

A survival analysis of manufacturing firms in export markets*

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Abstract

Two main findings in the trade literature are that exporters are better than non-exporters, and the existence of a high persistence in the export status. The evidence so far provides more support to the argument of the self-selection of the more efficient firms into exporting in presence of entry sunk costs, than to the existence of benefits attributed to exporting (learning-by-exporting). This paper proposes an alternative way of empirically addressing the persistence in export behaviour. We study what keeps a firm exporting once it has started to export. For this purpose, we estimate three discrete time proportional hazard models that account for unobserved individual heterogeneity. The dataset is a sample of Spanish manufacturing drawn from the *Encuesta sobre Estrategias Empresariales* for 1990-2001. We find that persistence is high and that firms exporting to “closer” markets survive longer than those exporting to uncertain markets. Other firm, product and market characteristics are important determinants of survival in export activities.

Key words: learning-by-exporting, persistence in trade, proportional hazards models

JEL classification: C41, F1, L1

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1. Introduction.

The empirical literature on exports has commonly found both that, at any point in time, exporters (either plants or firms) are better than non-exporters in any performance dimension (such as efficiency, size, survival prospects, etc.), and the existence of a high persistence in the export status.¹ These studies have tested two alternative but not exclusive hypotheses related to the direction of causality, that is, whether good firms become exporters (self-selection) or whether exporting improves firm performance (learning-by-exporting).

On the one hand, the self-selection of the more efficient firms into export markets is due to the existence of entry costs, at least partially sunk, into foreign markets. These costs are related to gathering information about demand conditions abroad (market research), production costs to modify domestic products to meet foreign preferences (related to product design and/or quality standards), transportation, distribution (costs of setting up distribution networks) or marketing costs. These entry barriers cannot be overcome by less successful firms.

On the other hand, the positive effects attributed to exporting have been widely argued, at least from a theoretical standpoint. They entail gains to firms, such as growth in sales, higher risk diversification, knowledge flows from international buyers (about technological expertise of buyers, consumer tastes, and the available products) and from competitors (about international best practices), leading to an improvement in efficiency, product quality and survival chances.

Whereas the evidence is broadly consistent with the self-selection hypothesis, the hypothesis that exporting boosts performance has received

¹ See among others, Bernard and Jensen (1995, 1999), Clerides *et al.* (1998), Delgado *et al.* (2003), and Aw *et al.* (1997). Wagner (2005) summarizes the main findings of this literature.

less support.² There are some factors that explain the little empirical evidence supporting the benefits of exporting obtained when comparing performance between exporters and non-exporters. First, regardless of whether firms' efficiency gains are acquired from abroad, the exporters' expertise may spread out among non-exporters in a region or country, especially among non-exporters surviving over time. Hence, differences in efficiency may fade away.

Secondly, the learning-by-exporting effect is underestimated because export activity is positively correlated to survival chances of the firms. As the incidence of exit (failure) is higher for non-exporters, the less productive firms will probably leave the market, raising the average productivity of surviving non-exporters (or average growth). In contrast to this, if exporters have better survival prospects, then their productivity distribution is made of the full range (or a higher proportion of it) of firm productivity levels. As a result, the differences in productivity and productivity growth rates are smaller.

Thirdly, Girma *et al.* (2004) argue that an accurate assessment of the learning-by-exporting hypothesis requires to compare the performance of the firm after entry into export with what would have happened to the firm had it not entered the export market, which is unobservable. The common assumption by the empirical literature has been to assume that all (surviving) non-exporting can provide this counterfactual. These authors find evidence of learning-by-exporting using matching methods.

Despite the mixed results regarding the learning-by-exporting effect, the evidence suggests the existence of high persistence in export activities. Thus, Bernard and Jensen (2004) report that over 78% of US exporting plants in 1984 survived exporting by 1992. In the Spanish manufacturing sector, over

² See Wagner (2005) for a revision of the empirical literature testing these hypotheses.

48% of new exporters stay in at least for 10 years. However, so far little attention has been paid to explain the determinants of survival in exporting.

An adequate benchmark to gain insight into the factors driving the decision to export are the models that consider this firm decision as an entry decision under uncertainty that involves sunk costs. At any period, heterogeneous firms will have to decide whether to enter export markets if they did not export before, or whether to stay in or exit if they did. Therefore, as suggested by the self-selection hypothesis, only the more efficient firms will find it profitable to enter foreign markets. Besides, profit-maximizing firms will be more likely to stay in when entry involves sunk costs and re-entry is a possibility. The theoretical models by Dixit (1989a, 1989b) and Krugman (1989) suggest that the existence of sunk costs leads to persistence in firm exporting behaviour (hysteresis).³ Furthermore, if learning-by-exporting is relevant, exporting today should raise a firm's profitability tomorrow (Clerides *et al.* 1998), making more likely the stay in decision and leading to expect persistence in export activities. In this framework, the height of sunk costs and those factors shaping a firm's profitability (including factors that enhance learning-by-exporting, such as firm and market characteristics), are important determinants of factors the export decision.

In this paper, we examine the determinants of survival in exporting using survey data for Spanish manufacturing firms, for the period 1990-2000, drawn from the *Encuesta sobre Estrategias Empresariales* (ESEE, hereafter). This study departs from the previous literature in that it provides an alternative empirical methodology to address the persistence in firm exporting behaviour. Whereas previous work has focused either in examining the determinants of the firm's decision to export or in assessing the existence of

³ The empirical work by Roberts and Tybout (1997), Bernard and Wagner (1998), Bernard and Jensen (2004), Campa (2004) and Máñez *et al.* (2004) supports the existence of sunk costs.

sunk costs, our interest lies on investigating what makes a firm stay longer exporting, once it has become an exporter. The empirical work is carried out using survival methods controlling for the existence of unobserved individual heterogeneity (such as unobserved firms organizational capabilities, network contacts, access to specific assets, etc.) that, if ignored, may lead to strongly inconsistent estimates of the included covariates.

This question has important policy implications. Policy-makers are usually convinced that export promotion is positive given that exporters are good firms. However, in order to figure out what the effects of export promotion policies are, we need to understand what happens to firms after they enter the export market. Entry into export markets is costly and, at least partially, a portion of the investment irrecoverable in the event of exit. In addition, there may exist some benefits from keeping exporting for some time (which might spread out among domestically-orientated firms). Given that resources are scarce, it is important to make sure that resources are efficiently allocated to “survival-winners”. These are relevant considerations to inform export-led growth policies. Thus, non-selective policies aimed at either fostering firms’ efforts to enter foreign markets or reducing entry barriers may be a waste of resources, as some entrants could turn out to be ill-suited to survive in export markets.

To anticipate the results, we find that the longer a firm exports the longer it will remain doing so. Besides, firms exporting to closely-related markets export for longer than those exporting to other markets. Furthermore, some other firm, industry and export market characteristics, such as size, productivity, export intensity, and operating in a final consumption goods industry, are found to be important determinants for exports survival of Spanish firms.

The rest of the paper is organised as follows. In section 2 we present the data and analyse exporting spells (episodes) for Spanish manufacturing firms. Section 3 is devoted to present the hypotheses about the determinants of survival in the export markets. The statistical methodology is revised in section 4 and the estimation results are summarised in section 5. Finally, section 6 concludes.

2. Analysing the data and exporting spells.

The dataset has been built up using information from the ESEE (up to the year 2001), which is an annual survey of Spanish manufacturing firms sponsored by the Ministry of Industry and carried out since 1990.⁴

The unit of observation in this study is the exporting spell by a firm starting after 1990. That is, the uninterrupted number of years a firm exports.

Some features of the ESEE make it suitable to examine the determinants of firm duration in exporting using survival methods. First, it comprises a representative sample of the population of Spanish manufacturing firms by industry and size strata over time. Secondly, the ESEE provides relevant firm characteristics on a yearly basis, such as size, labour productivity or R&D intensity, which have been found to be important drivers of firms export decisions and might also be driving the survival of firms in international markets. Finally, this survey also allows identifying firms that continue exporting, quit this activity, stop answering the survey or fail over the *observation window* (1990-2001). We exclude from the analysis those spells corresponding to firms that fail. As for many of these spells the end of the exporting spell coincides with firm failure, their inclusion could bias the results.

⁴ See <http://www.funep.es> for further details.

After cleansing the data, we end up with a sample of 1414 observations corresponding to 407 exporting spells, 40.3% of which ended during the sample period. These 407 spells correspond to 317 different firms. The Kaplan-Meier estimate of the survival function (Figure 1) shows that around 37.5% of firms survive in export markets less than 4 years, and 50% are still operating in these markets after 10 years.

[Insert Figure 1 about here]

3. Determinants of export survival.

A framework to study the export decision over time (thus, including the decision to continue exporting) is the Dixit-type model posed by Roberts and Tybout (1997), Clerides *et al.* (1998), and Bernard and Jensen (2004), among others. The decision to export can be seen as an entry decision that involves sunk costs in the presence of uncertainty.

Following this approach, it can be assumed that a firm incurs sunk entry costs every time it decides to enter or re-enter foreign markets. These entry costs (totally, or at least partially, irrecoverable if the firm exits) are associated to researching foreign demand and competition, to establishing marketing channels, to adjusting its product and packaging characteristics to meet foreign tastes and/or to fulfil the quality and security legislation of destination countries, etc. Further, one can think of the existence of per-period exporting fixed costs from dealing with wholesalers, retailers, customers, etc.

A firm enters to export if current and expected profits are higher than sunk start-up costs. Likewise, an incumbent exporter continues exporting whenever current gross operating profits from exports plus the expected

discounted future payoffs from remaining exporting (that include the value of avoiding start-up costs next period and any positive learning-by-exporting effects that accrue to firms from foreign market experience) are higher than the option value of exit.⁵ The latter comprises both operating fixed costs and salvage value, net of exit costs. A firm's profitability is shaped by firm characteristics, and by exogenous factors, such as industry and export market characteristics as well as the business cycle.⁶ Obviously, the presence of high entry costs to exporting creates a barrier to entry that only the most successful firms overcome (self-selection of most efficient firms into export markets). However, the focus of this paper lies on examining what keeps a firm exporting once it has become an exporter.

We discuss the expected effect of all the factors that determine the stay in/exit from export markets decision in turn. Table 1 provides detailed information on the variables used in our empirical work.

[Insert Table 1 about here]

(i) Negative duration dependence.

High sunk entry costs imply high exit costs when re-entry is a possibility (Dixit, 1989a). Sunk costs yield an option value of waiting and thus increases the region where the firm chooses not to act (that is, to stay in). Once exporting, it may be optimal to continue exporting even if gross profits do not cover fixed costs since, by remaining in the export market, the firm avoids future re-entry costs. Therefore, sunk costs *per se* cause persistence in the exporting status.

⁵ Expression (6) in Clerides *et al.* (1998) gives the condition to participate in export markets worked out from the dynamic programming problem in expression (5) of that paper.

⁶ Year dummy variables are introduced to account for macroeconomic effects.

In survival analysis, sunk costs are expected to lead to negative duration dependence. That is, the probability of spell ending decreases the longer it goes on.

Further, negative duration dependence may also be related to a firm's need to incur updating costs (totally, or at least partially, sunk) in order to continue exporting, and/or to the learning-by-exporting effect not explicitly captured by other observed characteristics of the firms.

In each period, firms will probably have to update their sunk costs if they are to continue exporting. These outlays are related to the adaptation of new products to changing export market conditions, changes in the marketing and distribution channels, etc. The size of these updated costs will depend both on a firm's own updated investments and those of its competitors. These costs may cause negative duration dependence through two routes, which we shall discuss in turn.

First, as accumulated sunk costs rise, entry costs increase over time and thus re-entry is increasingly costly, so firms are less likely to stop exporting. The argument is that when a firm stops exporting this knowledge rapidly depreciates, and so the firm will lose all the expertise acquired over the years of continuous exporting.⁷

Secondly, the investments associated to the updating of sunk costs contribute to the within-spell learning-by-exporting process that improves a firm's survival chances. Learning-by-exporting arises from knowledge flows from international buyers (related to technological expertise, consumer product preferences and competing products in international markets), and from competitors (exposure to best practices in international markets).⁸ This accumulation of knowledge over time may improve exporters' performance in

⁷ See Mañez *et al.* (2004) for the Spanish case.

⁸ See Wagner (2005) and Clerides *et al.* (1998).

dimensions such as productivity and their growth rate (Bernard and Jensen, 1999), and the likelihood of introducing process and product innovations (Salomon and Shaver, 2005). Hence, this may lead to increased price-cost margins, through unit cost reductions and/or higher prices (for instance, due to higher product quality), as well as to increases in foreign demand, which raises expected payoffs from continuing exporting, and thus reducing the likelihood of export exit over time.

On empirical grounds, we use reduced-form survival models (discussed in section 4) in which persistence may initially be caused both by learning-by-exporting and by sunk costs.⁹ The models include a sufficiently flexible baseline hazard and some firm attributes (discussed in the next subsection below), which help to explain differences in firms' exporting fates. These models also allow for unobserved individual heterogeneity to account for those factors unobservable to the econometrician, such as managerial ability, that may affect the decision to export by the firm and contribute to explain the observed survival outcomes. Since these characteristics are potentially permanent and unobservable, they would induce persistence in export status (either in or out of the market), that would lead to overestimate the entry (and re-entry) costs and the learning-by-exporting effects.

Therefore, the baseline hazard functions should exhibit negative duration dependence. Moreover, negative duration dependence is not necessarily linear if learning is more intense over the first exporting years. In this line, Besedeš and Prusa (2003) find, for import activities, that duration dependence is negative and that the survival probability first drops sharply, then levels off and finally decreases very slowly. This result indicates the

⁹ Bernard and Jensen (2004) argue that without a structural model of the production and cost functions, it is not possible to identify inter-temporal spillovers due to learning and those due to sunk costs.

presence of a type of threshold effect. Therefore, this suggests that once a trade relationship has been established and lasts for a few years, it will probably continue for a long time.

(ii) Firm attributes.

Persistence in exporting results from attributes of the firms themselves. We discuss the expected effect on survival of firm performance, export intensity, foreign capital participation, and R&D intensity and R&D results in turn.

Firm Performance

Size and productivity are used to account for firm performance. Size may proxy for several effects, such as lower unit costs given that larger firms are more likely to produce close to their minimum efficient scale, which raises their expected payoffs from exporting and thus increases their likelihood of survival in export markets. Another link between size and exports may reflect scale economy-based exporting (Krugman, 1980, 1984). The exploitation of economies of scale in exporting is a common argument used to support a positive association between firm size and exports. In addition, larger firms may have better access to specific inputs (capital or qualified workers) and information, may face better tax conditions, etc., which can ease the maintenance of firms in foreign markets.

There are also arguments to expect a positive correlation between firm productivity and survival in exporting. As long as either fixed costs of selling abroad are higher than those in the domestic market or output prices are lower in international markets, only highly productive firms will find that continuing to export is profitable. More productive firms are in a better position to face strong competition in international markets as productivity is highly related to the differential competitiveness of firms.

Export intensity

The higher the firm export intensity, the higher its accumulation of knowledge about export markets, export channels, foreign demand and tastes, and thus the higher the learning-by-exporting effect. Castellini (2002) reports some evidence suggesting that the productivity of exporting firms may grow with increases in export intensity. This effect is analogous to the positive relation between firm size and survival predicted by the learning literature (Jovanovic, 1982; Ericson and Pakes, 1995).

Furthermore, a firm's exporting intensity may also be catching the degree of its dependence on export markets. A firm that exports a large share of its production will devote considerable effort to continue exporting because replacing the foreign market with the domestic market is neither easy nor fast.

Foreign capital participation

The effect of foreign capital investments on export survival will depend on whether they seek to establish an exporting platform or to find a new market (Dunning, 1977, 1981).

When foreign direct investment is based on competitive advantages of the domestic firm over the exporting market, the domestic market might be seen as an exporting platform and foreign participation might be considered as a signal of the unobserved quality of the controlled firm. In this case, a positive relationship between foreign ownership and exporting activity is expected. Based on this argument, it may be argued that non-domestically owned firms might enjoy better access to foreign markets due to complementarities with other businesses within the same group. It has been frequently pointed out that firms controlled by foreign capital are usually more efficient and so their presence in foreign markets should be higher and longer.

However, under the market-seeking hypothesis, the aim of foreign direct investment is to enter a market in which an exporting strategy has not been successful. Thus, the domestic firm might be seen as a platform to sell in a new market. Further, the foreign owner could impose restrictions on its foreign subsidiary (for example, limiting sales to the subsidiary domestic market). Under this hypothesis, we expect a negative relationship between foreign ownership and persistence in the firm's export status.

R&D activities

In the literature on dynamic trade models, Vernon (1966) pointed out that technological leaders develop and export a product until others learn how to manufacture it and enter the market. Other authors suggest that exporting firms may need to innovate to face greater competitive pressure in international markets (Kleinschmidt and Cooper, 1990; Kotable, 1990) and to adapt to changing competitive environments. Hence, R&D activities, especially if they are successful, seem to enhance firms' competitive advantages and lead to longer survival in exports.

R&D intensity may also capture, to some extent, a firm's innovation-effort, which could proxy for vertical product differentiation. Firms selling high-quality products enjoy larger price-cost margins, which give them a competitive advantage in export markets that raises its survival prospects in exporting.

(iii) Industry characteristics.

Survival in export markets is also affected by the features of the industry, such as the characteristics of the product and the technological regime, in which a firm operates.

Product characteristics

The idea that trade in homogeneous and differentiated goods is different has long been established (Krugman, 1980; Helpman and Krugman, 1985).¹⁰ According to Rauch (1999), most consumer goods are classified as differentiated.¹¹ This author finds that exporting differentiated products involves higher sunk costs as it requires relationship-specific investments to adjust products to local consumer tastes or to establish distribution networks that meet the needs of the specific product. As a consequence, expected survival for differentiated products is longer. Further, Spanish firms are relatively specialized in exporting final consumer goods. The latter may be reflecting a comparative advantage on these goods that may lead to expect longer survival in this type of export market. This specialization on consumer goods, which according to Rauch are associated to higher sunk costs, reinforces Rauch's hypothesis.

Technological intensity of the industry

The technological intensity of the industry where the firm operates may also affect the length of its exporting spell, as this variable may capture technological opportunities, that is, the possibility of converting research resources into new products or superior production techniques, which might be positively correlated to the probability to persist in export markets

(iv) Export market characteristics.

The nature of the destination markets may also have an influence on survival prospects in exporting. To account for the influence of this effect, we include three dummy variables that capture different destinations (*European Union, other OECD countries, and rest of the world*).

¹⁰ Besedeš and Prusa (2004) empirically study this and find that the hazard rate is at least 18% higher for homogeneous goods than for differentiated goods in US import trade relationships.

¹¹ Using the concept of product substitutability, Rauch (1999) classifies products as differentiated, reference priced, and homogeneous.

There are two arguments, at least, that suggest the existence of a positive correlation between closeness and export survival. That is, exporting spells associated to the European Union export markets are expected to be longer than those of the other OECD countries, and the exporting spells associated to the other OECD countries to be longer than those of the rest of the world.

The first argument is that updating costs over time are lower in closely-related markets such as the European Union because of shared institutions, cultural similarities, closer consumer tastes, shorter physical distance, no internal borders, no tariffs and/or lack of uncertainty and risk associated to changes in tariff systems, and smaller fluctuations of exchange rates between countries, with the subsequent reduction in international transaction risks. In fact, trade gravity models also support some of these factors (see Frankel, 1997).

Secondly, if learning-by-exporting takes place through knowledge flows (on new production methods, inputs, product design, etc.), all destination markets may not equally promote this learning effect. Probably the extent of these advantages depends on the nature of the export markets. The return to exporting to advanced countries is probably higher than those attained by exporting to less developed countries, especially in high-tech products. Trofinenko (2005) finds a positive relationship between the ability to benefit from exporting and the efficiency of the plant, and this effect is particularly true for exporting to advanced countries.

4. Econometric methodology.

The survival models implemented in this work are discrete time proportional hazard models that aim to capture the particular nature of the dataset. The

estimation method allows for a fully non-parametric estimation of the baseline hazard. Survival methods are also adequate in the presence of right-censored observations and are able to handle time-varying covariates. The latter together with the control for unobserved individual heterogeneity helps to fully identify the effects of survival time on duration in exports (duration dependence).

Duration (time) is treated as a discrete variable, not because it is intrinsically discrete but because the data is available on a yearly basis (interval-censored data). That is, we know whether a firm exported in a given year of the survey. Time intervals in our data set are of one year. Thus, the interval boundaries are the positive integers $j=1, 2, 3, 4, \dots$, and the interval j is $(j-1, j]$. One exporting spell can either be complete ($c_i = 1$) or right censored ($c_i = 0$). A censored exporting spell i with length j intervals contributes to the likelihood function with the discrete time survivor function (the probability of survival until the end of interval j):

$$S_i(j) = \Pr(T_i > j) = \prod_{k=1}^j (1 - h_{ik}), \quad (1)$$

where $T_i = \min\{T_i^*, C_i^*\}$, T_i^* is some latent failure time and C_i^* some latent censoring time for spell i , and $h_{ik} = \Pr(k-1 < T_i \leq k | T_i > k-1)$ is the discrete hazard (the probability of ending the spell in interval k conditional to the probability of survival up to the beginning of this interval). A complete spell i in the j interval contributes to the likelihood with the discrete time density function (the probability of ending the spell within the j interval):

$$f_i(j) = \Pr(j-1 < T_i \leq j) = S(j-1) - S(j) = \frac{h_{ij}}{1 - h_{ij}} \prod_{k=1}^j (1 - h_{ik}). \quad (2)$$

Using (1) and (2), the log likelihood function for the sample of spells is:

$$\log L = \sum_{i=1}^n c_i \log \left(\frac{h_{ij}}{1-h_{ij}} \right) + \sum_{i=1}^n \sum_{k=1}^j \log(1-h_{ik}). \quad (3)$$

Allison (1984) and Jenkins (1995, 2004) show that (3) can be rewritten as the log likelihood function of a binary dependent variable y_{ik} with value one if spell i ends in year k , and zero otherwise:

$$\log L = \sum_{i=1}^n \sum_{k=1}^j [y_{ik} \log h_{ik} + (1-y_{ik}) \log(1-h_{ik})]. \quad (4)$$

This allows discrete time hazard models to be estimated by binary dependent variable methods and time-varying covariates to be incorporated.

Following Prentice and Gloeckler (1978), we assume that h_{ik} is distributed as a complementary log-log (*cloglog*) to obtain the discrete time representation of an underlying continuous time proportional hazard:

$$\begin{aligned} c \log \log [1-h_j(x_{ij})] &\equiv \log(-\log[1-h_j(x_{ij})]) = \beta_0 + x_{ij}\beta + \gamma_j \\ &\Rightarrow h_j(x_{ij}) = 1 - \exp[-\exp(\beta_0 + x_{ij}\beta + \gamma_j)], \end{aligned} \quad (5)$$

where γ_j is the interval baseline hazard (a non-parametric specification that allows to test for a flexible type of duration dependence), and x_{ij} are covariates which may be time-varying (although constant within intervals).

Incorporating unobserved heterogeneity, the *cloglog* model in (5) becomes

$$h_j(x_{ij}) = 1 - \exp[-\exp(\beta_0 + x_{ij}\beta + \gamma_j + u_i)], \quad (6)$$

where $u_i \equiv \ln(v_i)$, and v_i originally enters the underlying continuous hazard function multiplicatively, $h(t, x_{it}) = h_0(t) \exp^{\beta_0 + x_{it}\beta} v_i$. Usually v is assumed to be Gamma distributed with unit mean and variance σ^2 to be estimated from the data (Meyer, 1990).¹²

¹² Up-to-date Stata programs drawn up by S. Jenkins that implements the *cloglog* with gamma-distributed unobserved heterogeneity is available from <http://www.bc.edu/RePEc/bocode/p> or

Alternatively, unobserved heterogeneity can be treated non-parametrically by assuming that there are several different types of individuals (or “mass-points” in the distribution of individual heterogeneity) so that each individual has associated probabilities to the different “mass-points” (Heckman and Singer, 1984). This implies different intercepts for the hazard function, each one for a different type. For instance, if a model with two types is assumed (type=1, 2), then the hazard becomes

$$h_{j,type}(x_{ij}) = 1 - \exp\left[-\exp(m_{type} + \beta_0 + x_{ij}\beta + \gamma_j)\right]. \quad (7)$$

The intercept for type-1 individuals is β_0 and for type-2 individuals it is equal to $m_{type2} + \beta_0$ (the “mass-point” for type-1 is normalized to zero).¹³

The lack of control for unobserved individual heterogeneity may cause some problems. First, the degree of negative (positive) duration dependence in the hazard is over-estimated (under-estimated). This is the result of a selection process. For instance, with negative duration dependence, high v -value individuals finish the spell more rapidly. Then, as time goes by, a higher proportion of individuals with low values of v remain alive, which implies a lower hazard. Secondly, positive (negative) β parameters are under-estimated (over-estimated). Finally, the estimated coefficients can no longer be interpreted as the proportionate response of the hazard to a change in a given covariate.

5. Results.

Table 2 shows estimation results for the discrete time proportional hazard model (complementary log-log model, *cloglog*). We have estimated three

it can also be obtained, inside Stata, by typing `ssc install pgmhaz8`. An initial version of the program was presented in Jenkins (2001).

¹³ A Stata program elaborated by S. Jenkins that implements the *cloglog* model with non parametric unobserved heterogeneity is available from <http://fmwww.bc.edu/RePEc/bocode/>, or inside Stata, typing `ssc install hshaz`.

different models. First, a *cloglog* model that assumes a Gamma distribution for an included individual heterogeneity term. Secondly, a *cloglog* model that treats unobserved individual heterogeneity non-parametrically. Thirdly, a *cloglog* model that does not take into account any potential unobserved individual heterogeneity. The three estimates also treat the shape of the baseline hazard function non-parametrically. This function cannot be estimated for periods with no spell completions. Given the nature of our dataset, with no events in survival periods 9 and 10 and few events in survival periods 5, 6, 7 and 8, we have grouped the data for survival years 5 and 6 and for survival years 7 to 10, leading to the dummy variables *d56* and *d78910*, respectively.

The estimates for the three estimated models give quite similar results as we do not find evidence of unobserved heterogeneity in the first two models. In the model in which a gamma distribution is assumed for the heterogeneity term we cannot reject the null hypothesis that the unobserved heterogeneity variance component (σ^2) is equal to zero. We carry out this test by means of a *Chibar2(01)* statistic¹⁴ and obtain that the *Chibar2(01)* is equal to 1.230 with a *p*-value of 0.134. In the model in which heterogeneity is treated non-parametrically, we cannot either reject that the mass-point for type 2 is statistically no different from the mass-point for type 1, which means that there is no unobserved individual heterogeneity. We estimate that mass point 2 is equal to -20.384 with a *p*-value of 0.993. These results suggest that the *cloglog* model with no unobserved heterogeneity is the appropriate one. Hence, we only report the estimates for this model, and thus our comments and prediction results are based on it.

¹⁴ See Jenkins (2004) and Gutierrez *et al.* (2001) for details.

[Insert Table 2 about here]

Figure 2 depicts the predicted discrete hazard rates that show the evolution of the risk of export-spell end over time. The discrete hazard rates correspond to a representative spell for which all covariates except those catching duration dependence (i.e., the duration-period dummies) have been set at their sample means.¹⁵ We also graph the hazard rate for the “best” and “worst” firms.¹⁶ By visual inspection of figure 2, the predicted discrete hazard rates decrease from survival years 1 to 6, slightly increase up to survival year 7, and then remain constant afterwards. As expected, a huge difference between the hazard rate of the “best” and the “worst” firm arises.

[Insert Figure 2 about here]

Similar patterns to those in figure 2 arise from the estimates of the duration interval dummies (Table 2) that inform us about the shape of the baseline hazard. Smaller values are associated with smaller hazards (i.e. longer durations). However, to further check the significance of these increases and decreases we carry out pair wise comparisons of the duration dependence exponentiated parameter estimates. From this testing procedure we can conclude: first, differences in hazard rates from survival years 1 to 3 are statistically non-significant; secondly, differences in hazard rates from survival years 4 to 10 are also statistically non-significant; and finally, the constant hazard rates for years 1 to 3 is statistically higher than the constant hazard

¹⁵ Given that in our analysis all the covariates are included as sets of dummy variables, to characterise the representative spell we set the dummy containing the mean value (of the original continuous variable) equal to one.

¹⁶ To calculate the “best” and the “worst” firm, we set all covariates to the highest and the lowest possible values in our sample, respectively.

rate for years 4 to 10. Therefore, we detect negative duration dependence, and the existence of non-linearities in the pattern of negative duration dependence.

The existence of negative duration dependence is consistent with the theoretical predictions of the Dixit-type models of entry. Due to the existence of sunk costs and learning-by-exporting, the decision of whether to export becomes a forward-looking problem in which a firm makes its decision based on the current net operating profits and the expected future payoffs from exporting (which consist of the value of avoiding future re-entry costs as well as expected profitability gains from exporting). As suggested by figures 1 and 2, a significant share of entrants fail to survive in the first years after entry. Hence, there likely operates a self-selection mechanism driving good firms into export, but persistence is remarkable among those surviving some time after entry, which is consistent with the findings of learning models of firm dynamics (Jovanovic, 1982; Ericson and Pakes, 1995).

Our results support the existence of a learning-by-exporting process in presence of updating sunk costs and depreciation of knowledge. Furthermore, the non-linearly decreasing shape of the baseline hazard reveals some specific characteristics of this process. First, the fact that the hazard rate is the same for the first three exporting years suggests that the initial sunk entry costs that firms incur to enter export markets allow them to export for three years without incurring significant updating costs. Small updating costs imply slow learning-by-exporting, suggesting that participation in export markets does not ensure learning *per se*. Secondly, the significant decrease in the hazard rate in the fourth year suggests that updating costs become important after the third period of exporting. These investments significantly increase re-entry costs, accelerate learning-by-exporting, and so delay exit. Finally, we find no evidence of further learning after the fourth consecutive year of exporting,

since there are no differences between the hazard rates of identical firms exporting uninterruptedly for more than four years.¹⁷

In relation to firm performance characteristics, we find that large firms survive longer in export markets than small firms (the hazard rate for large firms is 50.7% lower than that for small firms). As expected, more productive firms have longer exporting spells: the hazard rate of the firms in the upper third of the productivity distribution is 58.5% lower than that of the firms in the medium and lower thirds.¹⁸ This may suggest the existence of a threshold in the relationship between productivity and the duration of exporting spells.

As for other firm characteristics, higher export intensities (above the median) extend exporting survival prospects by about 40.4%. Thus, export intensity enhances learning-by-exporting, leading to expect higher survival. Foreign capital participation does not appear to significantly affect the survival of firms in export markets. This lack of significance could be due to the fact that neither the market seeking hypothesis nor the exporting platform hypothesis exclusively explains the behaviour of foreign direct investors. If a proportion of foreign direct investment is market seeking and another part aims to establish an export platform, the two types of foreign direct investment could offset each other and cause the foreign capital participation variable to be non-significant.

Furthermore, we find no effect of R&D activities, measured either by their intensity or by their results, on a firm's export survival. In addition, the technological intensity of the industry in which a firm's operates does not seem to affect its survival prospects in export markets.

¹⁷ Caution must be taken when analysing the last survival years given the scarce number of exits.

¹⁸ Along the same lines, Bernard and Wagner (1998) and Bernard and Jensen (1999) find that more productive firms are more likely to enter export markets.

As regards product characteristics, a firm producing a final consumption product enjoys a better chance of survival in international markets. Its risk of exit from exporting is 31% lower than that of firms producing and selling other products. Therefore, our results confirm Rauch's hypothesis (1999).

Finally, looking at characteristics of the destination markets we find that firms exporting primarily to the European Union and to the rest of the OECD countries have, respectively, a 63% and 67% lower risk of ending an exporting spell than firms exporting to the rest of the world. These results confirm the importance of closeness (as defined in section 3) to explain export survival. Furthermore, the hazard rate of spells corresponding to firms whose main market is the European Union is not significantly different from that of spells of firms whose main market is the rest of OECD countries.

Regarding the set of year dummies introduced to capture the business cycle, we find that the lower probability of exit corresponds to 1991 (the omitted year in estimation). Then, in ascending order according to the probability of exit, we find 1998 (although statistically significant at 11% confidence level), 1993 and 1992. However, a pair wise testing procedure shows that the differences in hazard risks for these three years are not statistically significant.

In relation to the robustness check of the assumption of independence of spells for a given firm, we have repeated estimation restricting the sample to only the firms' first spells. Results from the *cloglog* model with and without unobserved individual heterogeneity yield to similar results to those reported in table 2. Besides, duration dependence and cyclical behaviour patterns are maintained under the more restricted sample. Hence, all these results seem to support the assumption of independence of spells.

Finally, we have exploited further our results. First, we have estimated both the predicted discrete hazard rates and survival functions by firm export destination.¹⁹ These results are reported in figures 3 and 5. As regards to hazard rates we find that the probability of dropping from exporting decreases across time for all destinations up to survival year 5, and slightly rises afterwards. However, this decrease is smoother for firms exporting to the EU or other OECD countries indicating that firms exporting to these markets enjoy a higher probability of survival than firms exporting to other countries. As regards to the survivor function, we also find significant differences whether a firm is exporting to either the UE or the rest of OECD countries against exporting to the rest of the world. We get that around 80% of the exporting spells which destination market is either the UE or the rest of the OECD endure around 3 years, and about 60% of them last more than 10 years. Whereas these figures are 50% and 25% for exporting spells which destination market is the rest of the world. This result indicates that persistence is very high for firms exporting to “closer” markets in contrast with the persistence of those firms exporting to far away markets.

Secondly, we have estimated both the predicted discrete hazard rate and the survival functions for the “best”, the “mean” and the “worst” hypothetical firms in our sample. We find significant differences in the failure risk over time for these three types of firms. While “best” firms enjoy a zero failure risk “worst” firms face a much higher probability of exiting. Although this probability is decreasing across time for 5 survival periods and remains around a 20% afterwards. As regards to the survival function we find that around 100% of the exporting spells for the “best” firms last more than 10

¹⁹ We graph 3 representative firms according to 3 possible destination markets, by setting all covariates to sample mean values except for the variable accounting for the destination market.

years. Whereas approximately all of the exporting spells for the “worst” firms are extinguished after 10 years.

[Insert Figures 3, 4 and 5 about here]

6. Conclusion.

This paper has used Spanish manufacturing data to investigate the determinants of persistence in firms’ exporting behaviour. One important contribution of this paper is related to the estimation methods used.

The advantages of the estimation methods implemented in this paper, when compared to previous analysis of persistence in exporting behaviour, are: first, they allow for a fully non-parametric estimation of the baseline hazard function, and permit a full identification of the effect of survival time on the length of the exporting spell; and, secondly, the estimation of both parametric and non-parametric unobserved individual heterogeneity survival models makes it possible to carry out a robust test for the presence of unobserved individual heterogeneity.

The findings of this paper support the existence of negative duration dependence. That is, the longer a firm continuously exports, the longer it will remain doing so. This result is consistent with the existence of both entry costs (totally, or at least partially, sunk –irrecoverable if the firm quits) and learning-by-exporting, in the presence of updating sunk costs and the depreciation of knowledge.

Secondly, we find that exporting spells of firms exporting to closely-related markets are significantly longer than those of firms exporting to more unknown or uncertain markets. In this respect, Spanish firms selling to the European Union and to the rest of the OECD countries face a lower risk of

ending an exporting spell than those firms selling to countries in the rest of the world. These results confirm the importance of closeness (as defined in section 3) to explain export survival. Finally, other firm characteristics such as size, productivity, export intensity and producing in a final consumption industry enhance exporting survival.

Our findings contribute to better understand the determinants of firm survival in export markets and have implications for export promotion policies. Thus, this paper suggests that if permanence in exports is desirable, policy makers should devote resources to those firms with a higher probability of survival in exports rather than to merely reduce entry costs indiscriminately. Likewise, policies should be directed to encourage firms' efforts to strengthen their relative position in foreign markets. Further, closely-related markets might be important in export survival, among other things, for their lower updating (sunk-) costs over time. For every period the firm exports, the initial sunk investment requires a maintenance cost. If the maintenance is not spent, the sunk asset disappears (i.e. the firm exits export markets). Thus, policies aimed at keeping firms in export markets should improve information and exporting infrastructures to decrease firm maintenance costs.

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Tables

Table 1. Variable definitions.

Duration	Spell duration in years
<i>Firm characteristics</i>	
Size group	Dummy variable that takes value one if the firm has more than 200 workers, and zero otherwise.
Productivity1	Dummy variable that takes value one if the firm's labour productivity belongs to the first third of the sample labour productivity distribution, and zero otherwise.
Productivity2	Dummy variable that takes value one if the firm's labour productivity belongs to the second third of the sample labour productivity distribution, and zero otherwise.
Productivity3	Dummy variable that takes value one if the firm's labour productivity belongs to the upper third of the sample labour productivity distribution, and zero otherwise.
Export intensity	Dummy variable that takes value one if the firm's export intensity (exports-to-sales ratio in %) is greater than the median, and zero otherwise.
Foreign	Dummy variable that takes value one if the firm has foreign capital participation, and zero otherwise.
R&D intensity1	Dummy variable that takes value one if the firm does not invest in R&D, and zero otherwise.
R&D intensity2	Dummy variable that takes value one if the firm's R&D intensity (R&D expenditure to sales ratio in %) is greater than 0% and lower than or equal to 1, and zero otherwise.
R&D intensity3	Dummy variable that takes value one if the firm's R&D intensity is greater than 1% and lower than or equal to 2.5%, and zero otherwise.
R&D intensity4	Dummy variable that takes value one if the firm's R&D intensity is greater than 2.5%, and zero otherwise.
R&D results	Dummy variable that takes value one if the firm obtains at least one innovation result (a patent, a utility model or a process innovation), and zero otherwise.
<i>Industry characteristics</i>	
Final consumption	Dummy variable that takes value one if the firm belongs to a final consumption industrial sector, and zero otherwise. We consider as final consumption sectors: meat, food and tobacco, beverages, textiles, leather and shoes, motors and cars, furniture and other manufacturing goods.
Low technology	Dummy variable that takes value 1 if the firm belongs to a low-technological intensity industry (meat, beverages, textiles and clothing, leather and shoes, timber, paper, printing, non-metallic mineral products, metallic products, furniture and other manufacturing goods) and 0 otherwise.
Medium technology	Dummy variable that takes value 1 if the firm belongs to a medium-technological intensity industry (food and tobacco, rubber and plastic, and ferrous and non-ferrous metals) and 0 otherwise
High technology	Dummy variable that takes value 1 if the firm belongs to a high-technological intensity industry (chemical products, industrial and agricultural machinery, office machines, electric and electronic machinery and material, vehicles cars and motors, and other transport equipment), and 0 otherwise.
<i>Export market characteristics</i>	
European Union	Dummy variable that takes value one if the firm exports mostly to European Union markets, and zero otherwise.
OECD	Dummy variable that takes value one if the firm exports mostly to OECD markets, and zero otherwise.
Rest	Dummy variable that takes value one if the firm exports mostly to markets other than the European Union and OECD markets, and zero otherwise.
<i>Business Cycle</i>	
Year dummies	Dummy variables that take value one for the corresponding year and zero otherwise.

Table 2. Maximum likelihood estimates for the discrete time proportional hazard models.
cloglog without individual unobserved heterogeneity

	Hazard rate	<i>p</i> -value
<u><i>Firm attributes</i></u>		
Size group	0.493	0.027
Productivity2	0.923	0.639
Productivity3	0.415	0.001
Export intensity	0.596	0.005
Foreign capital participation	1.040	0.897
R&D intensity2	1.188	0.439
R&D intensity3	0.594	0.209
R&D results	0.783	0.139
<u><i>Industry characteristics</i></u>		
Final consumption	0.693	0.031
Medium technology	1.314	0.276
High technology	1.173	0.512
<u><i>Export market characteristics</i></u>		
Exporting to EU	0.371	0.000
Exporting to OECD	0.332	0.033
<u><i>Business cycle</i></u>		
Year 1992	2.965	0.047
Year 1993	2.542	0.090
Year 1994	1.618	0.397
Year 1995	1.135	0.824
Year 1996	1.482	0.481
Year 1997	1.623	0.371
Year 1998	2.354	0.112
Year 1999	0.888	0.832
Year 2000	0.964	0.947
<u><i>Duration dependence</i></u>		
d1	0.435	0.144
d2	0.345	0.082
d3	0.299	0.057
d4	0.236	0.033
d56	0.109	0.002
d78910	0.154	0.013
Log likelihood	-456.531	
N. of observations	1414	
N. of spells	407	

Figures.

