertaken by the firm, either product or process innovations.

The paper is structured as follows. After this introduction, section two undertakes a review of the literature related to the subject of firm survival. In section three we describe the methodology, discussing the criticisms and the advantages of the method of analysis chosen. Section four describes the data base and the variables to be introduced in the analysis. We then describe the main results from our study in section five. Finally, section six concludes.

2. EMPIRICAL REVIEW

Among the theoretical studies that examine the business skills that ensure that a business survives and grows at an individual level, we find the group based on the *theory of competitive advantage with* Klepper (1993, 1996a, 1996b) as its main reference. He stresses the importance of accumulative economies of scale in R&D, a characteristic which gives an advantage to firms that enter an industry early on as opposed to late entrants. On the other hand, at a more aggregate level, the literature based on the life cycle of one industry has a series of clearly established factors that allows for a longer survival, which are related with the different stages of a firm's life cycle. Thus we find economies of scale, learning curves and barriers to entry and financial resources which are combined with the maturity and technological change and which determine the competitive behaviour of the firm, which should be considered as the key factors in industrial evolution. Additionally, following the literature based on product market competition, and specifically on the *shakeout* focus, we find the Jovanovic and McDonald’s study (1994), in which the earliest entrants employ a common technology, which after a certain time is replaced by a new technology. This new technology ensures low unit costs and, therefore, a higher level of output per firm. The transition to the new technology incorporates an exit or shakeout of the first generation of firms, and the survival of a small number of firms which now employ this new, large-scale technology.

Analysing the empirical evidence on firm’s survival, we find a broad literature analysing the impact of aspects such as maturity, size, changes in ownership, market structure, technological level, among other internal characteristic of the firm, but their general point of view is based on the passive learning way of operation. In other words, in the *passive learning theory* the firm concentrates their managerial behaviour in the adoption of techniques until then learned from the other agents working in the industry in which the firm operates. The longer the firm operates in the market the more experience it acquires, so that firms base their way of operation on short-term investments which tend to be modified as other new ones appear and are totally influenced by their size and their age.

Concerning the maturity of the firm, after Jovanovic (1982) explained the hypothesis that the likelihood of survival increases as the firm operates in a market, the same relationship was also pointed in others firm models (Ericson and Pakes, 1995; Olley and Pakes, 1996). The main explanation of this positive effect is related with the fact that the firms that have entered the market become aware of their abilities and their levels of efficiency and increase their learning about new ways of operation from other agents that are operating in the same market. The same finding has been found empirically by other authors for different countries studies (e.g. Dunne *et al.* 1988, Audretsch 1991, Bernard and Jensen 2002, for the US manufacturing industries case; Colombo and Delmastro 2001 for Italy; Harris and Hassaszadeh 2001 for UK; Segarra and Callejón 2002 for Spain; Strotmann 2005 for German; among others). However, Agarwal and Audretsch (2001) found – for the US 33 product markets- that in very late stages of the firm's life cycle, the probabilities of surviving slowly fall. Agarwal named this fact as the existence of the *senility effect* and it is explained by the fact that older firms face a relatively high likelihood of exiting the market due to the erosion of their technology, products, business concepts and management strategies over time. For the Spanish case, there is some evidence in favour of this non-linear effect of firm's age on the probability of survival, so that both younger and older firms face a higher hazard of exit (Farinas and Moreno, 2000; Esteve et al, 2004).

In relation to the size of the firm*,* the main hypothesis that the literature has addressed is that the probability of survival is positively related to a firm's size. The empirical literature focussed their analysis on the effect of the start-up size, following the thesis of the *liability of smallness* (e.g. Audretsch and Mahmood 1994, 1995; Mata and Portugal 1994, 1999; Tveteras and Eide, 2000; Segarra and Callejón, 2002; Görg and Strobl, 2003, Strotmann, 2005). The main explanation for this fact is that there is a huge amount of firms that enter a relative low scale of operation and have associated disadvantages with respect the firms that are still operating in the market with a higher scale of operation. These disadvantages, which act as entry barriers in the majority of the cases, are associated with the development of scale economies or the different accessibility to financial or labour capital markets. Even though in the vast majority of studies the effect of size on firm survival is positive, there exist some papers with evidence against this positive effect. Mahmood (1992), through an analysis of the differences in the survival prospects between industries taking into account their technological level, found that the start-up size seems to have the same negative effect in the two technological level industries he considers. Other studies find a non-linear relationship between current size and firm survival, in other words, survival likelihood increases with firm size but at a decreasing rate (Evans, 1987; Hall, 1987). Finally, Mata *et al.* (1995) found that the current size of the firm acts as a better survival predictor than their start-up size.

Taking into account the considerable heterogeneity between the firms that operate in a same market, part of the literature on firm survival has also tried to control the technological level of the industry where the firm is operating (e.g., Audretsch, 1991; Mahmood, 1992;

Audretsch and Mahmood 1994, 1995; among others). The main findings are in favour of the existence of significant effects between the technological regime and the likelihood of survival. The more the firms that belong to an industry innovate, the higher their survival. On the contrary, firms belonging to industries with lower technological levels seem to have a lower probability of survival due to the presence of higher scale economies among other aspects. However, for the Spanish case Segarra *et al.* (2002) seem not to find a positive relationship between the technological opportunity level of the sector of activity and firm survival.

Differences in ownership structures among other internal aspects might also influence the survival probability of the firms that operate in a market The main finding is that changes in the ownership (acquisitions, greenfield or brownfield developments, among others) have a negative effect in the probability of survival (Harris and Hassaszadeh, 2002;.Bernard and Jensen, 2002; Kimura and Fujii, 2003). Additionally, multinationals firms seem to be more likely to exit the market than indigenous firms. One possible explanation is that a foreign multinational company may find it easier to transfer production facilities from one country to another than a comparable indigenous plant (e.g., Colombo and Delmastro, 2000; Harris and Hassaszadeh, 2002; Görg and Strobl 2002, 2003; Esteve *et al.*, 2004; Mata and Portugal, 2004).

With respect to the type of analyses developed to study firms' survival, various different techniques are envisaged. Part of the literature uses logit or probit models of discrete choice (e.g., Audretsch, 1995; Littunen, 2000; Colombo and Delmastro, 2000, 2001; Heshmati, 2001; Headd, 2002, among others), in which the dependent variable is the probability of exit or otherwise. Another type of modelling used is that of models for censored data, where the dependent variable always takes positive values and is constituted by the time that have passed since the firm's foundation (Audretsch *et al.*, 1999). And finally, some authors have used simple regression by the least squares procedure (Van Praag, 2003; Karlsson and Nyström, 2003). But the use of such models fails to take into account considerable information and in most cases depends on data for cohorts of firms so that the study becomes limited to the representativeness of the sample. In order to solve the problems presented by these models, microeconometric techniques were adopted (parametric and non-parametric) through the estimation of duration models.

The econometric duration models consider the dynamics of the whole process, that is, they take into consideration the evolution in a firm's life over time, so not only is it of relevance whether a firm decides to exit a market during the period of study, but it is also important to see the evolution of the risk of exit and the determinants of this event over time. Most studies that analyse growth following the entrance using these techniques only analyse a cohort of firms (Audretsch, 1991; Mahmood, 1992; Mata and Portugal, 1994; Audretsch and Mahmood, 1995; Agarwal, 1997; Agarwal and Audretsch, 2001; Segarra and Callejón, 2002; Segarra *et al.*, 2002). The use of a cohort of firms reduces the study to an analysis of a series of firms that have many characteristics in common and, therefore, we lose information about the different characteristics that arise if the firms decide to enter the market at different times, or what amounts to the same, if the event begins before or after the moment chosen as the initial moment in the time period analysed. Furthermore, as Mata *et al.* (1995) point out, most studies only take into consideration the conditions of the firm at the moment in which it is set up, assuming thereby that the conditions at the moment in which the firm is established will determine its likelihood of survival during its life. However, as a firm operates, it is quite likely that the variables under study will vary over time and it is probable that the most recent observations of these variables will have more influence in predicting survival than those recorded at the beginning of the period. The use of different cohorts of entrants allowed them to analyse the effect of a firm's age on the probability of survival, something which cannot be done when only one cohort of firms is analysed, since all will have the same age and will have suffered the same changes during their respective lifetimes. Furthermore, it led them to consider the size of the firm over time, leaving the size at the time of its foundation as a possible regressor to explain the likelihood of firm survival.

In the present paper, we follow the ideas of the *active learning theory* in which in addition to the experience that a firm might acquire, other factors related to the exploring and speculative idea that follows the firm or the entrepreneur may play a substantial role in explaining the firms' survival. In addition to analysing the factors that have previously been studied, we also analyse aspects related to the type of innovative behaviour undertaken by the firms as well as the effect of the results of this continuous innovative behaviour (product and process innovative business competitive strategies).

3. METHODOLOGY

In order to analyse the effect of the competitive behaviour of a firm on its survival we use duration models. The variable of interest in duration analysis is the length of time that passes between the moment at which the phenomenon begins and the moment in which either the phenomenon terminates or the measurement is taken, which might occur at a time before the termination of the phenomenon. Thus, as we can see, on occasions, when the measurement is taken the phenomenon might not yet have finished. For this reason, both the use of conventional statistical methods and estimation by minimum squares are not adequate for the duration analysis of a process, since they fail to consider the censor problem in the data. These methods use the information in an incomplete manner, due to the fact that in the moment of performing the study there exist a series of cases for which we do not know what their life trajectory will be and a further series of variables that will undergo modifications throughout the time period being analysed. In this case, the estimation by ordinary least squares will provide us with biased and inconsistent estimates. Furthermore, in such cases the likelihood of the event occurring (that the firm exits the market) will not be conditioned to the evolution of the individual throughout the period being analysed (having remained in the market until the moment immediately before deciding to exit), but rather will be centred on the mean probability of the occurrence of the event during the period under study. For this reason, we will use models that take into consideration the censor inherent in these data.

First, we undertake a number of non-parametric tests of equality of the survival functions for some of the variables, which are subsequently used in the survival analysis using parametric regressions. The tests analysed are the Peto-Peto-Prentice test, the Wilcoxon-Breslow-Gehan test, the Long-rank test and the Tarone-Ware test, which are based on the χ^2 test. These tests compare two or more distributions and comprise the weighted sum of the differences between the actual number of firm exits and the expected value, for each of the groups being compared. The difference between the tests lies in the method of weighting. Thus, the Long-rank test is used when it is believed that the survival functions are proportional between the groups being compared; the Wilcoxon-Breslow-Gehan test when the survival function might not be proportional and when the censor patterns are believed to be equal between groups; the Peto-Peto-Prentice test when the survival function varies in a non-proportional manner and also when there is a requirement to control for possible differences in the censor patterns of the various groups; and the Tarone-Ware, like the Wilcoxon's test, is appropriate when hazard functions are thought to vary in ways other than proportionally and when censoring patterns are similar across groups, although it is less susceptible to the failure and censoring pattern in the data than Wilcoxon's test.

Afterwards, we move on to analyse the factors determining survival in the case of the Spanish firms, using a representative sample of data censored both from the left (firms founded before 1990) and from the right (firms that will survive beyond 2001), in order to obtain the maximum amount of information. The analysis of the determinants of the survival of Spanish manufactures is carried out by estimating a parametric duration model. Specifically, we use a hazard model with variables that vary over time. In line with Mata *et al.* (1995) and Harris and Hassaszadeh (2002), $T \geq 0$ denotes the duration, which has some distribution in the population and t denotes a particular value of T. For us T is the time at which a firm leaves the initial state. We define the hazard rate as the probability of a firm exiting the market at time t having survived until this same point in time:

$$h(t; X_{(t)}) = \lim_{dt \to 0} \frac{P(t \leq T < t + dt \mid T \geq t, X_{(t+dt)})}{dt}$$

where $X_{(t)}$ is the matrix of explanatory variables at time t and $h(t)$ is a variable reflecting the instantaneous rate of market exit.[1] In order to implement it empirically, we must first formulate a functional form of the model, and the most frequently selected option is the specification of a Cox Model or a proportional hazard model

$$h\left(t / X_{(t)}\right) = h_0(t) \exp\left[X_{(t)} \beta\right]$$

where $h_0(t)$ is known as the baseline function and β is the vector of the regression parameters.

If the baseline function is not specified, as in our case here, we are dealing with a semi-parametric duration model. This model is adequate, as Cox (1972) suggests, in the presence of explanatory variables that vary over time and when there exists a high incidence of censored data. This model can be endowed with a specific functional form and thus obtain a parametric duration model, which would improve its efficiency, but it would also be associated with a series of inconveniences such as being conditioned by the correct choice of the model and the giving rise to inconsistent estimates due to the presence of unobserved heterogeneity, inconveniences that could be solved with the application of the semi-parametric model (Dolton and Van der Klauw, 1995). However, as our analysis is based on annual data we are only able to observe failure times in a discrete manner (*ties*). We only know which and how many firms exit the market from year to year without being able to distinctly order their failure times within each period (Cox and Oakes, 1984). Therefore, the method of Breslow (1974) is used within the Cox proportional hazard framework for correcting the partial likelihood function in order to cope with the existence of ties and to get unbiased and consistent estimates[2].

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[1] A discrete version of the function could be written in the following form:

$$h(t; X(t)) = P[\text{exit at } t \mid \text{survival at } t; X(t)] = P[T=t \mid T \geq t, X(t)]$$

[2] The alternative use of the method by Efron (1977) leads to almost identical results.

To check the sensitivity of the findings to different model assumptions, we also estimate parametric accelerated failure time (AFT) models. In the AFT models, the natural logarithm of the survival time ln *t* is expressed as a linear function of the covariates, yielding the linear model

$$\ln t_j = X_j \beta + z_j$$

where X_j is a vector of covariates per individual (j), β is a vector of regression coefficients, and z_j is the error with density $f(\ )$. The distributional form of the error term determines the regression model. If we let $f(\ )$ be the normal density, the lognormal regression model is obtained. Similarly, by letting $f(\ )$ be the logistic density, the log-logistic regression is obtained. The effect of the AFT model is to change the time scale by a factor of $\exp(-X_j\beta)$. In the proportional hazard rate model, the concomitant covariates have a multiplicative effect on the hazard function

$$h(t_j) = h_0(t) g(X_j)$$

where $h_0(t)$ is the baseline hazard function and $g(X_j)$ is a nonnegative function of the covariates. So, additionally to the baseline hazard function, taking into account the discreteness of our database, we estimate two types of models, the lognormal and the log-logistic. In the first one, the natural logarithm of time follows a normal distribution; whereas for the log-logistic distribution, the natural logarithm of time follows a logistic distribution.[3]

The lognormal hazard, survival, and density functions are respectively

$$h(t) = \frac{\frac{1}{t\sigma\sqrt{2\pi}} \exp\left[\frac{-1}{2\sigma^2}\{\ln(t) - \mu\}^2\right]}{1 - \Phi\left\{\frac{\ln(t) - \mu}{\sigma}\right\}}$$

$$S(t) = 1 - \Phi\left\{\frac{\ln(t) - \mu}{\sigma}\right\}$$

$$f(t) = \frac{1}{t\sigma\sqrt{2\pi}} \exp\left[\frac{-1}{2\sigma^2}\{\ln(t) - \mu\}^2\right]$$

where $\Phi(z)$ is the standard normal cumulative distribution function and σ is the standard deviation. The lognormal regression is implemented by setting $\mu_j = X_j \beta$ and treating the standard deviation σ as an ancillary parameter to be estimated from the data.

[3] We have also estimated other functional forms such as the Weibull and the Generalized gamma models to account for different survival distribution functions. However, following the AIC criterion and taking into

The log-logistic regression is obtained if z_j has a logistic density. The log-logistic hazard, survival, and density functions are respectively

$$h(t) = \frac{\lambda^{\frac{1}{\gamma}} t^{\frac{1}{\gamma}-1}}{\gamma\left\{1 + (\lambda t)^{\frac{1}{\gamma}}\right\}}$$

$$S(t) = \frac{1}{1 + (\lambda t)^{\frac{1}{\gamma}}}$$

$$f(t) = \frac{\lambda^{\frac{1}{\gamma}} t^{\frac{1}{\gamma}-1}}{\gamma\left\{1 + (\lambda t)^{\frac{1}{\gamma}}\right\}^2}$$

This model is implemented by parameterizing $\lambda_j = e^{-x_j\beta}$ and treating the scale parameter γ as an ancillary parameter to be estimated from the data.

The duration models showed above can be estimated under the assumption that the hazard rate is completely determined by the included covariates (i.e. there is no unobserved heterogeneity). The neglect of unobserved heterogeneity in estimating a model might bias the estimated duration dependence of the hazard rate towards negative duration dependence. To check the robustness of the results with respect to unobserved heterogeneity all parametric models were re-estimated as *frailty models* with unobserved heterogeneity. Independent from the parametrisation used the conclusions about the determinants of survival do not have to be modified when taking into account unobserved heterogeneity. At the observation level, frailty is introduced as an unobservable multiplicative effect α on the hazard function such that:

$$h(t|\alpha) = \alpha h(t)$$

where *h(t)* is a non-frailty hazard function, say, the hazard function of any of the previous models. The frailty α is a random positive quantity, and for purposes of model identifiably it is assumed to have mean one and variance θ. A likelihood ratio test will be used to check whether there is significant evidence of unobserved heterogeneity.

account the discreteness of our database we decided only to show the lognormal and the log-logistic models. The results of the other estimations can be provided upon request.

4. DATABASE, DEFINITION OF VARIABLES AND RESEARCH HYPOTHESIS[4]

Data are obtained from the Survey of Entrepreneurial Strategies (henceforth ESEE) produced by the "Public Enterprise Foundation" of Spain. 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 number of companies representing manufacturing industries in Spain on an annual basis. Its design is relatively flexible and it has two applications. On the one hand, it provides in-depth knowledge of the industrial sector's evolution over time by means of multiple data concerning business development and company decisions. It is also designed to generate microeconomic 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 ten 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 its most outstanding characteristics is its high degree of representativeness. It contemplates the production activity of firms aggregated to a 2-digit level corresponding to the manufacturing sector. This aggregation in 20 industries corresponds to the NACE-CLIO[5].

In order to analyse the effect that the competitive strategy adopted by the firm has on its survival, the explanatory variables explained in the paragraphs below have been included drawn from both the leading theoretical and empirical studies conducted in the field.

First, in order to reflect cost competition, the marginal price-cost ratio (*mpcr*) of the firm in the year under analysis is included, as it has been done by other authors albeit for the whole industrial sector to which the firm belongs (Audretsch and Mahmood, 1995; Segarra and Callejón, 2002; Segarra *et al.*, 2002). This variable is constructed as the total value of the production minus the variable costs of production divided by the total value of production, where the total value of production constitutes the sum of sales and the variation in sales stocks and the cost variables of production. The latter is the sum of the intermediate consumer goods and the labour costs. The intermediate consumer goods are calculated by summing the purchases and the external services and subtracting the variation in the sales stocks. According to Audretsch and Mahmood (1995), industries that present high margins for this variable will tend to compensate for the disadvantages of costs relative to the size of the firm,

[4] For further information concerning the data, you can see Fariñas and Huergo (1999) and Fariñas and Jaumandreu (1994, 1999).

thereby reducing the risk of newly founded establishments. *Then, the hypothesis formulated is that in the case of high marginal price-cost ratios, the probabilities of survival are much greater.*

In the case of competition through product differentiation, we need to consider the two possible types of differentiation, specific and technological differentiation. In order to examine the specific differentiation, we construct a dichotomous variable that takes the value of 1 when the firm makes any investment in advertisement in the year under review and zero when no investment is made *(adv).* The effect of advertisement on industrial dynamics has been analysed elsewhere for the case of Spain obtaining a positive influence on the firm survival (Lafuente and Lecha, 1988; Aranguren, 1999; Segarra and Callejón, 2002; Segarra *et al.*, 2002). The variable that seeks to explain the technological differentiation is a dichotomous one that takes the value of 1 when the firm incurs research and development costs and null when it has no such costs *(rdc).*The effect of investment in innovation on the probability of market survival has been analysed by several authors with the common finding that the survival probability increases with the technological level of the firm measured by R&D expenses (e.g., Hall, 1987; Mahmood, 2000; Segarra and Callejón, 2002). *The hypothesis is that the use of some type of product differentiation gives the firm a greater probability of survival.*

Following the ideas of the theory of active learning (Klepper, 1996; Jovanovic and McDonald, 1994), a number of variables have been introduced to reflect the effect not just of the expenses incurred in innovation, but also those attributable to the type of innovation made by the firm (product or process innovation). In relation with product innovations[6], we introduce a dichotomous variable that describes if the firm introduced new or improved products on to the market in a given year or not (*prod).* This is done in order to observe the effect obtained by the firm in seeking to get a positive result from its investment in innovations and the effect of the introduction of new products on the market in which the firm operates. Littunen (2000) introduces a dichotomous variable that takes the value of 1 if the firm introduces one product and a value of 2 if the firm launches more than one new product on the market. Using a logit model, and in the case of Finnish manufacturers, he reports that the introduction of products on the market by the firm increases the probability of its

[5] NACE is a general industrial classification of economic activities within the European Union and CLIO is the Classification and Nomenclature of the Input-Output table. Both classifications are officially recognised by the Accounting Economic System (National Institute of Statistics INE: http://www.ine.es)

[6] Product innovations are defined as completely new products or modifications that mean that the new product is quite different from the product previously being produced.

remaining in the market. In our paper, focusing on the firm's product differentiation strategies with respect to its direct competitors, we introduce several variables that define the type of product innovation with respect to the products that were previously being produced. The variable *mat* is a dichotomous variable that takes a value of 1 when the product is new thanks to the use of new materials being used in its production. The variable *comp* takes a value of 1 when the new product incorporates new components or intermediate products; the *des* variable takes a value of 1 when the product incorporates a new design or means of presentation, and finally, the *func* variable is a dichotomous variable which takes a value of 1 when the new product fulfils a different function or functions. *The hypotheses that are formulated from the use of these variables are that they present a positive effect on a firm's likelihood of survival, given that the firm uses strategies to differentiate its product from that of its competitors and, thus, it wins a greater market share in the industry in which it operates.*

Similarly, the number of process innovations[7] made in a given year by the firm is introduced in order to observe the effect of these innovations on its likelihood of survival (*proc)*. This variable will show if the competitive strategy adopted by the firm is due to a strategy based on production flexibility. Some studies analyse the adoption of new production processes obtaining a positive effect between the application of a range of advanced manufacturing technologies and firm survival (Doms *et al.*, 1995; Colombo and Delmastro, 2001). To complement the effect of the introduction of new processes, in order to see what type of modification in the production process has been adopted, two variables are constructed. First, the variable *mach* is a dichotomous variable which takes a value of 1 when the modification made involves the introduction of new machinery, and the variable *org* is a dichotomous variable that takes a value of 1 when the firm has adopted new methods in its organisation of production and a null value when the opposite is the case. Finally, we also construct the variable *both* that takes a value of 1 when the firm decides to improve their organization and also their methods of production at the same time. *The hypothesis that is formulated from the analysis of the theoretical literature is that firms that adopt strategies in order to make their production more flexible obtain cost savings which mean that their likelihood of survival is greater than those which do not adopt such strategies.*

Below we present the description and construction of a set of variables, and their corresponding hypotheses which, while they are not related to the competitive strategy of the

[7] Process innovations are defined as major modifications in the production process.

firm, have been analysed in the literature as determinants of firm survival. We are referring to the size and the age of the firm, the participation of foreign capital and the technological opportunity of the sector in which the firm is operating.

To control for the size of the firm, we use the number of employees as at the 31 December of the year under review. It can be seen that by adopting panel data we can incorporate the size of the firm for each year and, thereby, we use more information than those studies that only consider this variable at the time of the firm's start-up (Mahmood, 2000; Colombo and Delmastro, 2001; Becchetti and Trovato, 2002; Harris and Hassaszadeh, 2002) or at the time of its closure (Audretsch, 1995). Furthermore, according to Mata *et al.* (1995), this variable is a better predictor of the probability of failure than the variable of the size of the firm at the time of establishment, which other authors have tended to use. However, instead of introducing the absolute value of employees, we decided to introduce a set of dichotomous variables according to different categories, so as to take the non-linear size effect on the probability of surviving one more year. These variables classify the firms in several groups: lower than 20 employees (*size20*), between 20 and 50 employees (*size50)*, between 50 and 100 *(size100),* between 100 and 200 *(size200)* and more than 200 employees *(large)*. *The hypothesis is that the larger the firm, the greater its likelihood of survival or the lower its risk of failure.*

In the case of the age of the firm, four dichotomous variables are constructed in order to describe the effect of having passed a given stage in a firm’s life-cycle These variables classify the firms in five groups: those that have been operating for between 0 and 6 years (age6), between 6 and 10 years (*age10*), between 10 and 25 years (*age25*), between 25 and 50 years (*age50*), and finally, over 50 years (*aget*). *By introducing this variable we are seeking to check whether firms that have reached a certain age have a greater likelihood of surviving another year.*

In line with those studies that consider ownership structure and the firm's capital to be important explanatory variables of firm survival, we also incorporate a variable proxying the participation of foreign capital. Most of the papers that introduce this variable as an explanatory factor do so as a dichotomous variable that takes the value of 1 when the firm is a multinational company (Headd, 2002; Harris and Hassaszadeh, 2002; Görg and Strobl, 2003) or when it forms part of a foreign holding group (Colombo and Delmastro, 2000). Following the previous literature we construct a dichotomous variable (for) that takes a value of one when the control of the firm is in hands of a foreign owner, in other words, when the percentage of foreign shareholders exceeds 50%. According to previous literature, the hypothesis that is formulated is that foreign firms have lower likelihood of survival than domestic ones. *The idea behind this hypothesis is related with the higher risky development strategies and the substantially higher sunk costs of plant creation in developing countries compared to the firms that are mostly participated by domestic capital.*

In order to control how belonging to a given sector of activity affects a firm's likelihood of survival, we include a set of dichotomous variables regarding the technological opportunity level of the sector of activity in which the firm is operating. We classify the sectors of activities in three groups, lower, medium and high technological levels, according to the OECD classification[8]. *We assume that the technological level of the sector of activity in which the firm operates has an important effect on the survival of the firm, taking into account the different competitive scenario that the firm faces in each level of technology.* Finally, we introduce a set of year dummy variables to capture the macroeconomic effect or to control for a possible influence of the business cycle on the likelihood of survival.

Most studies that analyse firm survival assume that firms have full knowledge of what their competitors are doing and act accordingly. Thus, in such studies most of the variables that account for firm survival with industry-based data are the same. Here, however, we take the view that a firm's behaviour is not so rational, in the belief that an analysis of the way in which the competitive strategy adopted by the firm might influence its survival is determined exclusively by the individual strategic decisions that the firm adopts. This is the reason why the firm's internal variables are included instead of the variables that give information about the industry to which it belongs or the market in which it operates. Thus, our results show the effect of the behaviour adopted by the firms following, in part, the line adopted by Ericson and Pakes (1995, 1998) when studying market entry in a situation in which the entrepreneurs act as optimising agents who take into consideration market conditions and what they hope to obtain from the market when deciding to enter. In our study, the entrepreneurs need to modify their business behaviour in order to remain in the market.

5. RESULTS

Table 2 shows the results of the non-parametric tests of homogeneity for the variables proxying the firm's competitive behaviour that are afterwards included in the regression analysis. Given the characteristics of the database and in order to reduce the heterogeneity, we proceed to conduct a differentiated analysis with the firms grouped according to their size. It

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[8] See Table 1 for a more detailed analysis about this classification.

can be seen that the tests vary according to the sample used. When all the firms are included, all the tests reject the null hypothesis of homogeneity, except in the case of those firms that base their product innovations on improvements to their internal organisation. The same result is obtained when the sample of small firms is considered. As for the large firms, the differences between groups are not significant in most cases. Only the fact of their incurring or not in research and development costs, undertaking process innovations and using new machinery in the production process seem to involve the most significant differences.

Thus, according to the test results, it can be concluded that, in general terms, the firms that incur research and development expenses and that carry out advertisement investments present a survival function that differs from that of those that do not adopt these strategies of product differentiation. The same result is also observed for those firms that opt for an active innovation in placing themselves ahead of their competitors, both as regards process and product innovations. However, whereas this result holds for small firms, in which product differentiation and process and product innovations are important in explaining their survival, it does not seem to be so important for the firm's risk rate of the large ones.

To analyse the specific effect of each variable proxying the competitive strategy adopted by firms on their survival, once controlled by general internal characteristics of the firms, in Table 3 we present the results of the estimation of the Cox regressions. As a general result, given the high number of explanatory variables that are significant in the regressions, we can have an idea of the relevance of the competitive strategies adopted on the survival of firms in Spanish manufactures. The interpretation of the effect of the explanatory variables in this type of models is determined by the hazard ratios. Thus, a parameter value greater than one implies that this variable has a negative effect on the expected survival of the firm, while a value below one is indicative of a positive effect on the likelihood of survival or a negative effect on the firm's risk of failure rate, given that the two are inverse concepts.

A first conclusion to be drawn from our results, bearing in mind the different samples analysed, is that the results obtained when considering the whole sample of firms approximate more closely the results obtained when the sample of small firms is used. This is probably due to the fact that Spanish manufactures are, in the main, composed of small and medium-sized firms, which adopt very different strategies from those of their larger counterparts that compete with them in the market.

We firstly analyse the impact of the control variables on the firm survival. With respect to the age of a firm, we obtain that it appears to be a relevant factor in a firm's survival in all stages of the life-cycle, except for firms with more than 50 years (we excluded *age6* for avoiding collinearity problems). It can be seen that this effect appears to be more important in the likelihood of survival of small firms since in the case of large firms they are not significant. This result is in line with the idea in Colombo and Delmastro (2001) claiming that the probability of market exit falls as the age of the firm increases. With the passing of time, according to their findings, the information acquired by the firm leads them to revise the estimates of their efficiency, in other words, they gradually reduce the probability of receiving "unwelcome news" that might lead to their closure. Many studies have analysed the effect of age on a firm's survival and similar conclusions as those presented here have been obtained (Dunne et al, 1988; Phillips and Kirchhoff, 1989; Audretsch, 1991; among many others). Even Agarwal (1997) points to the *senility effect* meaning that in very late stages of a firm's life cycle, the probabilities of surviving slowly fall, an idea that could be behind the non-significance of the variable proxying the age of firms with more than 50 years operating in the market.

Our models also reflect the non-linear size effect on the likelihood of firm survival. As the size of the firm increases there exists a higher positive effect in the firm survival taking into account the lower size of the category that has been discarded to avoid collinearity problems. This is a highly standard finding in the literature on survival, with many studies drawing the same conclusion both in the case of Spain (Fariñas and Moreno, 2000; Segarra *et al.*, 2002; Esteve *et al.*, 2004) and at an international level (Evans, 1987; Hall, 1987; Agarwal, 1997; Tveteras and Eide, 2000; Görg and Strobl, 2003; among many others). Spanish manufacturing firms suffer from the *liability of smallness*, in other words, small firms are more exposed to the risk of exit.

The presence of foreign capital appears to increase the risk of failure. There is not a consensus on the effect of this variable on survival. Firms with foreign capital are, as Colombo and Delmastro (2000) argue, more likely to survive and to be less sensitive to fail than the firms in the country of origin. But a number of authors presenting evidence from different countries draw the same conclusion as ours (Mata and Portugal, 2004; Esteve *et al.*, 2004). Among other explanations, Görg and Strobl (2003) claim that foreign-owned establishments are more likely to represent stronger competition with the multinationals in the sector that export the same product and thus they may suffer a negative effect from this strong competition. Furthermore, they suggest that the explanation might lie in the fact that firms of this type have to pay tariffs and other types of taxes, which the domestic firms do not have to. So, when they fail to reach their expected targets they exit the market. Other possible explanation could lie in the fact that multi-plant firms are more likely to close plants, and since foreign firms are more likely to be multi-plant firms, foreign owned firms would present lower survival rates. The higher likelihood of closing plants by multi-plant firms may be due to the greater efficiency of multi-plant units in re-employing their labour and productive facilities, thus facing lower costs of closing a plant (Baden-Fuller, 1989).

Now we turn to the variables reflecting the competitive strategy of the firms. As for the *classic* competitive strategy based on investing in advertisement and research and development, in the light of the results obtained here we can conclude that it would seem to be a type of strategy more in line with that adopted by smaller firms, although it is also of considerable importance when we look at the whole of the sample.

Specifically, research and development costs have a positive effect on a firm's likelihood of survival. This effect seems to be significant in small firms, yet by contrast, it does not appear to be a consistent result for large firms. The existing literature also reports this positive effect for this variable on the probability of a firm surviving, showing how a greater investment in R&D reduces the firm's hazard rate (Hall, 1987; Audrestch, 1995; Audrestch and Agarwal, 2001). R&D activities contribute to building a stock of knowledge that increases de market value of the firm and consequently its likelihood of survival.

Investment in advertisement as a factor in product differentiation and as a means of reducing the risk of failure appears to be significant only in small Spanish firms. In most cases, the large firms understand this set of costs as part of their ordinary activity and, therefore, it is not a determining factor in their survival. The study by Caves and Porter (1977) claims that the theory of strategic groups operating in an industry in which mobility barriers exist suggest that a strategy based on product differentiation would facilitate viability in cases in which the scale of results is small. Thus, in our results, we can see that advertisement exercises a barrier effect on survival for smaller firms, but not for their larger counterparts.

As for the variable that describes possible cost competition, we note that the higher a firm's marginal price-cost ratio becomes, the lower its risk of failure. In line with Audretsch and Mahmood (1995), the positive impact of this variable can be attributed to the fact that the marginal price-cost ratio is higher in concentrated industries where it is easier to detect and penalise the new entrants to the sector. Likewise, Audretsch (1991) and Audretsch *et al.* (2000) comment that high margins ensure the survival of firms that have just been created or which have a sub-optimal production scale in the short term, though not in the long term. In the case of Spain, this effect has been analysed by Segarra *et al.* (2002) and by Segarra and Callejón (2002), who both reach the same conclusion as in our study.

The effect of implementing constant innovations, both as regards new products and new production processes appears to have a determining role in a firm's probability of survival. In other words, a firm's ability to innovate will determine the likelihood of their remaining in business. In the case of process innovations, this result is consistent for all the size subsamples under consideration, whereas it is not the case for product innovations in the case of large firms.

Process innovations have a significant positive effect on the likelihood of survival for all the samples under consideration. The competitive strategy of improving production techniques generally have a direct effect on the reduction of costs both in personnel (with the introduction of computerised techniques) and in production costs and therefore in productivity growth (Huergo and Jaumandreu, 2004). Regarding firm survival, few studies include a similar variable to this one. As far as we know, only the papers by Doms *et al.* (1995) and Colombo and Delmastro (2001) analyse the role of differences in productivity based on the adoption of advanced manufacturing technologies on the closure of firms. According to their studies, firms that have used this type of advanced technology present a lower closure rate. Going a bit further away, they claim that while the adoption of new basic equipment directly affects production costs, the adoption of more advanced categories of production equipment might be a sign of a firm's greater ability to differentiate and improve its product as well as alleviating cost competition.

Taking into account the ideas of the *active learning theory*, the active force of the entrepreneurs pointed by Ericson and Pakes (1995) can be explained by the introduction of new products in the market and new processes of production on every stage of their life as the ways of having the optimal market behaviour based on the exploration of speculative ideas or the perception of profit opportunities. As we can see, the significant and positive effect of the variables associated with the business innovative activity forces the established competitors having a continuous production of process and product innovations in front of new producers for maintaining their position in the market and for not ending their activity due to the birth of new producers.

Columns numbered II analyse the type of innovations introduced. As for the innovation in production processes, it can be seen that competitive strategies involving the incorporation of new machinery *(mach)* or having at the same time new organizational and new process of production strategies *(both)* are those that have a significant effect on firm survival. For the new products introduced in the market, the design of these new products that are launched on the market *(des)* is the only one having a significant effect on firm survival. The latter constitutes a significant strategy because in most cases providing a product with a new design implies making major changes to the production process.

Regarding the technology level, the results show that belonging to a higher dependent technological sector implies a higher likelihood of survival than firms that belong to a lower technological level, the eliminated category. In line with Mahmood (1992), an explanation for this differentiation between sectors might lie in the fact that firms less dependent on technology and producing more homogenous goods are more strongly influenced by the presence of scale economies associated to lower likelihood of surviving. Agarwal (1998) also observes that those firms that are less dependent on technology and which have been in the market for a considerable number of years face higher risks of closure, whereas, firms that operate in a sector in which the dependence on technology is higher appear to have a greater likelihood of surviving (the case of the machinery and metal product industries). Audretsch (1995) finds that while the likelihood of new entrants' surviving is generally lower in highly innovative industries, those new firms that do survive the first few years subsequent to entry actually have a greater likelihood of surviving. Thus, it appears that a highly innovative environment promotes the survival and growth of those entrants able to adjust successfully in the market but at the same time serves as a mechanism of excluding those entrants unable to adjust successfully in a highly innovative industry. Finally, although not reported in the tables, the coefficients associated with the year dummies included to control for the changes in macroeconomic conditions are clearly significant. This indicates that overall conditions matter, but no clear pattern is visible from the estimated coefficients.

In a further step of our study, we incorporate some assumptions of the functional form of the firm survival distribution. Although several parametric regressions were undertaken, we only report the results of the two that offered lower AIC values, that is the log-logistic and the log-normal regressions. The results are given in Table 4. The main result of the developed regressions is the maintenance of the significance and the sign of the effect of all the variables proxying the competitive strategy of firms. The only effect which varies with respect to the results obtained without imposing any kind of functional form is that of size. Only the largest category has a positive effect with respect to the non-included category of the smallest size.

To check the robustness of the results of the parametric regressions, we also estimate the log-logistic and the lognormal regressions as *frailty models* with unobserved heterogeneity. The results are the ones provided in the columns of Table 4 indicated by YES in the row referred as gamma heterogeneity. We obtain that the unobserved heterogeneity is statistically significant in all the models (the likelihood ratio test shows that there is significant evidence for unobserved heterogeneity), explaining us the convenience of bearing with it. The unobserved heterogeneity can explain the differences between different expectations that the firms elaborate depending on different market perspectives and also the dynamic of the process. Once again, the main conclusions are maintained with respect to all the variables included in the regression, showing the consistency of our analysis.

6. CONCLUSIONS

We have conducted a detailed analysis on the impact of the principal strategies that have determined the competitive behaviour of firms operating in the Spanish manufacturing sector during the nineties on the firms' survival. The analysis is based on the optimal competitive behaviour of the firms taking into account the *active learning theory* developed by Klepper and Ericson and Pakes.

The theory underpinning industrial dynamics is today richly abundant but it continues to base its main arguments on the theory of market selection formulated by Jovanovic (1982), who devised a model in which market selection is based on the business efficiency acquired by a firm operating within that market. Thus, firms that fail to learn from those that are already well established or from their own experience, because of a lack of efficiency, are forced to abandon the market leaving the firms that know how to be efficient as the market's sole survivors. Over the years, it has been shown that in addition to the experience that a firm might acquire, other factors might also be significant in determining its competitive strategies, such as the theory that relates improvements in competitiveness with business innovation (Klepper, 1996; Ericson and Pakes, 1995). In this study, basing our analysis on Jovanovic's theory and the improvements made to it by Ericson and Pakes and Klepper, among others, we have selected the principal strategies adopted by firms to make themselves as competitive as possible. Among the strategies adopted we have considered those of technological and specific differentiation as well as different product and process innovations.

On conducting the study so that different firm sizes were taken into consideration, it was noted that the results tended to differ, indicating that the strategies adopted by the firms vary in accordance with their size - a characteristic that has been widely studied elsewhere. The behaviour of Spanish industry as a whole seems to approximate more closely that of the small firm as the strategies adopted tended to be more similar to the strategies of these firms than to those of the large firm.

Regarding the various competitive strategies analysed, we can resume the main results as follows. For classic competitive strategies, we have found that having continuous research and development investments and developing a price differentiation strategy (measured by the marginal price-cost ratio) has a positive effect on the likelihood of survival, whereas the impact of advertisement expenses is not significant. The analysis of the active learning theory is focussed in the study of the strategy based on continuous product and process innovations. We have found that the introduction of new products or the modifications of the current business product in the market through changes in its design implies an increase in the firm survival. In the case of process innovations, Spanish manufacturing firms that introduce new machinery or introduce changes in the organization and in the machinery simultaneously reduce their risk of failure.

Among the variables introduced here, and studied previously in other analyses, it can be seen that the hazard rate falls as the size and age of the firm increases, although the relationship is not linear. By contrast, the presence of foreign capital appears to have a negative influence on the probability of survival of the Spanish manufacturing firm. Finally, accounting for sectoral effects we have found that having a firm in an industry considered to be of medium or high technological level seems to increase the probability of survival.

To conclude, having analysed a sample of Spanish firms throughout the nineties and the first few years of this decade, it can be seen that the effect of the competitive strategies adopted by these firms differs in accordance with the size of the firm, and that both investment in innovations and the innovative behaviour undertaken by the firm throughout its life cycle emerge as important factors determining the likelihood of their surviving.

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APPENDIX

NACE-93 2-digits industrial classification	Technological Opportunity Level
Textiles and Clothing Leather and Footwear Wood Paper Furniture	Lower
Meat industry Food and Tobacco products Beverages Rubber and Plastics Non-metallic mineral products Metallurgy Metal products	Medium
Office machinery Computer Processing Optical and similar equipment Chemical products Machinery and Mechanical equipment Electrical and Electronic machinery and maderial Motors and autos Other transport material Publishing and Graphic arts	High

Table 1. Sectoral opportunity level classification

	ALL FIRMS				SMALL FIRMS				LARGE FIRMS			
	Long Rank	Peto-Peto-Prentice	Wilcoxon Breslow	Tarone-Ware	Long Rank	Peto-Peto-Prentice	Wilcoxon Breslow	Tarone-Ware	Long Rank	Peto-Peto-Prentice	Wilcoxon Breslow	Tarone-Ware
RDC	36.87	36.67	33.66	36.08	15.14	14.60	11.37	13.49	5.25	5.45	7.29	6.38
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0007)	(0.0002)	(0.0220)	(0.0196)	(0.0069)	(0.0115)
ADV	10.90	11.08	11.07	11.36	10.67	10.55	8.95	10.18	1.10	1.03	0.42	0.74
	(0.0010)	(0.0009)	(0.0009)	(0.0008)	(0.0011)	(0.0012)	(0.0028)	(0.0014)	(0.2939)	(0.3107)	(0.5147)	(0.3912)
MAT	4.51	4.38	2.92	3.75	6.10	5.65	3.15	4.57	2.03	1.93	1.32	1.66
	(0.0337)	(0.0364)	(0.0873)	(0.0527)	(0.0135)	(0.0175)	(0.0760)	(0.0325)	(0.1546)	(0.1649)	(0.2501)	(0.1982)
COMP	5.26	5.26	4.31	4.89	6.12	5.95	4.36	5.34	1.85	1.80	1.44	1.64
	(0.0218)	(0.0218)	(0.0379)	(0.0270)	(0.0133)	(0.0147)	(0.0367)	(0.0209)	(0.1739)	(0.1793)	(0.2294)	(0.2008)
DES	15.77	15.85	14.39	15.37	9.54	9.26	7.00	8.36	0.40	0.47	1.01	0.71
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0020)	(0.0023)	(0.0081)	(0.0038)	(0.5258)	(0.4937)	(0.3139)	(0.4009)
FUNC	8.03	8.28	7.75	8.07	5.92	5.96	4.88	5.56	0.00	0.00	0.03	0.00
	(0.0046)	(0.0040)	(0.0054)	(0.0045)	(0.0150)	(0.0147)	(0.0272)	(0.0184)	(0.9464)	(0.9784)	(0.8591)	(0.9537)
MACH	27.17	27.91	29.08	28.98	20.41	20.85	20.69	21.25	5.15	5.38	6.94	6.21
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0232)	(0.0204)	(0.0084)	(0.0127)
ORG	0.03	0.02	0.02	0.00	0.18	0.24	0.62	0.42	0.58	0.58	0.59	0.59
	(0.8585)	(0.9024)	(0.8897)	(1.0000)	(0.6726)	(0.6223)	(0.4295)	(0.5167)	(0.4463)	(0.4467)	(0.4416)	(0.4410)
BOTH	31.33	30.55	25.54	28.71	17.09	16.49	13.07	15.15	4.67	4.60	3.95	4.31
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0307)	(0.0319)	(0.0470)	(0.0378)
PROD	24.40	24.87	24.94	25.42	11.35	11.24	9.77	10.83	0.99	1.13	2.32	1.64
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0008)	(0.0008)	(0.0018)	(0.0010)	(0.3197)	(0.2878)	(0.1280)	(0.2003)
PROC	62.09	60.94	51.91	57.93	27.54	26.41	20.46	24.23	17.03	17.15	17.11	17.39
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Table 2. Non-parametric tests

SAMPLES	ALL FIRMS		SMALL FIRMS		LARGE FIRMS	
MODEL	I	II	I	II	I	II
AGE						
AGE10	0.6519**	0.6440**	0.5474***	0.5204***	2.1894	2.3261
AGE25	0.6181***	0.5937***	0.5256***	0.4666***	1.1256	1.4064
AGE50	0.6483**	0.6955**	0.6128***	0.6206**	0.7127	0.8242
AGE T	1.0221	1.0853	0.7818	0.7912	1.5807	1.8239
SIZE						
SIZE50	0.7857**	0.7356**				
SIZE100	0.6942*	0.6362*				
SIZE200	0.8714	0.7361				
LARGE	0.4574***	0.4131***				
FOR	1.6932***	1.9334***	1.5317**	1.6452**	1.552*	1.6984**
RDC	0.6601**	0.6376**	0.6487**	0.5799**	0.6361*	0.7060
ADV	0.8922	0.8975	0.7996*	0.7990*	1.2185	1.3012
MPCR	0.8127***	0.8148***	0.8143***	0.8188***	0.8333**	0.8459**
PROD	0.7727*		0.7072**		1.2496	
MAT		1.0827		0.7737		2.0205*
COMP		1.3417		1.0180		2.1308
DES		0.7115*		0.7491		0.5430
FUNC		1.0136		0.9795		0.9389
PROC	0.5683***		0.6207***		0.3909***	
MACH		0.3994***		0.4153***		0.2916**
ORG		1.0109		1.2777		0.4654
BOTH		0.4418***		0.4240***		0.3855***
TECHNOLOG : MED	0.5546***	0.5610***	0.4811***	0.4655***	0.9827	1.2970
HIGH	0.5649***	0.5751***	0.5539***	0.5467***	0.7363	0.9138
Year Dummies	YES	YES	YES	YES	YES	YES
N observations	20189	18126	13839	12431	6351	5696
N individuals	3406	3157	2565	2341	1100	1052
N failures	434	374	360	308	74	66
LR χ^2	227.67***	208.87***	171.24***	165.15***	51.25***	53.84**
Log –Likelihood	-3213.312	-2723.437	-2562.296	-2148.493	-457.74	-399.54

Table 3. Regression results for Cox models[9]

[9]***indicates significance at the 1% level, ** at the 5% level and * at the 10% confidence level.

MODEL	LOG-LOGISTIC REGRESSIONS				LOGNORMAL REGRESSIONS			
Gamma heterogeneity	(I) NO	(I) YES	(II) NO	(II) YES	(I) NO	(I) YES	(II) NO	(II) YES
AGE: AGE10	0.2820***	0.2824***	0.3677***	0.3733***	0.3533***	0.3439***	0.4411***	0.4405***
AGE25	0.3358***	0.3328***	0.4399***	0.4399***	0.3934***	0.3811***	0.4931***	0.4913***
AGE50	0.3223***	0.3291***	0.3697***	0.3849***	0.3831***	0.3853***	0.4162***	0.4304***
AGE T	0.1730***	0.1790***	0.1781**	0.1962***	0.2057***	0.1926**	0.2043**	0.2088**
SIZE: SIZE50	0.0548	0.0438	0.1060*	0.0869	0.0816*	0.0671	0.1374**	0.1076*
SIZE100	0.0987	0.0866	0.1729*	0.1485	0.1227	0.1094	0.1913*	0.1666
SIZE200	0.0155	0.0163	0.0902	0.0927	0.0068	0.0171	0.1012	0.1084
LARGE	0.2177***	0.2077***	0.3347***	0.3107***	0.2579***	0.2426***	0.3623***	0.3243***
FOR	-0.1681***	-0.1797***	-0.2785***	-0.2954***	-0.2072***	-0.2166***	-0.3125***	-0.3269***
RDC	0.1318**	0.1319***	0.1778***	0.1827**	0.1555***	0.1523***	0.2041***	0.1947***
ADV	0.0410	0.0312	0.0462	0.0327	0.0329	0.0215	0.0309	0.0138
MPCR	0.3474***	0.6947***	0.4185***	0.9525***	0.2182***	0.8309***	0.2558***	1.0808***
PROD	0.0992**	0.0754*			0.1119**	0.0967*		
MAT			-0.0167	-0.0157			-0.0460	-0.0381
COMP			-0.1266	-0.1274			-0.1556	-0.1596
DES			0.1599*	0.1305*			0.1853*	0.1674*
FUNC			0.0272	0.0001			0.0307	0.0321
PROC	0.1622***	0.1592***			0.1953***	0.1821***		
MACH			0.3456***	0.3197***			0.3978***	0.3414***
ORG			-0.0226	-0.0131			-0.0186	-0.0056
BOTH			0.3230***	0.3059***			0.3168***	0.2876***
TECHNOLOG : MED	0.1835***	0.1815***	0.2355***	0.2259***	0.2238***	0.2144***	0.2741***	0.2549***
HIGH	0.1941***	0.1966***	0.2414***	0.2414***	0.2381***	0.2415***	0.2805***	0.2850***
Year Dummies	YES	YES	YES	YES	YES	YES	YES	YES
CONS	0.6156***	0.5181***	2.1977***	2.0981***	0.9066***	0.7577***	2.3445***	2.2162***
N observations	20189	20189	18126	18126	20189	20189	18126	18126
N individuals	3406	3406	3157	3157	3406	3406	3157	3157
LR χ^2	495.35***	486.93***	366.05***	363.50***	436.14***	450.87***	328.24***	339.18***
Log –Likelihood	-1323.074	-1299.386	-1115.138	-1091.816	-1333.663	-1311.227	-1122.570	-1100.92
LR-test on unobserved heterogeneity (H_0: θ=0)		46.40***		46.64***		44.87***		43.30***
Akaike information criterion	2700.744	2655.698	2267.61	2248.405	2722.778	2680.162	2308.82	2267.61

Table 4. Regression results for log-logistic and lognormal parametric models (All firms sample) [10]

[10]***indicates significance at the 1% level, ** at the 5% level and * at the 10% confidence level.