Foreign presence, technical efficiency and firm survival in Greece: a simultaneous equation model with latent variables approach

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Chapter 10
FOREIGN PRESENCE, TECHNICAL EFFICIENCY AND FIRM SURVIVAL IN GREECE: A SIMULTANEOUS EQUATION MODEL WITH LATENT VARIABLES APPROACH

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1. INTRODUCTION

One of the most interesting issues in the literature of applied industrial organization is firm entry. The procedure of entry is important for the evolution of markets because it affects their structure, and hence the degree of competition and the ensuing profits and consumer welfare[1]. Drawing from this literature research interest in recent years has moved towards the factors that affect firm survival. Numerous studies took into consideration different firm level characteristics such as age, size, location, profitability, leverage, liquidity, as well as sectoral characteristics including market concentration, capital intensity, level of technology and more recently the presence of foreign firms.

The impacts of foreign presence are ambiguous. The benefits include the inflow of superior technical knowledge that is adapted by new firms and leads to increases in local firms' productivity and performance. These spillover effects can come through employment turnover, direct contact of foreign companies with local agents, increased competition between the more productive foreign firms and the less productive domestic rivals or reverse engineering. The costs stem from the fact that foreign firms produce on a lower cost curve than local industry, thereby crowding out more costly domestic rivals. The intense competition that foreign firms bring along may also increase failure probabilities in their markets, if other firms are not equipped to face such a strong competitive pressure.

In addition, interest was directed towards exploring the role of efficiency on the probability of firm survival. Technical efficiency concerns either the production function or the cost function. From the production function point of view a firm is technically efficient if it produces the maximum output possible given the level of inputs. From the cost function point of view a firm is technically efficient if it produces with the minimum cost given the level of output and input prices. Whichever way technical efficiency is measured, it is thought to affect firm performance and hence survival.

The scope of our paper is to explain how firm and sectoral level characteristics such as size, age, financial profile, capital intensity, technical efficiency, market concentration, foreign penetration etc. affect the probability of exit, using data for the Greek manufacturing industry in 1997-2003. Specifically, we focus on the role that technical efficiency and foreign spillover effects have on survival. For this purpose we first employ a CES translog production function to estimate technical efficiency and we then use the hazard function, corresponding to the Exponenial and Weibull distributions, as well as a simple Cox model to estimate the effect that firm and sectoral level variables have on the survival probabilities of Greek manufacturing firms.

2. SURVIVAL LITERATURE

The first studies about the concept of firm survival have been of a theoretical nature. Ghemawat an Nalebuff (1985) concluded that in a declining industry with firms with asymmetric market shares and identical unit costs, the survivability is inversely related to size, i.e., the largest firm is the first to leave and the smallest is the last, because it can ''hang on'' longer than the large firm. Reynolds (1988) built a dynamic, game theoretic model to examine the plant closing and exit strategies of firms operating in a declining industry. His results support that in single-plant firms, high-cost plants close before low-cost plants in equilibrium. In a multi-plant duopolists case, a larger firm begins closing plants before a smaller firm as long as cost differences across plants are not large. Finally, Whinston (1988) concluded that when we have multi-plant firms, the generalization that the larger ones exit first, does not hold. The pattern of capacity reduction depends on a number of features related to the structure of the industry and the type of decline.

Moving now to empirical evidence, Dunne, Roberts and Samuelson (1988), examined the patterns of firm entry, growth and exit in U.S. manufacturing based on panel data for the period 1963-1982. They found that plant survival is positively associated with plant age and plant size, and that exit rates vary across industries and persist over time. Baden-Fuller (1989), in his research for U.K. steel castings in 1975-1983 found that profitability does influence the exit decision of a firm. He also concluded that diversified firms and firms that also operate in other business, other things equal, are more likely to make the decision to close a plant. Deily (1991) examined the plant closings of integrated steel firms for the period 1977-1987. He found that larger firm size is associated with a reduced likelihood of exit, steel multi-plant firms competing with minimills are more likely to close a plant and, finally, less profitable steel plants are shut down.

Audretsch (1991) examined the survival probabilities of new firms in the U.S., by using data for 1976-1986 and taking into account among other firm characteristics the innovating activity of firms. He found that new-firm survival is positively related with the extent of innovative activity and that short-run survival is positively related with market concentration. In addition, the existence of substantial scale economies and a high capital-labor ratio required by a sector lower firm survival probabilities. These results vary considerably with the time interval considered.

In a later study, Audretsch (1995) used cross sectional data for U.S. manufacturing, and confirmed that scale economies and product differentiation do constitute a barrier to survival. He also concluded that the likelihood of survival and the post-entry growth rates vary systematically from industry to industry. Moreover, he found that in industries where innovative activity of small firms plays an important role, the likelihood of new entrants' survival over a decade is lower than in industries where innovative activity is less important. More specifically, the likelihood of surviving an additional two years for the entrants that have already survived the first few years is actually greater in highly innovative industries. Also, new entrants that manage to adjust and offer a viable product have a higher likelihood of survival in highly innovative environments.

Audretsch and Mahmood (1995) investigated the relationship between firm survival and firm specific characteristics for U.S. new establishments. They found that the exposure of new establishments to risk tends to be greater in highly innovative environments. Furthermore, the likelihood of survival tends to be lower in industries where scale economies play an important role. The hazard rate is significantly lower for firms that have a large start-up size, whereas, it is significantly higher for establishments, which are branches of an existing enterprise than new independent enterprises. In addition, they found that as the gap between the minimum efficient size and start-up size increases, the hazard ratio also rises. A positive relationship between hazard rate and price-cost margin, as well as a greater hazard rate for new firms during periods of higher employment is also confirmed from their work. Finally, they reported a negative relationship among hazard rate and interest rates, size and wages.

Mata, Portugal and Guimaraes (1995), using panel data, examine the longevity of entrants in Portugal. The current (as opposed to initial) size of a firm affects positively both survival and growth rate. Also, size is an important determinant of survival particularly for de novo entrants. Moreover, plants that have grown face a lower probability of exit than otherwise identical units. In addition, past growth matters for survival and the higher the rate of plant creation in the industry, the lower the expected life of newborn units. Finally, a new firm has a higher survival probability if it enters growing industries or industries with little entry activity.

Doms, Dunne and Roberts (1995) examined the relationship among capital intensity, use of advanced manufacturing technology, growth rates and exit probabilities. Using U.S. data they found that capital intensive plants and plants employing advanced technology such as robots, lasers or computer controlled machinery have higher survival rates. Firm size, age and productivity were not sufficient statistics for characterizing the growth and failure patterns.

Santarelli (1998) used panel data for the Italian tourist sector, to estimate the relationship between the survival of tourist firms and their start-up size, on a region by region basis. He found that the relationship had the expected sign, although for some regions and for the country as a whole it didn't turn out to be statistically significant. Fotopoulos and Louri (2000), using data for Greek manufacturing industry in the 1982-92 period found that initial capital, growth and current size affect positively the probability of survival, while leverage (the ratio of debt to total assets) has the opposite effect. In addition, firms located in large urban centers have a higher survival probability following an 'urban incubator' argument.

Also, Santarelli (2000) using a Cox proportional hazard model, studied the link between duration of a new firm and its start-up size, as well as a series of industry-specific characteristics. He applied his model to the Italian financial intermediation industry. He found that regulatory reform in 1990 accelerated industry concentration, since before the regulatory reform, in 1989, entry was possible even for very small firms. In addition, larger new entrants survived longer than their smaller counterparts independently of the features of spatial and structural competition.

Bernard and Jensen (2002), employed two panel data sets of U.S. firms, one from 1987-1992 and a second one from 1992-1997, to examine the role of firm structure in manufacturing plant closure. They found that plants belonging to multi-plant or U.S. multinational firms have lower failure probabilities but this is due to the quality of the plants themselves rather than their nature. Also, age, size and capital intensity affect positively the probability of firm survival. But when they controlled for plant characteristics such us age, size, capital intensity and export status, they found that multi-plant and U.S. multinational firms are much more likely to close a plant.

Bernard and Sjoholm (2003), examined if foreign ownership affects firm survival in a developing country. Using data for Indonesian manufacturing in 1975-1989, they concluded that a foreign owned firm with any degree of foreign ownership had substantially lower failure probabilities than plants with only domestic ownership. But when controlling for plant size and productivity, foreign plants were more likely to close than similar domestic plants.[2]

3. FOREIGN FIRMS AND SPILLOVERS

Caves (1974) was probably the first researcher to report empirical results about spillover effects stemming from the presence of foreign firms in domestic markets. He used cross-sectional data for Canada and Australia and found evidence of positive spillovers affecting domestic firms. His work has since been extended from a number of researchers. Globerman (1979) used cross sectional data and obtained estimates of labor productivity for domestically owned plants in Canada. He found that labor productivity differences across Canadian owned plants are positively related to capital intensity, plant scale economies, labor quality, average hours per employee, and foreign ownership. The differences in labor productivity are derived partly from spillover efficiency benefits associated with foreign direct investment.

Blomstrom (1986) using cross sectional data, found that foreign presence in Mexican industry is positively related to efficiency. Also, foreign entry is related to positive changes only in the ''modern'' part of the industry. Finally, the most important source of spillover efficiency is found to be the competitive pressure induced by foreign firms. Haddad and Harrison (1993) used a firm level panel-data set for Morocco and they examined whether technology spillovers exist in Moroccan manufacturing sector finding evidence for negative spillover effects stemming from multinationals during the period 1985-1990.

Blomstrom and Kokko (1998), in their review article, support that spillover effects exist, that they are substantial between industries, that they depend on the level of capability and competition and that they vary systematically between countries and industries but there is no comprehensive evidence on their exact nature or magnitude. Finally they argue that the impacts of spillovers on the home country are likely to depend on what activities multinational firms retain in their home country and how internationalized the firms are.

Aitken and Harrison (1999) used panel data on Venezuelan plants to find that foreign equity participation is positively correlated with small enterprise plant productivity. They also found that an increase in foreign ownership negatively affects the productivity of domestically owned plants. The net effect of these two offsetting effects is almost negligent for the economy.

Blomstrom and Sjoholm (1999) used cross sectional data for Indonesia and examined firstly, if majority and minority owned establishments differ in terms of productivity levels and secondly, if the degree of spillovers differs with the degree of foreign ownership. They found that labor productivity is higher in foreign-owned establishments and that domestic establishments benefit from spillovers from FDI. Also the degree of foreign ownership does neither affect the level of labor productivity in foreign firms nor the degree of spillovers to the domestic sector. Finally, they found that spillovers were restricted to non-exporting local firms, probably because export oriented firms already face competitive pressure from the world market.

In a separate work for Ireland, Gorg and Strobl (2003) examined the effect of multinational corporations' (MNCs) presence on the survival Irish firms. Using panel data for the period 1973-1996 found that when controlling for plant and sector specific effects, the presence of MNCs has a positive effect only on indigenous plants in high-tech industries, which suggests the presence of technology spillovers. They did not find any positive effect of MNCs presence on survival of firms, which belong to low-tech sectors. They finally found that the presence of MNCs has a negative effect on the survival of other foreign-owned plants in the low-tech sectors. Finally, Dimelis and Louri (2004) based on cross-sectional data for Greek manufacturing industry found that positive spillovers come from firms with minority foreign ownership. Also, they argued that it is mostly small firms that take advantage of these positive spillovers rather than large firms.

4. TECHNICAL EFFICIENCY AND HAZARD MODELS

One of the fundamental implications we also wish to examine in this work is the effect of technical efficiency on the probability of firm survival. To estimate technical efficiency we employ the translog production function model which is a flexible functional form capable of approximating the unknown production function up to second order. We begin with the assumption that each company's production function relates output, Y, to two inputs, capital, K, and labor, L, and a time trend T. We then have $\ln Y = f(\ln K, \ln L, \ln T)$.

The translog production function is:

$$\ln Y = \alpha_0 + \alpha_1 \ln L + \alpha_2 \ln K + a_3 \ln T + \alpha_4 \frac{1}{2}(\ln L)^2 + \alpha_5 \frac{1}{2}(\ln K)^2 + \\ + \alpha_6 \frac{1}{2}(\ln T)^2 + \alpha_7 (\ln L)(\ln K) + \alpha_8 (\ln L)(\ln T) + \alpha_9 (\ln K)(\ln T) + \varepsilon.$$

Obtaining returns to scale and the technical change index is straightforward. For estimation purposes this theoretical model is cast in the form of a linear model with a composed error term, $y_i = x_i'\beta + v_i - u_i$, $i = 1,...,n$, where y_i is the log of production, x_i is a $k \times 1$ vector of log of inputs, β is a $k \times 1$ vector of parameters, v_i is a two-sided error term representing measurement error, and $u_i \geq 0$ is TI.[3] The stochastic assumptions are that $v_i \sim iidN(0, \sigma_v^2)$, $u_i \sim iid|N(0, \sigma_v^2)|$, and (x_i, v_i, u_i) are mutually independent. It is well known that this model can be estimated using the maximum likelihood method. The probability density of the dependent variable given the covariates is.

$$f(y_i | x_i) = (2/\sigma)\phi(-\varepsilon_i/\sigma)\Phi(-\lambda\varepsilon_i/\sigma),$$

where $\lambda = \sigma_u/\sigma_v$, $\sigma^2 = \sigma_v^2 + \sigma_u^2$, $\varepsilon_i = y_i - x_i'\beta$, and Φ denote the standard normal density and distribution functions. The log likelihood function is simply $\ln L = \sum_{i=1}^{N} \ln f(y_i | x_i)$ and standard numerical techniques can be used to obtain the maximum likelihood estimates and their asymptotic standard errors. Estimation of technical efficiency is possible using a result due to Jondrow, Lovell, Materov, and Schmidt (1982) which provides the expected value of u_i given the observed data. This expectation is:

$$E(u_i | y_i, x_i) = \frac{\sigma\lambda}{1+\lambda^2}\left[\frac{\phi(-\lambda\varepsilon_i/\sigma)}{\Phi(-\lambda\varepsilon_i/\sigma)} - \lambda\varepsilon_i/\sigma\right].$$

After estimating technical efficiency, we proceed to estimate the probability of firm failure (hazard). It is, however, necessary first to understand the estimation issues involved and this necessitates a full presentation of the econometric model. We consider the following stochastic production frontier with unbalanced panel data:

$$y = \mathbf{x}_{it}'\beta + v_{it} - u_{it}, \qquad (1)$$
$$t = 1,...,T_i,\ i = 1,...,n,$$

where $\mathbf{x}_{it}$ is a $k \times 1$ vector of inputs, β is a $k \times 1$ vector of parameters, v_{it} is a two sided disturbance reflecting measurement error, and u_{it} is a non-negative disturbance representing technical inefficiency. Estimation techniques for (1) are well known in the literature under various distributional assumptions about the one sided error component.[4]

In this paper we are interested in modeling survival of firms and its connection with firm performance reflected in technical inefficiency. While many studies, as mentioned in section 2, have been concerned with survival, very few have been concerned with the role of technical inefficiency.[5]

Given a random variable T with probability distribution $f(t)$, and the survival function $S(t) = 1 - F(t)$, where $F(t)$ is the distribution function, the hazard rate can be defined

$$\lambda(t) = \lim_{\varepsilon \to 0} \frac{\Pr[t \le T \le t + \varepsilon | T \ge t]}{\varepsilon} = \frac{f(t)}{S(t)}. \qquad (2)$$

Many models have been proposed in the literature for the hazard rate or the survival function, viz. the Exponential, Weibull, lognormal, and log-logistic.[6] For example the Exponential model has $\log S(t) = -\lambda t$, where $\lambda > 0$ is a parameter, the constant hazard rate. The probability density is given by $f(t) = \lambda \exp(-\lambda t)$. For the Weibull model, the hazard rate is $\lambda(t) = \lambda p(\lambda t)^{p-1}$. The probability density function is $f(t) = \lambda p(\lambda t)^{p-1} \exp\left[-(\lambda t)^p\right]$ and the survival function is $F(t) = \exp\left[-(\lambda t)^p\right]$.

The data available for firm i are $D_i = \{y_{it}, \mathbf{x}_{it}, T_i, \mathbf{z}_i, I_i; t = 1,...,T_i\}$, $i = 1,...,n$, where I_i is an indicator variable equal to 1 if the firm ceased to exist at some date $\tau \ge T_i$, and zero otherwise, and z_i is an $m \times 1$ vector of covariates that are thought to be determinants of survival on prior grounds. The firms that survived are also known as "censored". It will be useful to define the set of censored observations, $C = \{i : I_i = 0\}$ (the set of survived firms) and the set of firms that ceased to exist, $U = \{i : I_i = 1\}$, which is the set of uncensored firms.

When the stochastic production frontier in (1) is estimated, a measure of technical inefficiency, say $\hat{u}_{it}$, can be obtained using the Jondrow, Lovell, Materov and Schmidt (1982) formula. This is simply the expected value of u_{it} given the data. The intention here is to estimate the survival function in (2) when the parameter λ depends on the covariates z_i - an $m \times 1$ vector - and certain covariates include *functions of technical inefficiency*, viz.

$$\log \lambda_i = \mathbf{z}_i' \boldsymbol{\gamma}_1 + \mathbf{h}(u_{it})' \boldsymbol{\gamma}_2 , \tag{3}$$

where $\mathbf{h}(u_{it})$ is a $q \times 1$ vector of *functions*. In the simplest case, $q = 1$, we can choose $h(u_{it}) = \bar{u}_i = T_i^{-1} \sum_{t=1}^{T_i} u_{it}$, average technical inefficiency but higher empirical moments may be included to investigate aspects of the way in which technical inefficiency impacts on survival. From the way (2) is formulated it is clear that the hazard parameter λ cannot vary over time since we examine survival from the point of view of a time period that is posterior to the sample period induced by (1). For that reason, the $\mathbf{h}$ functions must be time averages or involve certain similar operations implicit in their definition.

Proceeding as if u_{it} is known or estimated, the log-likelihood function of the model is

$$\ln L(\boldsymbol{\theta}; \mathbf{D}) = \sum_{i \in U} \ln f(T_i | \boldsymbol{\theta}) + \sum_{i \in C} \ln S(T_i | \boldsymbol{\theta}) , \tag{4}$$

where: $\boldsymbol{\theta}$ is the vector of all unknown parameters in the model and, for the Exponential case, $f(t_i) = \lambda_i \exp(-\lambda_i t_i)$, where λ_i was defined in (3). Substituting in (4) we get

$$\ln L(\boldsymbol{\theta}; \mathbf{D}) = \sum_{i \in U} [\log \lambda_i - \lambda_i T_i] - \sum_{i \in C} \lambda_i T_i . \tag{5}$$

The log-likelihood function in (5) can be estimated using standard numerical techniques. The problem with this approach is that technical inefficiency is not known and has to be estimated. To proceed we assume that $v_{it} \sim IN(0; \sigma_v^2)$, $u_{it} \sim IN(0; \sigma_u^2)$, that they are mutually independent and independent of all variables in x_{it} and z_{it}. Moreover, we assume that

$\{y_{it};t=1,...,T_i\}$ and T_i are independent for all $I=1,...,n$. The endogenous variables in our model are y_{it} and T_i T_i. Our model is given by the following assumptions:[7]

1. Conditional on $\mathbf{x}_{it}$ and u_{it} we have $y_{it} \sim IN(\mathbf{x}_{it}'\boldsymbol{\beta} - u_{it};\sigma_v^2)$.
2. Conditional on I_i the probability density of T_i is $f(T_i;\mathbf{u}_i,\boldsymbol{\gamma})^{1-I_i}$ $S(T_i;\mathbf{u}_i,\boldsymbol{\gamma})^{I_i}$, where $\boldsymbol{\gamma}=[\boldsymbol{\gamma}_1',\boldsymbol{\gamma}_2']'$.
3. Conditional on $\mathbf{x}_{it}$, u_{it} and I_i, the random variables T_i and $\mathbf{y}_i=[y_{i1},...,y_{i,T_i}]'$ are independent.
4. The random variables u_{it} are distributed independently according to a half-normal distribution, $u_{it} \sim |N(0,\sigma_u^2)|$, and are independent of $\mathbf{y}_i$ and T_i conditional on x_{it}, z_{it} and I_i.

The central object of interest is the joint distribution of endogenous variables which, in this instance, is given by

$$f(\mathbf{y}_i,T_i|x_{it},z_{it},I_i,\theta)=\int_{R_+^{T_i}}(2\pi\sigma_v^2)^{-T_i/2}(\pi\sigma_u^2/2)^{-T_i/2}\exp\left[-\frac{\sum_{t=1}^{T_i}(y_{it}-x_{it}'\beta+u_{it})^2}{2\sigma_v^2}+\right.$$

$$\left.-\frac{\sum_{t=1}^{T_i}(u_{it})^2}{2\sigma_u^2}\right]\cdot f(T_i;\mathbf{u}_i,\gamma)^{1-I_i}S(T_i;\mathbf{u}_i,\gamma)^{I_i}d\mathbf{u}_i \tag{6}$$

where $f(T_i;\mathbf{u}_i,\gamma)$ and $S(T_i;\mathbf{u}_i,\gamma)$ represent the density and survival function respectively where the dependence on $\mathbf{u}_i=[u_{i1},...,u_{iT_i}]$ and the parameter vector θ is made explicit. This expression can be derived as follows. Clearly,

$$f(\mathbf{y}_i,T_i|\mathbf{x}_{it},\mathbf{z}_{it},I_i,\boldsymbol{\theta})=\int_{R_+^{T_i}}f(\mathbf{y}_i,\mathbf{u}_i,T_i|\mathbf{x}_{it},\mathbf{z}_{it},I_i,\boldsymbol{\theta})d\mathbf{u}_i=$$

$$=\int_{R_+^{T_i}}f(\mathbf{y}_i,T_i|\mathbf{x}_{it},\mathbf{z}_{it},I_i,\boldsymbol{\theta},\mathbf{u}_i)f(\mathbf{u}_i|\mathbf{x}_{it},\mathbf{z}_{it},I_i,\boldsymbol{\theta})d\mathbf{u}_i$$

From the half-normality distributional assumption, we have

$$f(\mathbf{u}_i | \mathbf{x}_{it}, \mathbf{z}_{it}, I_i, \boldsymbol{\theta}) = (\pi\sigma_u^2/2)^{-T_i/2} \exp\left[-\frac{\sum_{t=1}^{T_i} u_{it}^2}{2\sigma_u^2}\right], \ i = 1,...,n \ .$$

The distribution $f(\mathbf{y}_i, T_i | \mathbf{x}_{it}, \mathbf{z}_{it}, I_i, \boldsymbol{\theta}, \mathbf{u}_i)$ can be easily obtained from the fact that conditional on $x_{it}, z_{it}, I_i, \theta, u_{it}$, the y_{it} is normally distributed and the fact that $\{y_{it}; t = 1,...,T_i\}$ and T_i are independent for all $i = 1,...,n$.

The problem is that even when the **h** function consists of average technical inefficiency the multivariate integral in (6) cannot be computed in closed form. This integral, however, is essential in formulating the log-likelihood function of the model, which is given by

$$\ln L(\mathbf{y}, \mathbf{T}; \mathbf{X}, \mathbf{Z}, \mathbf{I}, \boldsymbol{\theta}) = \sum_{i=1}^{n} \log f(\mathbf{y}_i, T_i | \mathbf{x}_{it}, \mathbf{z}_{it}, I_i, \boldsymbol{\theta}) \ . \quad (7)$$

The problem, of course, becomes worse when the **h** function includes *complicated components* like for example $T_i^{-1}\sum_{t=1}^{T_i}(u_{it} - \overline{u}_i)^2$, or $T_i^{-1}\sum_{t=1}^{T_i}(u_{it} - u_{i,t-1})$, or even $T_i^{-1}\sum_{t=1}^{T_i}\max(0, u_{it} - u_{i,t-1})$, viz. the variability of technical inefficiency, its average *change* over the sampling period, or the average *improvement* in technical inefficiency. All these constitute indispensable components of any serious analysis seeking to make inferences about the extent to which technical inefficiency is important for firm survival.

To implement our models we employ the hazard function of the Exponential and Weibull distributions and follow a two-stage estimation approach. First, the stochastic production frontier is estimated, and second, the survival likelihood is maximized. Functions of technical inefficiency are treated as ordinary regressors after evaluating the **h** functions at the estimates of technical inefficiency derived from the first stage.

For the Exponential distribution the hazard is

$$\lambda(t) = \lambda \ ,$$

where $\lambda(t)$: rate at which plants exit at time t given that they have survived in $t-1$, (λ: parameter, t: time). The survival function in this case is the following:

$$S(t) = e^{-\lambda t},$$

In addition, we also employ the Weibull duration model:

$$\lambda(t) = \lambda p(\lambda t)^{p-1},$$

where: $\lambda(t)$: rate at which plants exit at time t given that they have survived in $t-1$ (λ: parameter, p: parameter, t: time). The survival function for this case is the following:

$$S(t) = e^{-(\lambda t)^p}.$$

The hazard function for the Weibull distribution is monotonically increasing or decreasing depending on p.

5. ECONOMETRIC ESTIMATIONS

5.1. Data

The study makes use of 3,142 firms manufacturing firms operating in Greece in period 1997-2003. Individual firm information has been derived from the ICAP directory, which provides financial data based on the published accounts of all Plc. and Ltd. firms in Greece. Information on employment and foreign ownership is also collected and given to us by ICAP.

Table 1 presents a summary of the sample. From the 3,142 firms only 2,893 survived the entire period of interest. Of them 249 'died' before 2003. From the firms that did not survive until 2003, 45 died in 1997, 42 died in 1998, 29 in 1999, 26 in 2000, 41 in 2001 and 66 died in 2002. Table 1 also presents the number of firms that belong to each sector each year. Table 2 presents the products that each sector produces. Foreign participation exists in 163 firms. Table 3 presents the descriptive statistics of the firms that enjoy foreign participation. From them 159 survived the entire period of interest (1997-2003). From the 163 'foreign' firms, 92 exhibit majority foreign ownership (foreign ownership >50%) and 71 exhibit minority foreign ownership (foreign ownership ≤50%).

Table 1 – Survival data (1997-2003) by sector

Sector	1997-1997	1997-1998	1997-1999	1997-2000	1997-2001	1997-2002	1997-2003
40	10	8	8	9	9	17	597
49	0	1	0	1	0	0	17
55	4	6	3	3	9	8	436
59	1	2	0	0	1	2	53
60	3	0	2	3	1	4	166
63	5	4	2	1	3	5	267
72	1	3	0	0	2	1	185
74	1	4	3	0	0	2	96
75	1	1	0	0	0	0	73
76	0	0	0	0	1	1	7
79	6	4	1	2	8	8	329
82	3	2	4	3	4	6	265
88	4	5	2	2	2	7	222
92	3	0	1	2	1	4	66
99	3	2	3	0	1	1	114
Total	45	42	29	26	42	66	2,893
Survived							2,893
Failed							249
Total							3,142

Table 2 - Description of sectors

Sector	Products
40	Food, Agricultural, Beverages
49	Tobacco
55	Textiles, White linen, Fabric made, Garments, Underwear, Accessories
59	Footwear, Leather, Fur
60	Wood, Cork, Furniture
63	Paper, Newspapers, Magazines, Publishing, Printing, Graphic arts
72	Rubber, Plastics
74	Chemical, Gases, Paints, Explosives
75	Medicines, Cosmetics, Detergents
76	Liquefied gas bottling, Petroleum, Coal products
79	Quarries, Mines, Salt works, Non metallic mineral products
82	Primary metal products, Metal products and structures
88	Machinery, Electric and electronic equip., Electric appliances, Lighting fixtures
92	Transportation means
99	Miscellaneous manufactured products

Table 3 – Survival data of foreign firms by country of origin

Country	1997-1997	1997-1998	1997-1999	1997-2000	1997-2001	1997-2002	1997-2003
Australia	0	0	0	0	0	0	1
Austria	0	0	0	0	0	0	2
Belgium	0	0	0	0	0	0	4
Cyprus	0	0	0	0		0	16
Denmark	0	0	0	0	0	0	1
England	0	0	0	0	0	1	11
France	0	0	0	0	0	0	16
Germany	0	0	0	0	0	0	17
Ireland	0	0	0	0	0	0	5
Italy	0	0	1	0	0	0	8
Japan	0	0	0	0	0	0	1
Libya	0	0	0	0	0	1	0
Liberia	0	0	0	0	0	0	3
Lichtenstein	0	0	0	0	0	0	2
Luxemburg	0	0	0	0	0	0	14
Netherlands	0	0	0	0	1	0	23
Norway	0	0	0	0	0	0	1
Panama	0	0	0	0	0	0	3
Scotland	0	0	0	0	0	0	1
Spain	0	0	0	0	0	0	3
Sweden	0	0	0	0	0	0	2
Switzerland	0	0	0	0	0	0	16
U.S.	0	0	0	0	0	0	9
Total	0	0	1	0	1	2	159
%>50							92
$\% \leq 50$							71
Total							163

5.2. Variables

The theoretical analysis, the econometric models employed and the availability of data, drive the choice of independent variables that we use in this work. These are:

LOGSIZE: logarithm of firm total assets;

LOGK/L: the logarithm of the ratio of fixed assets to the number of employees;

LEVERAGE: the ratio of debt to total assets;

LIQUIDITY: the ratio of working capital to total assets;
NPMARG: the ratio of net profits to production (sales);
PROFTA: the ratio of net profits to total assets;
DEBTSAL: the ratio of debt to sales;
SPILL (SPILLOVER EFFECT): the ratio of fixed capital belonging to foreign firms in the industry to total fixed capital of the industry;
HERFINDAHL (CONCENTRATION): measured by Herfindhal Index which is defined as follows: $H = \sum_{i=1}^{n}\left(\frac{x_i}{X_i}\right)^2$, where x_i: employment of n individual plant in the industry; X_i : total employment in the industry.
AGE: the difference between the current year and the first recorded year for the plant;
INEFF (TECHNICAL INEFFICIENCY): as provided by the stochastic production frontier estimation;
INEFF^2: inefficiency raised to the power of 2;
DINEFF: the improvement in efficiency. Only positive changes in efficiency are taken into consideration;
FOREIGN>50%: dummy variable taking the value of 1 if foreign ownership in a firm's capital exceeds 50 percent (majority foreign ownership),
FOREIGN≤50%: dummy variable taking the value of 1 if foreign ownership in a firm's capital is less than 50 percent (minority foreign ownership);

From the variables presented above, LOGSIZE, LOGK/L, LEVERAGE, LIQUIDITY, DEBTSAL, AGE, NPMARG, PROFTA, INEFF, INEFF^2 and DINEFF and FOREIGN> or ≤50% are firm level variables, whereas SPILL and HERF are sectoral variables.

5.3. Estimation Results

Before proceeding to hazard estimations, we employed the translog production function and estimated the technical efficiency of each firm. The estimation of the translog production function is presented in Table 4. The technical (in)efficiency thus produced is then used in the hazard estimations. Next, we estimate hazard functions for the Weibull and the Exponential distributions, as well a simple Cox hazard model. The results are presented in Tables 5, 6 and 7 and show persistent similarities.

As can be seen in these Tables the variable LOGSIZE is always significant with a negative coefficient, which means that size affects negatively the probability of exit, or has a positive effect on firm survival. This result has been supported by many researchers such as Dunne, Roberts and Samuelson (1988), Deily (1991), Audretch and Mahmood (1995), Mata, Portugal, Guimaraes (1995), who found a positive relationship between firm size and survival. The coefficient of LOGK/L is also consistently significant with a positive sign, which means that high capital requirements increase the hazard. This result contradicts findings by Doms, Dunne and Roberts (1995) and Bernand and Jensen (2002), but it is in the same line with the results of Audretsch (1991), who supports that substantial high capital-labor ratio tends to lower the likelihood of firm survival. LEVERAGE as well as DEBTSAL have also highly significant and positive coefficients meaning that high levels of debt (requiring high interest payments) reduce the likelihood of survival, a result also found in Fotopoulos and Louri (2000). From the financial variables LIQUIDITY as well as NPMARG and PROFTA have also positive and significant coefficients, meaning that firms with high liquidity and/or high profitability suffer a higher exit rate, a result often discussed in the mergers and acquisitions literature where high liquidity and profitability have been found to induce takeover behaviour on behalf of rivals, consequently endangering the firms'existence.

Table 4 - Translog production function estimation

Parameters	Coefficient	Estimates	Standard Error	Est./s.e.	Probability
Constant	A_0	12.8360	0.2221	57.801	0.0000
lnL	α_1	0.5582	0.0706	7.903	0.0000
lnK	α_2	-0.2290	0.0413	-5.544	0.0000
lnT	α_3	0.0311	0.0243	1.284	0.1991
½(lnL)^2	α_4	0.1327	0.0169	7.840	0.0000
(lnL)(lnK)	α_7	-0.0212	0.0083	-2.566	0.0103
(lnL)(lnT)	α_8	0.0028	0.0042	0.667	0.5047
½(lnK)^2	α_5	0.0379	0.0045	8.374	0.0000
(lnK)(lnT)	α_9	0.0040	0.0024	1.656	0.0978
½(lnT)^2	α_6	-0.0108	0.0029	-3.673	0.0002
	σ_v	0.5572	0.0081	68.557	0.0000
	σ_u	0.8098	0.0238	34.069	0.0000

The impact of the sectoral variable FDI SPILLOVERS on the probability of exit is persistently significant and positive. In sectors with strong foreign presence, competition may be harsher, thus driving firms out of the market. Although it has been found that strong foreign presence impacts positively on the productivity of all (domestic and foreign) firms in a market (Dimelis and Louri, 2002), our results show that the negative side of spillovers, which is increased competition, is prevailing and increases hazard. A negative effect of foreign spillovers to firm survival can also be found in Haddad and Harrison (1993). The other sectoral variable, namely market concentration as represented by the Herfindahl index has also been estimated to affect hazard in a positive way - though not always statistically significant - which means that oligopolistic market structures do not enhance firm survival. It may be that concentration effects are harder for smaller and younger firms in a sector but such diversified behaviour could not be distinguished with our data. It is interesting that AGE has been estimated to have a negative and significant sign on hazard, meaning that older firms have a higher probability of survival probably due to accumulated experience and recognition. The age result is similar in Audretsch (1991 and 1995), Dunne, Roberts and Samuelson (1988) and Bernard and Jensen (2002).

Table 5: Hazard estimations (Weibull distribution)

Parameters	Estimates Weibul 1	Probability Weibull 1	Estimates Weibull 2	Probability Weibull 2	Estimates Weibull 3	Probability Weibull 3
Constant	2.413	0.005	1..939	0.022	1.912	0.025
logsize	-2.115	0.000	-2.010	0.000	-2.023	0.000
logK/L	0.072	0.001	0.081	0.000	0.085	0.000
leverage	0.153	0.000	0.221	0.000	0.224	0.000
liquidity	0.302	0.025	0.317	0.015	0.344	0.013
npmarg	0.049	0.113				
profTA			0.383	0.068	0.384	0.067
debtsal	0.011	0.070	0.005	0.063	0.005	0.064
Foreign>50%	0.119	0.451			0.111	0.486
Foreign≤50%	0.206	0.074			0.195	0.095
spill	0.065	0.001	0.070	0.000	0.067	0.001
Herfindahl	0.271	0.346			0.304	0.287
age	-0.077	0.000	-0.079	0.000	-0.079	0.000
ineff	0.357	0.010	0.461	0.009	0.464	0.009
$ineff^2$	-0.102	0.254	-0.102	0.226	-0.102	0.230
dineff	0.899	0.171	0.675	0.165	0.678	0.166
Weib p	2.567	0.000	2.556	0.000	2.554	0.000

From the variables measuring the technical (in)efficiency of firms the INEFF variable, has a significant and positive effect on hazard, meaning that technically inefficient firms are less likely to survive. Thus, it is important for firms to improve on their technical skills in order to become more efficient and reduce their probability of failure. Finally, a higher empirical moments of efficiency as measured by the $INEFF^2$ and DINEFF are not found to exert any significant effects. As far as DINEFF is concerned the results were similar when it was including both positive and negative changes in efficiency as when it was including only improvements.

Table 6: Hazard estimations (exponential distribution)

Parameters	Estimates Exponential 1	Probability Exponential 1	Estimates Exponential 2	Probability Exponential 2	Estimates Exponential 3	Probability Exponential 3
Constant	17.574	0.000	17.085	0.000	16.962	0.000
logsize	-10.412	0.000	-10.329	0.000	-10.396	0.000
logK/L	0.357	0.000	0.366	0.000	0.385	0.000
leverage	0.813	0.000	0.999	0.000	1.008	0.000
liquidity	1.763	0.007	1.674	0.010	1.769	0.006
npmarg	0.054	0.224				
profTA			1.311	0.059	1.262	0.065
debtsal	0.018	0.005	0.017	0.004	0.015	0.007
Foreign>50%	0.056	0.955			0.091	0.927
Foreign≤50%	0.725	0.092			0.641	0.202
spill	0.026	0.002	0.027	0.002	0.025	0.002
Herfindahl	2.189	0.083			2.142	0.089
age	-0.112	0.000	-0.113	0.000	-0.114	0.000
ineff	1.146	0.010	1.421	0.002	1.420	0.002
$ineff^2$	-0.113	0.347	-0.182	0.153	-0.168	0.167
dineff	0.034	0.937	0.073	0.868	0.082	0.851

Table 7: Hazard estimations (Cox model)

Parameters	Estimates Cox 1	Probability Cox 1	Estimates Cox 2	Probability Cox 2	Estimates Cox 3	Probability Cox 3
Constant						
logsize	-1.026	0.000	-1.029	0.000	-1.028	0.000
logK/L	0.667	0.003	0.723	0.001	0.744	0.001
leverage	0.844	0.000	0.979	0.000	0.979	0.000
liquidity	1.332	0.030	1.311	0.034	1.364	0.027
npmarg	0.124	0.138				
profTA			1.497	0.005	1.407	0.008
debtsal	0.017	0.004	0.014	0.008	0.014	0.008
Foreign>50%	-0.814	0.420			-0.787	0.436
Foreign≤50%	-0.132	0.823			-0.065	0.911
spill	0.032	0.000	0.034	0.000	0.032	0.000
Herfindahl	2.166	0.101			1.743	0.211
age						
ineff	0.747	0.067	0.918	0.029	0.948	0.024
$ineff^2$	-0.126	0.218	-0.143	0.169	-0.148	0.153
dineff	0.345	0.432	0.514	0.248	0.510	0.254

Finally, the role of foreign ownership in hazard was also estimated. Findings in the empirical literature have shown that foreign firms are more productive than domestic firms, hence foreign ownership could be expected to exercise a positive effect on survival. Initially, foreign ownership was included in our estimations through a dummy taking the value of 1 when a firm had any percentage (from 1% to 100%) of foreign ownership in its capital as recorded in its accounts. Such a variable was not found to be significant in any case and hence it is not reported in our estimations. Bernard and Sjoholm (2003) reported a similar finding. But since firms with majority foreign ownership in their capital could be thought to show a different failure rate than firms with minority foreign interests, their separate effects were also estimated. As can be seen in Tables 5, 6 and 7 the effects of foreign ownership as shown by FOREIGN >50% and FOREIGN ≤50% were not found to be significant in any case, meaning that once other firm characteristics such as size, age, financial profile and structural effects are taken into account the sheer fact of foreign ownership does not exercise any differentiating impact on firm survival.

6. CONCLUSIONS

In this paper we used a panel data set including 3,142 Greek manufacturing firms covering the period 1997-2003 to estimate the effects that specific firm- and market-level variables, drawn from different strands of literature (such as survival, foreign direct investment and technical efficiency analyses) have on firm survival. Our main focus was *a*) the effect of foreign presence both in a sectoral market (through spillover effects) as well as in the ownership of a firm, and *b*) the effect that technical efficiency might have on the probability of firm failure. For this purpose, we employed a simultaneous equation model with latent variables approach. Initially the translog production function to estimate technical efficiency and then fed the resulting estimates of technical (in)efficiency (as well as higher moments of it) to our hazard functions. We reported findings estimated from the Exponential and the Weibull distributions as well as from a Cox hazard model. Our variables show a persistent behaviour across all estimations.

The first basic conclusion is that foreign spillovers exercise a positive impact on hazard, unveiling possibly the increased competitive pressure existing in sectors where foreign firms have a stronger presence, rendering survival probabilities harder. In contrast, foreign firm ownership (majority or minority) does not exercise any significant effect on survival, meaning that foreign firms do not have any distinctive survival advantage (potentially stemming from their foreign parent experience or protection) compared to their local rivals (once their other specific characteristics are accounted for).

The second important result is that technical efficiency affects a firm's hazard negatively, that is it positively influences survival. Following a two-stage estimation approach according to which the stochastic production frontier is first estimated, and the survival likelihood is maximized in a second step, functions of technical inefficiency are treated as ordinary regressors. While the first moment is estimated to be significant for survival, higher moments of efficiency have not been found to play a significant role. This is an interesting finding, pointing to the fact that since technically inefficient firms do not produce the maximum level of output given the amount of inputs used, they may as well be aware of the dangers for survival such a sluggish performance may generate.

An interesting extension of our empirical analysis could follow the direction of deepening our knowledge about the effects that innovation and technology level or technology gaps might have on hazard rates. How export performance affects survival prospects is a related issue that could also be worthwhile to investigate. Whichever way one proceeds, one thing that stands clear is that firm dynamics is a new and fascinating subject with many exploration possibilities.

NOTES

[1] For an exhaustive review of the entry literature see Geroski (1995).

[2] Other studies analysing firm survival include Agarwal (1997), Agarwal and Gort (1996), Audretsch (1994), Audretsch, Houweling and Thurik (2000), Audretsch, and Mahmood (1994), Dunne and Hughes (1994), Mahmood (1992 and 2000).

[3] See Aigner, Lovell, and Schmidt (1977), Meeusen and van den Broeck (1977), and Kumbhakar and Lovell (2000) for a survey.

[4] See for example Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977), Kumbhakar and Tsionas (2005a, 2005b and 2006), Tsionas (1999 and 2002). Also for excellent surveys of the literature see Greene (1993 and 2001), Bauer (1990), and Kumbhakar and Lovell (2000). We also refer to Greene (2004) for additional issues involved.

[5] For example Dimara, Skuras, Tsekouras and Tzelepis (2003), and Wheelock and Wilson (1995).

[6] See Kalbfleisch and Prentice (1980, pp. 21-30) and Greene (2000, p. 941).

[7] In the following, we are also conditioning on the parameter vector $\boldsymbol{\theta}$.

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