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The shadow of death: analysing the pre-exit productivity of Portuguese manufacturing firms

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Abstract The pre-exiting productivity profile of *mature* firms relative to survivors is examined along with an evaluation of how productivity affects the probability of exit along various dimensions. An empirical approach, based on an unbalanced panel of Portuguese manufacturing firms covering a 10-year period, is used. The findings confirm that market selection forces low-productivity firms to exit, but there is also evidence that a sizeable portion of low-productivity firms do not shut down. Conversely, there is a non-negligible fraction of high-productivity firms that do actually close. Consistent with some key theoretical predictions, our analysis reveals that exiting firms have a falling productivity level over a number of years prior to exit. Finally, the results from the survival model show that both small firms and ones with low productivity are relatively much more likely to exit the market. Industry and macro-environment are also found to have a non-negligible role on the exit of mature firms.

Keywords Exit pattern · Firm survival · Portugal · Pre-exit performance · Productivity

JEL Classifications D24 · D21 · L25 · L26 · L60

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1 Introduction

Although firm death is common (Caves 1998; Ahn 2001), the pre-exiting productivity pattern of *mature* firms has been a relatively neglected subject in the literature on industrial dynamics. In contrast, unsuccessful entrants have been extensively studied and reported on in the literature on post-entry performance (e.g. the special issues on "The Post-entry Performance of Firms" in the *International Journal of Industrial Organization*, 1995, and "The Survival of Firms in Europe" in *Empirica*, 2008, as well as several papers on new-firm survival in this journal). However, as pointed out by Haltiwanger et al. (2007), from a theoretical point of view, we may expect differences in exit behaviour across new and mature firms. In this context, Jovanovic (1982), for example, developed the notion that there is greater heterogeneity in productivity across new firms than across mature firms, leading to the conclusion that the determinants of firm failure are expected to be distinct between the two types of firms. The organizational ecology approach, in turn, has emphasized that mature and new firms do not interact with the environment in exactly the same way. From the point of view of the empirical literature, the least one can also say is that the evidence is largely favourable to the hypothesis that the exit of young and mature firms can be explained by a different set of determinants (e.g. Audretsch 1994; Bellone et al. 2006).

In the study reported here, we take a very pragmatic route and define a mature firm as one that is at least 10 years old.[1] It is well known that, for entrants, the rate of early mortality is very high during the first few years after entry, following which time the mortality decreases to finally stabilize somewhere between the sixth and the tenth year of life (Geroski 1995; Caves 1998). Based on the results of a Canadian study by Baldwin (1995), the exit rate for 1971 entrants was about 10% at the end of the first year, which is about twofold higher that for mature firms; after 10 years, however, the exit rate for both types of firms was roughly the same. For Swedish firms, Box (2008) found that the first 6 years were more hazardous than the following years, where no distinct pattern over time was detected, while for German firms, Strotmann (2007) found that the seventh year after birth seemed to be the critical point. It is also a well-known stylized fact that the growth rate among successful entrants is very high, although it may take more than one decade to achieve the incumbents' average size (Audretsch and Mata 1995; Geroski 1995; Mata et al. 1995).

With respect to the characteristics of exiting firms, the industrial organization literature (e.g. the stochastic models of industrial dynamics of Jovanovic 1982, Hopenhayn 1992 and Ericson and Pakes 1995) underscores two key propositions: (1) the exit of mature firms is concentrated among those firms at the lowest productivity level; (2) productivity decreases over a number of years prior to exit. In a somewhat contrasting position, however, approaches based on the labour economics perspective (e.g. Evans and Jovanovic 1989; Taylor 1999) and on the resource-based theory of the firm (e.g. Wernerfelt 1984; Barney 1991) have pointed out that firm exit may well be determined by factors other than strict firm performance.

The main objective of this paper is to examine the productivity performance of mature firms in the pre-exit period by using two alternative measures: total factor productivity (TFP) and labour productivity (LP). We will also evaluate how productivity affects the hazard rate, while controlling for other *internal* and *external* dimensions and for unobserved firm heterogeneity. In this study, the definition of exit comprises bankruptcy and voluntary closure.[2] To conduct the analysis, we will use an original unbalanced panel of Portuguese manufacturing firms covering the period 1991–2000 (annual observations; see Carreira and Teixeira 2008). By specifically focusing on the pre-exit analysis of firm-level productivity in a period of one decade, our aim is to shed further light on the profile of a typical mature exiting firm. We claim, in particular, that there is evidence in favour of the 'shadow of death' effect (after Griliches and Regev 1995), according to which exit does not happen by a stroke of misfortune, but rather is the result of a persistent productivity fall that seems to flag, to some extent, an impeding death. We also find that there is a sizeable portion of low-productivity firms that do not exit and, conversely, that there is a non-negligible fraction of high-productivity firms that do actually close.

The paper is organized as follows. Section 2 presents a brief theoretical incursion, plus some major empirical findings related to the pattern of exit of mature firms. Section 3 presents the data and discusses the methodology. Section 4 analyses the productivity gap between continuing and exiting firms (in the exiting year and over a given period prior to exit), and how internal and external factors influence the likelihood of a firm exiting the market. Finally, Sect. 5 offers some concluding remarks.

2 Theory and selected empirical findings

The main purpose of our analysis is to gain an understanding of the extent to which the exit of a mature firm is due to low productivity or, alternatively, to other non-productivity-related aspects ('non-economic-forced exit', after Harada 2007). Our testing hypotheses are thus primarily drawn from industrial organization, but we also try to extend

[1] Most empirical studies point to firms achieving the mature state somewhere between the sixth and tenth year of existence. In our dataset, the results from using an alternative threshold (e.g. 8 years) are virtually the same as the ones reported in Sect. 4.

[2] As pointed out by Headd (2003) and van Praag (2003), it would be preferable to distinguish voluntary from involuntary closures, but unfortunately (see Sect. 3.2) this distinction is not possible in our dataset. This limitation is present in virtually all empirical studies in the literature, with a few exceptions (e.g. Harada 2007).

the analysis to other strands of literature, namely by incorporating in our study other stylized facts extracted, in particular, from the resource-based theory of the firm, labour economics and organizational ecology.

The stochastic models of competitive markets developed by Jovanovic (1982), Ericson and Pakes (1995) and Hopenhayn (1992), inter alia, provide an interesting theoretical framework in which both heterogeneity across firms *and* entry and exit can be analysed. These models have a common presumption—that a firm's decisions (on entry, exit and investment, for example) seek to maximize the expected present discounted value of profits conditional on the current information set. In the Jovanovic model, for example, firms discover their own predetermined (but unknown) productive efficiency through a process of Bayesian learning from its post-entry profits. Firms then expand when they realize they are efficient, and shrink (or exit) when they learn they are not. In contrast, Ericson and Pakes (1995), while assuming that firms know their current productive efficiency, allow productivity to change over time either as the stochastic outcome of their (and rivals') investments or as the result of changes in overall market conditions (see also Pakes and Ericson 1998). Hopenhayn (1992), in turn, allows industry-specific effects to play a key role within a competitive industry in stationary equilibrium (see also Hopenhayn and Rogerson 1993; Cabral 1995; Asplund and Nocke 2003).

Given the strict connection between productivity and profits, four main predictions can be then derived from this literature: (1) firms do not survive if their productivity is below a certain critical level; (2) in the pre-exit period, the productivity of exiting firms falls continuously relative to that of survivors; (3) smaller and younger firms have a higher likelihood of exit than their larger and older counterparts; (4) industry and macro-environments do matter to survivability. We next discuss each one of these predictions, mainly from the point of view of the empirical research.

2.1 Productivity

The results of many empirical studies indicate that the likelihood of exit tends to decline with productivity. For example, Baily et al. (1992) and Doms et al. (1995), using a panel of U.S. manufacturing plants, report that the negative effect of productivity on the probability of exit is sizeable. In the case of U.K. and Spanish manufacturing sectors, Disney et al. (2003a) and Esteve-Pérez and Mañez-Castillejo (2008), respectively, found that high-productivity firms have a lower hazard rate. Bellone et al. (2006), in turn, observed that inefficient mature firms in the French manufacturing sector are more likely to shut down. However, in sharp contradiction with the results found by Almus (2004) for new German firms, Bellone et al. did not obtain an identical effect in the case of newly created firms. However powerful the stochastic model predictions may be, they have not received across-the-board confirmation in the empirical literature. For example, Baily et al. (1992), analysing the productivity performance of U.S. manufacturing, did not confirm the prediction that there is a critical productivity level below which firms necessarily shut down. Indeed, these authors found that while approximately 50% of exiting plants (in the 1972–1977 period) were from the bottom two (1972) quintiles, roughly 30% of exits were from the top two quintiles. Moreover, although closings were concentrated at the bottom of the productivity distribution, many low-productivity plants did not actually exit in the observed period.

The explanation of this apparent contradiction is often found outside the industrial organization approach. In the labour economics literature, for example, the analysis of exit has mostly focused on the business owner, in which case the decision to shut down depends not only on firm performance but also on the availability of alternative sources of ownership income as well as on other arguments of the owner's utility function (Evans and Jovanovic 1989; Taylor 1999). For its part, the managerial approach has extended the theorization to encompass the entrepreneur's human capital and his/her ability to implement a proper firm strategy (Gimeno et.al. 1997), while the resource-based view of the firm emphasizes that the chances of survival ultimately depend on firm's ability to exploit specific capabilities, which in turn are determined by the firm's revealed competence in the use of limited resources (Wernerfelt 1984; Barney 1991). In this line with this reasoning, Headd (2003) and Bates (2005), for the U.S., and Harada (2007), for Japan, have identified two types of closures: 'successful' closures (i.e. non-economic-forced exits) and 'unsuccessful' closures (failures). In this framework, it is then possible to observe low-productivity survivors and high-productivity exits, which implies that some other key factors are necessarily at stake (see Taylor 1999; Hamilton 2000; Morton and Podolny 2002; Saridakis et al. 2008).

Hypothesis 1 A higher productivity level reduces the probability of exit, all else being equal.

Hypothesis 2 Low- (high-) productivity firms with a higher (lower) ability to exploit specific capabilities have a lower (higher) probability of exit.

2.2 The 'Shadow of death' effect

The empirical literature also suggests that exiting firms do not face a 'sudden death'. On the contrary, firms tend to reveal a steady decrease in their productivity level relative to survivors well before closure. In particular, Griliches and Regev (1995) found that, for the Israeli manufacturing sector, firms appeared to signal their exit by exhibiting lower productivity several years before failure. This 'shadow of death' phenomenon was also detected by Bellone et al. (2006) for the French manufacturing sector.

The pre-exit performance has also been analyzed by observing changes in firm size (employment). However, while Troske (1996), using Wisconsin (U.S.) data on manufacturing firms older than 5 years, showed that firm relative size declines monotonically over an (8-year) period prior to exit, Wagner (1999), using a panel of manufacturing firms from Lower Saxony (Germany), did not confirm this finding.

Hypothesis 3 Exiting firms demonstrate a falling productivity level during a number of years prior to exit.

2.3 Age and size

In line with the predictions from industrial organization, the resource-based view of the firm has argued that the probability of exit declines with age and size as older and larger firms often command more resources and have higher managerial experience (tacit knowledge). Several empirical analyses indeed confirm that both larger and older firms are more likely to survive than smaller and younger ones—e.g. Dunne et al. (1989) for U.S. manufacturing plants; Mata and Portugal (1994, 2002) for Portuguese manufacturing establishments; Disney et al. (2003b) for U.K. manufacturing establishments; Esteve-Pérez et al. (2004) for Spanish manufacturing firms; Strotmann (2007) for Germany manufacturing firms; Box (2008) for Sweden firms.

Despite this evidence, the results from empirical research are not entirely conclusive with respect to the effect of firm age on survivability, as seemingly contradictory evidence from non-monotonic and U-shaped hazard rates has been reported (e.g. Esteve-Pérez et al. 2008; Esteve-Pérez and Mañez-Castillejo 2008). As a way of explanation, authors active in the field of organizational ecology have claimed that there are several other possible routes between age and exit, and, accordingly, have proposed the concepts of 'liability of newness', 'liability of adolescence' and 'liability of senescence' (Hannan 2005). According to the latter, for example, older firms tend to be relatively inert and, as a consequence, increasingly ill-suited to deal with quickly changing environments (Baum 1989; Hannan 1998). Clearly, in this case, the hazard rate of mature firms will tend to be higher. In turn, Geroski (1995) argued that if the goal is to measure firm capabilities with precision, then one should be better off using variables like Research and Development (R&D), advertising and labour quality rather than size and age.

Hypothesis 4 Larger firms have a lower probability of exit.

Hypothesis 5 There is no clear causal relationship between the age of a mature firm and the probability of exit.

2.4 Industry and macro-environment

Strengthening the claims that originate from industrial organization, the organizational ecology approach stresses environmental conditions as a key determinant of closure. It is expected, in particular, that relatively favourable market conditions will lead to a higher price–cost margin and, therefore, to a lower risk of failure of mature firms. The results from several empirical studies indeed confirm a positive impact of industry growth and industry size on the survival probability of firms (Audretsch and

Mahmood 1994, 1995; Mata and Portugal 1994, 2002; Audretsch 1995a, b; Mata et al. 1995; Bellone et al. 2006; Strotmann 2007). For its part, less market competition is expected to lead to a higher price–cost margin and to a higher probability of survival. A higher degree of market concentration, for example, is supposed to result in a lower risk of exit (Geroski et al. 2007; Strotmann 2007), although in this situation one cannot exclude the possibility of firms becoming somewhat more complacent, which may hurt survivability in the long run (Bellone et al. 2006). High entry rates, in turn, have a negative impact on the survival probability of firms (Mata and Portugal 1994, 2002; Mata et al. 1995; Geroski et al. 2007; Strotmann 2007). Firms in high-tech industries seem to have a lower probability of survival than firms in medium- and low-tech industries (Audretsch 1995b; Esteve-Pérez et al. 2004), although the evidence found by Strotmann (2007) does not seem to be totally favourable to the latter. Finally, the likelihood of exit tends to be closely related to the economic cycle, with the risk of death being lower in economic booms (Fotopoulos and Louri 2000; Geroski et al. 2007; Strotmann 2007; Box 2008; Esteve-Pérez et al. 2008; Fertala 2008).

Hypothesis 6 Favourable demand market conditions impact positively on the probability of survival, while the intensity of competition decreases the chances of survival.

Hypothesis 7 The probability of exit is inversely related to the economic cycle.

3 Data and methodology

3.1 The dataset

The raw data is drawn from Inquérito às Empresas Harmonizado (IEH), an annual business survey conducted by the Portuguese Statistical Office (INE). It contains, in particular, the detailed input and output information required to compute productivity at the firm level (see Carreira 2006). Our dataset of manufacturing firms comprises some 1,900 units from the central region (Região Centro) of Portugal that were observed over a 10-year interval (1991–2000, unbalanced panel). In this sample, firms with more than 100 employees were chosen with certainty, while those with 20–99 employees were drawn randomly. The sample is considered representative with respect to sectoral disaggregation (at the three-digit level), both in terms of employment size and output. Small and large firms were then weighted to ensure that the results are representative of the Portuguese population at the sector level.[3]

The longitudinal dimension of the panel was constructed using firm's identification number in the IEH dataset. Additional information with respect to birth/death year was drawn from Ficheiro de Unidades Estatísticas (FUE), also collected by INE. By combining these two datasets (i.e. IEH and FUE), it is possible to determine, with no margin of error, the status of any given unit in any given year: continuing, entering or exiting. In particular, an exit from the sample is taken as a closure if and only if the corresponding firm has been coded as 'dead' by the Valued Added Tax authority. Within our observation window, 293 closings were observed, leading to a total of some 6,800 data points (unbalanced panel).[4]

Clearly, there are advantages and weaknesses associated with this dataset. The main advantage is that the raw survey is assembled at the firm level rather than at the plant level, with the firm being the typical relevant unit in terms of the actual decision to exit the market. Another positive aspect is the length of the panel, which allows us to follow firms' performance over a sufficiently long period. The main weakness is perhaps the fact that we only observe firms with at least 20 employees, thus losing track of an important source of exit. In the Portuguese manufacturing industry, very small firms—i.e. those

[3] The aggregate results for the entire Portuguese manufacturing sector were also weighted. We note that Região Centro represents approximately one-seventh of the Portuguese gross domestic product and one-sixth of total employment. Either in terms of employment or output, the shares of each one of the 17 sub-sectors in the manufacturing aggregate at the national and Região Centro level are virtually the same, with the observed differences in 2000, for example, never exceeding 6% points.

[4] We note that the observation of exit is constrained by the characteristics of the IEH survey. Thus, in our dataset exit comprises bankruptcy and voluntary closure as well as the residual category of mergers/acquisitions, a rare and negligible event which according to Mata and Portugal (2002, 2004) does not exceed 1% of the total number of closures. A change in the sector of activity in turn is taken as diversification, not as an exit. All firms younger than 10 years were dropped from our sample.

with fewer than 20 employees—represent about 77% of the population of firms, but only 20% of the total manufacturing employment and 12% of the industrial production (Carreira 2006).

3.2 Methodology

We will first analyse the productivity of exiting firms relative to that of survivors as well as the rates of transition over specific time intervals in order to then estimate the determinants of exit using survival methods.[5] Given the characteristics of our dataset, survival models are more appropriate than the Probit or Logit approach to study the exit process (Mata and Portugal 1994; Esteve-Pérez et al. 2004). In particular, survival models are well suited to analyse how exit rates evolve over time, conditional on a given set of time-varying covariates and in the presence of the right-censored data (Esteve-Pérez and Mañez-Castillejo 2008; Esteve-Pérez et al. 2008).[6]

A key concept in survival analysis is the *hazard rate*, which can be defined as the probability that a firm exits the market at time t given that it has survived until t, conditional on a vector of covariates x_{it}. To estimate the hazard function, we employ the semi-parametric Cox Proportional Hazards (CPH hereafter) model (Cox 1972), given by

$$h(t|x_{it}) = h_0(t) \cdot \exp(x'_{it}\beta), \tag{1}$$

where h_0 is the baseline hazard function (whose parametric specification needs not to be specified), and x_{it} is a vector of internal and external determinants assumed to influence the hazard rate. (x_{it} includes both time-invariant and time-varying variables.) This is indeed the most widely used estimation method in firm survival analysis (Manjón-Antolín and Arauzo-Carod 2008). Compared to parametric proportional hazard models, the advantage of the semi-parametric CPH methodology is that it does not require particularly restrictive assumptions on the baseline hazard function. This is especially important when the parametric form of the underlying baseline hazard function is unknown a priori. The semi-parametric CPH approach also seems to be appropriate as our interest is not so much in the estimation of the underlying baseline hazard function but rather on the effect of productivity (and other determinants) on firm survival.

The CPH model can be expanded in order to incorporate unobserved individual heterogeneity. In this case, model (1) becomes

$$\begin{aligned} h(t|x_{it}) &= h_0(t) \cdot \exp(x'_{it}\beta) \cdot v_i \\ &= h_0(t) \cdot \exp(x'_{it}\beta + u_i), \end{aligned} \tag{2}$$

where v_i is a variable representing an unobserved, time-invariant, individual component (*shared 'frailty'*). v_i is also assumed to follow a gamma distribution with unit mean and finite variance σ^2. As we will see below, we will test the null hypothesis of no unobserved heterogeneity. Non-rejection of the null implies the non-frailty case [i.e. model (1)].

The CPH model assumes that the hazard function is continuous and hence that the firms can be exactly ordered in calendar time with respect to their time of failure. However, given that our dataset is annual, we cannot observe the exact time (day or month) of closure, which means that we have 'ties' in our grouped-form data (Cox and Oakes 1984). We solve this problem by implementing the method proposed by Efron (1977) (see also footnote 11).

Finally, to study the sensitivity of our findings, we estimate a piece-wise constant hazard model (PWCH hereafter) in which the baseline hazard [i.e. h_0 in model (1)] is assumed to be constant within a certain time interval (e.g. during an economic recession/expansion).[7]

3.3 Measurement issues and data description

Firm-level TFP and LP are our selected productivity measures. Following Baily et al. (1992), the indexes of productivity (ln TFP and ln LP, respectively) for firm i in year t are given by:

[5] See van den Berg (2001) for a detailed technical description of duration models. See also Manjón-Antolín and Arauzo-Carod (2008) for a survey on firm survival methods and evidence.

[6] Right-censoring in our dataset is due to panel rotation, on the one hand, and to firm's survival (i.e. survival after 2000), on the other. Since all firms in our sample started production some time (at least 10 years) before the beginning of the survey, the dataset is also left-censored. This is not a problem as our focus lies on the conditional probability of exit based on calendar time.

[7] This model was also implemented by Mata and Portugal (2002).

$$\ln \text{ TFP}_{it} = \ln Q_{it} - \alpha_K \ln K_{it} - \alpha_L \ln L_{it} - \alpha_M \ln M_{it}, \tag{3}$$

$$\ln \text{ LP}_{it} = \ln \text{ VA}_{it} - \ln L_{it}, \tag{4}$$

where Q_{it} and VA_{it} are the real gross output and the value added of the ith firm in year t, respectively; K_{it}, L_{it} and M_{it} are capital, labour and intermediate inputs, respectively; α_j denotes factor elasticities, with $j = K$, L, M. The gross output is given by the sum of total revenues from sales, services rendered, self-consumption of own production and the change in inventory of final goods. It is deflated by the producer price index at the three-digit level. The labour input is a 12-month employment average. The labour costs embrace all employment costs, including those related to social security payments, and were deflated by the labour price index in manufacturing. The intermediate input includes the cost of materials, services purchased and other operating costs; it is deflated by the gross domestic product (GDP) deflator. Capital stock is given by the book value of total net assets. Capital services are defined as the sum of the depreciation and the real interest on net assets. The real interest rate is given by the difference between the annual average of the long-term interest rate and the annual consumer price index. Finally, factor elasticities α_K, α_L and α_M are given by the corresponding industry average cost shares (three-digit level).

For a given firm, the variable *age* is calculated as the difference between year t and the birth year, while *size* is given by the monthly employment average. The *GDP growth* and *unemployment* (annual) series were extracted from the Organization for Economic Co-operation and Development (OECD) database.[8] To isolate industry-specific shocks from macro shocks, we computed the *industry growth* rate in deviation form from the GDP growth rate (the industry growth rate is calculated from INE). The *industry size* variable is computed, for each year, as a percentage of the largest (three-digit) industry output level observed in the sample. Following the OECD methodology (OECD 2005), the *industry technological regime* variable is proxied by a dummy variable equal to 1 if a firm belongs to an industry with high/medium R&D-intensity, and 0 otherwise. The variable *industry concentration* is generated directly from the firm-level output data and corresponds to the C-5 concentration ratio computed at the three-digit level. The *entry rate* is defined as the ratio of entering firms to the total number of firms (Carreira 2006). Finally, the variable *export intensity* is given by the share of exports in total output at industry level (two-digit level), and it is taken from the OECD database.

Table 1 Descriptive statistics of the productivity, age and size variables

Variables	All firms			Exiting firms		
	Small	Large	All	Small	Large	All
TFP	2.19	2.16	2.18	1.89	1.86	1.88
	(0.96)	(0.58)	(0.83)	(0.68)	(0.73)	(0.69)
Labour productivity	2.79	2.92	2.84	1.67	1.31	1.55
	(3.54)	(3.39)	(3.48)	(1.59)	(1.08)	(1.44)
Age	24.1	27.8	25.56	26.5	24.7	25.4
	(14.2)	(16.4)	(15.2)	(15.5)	(16.5)	(16.1)
Size	47.3	244.7	123.6	50.9	183.3	95.4
	(23.7)	(382.1)	(256.8)	(23.7)	(73.8)	(78.2)

TFP, Total factor productivity

Small and large firms are those with 20–100 employees and more than 100 employees, respectively. Standard deviations are given in parenthesis

Table 1 provides a brief summary of the selected variables in different subsamples: *all* and *exiting* firms, on the one hand, and by size groups, on the other. Clearly, exiting firms are, on average, less productive (and smaller) than the entire set of firms in the sample. However, no clear pattern is visible with respect to the role of age on the exit behaviour of mature firms. Table 2 gives the correlation across time-varying covariates and, as can be seen, the coefficients are all very small, except in the case of the pair *industry concentration–industry growth* and *industry concentration–technological regime*.

4 Empirical analysis

4.1 The productivity level of exiting firms

Table 3 shows the productivity level of exiting firms normalized by the average productivity of survivors, either in terms of TFP or labour productivity. (In each year, and by industry, the productivity of the 'control

[8] At http://stats.oecd.org/wbos/Index.aspx.

Table 2 Correlation across covariates

Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1] TFP	1										
[2] Labour productivity	0.21*	1									
[3] Age	−0.09*	−0.03	1								
[4] Size	0.02	0.05*	0.04*	1							
[5] GDP growth	0.08*	0.03*	−0.05*	−0.10*	1						
[6] Unemployment	−0.06*	−0.03*	−0.02	0.00	−0.21*	1					
[7] Industry growth	0.05*	0.18*	−0.04*	0.04*	0.09*	0.03*	1				
[8] Industry size	−0.07*	−0.02	0.03*	−0.01	0.14*	−0.05*	−0.18*	1			
[9] Technological regime	0.14*	0.12*	−0.03*	−0.03*	0.03*	−0.03	0.29*	−0.14*	1		
[10] Industry concentration	0.06*	0.21*	−0.04*	0.01	0.03*	−0.02	0.45*	−0.14*	0.57*	1	
[11] Entry rate	0.10*	0.07*	−0.17*	0.03*	−0.02	0.00	−0.04*	−0.24*	0.01	0.14*	1
[12] Export intensity	0.07*	−0.11*	−0.05*	0.11*	0.00	−0.03	−0.10*	−0.09*	0.20*	0.27*	0.21*

GDP, Gross domestic product

*Denotes statistical significance at the 0.05 level

Table 3 Productivity gap between exiting and surviving firms

	TFP	Labour productivity
Annual average	0.857	0.604
	(−5.010)	(−7.303)

In each year (and industry), the productivity of surviving firms is set to 1. Small and large firms are weighted at sector-level; aggregation is weighted over 17 two-digit industries by firm's output (TFP case) and employment (LP case), respectively. The *t* statistic of the null hypothesis of no productivity difference between exiting and continuing firms is given in parenthesis

group' of survivors was set to 1.) As can be seen, exiting mature firms are, on average, less productive than surviving firms by a 14 and 40% point margin, in the TFP and labour productivity cases, respectively. The hypothesis that there is no productivity differential between surviving and exiting firms is comfortably rejected by the data (at the 1% significance level).

While Table 3 shows that the productivity gap between exiting and surviving firms is, on average, sizeable, Table 4 goes a step further and looks at the specific position of exiting firms in the productivity distribution. Thus, as a first step, we ranked the firms in the sample according to their productivity level in order to subsequently compute the corresponding quintiles in selected years. For example, let us determine, in particular, the percentage of exiting firms in the period 1992–1994, located in quintile 1 in 1991. The analysis is divided into three exit sub-periods of equal length (1991–1994, 1994–1997 and 1997–2000) in an effort to match as closely as possible with the cycle fluctuations observed in the Portuguese economy in the 1990s.[9] The main result from Table 4 is that most failures in any of the three selected sub-periods come from the lower bottom of the distribution. For example, taking the exit period 1992–1994 (row 1, TFP measure), 63.2% of the total number of observed exits were, in 1991, in the two lowest quintiles, while only 26.3% were in the two top quintiles. In the case of LP, the corresponding percentages are 50.0 and 35.0. (Similar findings are obtained for 1995–1997 and 1998–2000.)

Next, we computed in each quintile both the fraction of firms that did not survive until the end of the selected exit period and the corresponding fraction of survivors. These two transition rates are presented in Table 5. Clearly, a substantial fraction of low-productivity firms has a non-negligible degree of resilience: in the TFP case, for example, only 7.9 (4.7%) of the firms that were in the first (second) quintile of the 1991 distribution closed in the subsequent 3-year period (this was 7.5 and 3.2%, in the labour productivity case, respectively).

[9] There was an overall slowdown in 1991–1994, followed by a clear economic recovery which in the last sub-period (1997–2000) seemed to have lost some momentum (Carreira and Teixeira 2008).

Table 4 Productivity of exiting firms

	1 (lowest)	2	3	4	5 (highest)	Total
Exit during:	TFP quintile in the year before the exiting period					
1992–1994	36.84	26.32	10.53	15.79	10.53	100
1995–1997	40.00	22.90	14.49	10.43	12.17	100
1998–2000	34.38	25.00	10.94	7.81	21.88	100
Exit during:	Labour productivity quintile in the year before the exiting period					
1992–1994	35.00	15.00	15.00	10.00	25.00	100
1995–1997	47.26	16.71	10.95	13.54	11.53	100
1998–2000	54.69	15.63	12.50	7.81	9.38	100

Values are given as percentages

Quintile 1 is the bottom productivity quintile. For example, the first cell on the top left means that 36.84% of exiting firms in the period 1992–1994 were in the bottom quintile of the 1991 TFP productivity distribution. Aggregation is weighted over 17 two-digit industries

Table 5 Transition rates

Quintile	Transition rates in 1994		Transition rates in 1997		Transition rates in 2000	
	Surviving	Exiting	Surviving	Exiting	Surviving	Exiting
	Quintiles in 1991		Quintiles in 1994		Quintiles in 1997	
	TFP					
1	92.13 [95.83]	7.87 [4.17]	94.25 [92.54]	5.75 [7.46]	93.04 [95.80]	6.96 [4.20]
2	95.33 [93.17]	4.67 [6.83]	98.07 [96.71]	1.93 [3.29]	94.64 [97.96]	5.36 [2.04]
3	96.55 [94.10]	3.45 [5.90]	97.14 [96.70]	2.86 [3.30]	98.07 [96.94]	1.93 [3.06]
4	95.65 [95.30]	4.35 [4.70]	98.80 [98.23]	1.20 [1.77]	97.97 [98.02]	2.03 [1.98]
5	98.41 [99.72]	1.59 [0.28]	97.40 [99.28]	2.60 [0.72]	95.53 [98.62]	4.47 [1.38]
	Labour productivity					
1	92.55 [91.77]	7.45 [8.23]	92.48 [90.52]	7.52 [9.48]	89.66 [88.42]	10.34 [11.5]
2	96.81 [97.12]	3.19 [2.88]	98.11 [98.80]	1.89 [1.20]	96.79 [97.19]	3.21 [2.81]
3	95.40 [97.34]	4.60 [2.66]	99.60 [99.97]	0.40 [0.03]	97.45 [96.96]	2.55 [3.04]
4	96.30 [97.64]	3.70 [2.36]	97.18 [95.81]	2.82 [4.19]	98.68 [99.06]	1.32 [0.94]
5	95.38 [95.59]	4.62 [4.41]	98.70 [97.97]	1.30 [2.03]	97.74 [99.12]	2.26 [0.88]

Values are given as percentages

Example: The first cell on the top left means that 92.13% of firms in the bottom quintile of the 1991 TFP productivity distribution survived up to at least 1994. The rates weighted by output (TFP case) and employment (LP case) are given in square brackets. Aggregation is weighted over 17 two-digit industries

Surprisingly enough, a substantial number of high-productivity firms did close: roughly 4.4 and 1.6% of the two top 1991 TFP quintiles (fourth and fifth quintiles, respectively) exited in 1992–1994. It is worthwhile noting that if we take the firm's relative size into account (using either output or employment as a weighting measure), the shares associated with the exit of high-productivity firms (the values in square brackets in the table) become smaller. An obvious implication from this finding is that most high-productivity exiting firms are indeed smaller than their surviving counterparts.

From Tables 4 and 5, there is therefore broad evidence in favour of hypothesis 2, according to which the decision to exit the market depends not only on firm productivity performance, but also on firm specific capabilities. In particular, in the high-productivity segment, large firms—the ones that are supposed to command a higher level of resources, according to the resource-based view of the firm—

Table 6 Pre-exit TFP relative to survivors

Year of exit	Years prior to exit								
	1991	1992	1993	1994	1995	1996	1997	1998	1999
1992	0.934								
1993	1.044	0.853							
1994	0.856	0.884	0.751						
1995	0.904	0.919	0.896	0.899					
1996	1.067	1.061	1.106	0.992	1.044				
1997	0.865	0.853	0.785	0.674	0.678	0.681			
1998	0.847	0.901	0.733	0.564	0.401	0.992	0.831		
1999	0.824	0.872	0.849	0.751	0.721	0.908	0.910	0.773	
2000	0.845	0.743	0.757	0.833	0.811	0.799	0.772	0.775	0.763

The productivity of surviving firms is set to 1. For example, the left cell in the last row means that in 1991 the productivity of 2000 exiting firms was, on average, 84.5% of the 1991 productivity of survivors. A surviving firm in this context means one that is still in operation in 2000. Aggregation is weighted over 17 two-digit industries

do seem to reveal a lower rate of exit than small firms.[10]

4.2 Pre-exit productivity performance

Having analysed the productivity profile of exiting firms, next we want to know whether exiting firms reveal any pattern of lower than average productivity over the pre-exiting period—the 'shadow of death' effect. Tables 6 and 7 show the time series of the average productivity of 1991 surviving firms, grouped by death-year cohort. The 'comparison group' comprises 2000 surviving firms—that is, firms that were still in operation in the year 2000. As expected from the previous discussion, in each death cohort, the productivity level 1 year before exit (any element of the main diagonal) is always lower than that of the survivors (the 1996 death cohort, TFP case, is the sole exception). On average, mature exiting firms are 16% points lower than surviving firms in terms of TFP, and 44% points lower in the labour productivity case.

There is also a persistent (and widening) productivity gap between survivors and exiting firms across all death cohorts. Let us take the 2000 death cohort as an example. In this case, the TFP disadvantage relative to the surviving group is 23.7% points in 1999. This productivity gap was already at the 15.5% point mark in 1991. (A stronger pattern is found in the case of the labour productivity measure.) Therefore, exiting firms seem to be characterized by a distinct productivity disadvantage relative to survivors not only in the year before exit but also over a good number of years prior to exit.

The CPH model implementation in Table 8 uses the lagged productivity index as the sole covariate, and it confirms quite emphatically the existence of 'shadow of death' effect.[11] Indeed, all lagged productivity terms (up to the fourth term) are statistically significant and negative, which is a rather clear confirmation of our hypothesis 3, which states that the productivity of exiting firms is persistently lower than that of survivors.

4.3 The determinants of the hazard rate

The analysis in Sects. 4.1 and 4.2 reveals that most deaths tend to be drawn from the lower tail of the productivity distribution. To test explicitly whether exit is more likely among low-productivity firms, while controlling for other variables, we estimate the

[10] Since our dataset does not contain information on employer's attributes nor other firm characteristics, such as liquidity constrains (see Cabral and Mata 2003; Oliveira and Fortunato 2006), we cannot explicitly test the 'non-economic forced exit' hypothesis.

[11] Estimation was performed using the *stcox* command with the *efron* and *shared* options of StataSE 9.2. The *strata (industry)* option was not implemented given that the productivity level of exiting firms was normalized by the average productivity of survivors at the industry level. The null hypothesis of no unobserved heterogeneity was not rejected.

Table 7 Pre-exit labour productivity relative to survivors

Year of exit	Years prior to exit								
	1991	1992	1993	1994	1995	1996	1997	1998	1999
1992	0.949								
1993	0.837	0.450							
1994	0.841	0.241	0.071						
1995	1.220	1.134	1.058	0.871					
1996	1.066	0.969	1.442	1.168	0.971				
1997	0.567	0.621	0.558	0.346	0.275	0.187			
1998	0.986	0.896	0.384	0.291	0.012	0.329	0.424		
1999	0.898	0.935	0.817	0.608	0.709	0.899	0.974	0.602	
2000	0.651	0.348	0.492	0.547	0.608	0.712	0.540	0.532	0.505

See footnotes to Table 6

Table 8 The 'shadow of death' effect

	Lag				
	$\tau = 1$	$\tau = 2$	$\tau = 3$	$\tau = 4$	$\tau = 5$
$TFP_{t-\tau}$	−1.14***	−1.18***	−1.36***	−1.13***	−0.38
	(0.14)	(0.19)	(0.22)	(0.25)	(0.57)
Log likelihood	−578.77	−509.72	−397.67	−328.34	−249.98
LR test	37.60***	22.75***	22.01***	12.00***	0.41
n	4,784	4,570	4,321	4,062	3,767
$LP_{t-\tau}$	−0.45***	−0.40***	−0.38***	−0.31***	−0.07
	(0.04)	(0.05)	(0.06)	(0.08)	(0.18)
Log likelihood	−562.45	−501.96	−396.93	−329.76	−250.53
LR test	72.10***	39.91***	24.77***	10.22***	0.13
n	4,830	4,615	4,364	4,103	3,806

***, **, and * denote statistical significance at the 0.01, 0.05 and 0.10 levels, respectively

Robust standard errors are given in parenthesis

The Cox Proportional Hazards (CPH) model regressions, with 'ties' handled with the method proposed by Efron (1977). The null hypothesis of no unobserved heterogeneity was not rejected. (The results from the unobserved heterogeneity model are available from the authors upon request.) The (log) TFP and (log) LP were normalized by the average productivity of surviving firms at industry level

hazard rate conditional on a wide set of covariates. As discussed in Sect. 2, the determinants of firm failure can be summarized into two broad categories. In the first place, we have the so-called *internal factors* to the firm, namely, productivity, size, and age; the *external factors* comprise the second set of determinants and include the industry and macro-environment variables, proxied in our case by industry growth, industry size, technological regime, concentration, entry rate and export intensity (industry), and GDP growth and unemployment (macro-environment variables). Since all *internal* determinants are expressed in logarithms, the estimated coefficients can be interpreted as elasticity parameters. Given the low (contemporaneous) correlation between the GDP growth rate and unemployment (see Table 2), we kept both variables in the regression.[12]

The results of the Cox proportional hazard model—model (1)—are presented in Table 9. Column (1)

[12] Two explanations for the low (negative) correlation between GDP growth and unemployment are possible: the first one is associated to a wide lag between job creation and the economic cycle observed in the Portuguese economy (e.g. Baptista and Thurik 2007); the second is related to the intense restructuring wave observed in the middle of the 1990s in the Portuguese manufacturing sector (Carreira and Teixeira 2008).

Table 9 Regression results from the Cox proportional hazard model

Variables	(1)	(2)
Firm-level		
TFP	−1.115***	
	(0.155)	
Labour productivity		−0.394***
		(0.037)
Age	−0.061	−0.021
	(0.193)	(0.186)
Size	−0.238**	−0.167
	(0.119)	(0.122)
Macro-level		
GDP growth	−5.923**	−6.299***
	(2.551)	(2.335)
Unemployment	0.952***	0.907***
	(0.263)	(0.264)
Industry-level		
Growth	−5.568**	−5.880***
	(2.538)	(2.324)
Size	−5.363*	−4.052
	(2.991)	(3.049)
Technological regime	−2.240**	−2.171**
	(1.058)	(0.989)
Concentration	0.777**	0.762**
	(0.356)	(0.336)
Entry rate	−0.155	−0.115
	(0.110)	(0.105)
Export intensity	−0.007	−0.003
	(0.019)	(0.017)
Industry dummies	Yes	Yes
Log likelihood	−628.454	−616.400
Wald test	114.15***	219.40***
n	4,546	4,546

***, **, and * denote statistical significance at the 0.01, 0.05, and 0.10 levels, respectively

Robust standard errors are given in parenthesis

CPH model regressions, with 'ties' handled with the method proposed by Efron (1977). The null hypothesis of no unobserved heterogeneity was not rejected. (The results from the unobserved heterogeneity model are available from the authors upon request.)

takes the TFP as the productivity measure, while in column (2) we have the labour productivity case. We also ran the CPH model with unobserved individual heterogeneity explicitly modelled. Since we cannot reject the null hypothesis that the frailty variance component is equal to zero at the 1% significance level (likelihood-ratio test), Table 9 only presents the coefficient estimates under the hypothesis of no unobserved heterogeneity. (The results from the unobserved heterogeneity model are available from the authors upon request.) In both columns (1) and (2), the null that all parameters are not statistically different from zero is rejected at the 0.01 level of significance (the Wald test at the bottom of the table). Given that our dependent variable is the hazard rate, a negative (positive) coefficient implies that the corresponding variable reduces (increases) the instantaneous probability of exit, thus increasing (decreasing) the chance of survival.

We now turn to the impact of productivity level on failures. We found that productivity—either TFP or labour productivity—is negatively signed, a confirmation that a higher productivity level reduces the hazard rate. The magnitude of the productivity effect is nevertheless quite distinct across the two productivity measures. If the TFP increases by 1%, then the hazard of exiting decreases by 0.67% $\{= [1 - \exp(-1.12)] \times 1\% = (1 - 0.33) \times 1\% = 0.67\%\}$, *ceteris paribus*. In the case of labour productivity, the corresponding reduction in the hazard rate is 0.33% $[= 1 - \exp(-0.39) = 1 - 0.67 = 0.33]$. In both cases, the evidence in favour of hypothesis 1 is quite clear.

The negative sign of the firm size variable also indicates that large firms are less likely than smaller firms to shut down, a result consistent with hypothesis 4. For the FTP case, if the variable size increases by 1%, then the hazard of exiting decreases by 0.21% $[= 1 - \exp(-0.24) = (1 - 0.79) = 0.21]$. However, the evidence seems to be less strong than that found for the productivity variable: in column (1), the size coefficient is significant at 0.05, while in column (2) it does not seem to be statistically significant at conventional levels.

For its part, the variable *age* does not have any statistically significant impact on the risk of exit, which seems to contradict most industrial organization predictions. Here we might refer again to Geroski (1995), who pointed out that the characteristics of other firms may well be capturing the impact of knowledge accumulation. In particular, in our case, this impact is likely to have been captured by the productivity and size variables. This possibility is contained in our hypothesis 5.

The coefficient of the industry growth variable is negative and statistically significant in specifications (1) and (2) of the table. Thus, industry growth increases survivability, which is consistent with the view that faster growing industries provide better survival opportunities for all units in operation. The risk of exit seems also to be lower when the size of the industry is higher, although the corresponding coefficient is not statistically significant in column (2). There is also evidence that the risk of exit is higher in highly concentrated industries, a result that seems to be more favourable to the organizational ecology approach than to the industrial organization predictions. In turn, the variables entry rate and export intensity do not seem to have any statistically significant impact on the likelihood of exit. The negative sign of the technological regime variable indicates that in high- and medium-tech industries firms are less likely to shut down than would otherwise be the case. On the whole, the results seem to confirm that favourable demand market conditions (measured by industry growth and size) have a positive impact on the probability of survival—our hypothesis 6—although we do not obtain confirmation that more competition (measured by the C-5, the entry rate and export intensity) induces exit. Finally, the unemployment rate is clearly negatively associated with survival, while the effect of a growing GDP is highly favourable to survival, as postulated by our hypothesis 7.[13]

5 Conclusion

In this study we provide an analysis of the exiting profile of mature firms in the Portuguese manufacturing sector over a 10-year period. First, the evidence we found on the existence of a productivity gap between exiting and surviving firms is consistent with the industrial organization prediction that market selection is grounded on efficiency reasons. However, low-productivity firms do not necessarily exit nor are firms with an above-average productivity immune to failure. The analysis of the productivity distribution, on the one hand, and the transition rates in different quintiles, on the other, clearly show that both low- and high-productivity firms exit. This result does not exactly fit standard industrial organization predictions, but it does confirm that complementary explanations are required for a full description of firm exit, as suggested by other strands of literature. Our evidence also shows that exit can not be definitively described as a 'sudden death' phenomenon, as exiting firms reveal a steady productivity decline over a period of several years prior to exit. Finally, hazard rate regressions substantiate the finding that a low productivity level increases the probability of exit, with industry- and macro-environment covariates having a non-negligible role on exit of mature firms.

We believe one quick recommendation can be drawn from our findings: since firms in economic trouble are likely to be inefficient, economic policy should in principle facilitate exit rather than protect inefficiency. However, given the impact of massive layoffs on aggregate unemployment figures, policy-makers tend instead to focus on broader policies of one-size-fits-all type, without giving a proper incentive to the firm's own selection of the critical competitiveness factors. In the absence of a well-built restructuring strategy that gives priority to efficiency gains, government relief programmes are doomed to vanish rather quickly without any enduring impact on economic growth. The confirmation of a shadow of death effect should also provide policy-makers with an extra incentive to focus on helping individual business to implement early warning systems that anticipate as much as possible key market disruptions. Managers, in turn, should be more effective in distinguishing cyclical from long-term competitiveness policies, focusing their attention predominantly on the latter.

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References

Ahn, S. (2001). Firm dynamics and productivity growth: A review of micro evidence from OECD countries. Economics Department Working Papers no. 297. Paris: OECD.

Almus, M. (2004). The shadow of death: An empirical analysis of the pre-exit performance of new German firms. *Small Business Economics, 23*(3), 189–201.

[13] The robustness of the results reported in Table 9 was analysed in the context of the PWCH model. The results from this model (available from the authors upon request) are virtually the same.

Asplund, M., & Nocke, V. (2003). Imperfect competition, market size and firm turnover. CEPR. Discussion Paper DP 2625. London: Centre for Economic Policy Research.

Audretsch, D. B. (1994). Business survival and the decision to exit. *International Journal of the Economics of Business, 1*(1), 125–137.

Audretsch, D. B. (1995a). Innovation, growth and survival. *International Journal of Industrial Organization, 13*(4), 441–457.

Audretsch, D. B. (1995b). *Innovation and industry evolution*. Cambridge: MIT Press.

Audretsch, D. B., & Mahmood, T. (1994). The rate of hazard confronting new firms and plants in US manufacturing. *Review of Industrial Organization, 9*(1), 41–56.

Audretsch, D. B., & Mahmood, T. (1995). New firm survival: New results using a hazard function. *Review of Economics and Statistics, 77*(1), 97–103.

Audretsch, D. B., & Mata, J. (1995). The post-entry performance of firms: Introduction. *International Journal of Industrial Organization, 13*(4), 413–419.

Baily, M. N., Hulten, C. R., & Campbell, D. (1992). Productivity dynamics in manufacturing plants. *Brookings Papers on Economic Activity, Microeconomics, 1992*, 187–249.

Baldwin, J. R. (1995). *The dynamics of industrial competition: A North American perspective*. Cambridge: Cambridge University Press.

Baptista, R., & Thurik, A. R. (2007). The relationship between entrepreneurship and unemployment: Is Portugal an outlier? *Technological Forecasting and Social Change, 74*(1), 75–89.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120.

Bates, T. (2005). Analysis of young, small firms that have closed: Delineating successful from unsuccessful closures. *Journal of Business Venturing, 20*(3), 343–358.

Baum, J. A. (1989). Liabilities of newness, adolescence, and obsolescence: Exploring age dependence in the dissolution of organizational relationships and organizations. *Proceedings of the Administrative Science Association of Canada, 10*, 1–10.

Bellone, F., Musso, P., Nesta, L., & Quéré, M. (2006). Productivity and market selection of French manufacturing firms in the nineties. *Revue de L'OFCE, 0*(Special Issue), 319–349.

Box, M. (2008). The death of firms: Exploring the effects of environment and birth cohort on firm survival in Sweden. *Small Business Economics, 31*(4), 379–393.

Cabral, L. (1995). Sunk costs, firm size and firm growth. *Journal of Industrial Economics, 43*(2), 161–172.

Cabral, L., & Mata, J. (2003). On the evolution of the firm size distribution: Facts and theory. *American Economic Review, 93*, 1075–1090.

Carreira, C. (2006). *Dinâmica industrial e crescimento da produtividade*. Oeiras: Celta Editora.

Carreira, C., & Teixeira, P. (2008). Internal and external restructuring over the cycle: A firm-based analysis of gross flows and productivity growth in Portugal. *Journal of Productivity Analysis, 29*(3), 211–220.

Caves, R. (1998). Industrial organization and new findings on the turnover and mobility of firms. *Journal of Economic Literature, 36*(4), 1947–1982.

Cox, D. R. (1972). Regression models and life-tables. *Journal of the Royal Statistical Society: Series B (Methodological), 34*(2), 187–220.

Cox, D. R., & Oakes, D. (1984). *Analysis of survival data*. London: Chapman & Hall.

Disney, R., Haskel, J., & Heden, Y. (2003a). Restructuring and productivity growth in UK manufacturing. *Economic Journal, 113*(489), 666–694.

Disney, R., Haskel, J., & Heden, Y. (2003b). Entry, exit and establishment survival in UK manufacturing. *Journal of Industrial Economics, 51*(1), 91–112.

Doms, M., Dunne, T., & Roberts, M. J. (1995). The role of technology use in the survival and growth of manufacturing plants. *Journal of Industrial Organization, 13*(4), 523–542.

Dunne, T., Roberts, M. J., & Samuelson, L. (1989). The growth and failure of U.S. manufacturing plants. *Quarterly Journal of Economics, 104*(4), 671–698.

Efron, B. (1977). The efficiency of Cox's likelihood function for censored data. *Journal of the American Statistical Association, 72*, 557–565.

Ericson, R., & Pakes, A. (1995). Markov-perfect industry dynamics: A framework for empirical work. *Review of Economics Studies, 62*(1), 53–82.

Esteve-Pérez, S., Llopis, A. S., & Llopis, J. A. (2004). The determinants of survival of Spanish manufacturing firms. *Review of Industrial Organization, 25*(3), 251–273.

Esteve-Pérez, S., & Mañez-Castillejo, J. A. (2008). The resource-based theory of the firm and firm survival. *Small Business Economics, 30*(3), 231–249.

Esteve-Pérez, S., Mañez-Castillejo, J. A., & Sanchis-Llopis, J. A. (2008). Does a "survival-by-exporting" effect for SMEs exist? *Empirica, 35*(1), 81–104.

Evans, D., & Jovanovic, B. (1989). An estimated model of entrepreneurial choice under liquidity constraints. *Journal of Political Economy, 97*(4), 808–827.

Fertala, N. (2008). The shadow of death: Do regional differences matter for firm survival across native and immigrant entrepreneurs? *Empirica, 35*(1), 59–80.

Fotopoulos, G., & Louri, H. (2000). Determinants of hazard confronting new entry: Does financial structure matter? *Review of Industrial Organization, 17*(3), 285–300.

Geroski, P. A. (1995). What do we know about entry? *International Journal of Industrial Organization, 13*(4), 421–440.

Geroski, P. A., Mata, J., & Portugal, P. (2007). Founding conditions and the survival of new firms. Working Paper No. 07-11. Aalborg: DRUID.

Gimeno, J., Folta, T., Cooper, A., & Woo, C. (1997). Survival of the fittest? Entrepreneurial human capital and the persistence of underperforming firms. *Administrative Science Quarterly, 42*(4), 750–783.

Griliches, Z., & Regev, H. (1995). Firm productivity in Israeli industry: 1979-1988. *Journal of Econometrics, 65*(1), 175–203.

Haltiwanger, J. C., Lane, J. I., & Spletzer, J. R. (2007). Wages, productivity, and the dynamic interaction of businesses and workers. *Labour Economics, 14*(3), 575–602.

Hamilton, B. H. (2000). Does entrepreneurship pay? An empirical analysis of the returns to selfemployment. *Journal of Political Economy, 108*(3), 604–631.

Hannan, M. T. (1998). Rethinking age dependence in organizational mortality: Logical formalizations. *American Journal of Sociology, 104*(1), 126–164.

Hannan, M. T. (2005). Ecologies of organizations: Diversity and identity. *Journal of Economic Perspectives, 19*(1), 51–70.

Harada, N. (2007). Which firms exit and why? An analysis of small firm exits in Japan. *Small Business Economics, 29*(4), 401–414.

Headd, B. (2003). Redefining business success: Distinguishing between closure and failure. *Small Business Economics, 21*(1), 51–61.

Hopenhayn, H. (1992). Entry, exit, and firm dynamics in long run equilibrium. *Econometrica, 60*(5), 1127–1150.

Hopenhayn, H., & Rogerson, R. (1993). Job turnover and policy evaluation: A general equilibrium analysis. *Journal of Political Economy, 101*(5), 915–938.

Jovanovic, B. (1982). Selection and the evolution of industry. *Econometrica, 50*(3), 649–670.

Manjón-Antolín, M. C., & Arauzo-Carod, J. M. (2008). Firm survival: Methods and evidence. *Empirica, 35*(1), 1–24.

Mata, J., & Portugal, P. (1994). Life duration of new firms. *Journal of Industrial Economics, 42*(3), 227–245.

Mata, J., & Portugal, P. (2002). The survival of new domestic and foreign owned firms. *Strategic Management Journal, 23*(4), 323–343.

Mata, J., & Portugal, P. (2004). Patterns of entry, post-entry growth and survival. *Small Business Economics, 22*(3–4), 283–298.

Mata, J., Portugal, P., & Guimarães, P. (1995). The survival of new plants: Start-up conditions and post-entry evolution. *International Journal of Industrial Organization, 13*(4), 459–481.

Morton, F. M., & Podolny, J. M. (2002). Love or money? The effects of owner motivation in the California wine industry. *Journal of Industrial Economics, 50*(4), 431–456.

Organization of Economic Co-operation and Development (OECD) (2005). STAN indicators. http://www.oecd.org/dataoecd/3/33/40230754.pdf

Oliveira, B., & Fortunato, A. (2006). Firm growth and liquidity constraints: A dynamic analysis. *Small Business Economics, 27*(2–3), 139–156.

Pakes, A., & Ericson, R. (1998). Empirical implications of alternative models of firm dynamics. *Journal of Economic Theory, 79*(1), 1–45.

Saridakis, G., Mole, K., & Storey, D. J. (2008). New small firm survival in England. *Empirica, 35*(1), 25–39.

Strotmann, H. (2007). Entrepreneurial survival. *Small Business Economics, 28*(1), 87–104.

Taylor, M. (1999). Survival of the fittest? An analysis of self-employment duration in Britain. *Economic Journal, 109*(454), C140–C155.

Troske, K. R. (1996). The dynamic adjustment process of firm entry and exit in manufacturing and finance, insurance, and real estate. *Journal of Law and Economics, 39*(2), 705–735.

van den Berg, G. J. (2001). Duration models: Specification, identification, and multiple durations. In J. J. Heckman & E. Leamer (Eds.), *Handbook of econometrics* (Vol. 5, pp. 3381–3460). North Holland: Amsterdam.

van Praag, C. M. (2003). Business survival and success of young small business owners. *Small Business Economics, 21*(1), 1–17.

Wagner, J. (1999). The life history of cohorts of exits from German manufacturing. *Small Business Economics, 13*(1), 71–79.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*(2), 171–180.