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# The Resource-Based Theory of the Firm and Firm Survival

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ABSTRACT. This paper examines the determinants of firm survival. We use hazard models to test a number of hypotheses mainly drawn from the Resource-Based Theory of the Firm. According to the Resource-Based View the ability of a firm to develop distinct capabilities enhances its ability to adapt to the changing competitive environment and improves its survival prospects. The results confirm that firms that develop firm-specific assets through advertising and making R&D (independently of the technological intensity of the industry) enjoy better survival prospects. Furthermore, failure risk increases up to about 20 years of trading, and then decreases to later rise in line with liability of ''adolescence'' and ''senescence.''

KEY WORDS: firm survival, resource-based theory, hazard rates, manufacturing, technological opportunity.

JEL CLASSIFICATIONS: C41, L1, L26, L60.

## 1. Introduction

Firms' entry and their survival patterns (that is, number and size of entrants, how long they last and the market share they achieve over time) are important elements to understand the dynamics of market competition. Entrants bring new products and processes into the markets introducing competitive pressure to incumbent firms. However, they find it difficult to survive. As the *Entry and Post-entry Performance literature* has pointed out, entry to markets is relatively easy but survival is not (Geroski, 1995).

The purpose of this paper is to investigate the determinants of firm survival using firm- and industry-level characteristics. To this end, we test a number of hypotheses concerning the determinants of firm survival primarily drawn from the Resource-Based Theory of the Firm,[1] and also from other two strands of the literature, such as the Industrial Organization and the Organizational Ecology. The Resource-Based View of the Firm emphasizes the firm's internal characteristics in order to explain why firms make different strategic choices that lead to different outcomes. Hence, the ability of a firm to develop distinct resources and capabilities enhances its ability to adapt to the changing competitive environment and improves its survival prospects.

Previous work on entry and post-entry survival has revealed a positive relationship between firms' age and (start-up and current) size and their likelihood of survival.[2] However, less attention has been devoted to assess the importance of firm strategies aimed at generating the necessary resources to successfully adapt to changing market conditions. Resource-based theories have focused their attention on the role of firm-level resources as source of competitive advantage. A central proposition is that firms are heterogeneous. Each firm is seen as a unique bundle of tangible and intangible resources and capabilities that are acquired, developed and expanded over time. The firm's resources and capabilities are the result of its strategic choices and resource commitments across time and ultimately determine its performance at any time.

Furthermore, previous studies have restricted to study the first few years of life of a cohort (or very few cohorts) of new firms to draw conclusions on post-entry performance. A shortcoming of this literature is that its findings arise from the study of a single cohort of new entrants with a short follow-up period. Therefore, the robustness of the empirical results critically rests on how representative the particular cohort

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examined is. In this line, Audretsch (1991) suggests that the determinants of new-entrants' survival crucially depend on the length of the period in which survival is measured. In addition, Wagner (1994) points out the convenience of analyzing several cohorts since the particular year of birth of a cohort may be important in explaining their life experience. Furthermore, the entry opportunities and survival chances of new firms also depend on how incumbents respond and adapt to the new competitive environment.

In this study we examine the survival of a representative sample of the population of Spanish manufacturing firms in operation in 1990 (that is, new firms as well as incumbents). This differs from previous studies that used the subset of entrants at a particular moment followed over a short period of time. The sample was drawn from the *Encuesta sobre Estrategias Empresariales* (ESEE, henceforth), a survey carried out annually since 1990.[3] It comprises 2028 firms, for which their entry date is known, and that are followed until 2000. Of them, 344 had failed by 2000. The ESEE provides broad information on a yearly basis on firm-specific characteristics that may affect survival.

Both non-parametric and parametric survival methods are used to examine the determinants of firm survival. These methods appropriately correct for the bias introduced by the sampling procedure since the short durations (that is, those firms that entered and exited the market before 1990) are absent (left-truncation).[4] They are also adequate in presence of right-censored observations (i.e. firms still in the market after 2000) and easily handle time-varying explanatory variables. Estimation of frailty survival models are employed to control for the presence of unobserved individual heterogeneity (that is, unobservable – to the researcher – firm-level characteristics that may affect the firms' survival chances).

To summarize, the contribution of this paper to the existing literature is threefold. First, the richness of our dataset allows analyzing, as proposed by the Resource-Based Theory of the Firm, whether the ability of a firm to develop distinct resources and capabilities improves its survival prospects. Secondly, analyzing the survival patterns of a representative sample of all the firms in the market, and not just a sample of new entrants followed over a short period of time, makes possible a detailed analysis of the effect of firms' age on their survival probability. Third, in our econometric analysis, the consideration of both parametric and non-parametric specifications of the baseline hazard and the control for unobserved heterogeneity allows to fully understand the patterns of duration dependence (effect of the passage of time in survival). Further, ignoring the existence of unobserved heterogeneity (when it is relevant) leads to biased estimates of both the explanatory variables (such as the effect of the firms' resources) and the duration dependence coefficients.

To anticipate the results, we find that, as hypothesized by the Resource-Based Theory of the Firm, firms' strategies that allow developing firm-specific assets, such as carrying out advertising and making R&D, enhance their survival prospects. We also find that 50% of the firms survive less than 26 years, with only a 25% of the firms in operation over 62 years. The hazard rate increases as the firm ages up to 20 years, then declines up to 35 years to finally increase. Moreover, some characteristics such as firm size, export activities and absence of foreign capital participation improve firms' survival performance. Besides, firms that have large price-cost margins and are highly productive are expected to survive longer.

The rest of the paper is organized as follows. Section 2 reviews the literature on the determinants of firm survival and proposes the hypotheses to be tested. In Section 3, the dataset is described and the methods used to study firm survival are briefly outlined. In Section 4, we present and discuss the main results. Finally, Section 5 concludes.

## 2. The determinants of firm survival

In this section we develop a number of hypotheses regarding the determinants of firm survival. These hypotheses are primarily drawn from the Resource-Based Theory of the Firm. However, we take an eclectic approach, as some hypotheses are also derived from other strands of the literature, such as the Industrial Organization and the Organizational Ecology.

### 2.1. *Age*

One of *Geroski's stylized facts* (Geroski, 1995) is that firms' survival chances are positively related to their age and size. New firms start at a small scale and face a high probability of exit. Thus, at any time, firm turnover is high in the fringe of the size distribution.

The theoretical models of firm and industry dynamics (for instance, Cressy, 2006; Ericson and Pakes, 1995; Jovanovic, 1982) lead to failure rates that vary with firm age. These models consider that heterogeneous firms make entry decisions incurring in sunk costs when they are uncertain about their true efficiency.[5] Thus, startup firms are usually smaller than incumbents, making them more vulnerable to changes in the environment. As time goes by, firms go through a legitimating process by learning about their abilities to be in business. Those firms ill-suited to survive (without the appropriate initial endowments and/or unable to develop the required capabilities) exit. This learning process may take several years, leading to expect much higher exit rates for a particular cohort in the first few years of its life than for older cohorts also operating in the same market at the same time period. In line with this, exit rates are expected to decrease as firms age (Dunne et al., 1989; Mata and Portugal, 1994).

Organizational ecologists argue that there may exist several relationships between age and survival. These authors have named them as liability of "newness," "adolescence" and "senescence." However, their preferred explanation of the age effects on survival is the so-called liability of "newness." This refers to the time organizations need to establish themselves, carry their specific investments, develop specific knowledge and appropriate routines, build up trust within them and with other organizations, etc. New organizations need time to develop their new organizational capabilities (Carroll and Hannan, 2000; Nelson and Winter, 1982; Stinchcombe, 1965). Until firms settle, they are less likely to be able to cope with severe environmental challenges than better and longer established organizations. Several empirical studies have found this result (Freeman et al. 1983). Thus, we hypothesize that:

> *Hypothesis 1a.* The probability of firm survival increases with age.

Other studies have found a different relationship between age and the probability of exit. The liability of "adolescence" predicts that failure rates have an inverted U-shaped relationship with age (Bruderl and Schussler, 1990; Fichman and Levinthal, 1991). New organizations can survive for a time with little risk of failure by drawing on the initial stock of endowments that they acquire at founding (e.g. venture capital funding, bank loans). Hence, failure rates reach a peak with the exhaustion of the initial resources and then decreases as only the fittest firms remain in the market. Based on this argument, we make the following hypothesis:

> *Hypothesis 1b.* The probability of exit of new entrants is initially low, then increases to reach a peak and eventually decreases.

According to the liability of "newness" and "adolescence" the early years of a firm's life are the riskiest, predicting that failure rates eventually decline with age. They differ in whether exit rates peak at founding or some years later. Other authors have found that beyond a certain age, the probability of exit may increase with time trading. According to the liability of "senescence" (Baum, 1989; Hannan, 1998) older firms are highly inertial and tend to become increasingly ill-suited to cope with changing competitive environment. Consequently, beyond a certain age (the start of the senescence) failure rates are expected to increase. Thus, on the basis of this argument we hypothesize that:

> *Hypothesis 1c.* Beyond a certain age, the risk of firm exit increases with age.

### 2.2. *Size*

Whereas some studies on survival relate size at time of entry with survival chances (for example, Acs and Audretsch, 1989; Audretsch et al., 1999; Nurmi, 2006), other studies focus on current size instead. The features of our dataset prevent us from using size at time of entry as an explanatory variable since we do not have this information for most of the firms. There is only information on size over the *observation window* (1990–2000). Anyway, there exist good reasons to argue that current size is an appropriate explanatory variable. For example, Levinthal (1997) underlines that a firm's ability to adapt to changing competitive environment is a central element to determine its survival. In the same line, Mata et al. (1995) point out that current size is a better predictor of a firm's survival prospects than initial size because the former contains information on how a firm reacts to its market success over time.

Independently of the variable used to proxy size, a number of factors suggest a positive relationship between size and the probability of survival. First, larger firms are more likely to have output levels close to their industry minimum efficient scale, and thus, less likely to be vulnerable than smaller firms that produce at a lower scale (Audretsch and Mahmood, 1994). Secondly, large firms are usually more diversified than smaller ones, which reduces their risk of exit since adverse conditions in one market can be offset by better conditions in other markets. Thirdly, in the firm and industry dynamics literature, firms' size and age represent the efficiency differences arising from differences in experience, managerial abilities, production technology and firm organization. Fourthly, larger firms may find it easier to raise capital, may face better tax conditions and may be in a better position to recruit qualified workers. Thus, we hypothesize that:

> *Hypothesis 2.* The probability of survival increases with firm size.

### 2.3. *Advertising and R&D activities*

According to the Resource-Based Theory of the Firm, the ability of firms to develop distinct capabilities largely determines their survival prospects (Barney, 1991; Wernerfelt, 1984). The generation of these firm-specific assets highly depends on firms' R&D and advertising behavior as it determines their ability to innovate and market their products. Firms that engage in R&D activities and advertising are more likely to develop firm-specific assets, which cannot be imitated by their competitors and provide the basis for their competitive advantage over time. Further, these activities may have considerable spillovers to the whole firm (Klette, 1996), and transform the firms' capabilities and competences in other areas.

The IO literature (for instance, Ericson and Pakes, 1995; Jovanovic, 1982) has pointed out to differences in efficiency as the main factor explaining differences in firms' fates. These differences have been usually measured by age and size. However, Geroski (1995) argues that these variables capture this relationship rather loosely. Thus, firms' advertising and R&D choices may help to better capture the firms' relative efficiency and its evolution over time. Firms that obtain innovations and carry out advertising improve their efficiency, which makes them fitter to survive.

Advertising outlays can also be considered, as in Sutton (1991), as endogenous sunk costs improving the firms' perceived quality image and enhancing consumers' willingness to pay for their products. Thus, advertising is expected to improve survival prospects. For Comanor and Wilson (1967), advertising has an anticompetitive effect as it raises barriers to entry, which softens the toughness of competition and makes exit less likely.

Thus, according to both the Resource-Based Theory of the Firm and the Industrial Organization literature, we hypothesize that:

> *Hypothesis 3.* Firms engaged in advertising endure a lower probability of exit.

As regards R&D activities, when a firm decides to invest in R&D it has two options: making or buying technology. Two features distinguish the buy decision from the make decision. On the one hand, whereas the make option implies uncertainty regarding the innovations to be obtained, the buy option implies direct purchase of technology. On the other hand, whilst the buy option implies dependence on the technology of others and does not secure firm-specific competitive advantages, the make option provides the firm with its own specific technology. Therefore, whereas making R&D provides firm-specific assets that are difficult to imitate, buying R&D grants assets to the firm that can be acquired by its competitors. Thus, drawing on the Resource-Based View of the Firm and the Industrial Organization literature (Almus and Nerlinger, 1999; Calvo, 2006; Cefis and Marsili, 2006), we make the following hypotheses:

*Hypothesis 4a.* Firms making R&D enjoy longer survival prospects than firms buying R&D.

*Hypothesis 4b.* Firms making R&D enjoy longer survival prospects than firms neither making nor buying R&D.

*Hypothesis 4c.* Firms buying R&D enjoy longer survival prospects than firms neither making nor buying R&D.

Furthermore, previous work (Audrestch, 1995; Segarra and Callejón, 2002) has pointed out that in highly innovative industries the likelihood of survival is smaller. Thus, we hypothesize that

*Hypothesis 5.* Firms operating in highly innovative industries experience a higher probability of exit.

### 2.4. *Firm performance*

We further use measures of firm productivity as well as firm profitability to proxy firm performance. A firm's productivity crucially determines its relative efficiency and therefore its probability of survival. Jovanovic (1982), Ericson and Pakes (1995), and Melitz (2003) predict that the probability of survival is smaller for low-productive firms. This argument leads to our next hypothesis, which posits that:

*Hypothesis 6.* More productive firms experience a lower probability of exit.

As for firm profitability, high profitability can be a sign both of efficiency and of market power. If higher profitability is related to higher efficiency, we have already argued that productivity enhances survival. If the origin of high profitability is market power, we also expect better survival chances for more profitable firms. That is, profits may provide the necessary resources to develop firm-specific assets by means of innovation and advertising that can ease firm survival (as hypothesized by the Resource-Based Theory of the Firm). Notwithstanding, there are also factors that might relate high profitability to shorter survival. First, highly innovative activities can render very high returns but also increase the risk of firm failure given the uncertainty associated to them. Secondly, highly profitable firms might be more likely to be acquired or be involved in mergers.[6] Hence, we hypothesize that:

*Hypothesis 7.* Profitability affects firm survival. However, higher firm profitability could be related to either larger or shorter survival times.

### 2.5. *Other firm characteristics*

We also analyze the impact of other firm characteristics, such as export intensity, legal structure and foreign capital participation, upon the survival of firms. Recent models of heterogeneous firms and international trade (Bernard et al., 2003; Melitz, 2003) predict that exporters are less likely to fail than non-exporters. In these models the relationship between exports and survival is driven by the relatively high productivity of exporters as opposed to exporting itself. Hence, we hypothesize that:

*Hypothesis 8.* The higher the firm's exporting intensity, the lower its probability of exit.

As for the effects of legal structure, Harhoff et al. (1998) argue that since the owners of limited liability corporations are not responsible for the debts of the firms, limited liability corporations are more likely to go bankrupt than unlimited ones, where the owners are accountable for possible losses with their personal wealth. Our dataset does not allow distinguishing between exit by liquidation and exit by bankruptcy. Notwithstanding, since voluntary exit usually happens before a firm goes bankrupt, the argument rose by Harhoff et al. (1998) is still valid in our case. In this line, Mata and Portugal (2002) find that unlimited liability firms are more likely to exit than limited liability ones. Thus, we make following hypothesis:

*Hypothesis 9.* Limited liability firms will survive longer than their unlimited liability counterparts.

The literature on the effect of foreign capital participation on survival performance is inconclusive. On the one hand, foreign capital participation may itself be signaling unobserved quality of the participated firm, which would suggest that foreign-owned firms have a higher probability of survival. On the other hand, firms doing business abroad may face harsher survival conditions related to the difficulty both of coordinating different business units and of adapting to local market competitive conditions (Hymer, 1976). Furthermore, Braconier and Ekholm (2000) obtain that multinational firms have higher elasticity of labor demand, as they can shift production among locations depending on local economic conditions. Recently, Mata and Portugal (2002) find that domestic new firms are more likely to exit if other factors that may affect survival are not taken into account. However, the effect of this characteristic on survival vanishes after controlling for other relevant explanatory variables. Thus, we hypothesize that:

*Hypothesis 10.* Foreign-participated firms may or may not face a lower probability of exit than non-participated firms.

## 3. Data and methodology

### 3.1. *Data*

For this study we use data from a yearly survey of the Spanish manufacturing firms sponsored by the Ministry of Industry (*Encuesta sobre Estrategias Empresariales*, ESEE) that started in 1990.[7] Some features of this dataset make it suitable to examine the determinants of firm survival.

First, it is comprised by a representative sample of the entire population of Spanish manufacturing firms (and not merely new firms) classified by industries and size categories in 1990. The sampled firms are followed up to 2000.[8] Furthermore, we know their birth dates (i.e. spell start dates) so that total time at risk of failure can be calculated. At this point, it is important to notice that a sample from the stock of Spanish manufacturing firms in 1990 cannot be considered a random sample to examine the determinants of firm survival due to the existence of left-truncated spells. That is, firms that were born and died before 1990 (short-duration firms) that would be, in principle, eligible to be in the ESEE are not included in our sample.[9] However, this is not a problem since the empirical methodology discussed in Section 3.2 is capable of accommodating such features and allows obtaining unbiased estimates of the determinants of firm survival.

Secondly, the ESEE provides extensive annual information on firm-level characteristics that may help unravel the determinants of firm survival.[10]

Thirdly, this survey also allows identifying firms that stay in business, exit or leave the survey over the *observation window* (1990–2000). A firm is computed to exit in year t when this is the last year in which the firm is independently in operation.[11] When two firms merge we do not compute it as two firms exiting and one "*de* novo" entering, but consider the bigger firm involved as the continuing firm and the smaller firm as the exiting one. Given that we are interested in measuring survival, we only use information in 2000 to identify those firms exiting in 1999.

Therefore our sample includes 2028 firms selected in 1990 followed up until 2000. Of them, 344 had exited by 2000, leading to 14,193 observations.

### 3.2. *Methodology*

The features of our dataset make survival methods adequate to examine the determinants of firm survival.[12] First, the dataset comprises both complete and incomplete spells. The former correspond to firms that exited the market during the sample period (1990–2000) so that their duration is known. For the latter, all we know is that they were still active when they either abandoned the risk set (i.e. the pool of firms that may fail at any time) for reasons other than failure (abandon the survey), or were still active in 2000, thus making the duration measure right-censored. Survival methods are capable of dealing with the presence of right-censored spells.

Secondly, some of the covariates used to explain firm survival vary over time (time-varying covariates). The consideration of time-varying covariates allows overcoming the limitation that arises from considering firm characteristics previous to the beginning of the period analyzed or at the time of entry as the unique determinants of the probability of firm survival across time (see Mata et al., 1995).

Thirdly, survival methods based on maximum likelihood estimation principle are appropriate to examine duration given the distinctive features of our data. The "selection bias" provoked by the fact that short-duration firms (firms that were born and died before 1990 but that if had been active in 1990 would have been eligible to be included in the ESEE) are not included in our sample can be handled using information about the elapsed time between sampling and the end of the followed-up period. That is, we analyze failures that have occurred by 2000 conditional on surviving in the stock until 1990 (date of sampling).

Therefore the likelihood contributions of both complete and incomplete spells (i.e. firms exiting and non-exiting over the sample period) must be conditioned on the fact that the firm survived sufficiently long to be at risk of being sampled in the stock. This is collected by each firm's survival function from its birth until the stock sampling date $\tau_i$, $S(\tau_i)$, which is the probability of survival from birth until 1990. Let us define $c_i$ as a censoring indicator that takes value 1 when the spell is complete and 0 when it is censored. The overall sample likelihood function is given by:

$$L = \prod_{i=1}^{N} \left[ \left[ \frac{f(T_i)}{S(\tau_i)} \right]^{c_i} \left[ \frac{S(T_i)}{S(\tau_i)} \right]^{1-c_i} \right] = \prod_{i=1}^{N} \left[ [\lambda(T_i)]^{c_i} \left[ \frac{S(T_i)}{S(\tau_i)} \right] \right] \quad (1)$$

Taking logarithms, the log-likelihood function is:

$$\ln L = \sum_{i=1}^{N} \left\{ c_i \ln \lambda(T_i) + \ln \left[ \frac{S(T_i)}{S(\tau_i)} \right] \right\} \quad (2)$$

where $T_i$ is firm $i$'s duration and $f(.)$, $S(.)$ and $\lambda(.)$ stand for the probability density, survival and hazard functions, respectively. The latter is a central concept in survival analysis. Following Kalbfleisch and Prentice (1980), the hazard function is defined as the instantaneous probability that a firm exits the market at time $t$ given that it has survived until this period $t$. It can be conditioned to a vector of covariates $X$, which may include both time-varying and time-constant explanatory variables:

$$\lambda(t; X) = \lim_{dt \to 0} \frac{\Pr[t \leq T < t + dt | T \geq t, X]}{dt} \quad (3)$$

where $T$ is a non-negative continuous random variable (duration).

The empirical estimates of the survival and hazard rates are obtained using the Kaplan–Meier product limit estimate procedure. Thus, the non-parametric estimate of the survival function (Figure 1) shows that 50% of the firms survive less than 26 years, with only a 25% of the firms in operation over 62 years.

Figure 2 depicts the smoothed hazard rate that shows the evolution of firms' failure risk. It rapidly increases with age, then decreases to later sharply rise.

The decline in the exit rate as firms age for intermediate durations (that is, negative duration dependence) might be due to the presence of individual heterogeneity. As time goes by, the remaining firms may be made up by an increasing proportion of firms fitter to survive. In the multivariate specification of firm survival, if these firm-specific abilities are not accounted for by explanatory variables we might be incurring in a problem of model-misspecification. We further discuss this below.

The goal of our analysis is to test the hypotheses outlined in section 2 concerning the

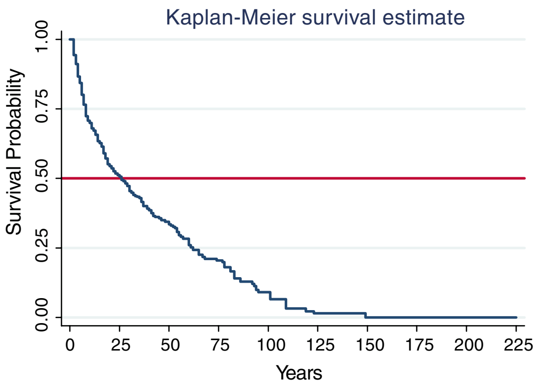


Figure 1. Kaplan–Meier estimate of the survival function.

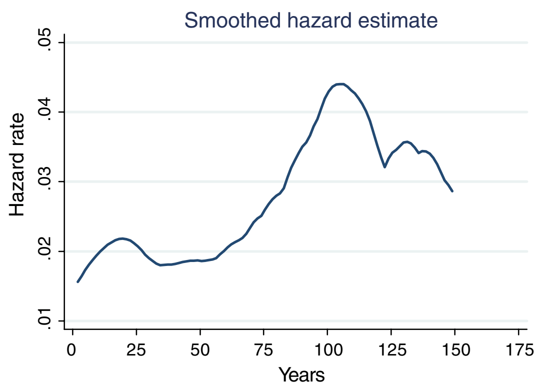


Figure 2. Non-parametric hazard function.

determinants of firm survival. Table A.1 provides detailed information on the explanatory variables used to test them. Dummy variables by year are also included to account for macroeconomic effects. The empirical work is carried out in two steps.

First, we examine the influence of explanatory variables individually by carrying out non-parametric tests of equality of survival functions across *r*-groups of firms according to the *r*-values of each of these covariates. These tests are extensions of non-parametric rank tests used to compare two or more distributions for censored data. Under the null hypothesis there is no difference in the survival rates for each of the *r*-groups at any of the failure times and this statistic distributes as a $\chi^2$ with $r-1$ degrees of freedom. At any failure time, the contribution to the *t*-statistic is obtained as a weighted standardized sum of the difference between the actual and expected number of exits for each of the *r*-groups. Given that the sampling procedure is different for firms above and below 200 employees, stratified tests taking this into account are also carried out.

Secondly, we undertake a multivariate analysis in order to evaluate the effect of each explanatory variable controlling for the effect of other covariates. Thus, we estimate the following proportional hazards model specification (Cox, 1972):

$$\lambda(t, X_i) = \lambda_0(t) \cdot \exp(X_i\beta) \tag{4}$$

where $\lambda_0(t)$ represents the baseline function obtained for $\exp(X\beta) = 1$, that is, the hazard function when all explanatory variables $X_i$ are set equal to 0. In this specification, the effect of a unit change of the independent variables is a constant parallel shift of the baseline function. This proportionality assumption can be tested using the test proposed by Grambsch and Therneau (1994).

Our estimating equation is the proportional hazards specification in (4). It may be made flexible enough so as to allow testing the different predictions derived from the theory. The baseline function can either be left unspecified leading to a semi-parametric model (Cox Proportional Hazards Model, CPHM hereafter) or be assumed to take a specific functional form. Misspecification of the baseline hazard function leads to inconsistent estimates, but semi-parametric models are less efficient than the correct parametric specification. Moreover, parametric representations of the duration distribution allow richer prediction results on firm duration.

The two parametric models we consider are the Weibull and the exponential models. If we assume that the *baseline function* takes the form $\lambda_0(t) = p \cdot t^{p-1} \cdot \exp(a)$ then we have the Weibull model

$$\lambda(t, X_i) = p \cdot t^{p-1} \cdot \exp(a) \cdot \exp(X_i\beta) \tag{5}$$

where $a$ and $p$ are the ancillary parameters to be estimated together with vector $\beta$. If $p > 1$ ($p < 1$), the risk of failure is monotonically increasing (decreasing) in age ($t$). For $p = 1$, the hazard rate is constant over time and we have the exponential model. In the latter model, the failure rate is independent of age, implying that the way in which the overall hazard varies over age is purely a function of how $X\beta$ varies over time. That is, age itself plays no role in explaining duration, which might be argued that should be the case if the process under study is fully understood (Cleves et al., 2004). Thus, there exist other features of the firms, such as *initial endowments* or *acquired capabilities* that explain observed differences in lifetime experiences across firms.

Furthermore, generalizations to the proportional hazards models in order to allow for unobserved individual effects are also estimated for the parametric specification (5). These models, known as *frailty models*, are survival-data analogue to random effects models in panel data and take the following specification,

$$\lambda(t, X_i \backslash \upsilon_i) = \upsilon_i \cdot \lambda(t, X_i) = \upsilon_i \cdot \lambda_0(t) \cdot \exp(X_i\beta) \quad (6)$$

where $\upsilon$, the unobservable individual effect ("frailty"), enters multiplicatively on the hazard function. This random variable is assumed both to be positive and to follow a gamma distribution with unit mean (required for identification) and finite variance ($\theta$) to be estimated from the data, as well as to be distributed independently of $t$ and $X$. The null hypothesis of variance equal to zero is tested. Under the null, unobserved heterogeneity is not important and the estimated model is the non-frailty model.

## 4. Results

We devote the first part of this section to briefly analyze the results[13] of the non-parametric univariate tests described in Section 3 (Methodology). The aim is to obtain a first picture of the individual effect of each one of the variables considered (and defined in Table A.1) on firm survival. The second part of this section thoroughly discusses the results obtained in the multivariate regression analysis and relates them with the hypotheses on the determinants of firm survival stated in Section 2.[14]

### 4.1. *Non-parametric tests results*

Table I presents the results for the log-rank and Wilcoxon tests of equality of survival functions across groups of firms classified by explanatory variables.[15] The results suggest the existence of remarkable differences in the survival prospects between groups of firms for each of the variables considered (except for the foreign capital participation variable -*pkext*-). Thus, large, highly-productive and conducting R&D (as opposed to buying or neither making nor buying) firms as well as companies carrying out advertising endure significantly better survival chances than their counterparts at the 1% level of statistical significance. In addition, limited liability firms survive longer (at a 10% significance level). The magnitude of these differences can be seen by comparing the last column of Table I that includes the median survival times by groups obtained by the Kaplan–Meier product limit estimate method. We further find that both in high and low innovative industries the competitive environment is significantly tougher than in the intermediate level ones. This finding seems to be consistent with Audretsch (1995) and Segarra and Callejon (2002). Interestingly, the highest survival performance does not correspond to the more profitable companies. Two plausible explanations for this result could be either that higher profitability is associated to risky activities, or that highly profitable industries attract entry making competition tougher and worsening survival chances.

Furthermore, given that the sampling procedure in the ESEE is different for firms over and under 200 workers, we also perform stratified log-rank tests of equality of survival functions. Table II displays the results. At first glance, we observe that median duration is greater for large firms (as previously suggested by the results for the size variable in Table I) for every explanatory variable. Besides, once we take into account the effect of size, most results are similar to those in Table I, although some worth mentioning differences arise. First, for large firms, there are no significant differences in the survival performance between advertisers and non-advertisers, firms operating in industries with different technological intensity and different legal form. Secondly, foreign capital participation turns

TABLE I
Non-parametric tests of equality of survival functions and median duration by explanatory variables

| | Log-rank | Wilcoxon | Median duration | |
|---|---|---|---|---|
| Size (dgrsize) | 31.28<br>(0.000) | 17.91<br>(0.000) | Dgrsize = 0<br>Dgrsize = 1 | 22<br>60 |
| Advertising (adv) | 27.79<br>(0.000) | 22.21<br>(0.000) | Adv = 0<br>Adv = 1 | 17<br>32 |
| R&D (rdgroup) | 58.78<br>(0.000) | 38.18<br>(0.000) | Rdgroup = 1<br>Rdgroup = 2<br>Rdgroup = 3 | 20<br>22<br>74 |
| Industry technological intensity (intec) | 20.27<br>(0.000) | 10.89<br>(0.004) | Intec = 1<br>Intec = 2<br>Intec = 3 | 19<br>60<br>28 |
| Productivity (pro) | 52.32<br>(0.000) | 33.94<br>(0.000) | Pro = 1<br>Pro = 2<br>Pro = 3 | 19<br>30<br>42 |
| Price cost margin (pcmi) | 131.38<br>(0.000) | 103.91<br>(0.000) | Pcmi = 1<br>Pcmi = 2<br>Pcmi = 3<br>Pcmi = 4 | 10<br>37<br>55<br>34 |
| Export intensity (expint) | 43.17<br>(0.000) | 26.80<br>(0.000) | Expint = 1<br>Expint = 2<br>Expint = 3 | 19<br>37<br>68 |
| Limited liability (limited) | 3.78<br>(0.052) | 3.13<br>(0.077) | Limited = 0<br>Limited = 1 | 22<br>29 |
| Foreign capital participation (pkext) | 0.35<br>(0.552) | 0.04<br>(0.833) | Pkext = 0<br>Pkext = 1 | 26<br>29 |

*Notes:*
1. See Table I for variable definitions.
2. 14,193 observations, 2028 firms, and 344 exits.
3. *P*-values in parentheses.
4. "Median duration" is the Kaplan–Meier estimate of the median duration for each group according to each explanatory variable.

significant (although at the 10% significance level) since it reduces the median duration of small firms, but has no effect on the duration of large companies.

### 4.2. *Estimation results*

Table III shows the results of estimating the proportional hazards specification (4) under different distributional assumptions for the baseline function: the semi-parametric CPHM (model 1), and parametric Weibull (model 2) and exponential (model 3).

We have tested for specification errors obtaining that we cannot reject the null hypothesis that the models are correctly specified. Moreover, the assumption of proportionality both for all variables jointly and for each variable has been tested using the tests proposed by Grambsch and Therneau (1994). The null hypothesis that the hazard rates are proportional cannot be rejected at a 5% significance level.

It can be observed that the estimates of the two parametric specifications of equation (4) are quite alike and similar to those of the semi-parametric CPHM. The CPHM that assumes no functional form for the baseline function is more flexible and leads to consistent estimates, but is less efficient than the appropriate parametric model.[16] As for the choice between the two parametric models, in the Weibull estimation we cannot reject the null hypothesis that $\ln(p) = 0$ (that is, $p = 1$). Therefore, our preferred parametric specification is the exponential model.[17] Furthermore, to test for unobserved individual heterogeneity, we estimate equation (6) assuming an exponential distribution for the baseline hazard function including an individual effect, $\upsilon$ (with mean 1 and variance $\theta$), multiplying the hazard function. However, the null hypothesis that the frailty variance component ($\theta$) is equal to zero is not rejected at a 1% significance level, suggesting that the non-frailty exponential model (model 3 in Table III) is the appropriate parametric model.[18] Hence, our comments focus both on the CPHM and on the exponential models. Prediction results are obtained using the latter model.

The inspection of the non-parametric estimate of the hazard rate (Figure 2) suggests that the risk of exit increases up to about 20 years of age, then declines up to 35 to later rise, accelerating beyond 75 years of age. Hence, our results support *hypotheses 1b and 1c* (in line with the predictions of liability of "adolescence" and liability of "senescence", respectively) since the hazard rate has initially an inverted U-shaped, and beyond a certain age increases.[19]

All covariates in our model are introduced as sets of dummy variables with the aim of capturing possible non-linear effects of the covariates on duration.

TABLE II
Non-parametric tests of equality of survival functions by explanatory variables, controlling for firm size

| | Small firms | | | Large firms | | | All firms |
|---|---|---|---|---|---|---|---|
| | Log-rank test | | Median | Log-rank test | | Median | Log-rank test |
| Advertising (adv) | 17.50 (0.000) | adv = 0 | 16 | 1.02 (0.313) | adv = 0 | 83 | 18.45 (0.000) |
| | | adv = 1 | 28 | | adv = 1 | 60 | |
| R&D (rdgroup) | 17.36 (0.000) | rdgroup = 1 | 19 | 23.05 (0.000) | rdgroup = 1 | 32 | 35.04 (0.000) |
| | | rdgroup = 2 | 16 | | rdgroup = 2 | 16 | |
| | | rdgroup = 3 | 37 | | rdgroup = 3 | 95 | |
| Industry technological intensity (intec) | 12.22 (0.001) | intec = 1 | 19 | 3.88 (0.143) | intec = 1 | 55 | 18.00 (0.000) |
| | | intec = 2 | 40 | | intec = 2 | 95 | |
| | | intec = 3 | 19 | | intec = 3 | 54 | |
| Productivity (pro) | 28.96 (0.000) | pro = 1 | 19 | 7.05 (0.029) | pro = 1 | 17 | 33.92 (0.000) |
| | | pro = 2 | 28 | | pro = 2 | 56 | |
| | | pro = 3 | 29 | | pro = 3 | 83 | |
| Price cost margin (pcmi) | 100.00 (0.000) | pcmi = 1 | 9 | 27.25 (0.000) | pcmi = 1 | 11 | 123.13 (0.000) |
| | | pcmi = 2 | 32 | | pcmi = 2 | 54 | |
| | | pcmi = 3 | 37 | | pcmi = 3 | 112 | |
| | | pcmi = 4 | 26 | | pcmi = 4 | 74 | |
| Export intensity (expint) | 12.40 (0.002) | expint = 1 | 18 | 54.00 (0.000) | expint = 1 | 30 | 22.57 (0.000) |
| | | expint = 2 | 31 | | expint = 2 | 57 | |
| | | expint = 3 | 37 | | expint = 3 | 110 | |
| Limited (limited) | 0.04 (0.848) | limited = 0 | 22 | 3.04 (0.814) | limited = 0 | 16 | 0.29 (0.588) |
| | | limited = 1 | 21 | | limited = 1 | 65 | |
| Foreign capital participation (pkext) | 3.80 (0.051) | pkext = 0 | 22 | 0.32 (0.571) | pkext = 0 | 74 | 3.52 (0.060) |
| | | pkext = 1 | 17 | | pkext = 1 | 55 | |

*Notes:*
1. 14,193 observations, 2028 firms, and 344 exits.
2. *P*-values in parentheses.
3. Variable definitions in Table I
4. "Median duration" is the Kaplan–Meier estimate of the median duration for each group according to each explanatory variable.

After controlling for all other variables, large firms endure better survival prospects than small firms, which is consistent with our *hypothesis 2*.[20] The instantaneous probability of exit for large firms is about 32–39% lower than that for small firms. This finding is consistent with most previous studies on firm survival (Caves, 1998; Geroski, 1995).

As stated in our *hypothesis 3*, and according to the Resource-Based Theory of the Firm, the hazard rate of advertisers is significantly lower than that of non-advertisers.[21] In particular, it is 71% of the hazard rate faced by non-advertisers.

To investigate whether the effectiveness of firms' R&D strategies depends on the *technological opportunities* surrounding the firm, in turn determined by the innovative environment of the particular industry in which the firm operates, we take into account whether the firm innovative activities take place in a high, medium or low technologically intensive industry.[22] A number of interesting findings arise.

First, survival performance of firms that make R&D is better than that of firms that neither make nor buy R&D, independently of the innovative intensity of the industry, which is in line with *hypothesis 4b*. Secondly, only in highly technological environments do firms that make R&D endure better survival prospects than firms whose R&D activity is limited to buying it. In the other two groups of industries, the difference in survival prospects of firms

TABLE III
Estimation results

| | Cox Estimation (model 1) | | Weibull Estimation (model 2) | | Exponential estimation (model 3) | |
|---|---|---|---|---|---|---|
| | Haz. Ratio | *P*-value | Haz. Ratio | *P*-value | Haz. Ratio | *P*-value |
| Dgrsize | 0.604 | 0.012 | 0.652 | 0.024 | 0.682 | 0.042 |
| Adv | 0.717 | 0.004 | 0.711 | 0.003 | 0.714 | 0.003 |
| Intrd12 | 1.068 | 0.867 | 1.006 | 0.987 | 1.008 | 0.983 |
| Intrd13 | 0.506 | 0.015 | 0.494 | 0.010 | 0.499 | 0.011 |
| Intrd21 | 0.645 | 0.006 | 0.633 | 0.003 | 0.643 | 0.005 |
| Intrd22 | 0.319 | 0.252 | 0.304 | 0.226 | 0.308 | 0.231 |
| Intrd23 | 0.202 | 0.000 | 0.199 | 0.000 | 0.200 | 0.000 |
| Intrd31 | 1.002 | 0.989 | 0.989 | 0.947 | 0.993 | 0.966 |
| Intrd32 | 1.211 | 0.735 | 1.241 | 0.668 | 1.221 | 0.693 |
| Intrd33 | 0.485 | 0.008 | 0.474 | 0.005 | 0.477 | 0.006 |
| Pro2 | 0.728 | 0.026 | 0.712 | 0.014 | 0.717 | 0.016 |
| Pro3 | 0.652 | 0.020 | 0.651 | 0.013 | 0.657 | 0.015 |
| Pcmi2 | 0.384 | 0.000 | 0.395 | 0.000 | 0.393 | 0.000 |
| Pcmi3 | 0.290 | 0.000 | 0.299 | 0.000 | 0.298 | 0.000 |
| Pcmi4 | 0.402 | 0.000 | 0.422 | 0.000 | 0.418 | 0.000 |
| Expint2 | 0.811 | 0.146 | 0.786 | 0.085 | 0.806 | 0.122 |
| Expint3 | 0.538 | 0.004 | 0.531 | 0.002 | 0.542 | 0.003 |
| Limited | 1.121 | 0.375 | 1.121 | 0.361 | 1.139 | 0.298 |
| Pkext | 2.167 | 0.000 | 2.025 | 0.000 | 2.032 | 0.000 |
| Y91 | 0.994 | 0.976 | 0.963 | 0.846 | 0.980 | 0.916 |
| Y92 | 1.321 | 0.147 | 1.307 | 0.138 | 1.346 | 0.100 |
| Y93 | 1.006 | 0.976 | 0.920 | 0.674 | 0.959 | 0.831 |
| Y94 | 0.904 | 0.651 | 0.863 | 0.487 | 0.907 | 0.645 |
| Y95 | 0.598 | 0.067 | 0.558 | 0.027 | 0.587 | 0.043 |
| Y96 | 0.877 | 0.610 | 0.742 | 0.218 | 0.786 | 0.321 |
| Y97 | 0.452 | 0.026 | 0.364 | 0.003 | 0.388 | 0.006 |
| Y98 | 1.228 | 0.442 | 0.996 | 0.988 | 1.066 | 0.795 |
| Y99 | 1.123 | 0.678 | 0.922 | 0.758 | 0.989 | 0.966 |
| Log-likelihood | −1747.381 | | −534.044 | | −534.987 | |
| Wald test (d. of f.) | 276.7 (28) | 0.000 | 314.12(28) | 0.000 | 319.54(28) | 0.000 |
| N. of observations | 14,193 | | 14,193 | | 14,193 | |
| N. of firms | 2028 | | 2028 | | 2028 | |
| N. of events | 344 | | 344 | | 344 | |
| | | | ln(p) | *P*-value | | |
| Weibull estimation | | | 0.094 | 0.48 | | |

*Notes:*
1. The coefficients indicate the effect on the risk rate of a change from 0 to 1 in the variable.
2. *P*-values are calculated from robust standard errors.
3. The Cox estimation has been carried out using the method proposed by Efron to deal with "ties" (when there is more than one firm exiting of a particular age).

pursuing these R&D strategies is not statistically significant. This result suggests that it is particularly in technologically intensive industries where the generation of firm-specific assets is crucial for the survival strategy of the companies. This is consistent with the findings of Audretsch (1995). Therefore, we only find empirical support for *hypotheses 4a* in high technological intensity industries. Thirdly, we do not find evidence in favor of *hypothesis 4c*, since there is no statistically significant difference between buying R&D and not doing it at all, independently of the technological regime of the industry. The evidence supporting *hypothesis*

*4b*, for all technological regimes, and *hypothesis 4a*, for high technological intensity industries, gives support to the Resource-Based Theory of the Firm. The ability of firms to generate firm-specific assets that cannot be imitated by their competitors, in this case by making R&D, largely determines their survival prospects.

Furthermore, both for firms making R&D and for firms neither making nor buying R&D holds that: (i) survival prospects are longer in intermediate technological intensity industries than in both low and high technologically intensive industries; (ii) we find no significant differences between low and high technological intensity industries. For those firms that only buy R&D, the technological regime of the industry has no significant effect on their survival probability. Thus, our results do not confirm *hypothesis 5* as hazard rates are not necessarily higher for firms operating in high technological intensity industries.

As regards the impact on firm survival of the variables used to proxy firm performance, as stated in *hypothesis 6*, more productive firms experience a lower probability of exit. Both the hazard rates of the firms in the second and upper third of the productivity distribution are lower (28% and 34%, respectively) than the hazard rate of the firms in the lowest third. However, the effect of productivity on survival is not linear as the hazard rates of the second and upper third of the productivity distribution are not significantly different.[23]

In line with *hypothesis 7*, profitability appears to be an important determinant of firm survival. Nevertheless, higher profitability does not necessarily mean longer expected lifetime. Despite the fact that the hazard ratios for all the groups of firms with positive price-cost margins are significantly lower than the hazard ratio of the group with negative price-cost margin, the firms that endure better survival prospects are those in intermediate price-cost margin interval (between 10% and 25%). The hazard rate of the intermediate price-cost margin group is 29% of that faced by firms with negative price-cost margins (the omitted category) and the hazard rates of high and ''low but positive'' price-cost margin groups are about 41% and 39%, respectively. Survival prospects for the firms with high price-cost margin (higher than 25% -*pcmi4*-) are not significantly different to those of the firms with ''low but positive'' margin (lower than 10% -*pcmi2*-). The non-linear effect of profitability on survival could be due to the two factors acknowledged in Section 3: first, high profitability can be associated to very risky activities with a high probability of failure; secondly, highly profitable firms are very appealing for potential buyers and/or firms willing to merge, raising the probability of being acquired and/or being involved in mergers.

In relation to the other firm characteristics considered in the analysis and once we control for other characteristics, export participation extends survival prospects only if exports represent an important proportion of the firm's sales. Whereas the hazard rate of a firm that exports less than 25% of its sales is not significantly different from that of firms that do not export, the hazard rate of a firm whose exports-to-sales ratio surpasses 25% is 46% lower, after taking into account other factors. Thus, we find evidence supporting *hypothesis 8* only for firms highly oriented to export markets.

Our results do not confirm *hypothesis 9*, since firm legal structure does not appear to significantly affect the survival of firms. However, in sharply contrast to the non-parametric results, foreign capital participation is clearly important for the prospects of firm survival (as stated in *hypothesis 10*).[24] The risk of exit is more than 100% higher for firms whose capital is participated by foreign capital as compared to that faced by non-participated firms.

We have also carried out-of-sample predictions performed using the estimated coefficients for the exponential model in Table III.[25] They allow us to characterize the ''fittest-to-survive'' firm created in 1991 with a 50% probability or surviving up to 639 years. It is a firm with these (constant-over-time) features: large, with no foreign capital participation, carrying out advertising and making R&D in an intermediate technologically intensive industry, clearly orientated towards exports markets, highly productive and with a legal structure different to limited liability. Some crucial aspects beneath this result seem to be the innovative environment in which the firm competes, and the participation of foreign capital. The deviations to this benchmark case leads to important changes in predicted median duration. It seems that participation of foreign capital is not a desirable feature if a firm aims at remaining in a market.[26] Firms orientated to international markets have better survival prospects. This could be consistent with the view that only efficient firms survive in markets where competition is tougher.

Furthermore, there are factors that ruin a firm's survival outcome. In particular, firms that are small (between 10 and 200 workers), whose capital is participated by foreign investors, with limited liability as legal form, not performing advertising, buying R&D in a highly innovative industry, making losses, no selling their products abroad and with low productivity will have an expected lifetime below 2.20 years with a probability of 50%. There are some important factors leading to this result. In particular, when designing its R&D strategy, it is important to evaluate the innovative regime in which the firm is going to operate. Buying R&D (that is, being an imitator) is probably not a mistaken strategy in intermediate innovative industries, but can place the firm in a very disadvantageous position in a highly innovative industry in which developing firm-specific assets by making R&D seems to be a crucial factor for firm survival. *Ceteris paribus*, the survival chances (in particular, its predicted median duration) of a ''poor'' performing firm rises from 2.2 to almost 9 years if the firm continues buying R&D but in an intermediate innovative industry rather than in a highly innovative environment.

This prediction exercise further allows gaining insights into crucial factors affecting expected survival. A firm with predicted median duration close to the sample predicted median will raise its expected median lifetime in almost 20 years (from 44.04 to 63.24 or 62.50, respectively) by slightly increasing its productivity or by starting advertising. Interestingly, if the firm continues making R&D but shifts from a medium-technological intensity industry to a high or low technological one, its survival chances dramatically shrink. Therefore, the technological regime in which a firm competes notoriously determines survival chances. This point has been previously risen and is consistent with the findings of Audretsch (1995) and Segarra and Callejón (2002).

## 5. Concluding remarks

This paper has used hazard models to test a number of hypotheses concerning the determinants of survival of Spanish manufacturing firms. The hypotheses have been primarily drawn from the Resource-Based Theory of the Firm.

An important difference with previous work is that our study includes a representative sample of all firms (over 10 employees) from the stock of all manufacturing firms in 1990, which are observed up to 2000, rather than a cohort of new firms followed over a short period of time after entry.

Our results confirm the predictions of the Resource-Based Theory of the Firm since firms' strategies that allow to develop firm-specific assets, such as advertising and making R&D, arise as crucial determinants of firm survival. On the one hand, survival prospects are better for advertisers. On the other hand, we find that in general, making R&D improves firms' competitive position. However, it is important to remark that the innovative environment in which firms competes affects the effectiveness of their R&D strategy. Hence, we find that it is particularly in technologically intensive industries where taking the lead in the innovative process by making R&D is crucial for survival.

We also find that firm age is important to explain survival outcomes. In fact, we observe a relatively unusual relationship between the hazard rate and age, more in line with the liability of ''adolescence'' and ''senescence'' than with to the liability of ''newness.'' The risk of exit increases in the early days of a firm, then decreases to later increase.

Furthermore, more productive firms and firms orientated to international markets have better survival prospects. Very likely, if a firm manages to maintain a significant exports-to-sales ratio is because the firm is fit to survive as competition in international markets is tougher, driving less efficient firms out of market.

Finally, our results are relevant from both policy and managerial points of view. From the policy standpoint, our results provide guidelines to design future industrial policies that can help firms to develop those potentialities required to stay in the market. Policy makers tend to focus on promotion of new firm entry given its impact on unemployment and economic activity. However, if these firms are not fit enough to survive, these effects will vanish shortly after entry and the negative effects in the medium term may even overcome the positive initial results. Therefore, in the long term it seems especially relevant to focus on the creation of firms capable to survive as well as on creating the appropriate incentives to allow existing firms to adapt to the changing competitive environment and survive longer. Nowadays, this is an important topic in developed countries given the extent of the phenomenon of industry delocalization towards less developed countries. From a managerial point of view, our results would encourage firms to pursue specific strategies, as for example investing in R&D to develop firm specific assets, in order to improve their competitive position and increase their survival chances.

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## Appendix

TABLE A.1
Variable definitions (Source: ESEE) (All variables are time-varying covariates)

| | |
|---|---|
| Dgrsize | Dummy variable that takes the value of 1 if the firm has more than 200 workers and 0 if otherwise |
| Adv | Dummy variable that takes the value of 1 if the firm advertising expenditure is positive and 0 if otherwise |
| Intec | Variable that takes the value of 1 if the firm belongs to a low- technological intensity industry, the value of 2 if the firm belongs to a medium-technological intensity industry, and 3 if the firm belongs to a high-technological intensity industry (see Table A.2) |
| Rdgroup | Variable that takes the value of 1 if the firm neither buys nor makes R&D, the value of 2 if the firm buys R&D, and the value of 3 if the firm makes R&D. |
| Intrd11 | Dummy variable that takes the value of 1 if the firm belongs to a low-technological intensity industry and it neither makes nor buys R&D and 0 if otherwise |
| Intrd12 | Dummy variable that takes the value of 1 if the firm belongs to a low-technological intensity industry and it buys but does not make R&D and 0 if otherwise |
| Intrd13 | Dummy variable that takes the value of 1 if the firm belongs to a low-technological intensity industry and it makes R&D and 0 if otherwise |
| Intrd21 | Dummy variable that takes the value of 1 if the firm belongs to an intermediate-technological intensity industry and it neither makes nor buys R&D and 0 if otherwise |
| Intrd22 | Dummy variable that takes the value of 1 if the firm belongs to a medium-technological intensity industry and it buys but does not make R&D and 0 if otherwise |
| Intrd23 | Dummy variable that takes the value of 1 if the firm belongs to a medium-technological intensity industry and it makes R&D and 0 if otherwise |
| Intrd31 | Dummy variable that takes the value of 1 if the firm belongs to a high-technological intensity industry and it neither makes nor buys R&D and 0 if otherwise |
| Intrd32 | Dummy variable that takes the value of 1 if the firm belongs to a high-technological intensity industry and it buys but does not make R&D and 0 if otherwise |
| Intrd33 | Dummy variable that takes the value of 1 if the firm belongs to a high-technological intensity industry and it makes R&D and 0 if otherwise |
| Pro | Variable that takes the value of 1 if the firm's labor productivity belongs to the first third of the sample labor productivity distribution, the value of 2 if the firm's labor productivity belongs to the second third of the productivity distribution, and the value of 3 if the firm's productivity belongs to the upper third of the labor productivity distribution |

TABLE A.1
continued

| | |
|---|---|
| Pro1 | Dummy variable that takes the value of 1 if the firm's productivity belongs to the first third of the labor productivity distribution |
| Pro2 | Dummy variable that takes the value of 1 if the firm's productivity belongs to the second third of the labor productivity distribution |
| Pro3 | Dummy variable that takes the value of 1 if the firm's productivity belongs to the upper third of the labor productivity distribution |
| Pcmi | The price cost margin is approximated by the value of gross output minus variable costs of production, divided by the value of gross output. The gross value of output is computed as sales + stock variation + other revenues. The variable cost of production is computed as intermediate consumption (raw material and services) + labor costs. The variable pcmi takes the value of 1 if the firm's price-cost margin is negative, the value of 2 if the firm's price-cost margin is greater than or equal to 0 and lower than or equal to 10%, the value of 3 if the firm's price-cost margin is greater than 10% and lower than or equal to 25%, and takes the value of four if the firm's price cost margin is greater than 25% |
| Pcmi1 | Dummy variable that takes the value of 1 if the firm's price cost margin is negative |
| Pcmi2 | Dummy variable that takes the value of 1 if the firm's price-cost margin is greater than or equal to 0 and lower than or equal to 10% |
| Pcmi3 | Dummy variable that takes the value of 1 if the firm's price-cost margin is greater than 10% and lower than or equal to 25% |
| Pcmi4 | Dummy variable that takes the value of 1 if the firm's price cost margin is greater than 25% |
| Expint | Variable that takes the value of 1 if the firm does not export, the value of 2 if the firm's export intensity is greater than 0% and lower than or equal to 25%, and takes the value of 3 if firm's export intensity is greater than 25%, |
| Expint1 | Dummy variable that takes the value of 1 if the firm does not export and 0 if otherwise |
| Expint2 | Dummy variable that takes the value of 1 if the firm's export intensity (ratio of export over sales) is greater than 0% and lower than or equal to 25% |
| Expint3 | Dummy variable that takes the value of 1 if the firm's export intensity (ratio of export over sales) is greater than 25% |
| Limited | Dummy variable that takes the value of 1 if the firm is a limited liability company and 0 if it has any other legal structure |
| Pkext | Dummy variable that takes the value of 1 if the firm's capital is participated by foreign capital and 0 if otherwise |

TABLE A.2
Industrial technological intensity (NACE–93 industrial classification)

| Industry | Industrial technological intensity |
|---|---|
| Meat industry | Low |
| Food and tobacco | Medium |
| Beverages | Low |
| Textiles and clothing | Low |
| Leather and shoes | Low |
| Timber | Low |
| Paper Industry | Low |
| Printing and printing products | Low |
| Chemical products | High |
| Rubber and plastic products | Medium |
| Non metallic mineral products | Low |

TABLE A.2
continued

| Industry | Industrial technological intensity |
|---|---|
| Ferrous and non-ferrous metals | Medium |
| Metal products | Low |
| Industrial and agricultural machinery | Medium |
| Office machines | High |
| Electric and electronic machinery and material | High |
| Vehicles, cars and motors | Medium |
| Other transport equipment | High |
| Furniture | Low |
| Other manufacturing products | Low |

## Notes

[1] Two salient contributions are Wernerfelt (1984) and Barney (1991).

[2] See Caves (1998) and the especial issue of *The International Journal of Industrial Organization* on "The post-entry performance of firms" (1995) for an overview.

[3] The ESEE does not include firms with less than 10 employees.

[4] Our sampling scheme is commonly named as *Stock sampling with follow up*, which differs from the more common sampling procedure in the survival literature known as *Inflow with follow up*.

[5] Norton and Moore (2006) study the effect of entrepreneurial risk evaluation on entry and growth decisions.

[6] Both Gimeno et al. (1997) and Dunne and Roberts (1991) find a positive relationship between firms' profitability and their survival chances. However, Siegfried and Evans (1992) find no relationship.

[7] The data used in this paper, Encuesta sobre Estrategias Empresariales (ESEE), are the property of the Fundacion Empresa Publica (FUNEP). It is possible to buy the data from the FUNEP at reasonable prices. Information about the dataset and how to access the data can be found at the following web page http://www.funep.es/esee/ing/i_esee.asp

[8] The sampling procedure of the ESEE is the following. Firms with less than 10 employees were excluded from the survey. Firms with 10–200 employees were randomly sampled by industry and size strata, holding around a 5% of the population in 1990. All firms with more than 200 employees were requested to participate, obtaining a participation rate around 60% in 1990.

[9] In survival analysis, this sampling scheme is known as stock-sampling with follow-up, delayed entry or left-truncated data.

[10] A limitation of our sample is that we have no information on firms at the time of entry, such as their start-up size, which has been commonly used in the *Entry and Post-entry literature*.

[11] It includes permanent end of operation, firm in liquidation process, and shift to non-manufacturing activities as well as being acquired.

[12] See Kiefer (1988) for a survey on the application of these models to economic studies.

[13] Along the empirical analysis (especially when examining median durations and expected durations), it is important to bear in mind that firms with less than 10 employees are not included in the ESEE.

[14] The empirical analysis has been carried out using Stata 8.2 Special Edition software.

[15] The Peto–Peto–Prentice test has also been carried out leading to similar results. The differences among these tests lie on the weights assigned to the differences between actual and predicted number of exits by group. The weight at each distinct failure time is 1 for the log-rank test, whereas it is the number of firms at risk for the Wilcoxon test. (see Cleves et al., 2004, for further details).

[16] As can be seen in Table III, in absolute value, the log-likelihood of CPHM more than trebles that of the two parametric models.

[17] Moreover, regarding the choice of a parametric model we have also carried out several tests of specification of the gamma model (more general parametric model) versus the lognormal, Weibull and exponential. We cannot reject the null hypothesis that the exponential is the true model at 5% level of statistical significance.

[18] $H_0$: $\theta = 0$. LR test $\left(\chi^2_{01}\right) = 0.000$ with $P$-value = 1.000. See Cleves et al. (2004) for a complete description of this test.

[19] It should be taken into account that our sample does not include firms with less than 10 employees and that the liability of "newness" suggests that most entrants are rather small.

[20] Results do not change if instead of considering two size groups, we consider a larger number of size groups, such as 10–20; 21–50; 51–200; 201–500; > 500 employees. Given the sampling procedure of ESEE, we split firms into two size groups.

[21] In addition to the advertising variable in Table A.1, we have also tried other specifications that take into consideration a firm's advertising intensity, but the relevant fact in our case seems to be whether a firm performs advertising or not.

[22] See Table A.2 for industry classification.

[23] The labor productivity measures may have some problems as they may be capturing some effects beyond differences in total factor productivity such as differential mark-ups across firms and variations in capital intensity.

[24] In addition to the variable *pkext* (Table A.1), the usual 10% and 25% thresholds of foreign capital participation have been used, but no difference on their effect on survival arose.

[25] These predictions are not reported in the paper but are available from the authors upon request.

[26] We must recall that acquisition is included as a possible exit route in our analysis.

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