DEPARTMENT OF ECONOMICS

ISSN 1441-5429

DISCUSSION PAPER 39/11

Exporting, R&D Investment and Firm Survival

Ratbek Dzhumashev[*], Vinod Mishra[†] and Russell Smyth[‡]

Abstract

This paper examines the effect of exporting on firm survival for a panel of Indian IT firms. We show that exporting has competing effects on firm survival. On the one hand, exporting and investing in productivity are complementary activities, while on the other exporting activity is an additional source of uncertainty for the firm. We show that both effects influence survival, but operate at different points in time. Specifically, the hazard facing exporters is higher than non-exporters in the initial phase following entry into the export market, reflecting the fact that exporters are particularly vulnerable to shocks in the start-up phase. However, over time, exporters benefit more from productivity gains than non-exporters and the hazard facing exporters falls below that confronting non-exporters.

Keywords: India, Firm survival, Information Technology, R&D, Exports
JEL Codes: L25, L86, C41

[*] Department of Economics, Monash University, Email: ratbek.dzhumashev@monash.edu
[†] Department of Economics, Monash University, Email: vinod.mishra@monash.edu
[‡] Department of Economics, Monash University, Email: russell.smyth@monash.edu

Introduction

Globalisation and rapid technological change in recent decades have increased the need for a better understanding of the effects of internationalisation on firm survival (Ilmakunnas & Nurmi, 2010). Heterogeneous firm trade models suggest that internationalisation has a positive effect on the productivity of some firms, while simultaneously forcing other firms to exit the market (Bernard *et al.*, 2003; Melitz, 2003). On the one hand, one would expect that exporting and investing in productivity are complementary activities. Given that access to foreign markets increases the effective size of the market, exporting will promote investment that increases firm-level productivity (Lileeva & Trefler, 2010). On the other hand, exporting activity also makes firms more susceptible to international demand shocks, meaning that exporting activity is an additional source of uncertainty for the firm. Hence, the overall impact of exporting activity on firm survival can be regarded as ambiguous.

The objective of this paper is to examine the effect of internationalisation on firm survival through marrying two literatures. The first is the literature examining the effect of export activity on firm productivity. This literature suggests that while exporting activity has a positive effect on productivity gains, it also increases the productivity thresholds required for survival, forcing the least efficient firms to exit (see Greenaway & Kneller, 2007 for a survey). The second is the literature examining the effect of innovation and productivity on firm survival. If markets work properly, competition would purge industries of inefficient firms. This literature generally suggests that higher productivity firms and firms with higher ability to innovate have higher survival rates (see eg. Aw *et al.*, 2007; Cefis & Marsili; 2006).

We do so for the Indian information technology (IT) sector. To this point there is only limited empirical evidence on the determinants of firm survival in India and most of it is somewhat dated (eg. Das & Srinivasan, 1997; Nafziger & Terrell, 1996). There are advantages in studying a narrowly-defined industry in which firms face similar characteristics. While the results for the industry may not be applicable to other industries, the established regularities from previous studies which are primarily based on data from manufacturing as a whole in developed countries need not be true of the IT sector in India (Das & Srinivasan, 1997).

Since the 1980s, favourable government policies and a massive computerisation drive in the public sector have spawned the development of indigenous firms in the Indian IT sector. The Indian IT sector is characterised by a high level of internationalisation, which makes it particularly susceptible to demand shocks in the United States. New firms are regarded as an engine of employment, economic growth and technological change. In the United States, new firms have been responsible for two-thirds of all innovations and 95 per cent of radical innovations since World War II and accounted for 70 per cent of new jobs in the 1990s (Srinivasan *et al.,* 2008*).* While there are not equivalent statistics for India, start-up firms in the high tech sector in India are also clearly important sources of innovation and job creation (Bhide, 2008). Hence, implicit in policies to set-up Indian IT firms has been the assumption that, once established, these firms will make a continuing contribution to the economy. Hence, while firm entry is of importance, duration is of more significance in meeting longer-term policy objectives related to employment and economic growth (Holmes *et al.,* 2010*).*

To realize our aims, we first motivate the empirical analysis through presenting a simple theoretical model linking export activity to firm survival. A contribution of the model is that our formulation of productivity evolution is more general than that formulated in previous papers (see eg. Aw *et al*., 2007; Bustos, 2011; Costantini & Melitz, 2008; Lileeva & Trefler, 2010). Specifically, in our model, exports have a positive effect on firm productivity, but are also an additional source of uncertainty. A feature of the model is that firms learn by exporting. In the initial phase, following entry into the export market, exporting firms face higher uncertainty, which may outweigh the productivity gains from international trade. However, over time the export-specific uncertainty diminishes, while exporting firms continue to benefit from higher productivity. The theoretical model suggests that the hazard facing exporters will initially be higher than non-exporters because of the higher uncertainty associated with exporting, but that over time, as the uncertainty diminishes and there is learning by exporting, the hazard facing exporters will fall below that of non-exporters.

Because exporting firms face and experience different types of shocks, different competition and different market conditions than domestic firms, to empirically test the predictions of the theoretical model we employ a hazard function to model firm survival in which the baseline hazard is allowed to differ for exporting firms and non-exporting firms. Foreshadowing the main results we find that firms with R&D expenditure face a lower hazard than firms without R&D expenditure, irrespective of whether they export, and that, consistent with the predictions of the model, exporters initially face a higher hazard than non-exporters, but over time the hazard confronting exporters falls relative to that facing non-exporters.

The Indian IT Context

India has emerged as one of the fastest growing economies in the world since the 1990s, reflecting the strong performance of its service sector. The IT sector has been an important reason for the strong performance of India’s service sector. India is considered a major global player in the software and IT sector. In the early 1980s the IT sector was concentrated in Mumbai, but by 1990 the IT sector had clusters in Bangalore, Chennai, Delhi, Hyderabad, Mumbai and Pune and these cities were responsible for the largest share of software exports.

These cities also had the highest concentration of R&D establishments (especially defence) as well as publicly funded engineering colleges (Srinivasan & Krueger, 2005). The IT sector has boomed since deregulation in the 1990s. In 1991, the Indian market opened up to imported goods and new foreign producers that radically altered the technology landscape. Many new firms began to invest in new technology to realize both efficiency gains and quality improvement. Outsourcing of IT needs by leading global companies to Indian IT firms has also increased since the beginning of the 1990s (Hung, 2009). The share of IT in GDP increased from 1.2 per cent in 1997-98 to 5.5 per cent in 2007-08 (Joshi, 2009).

Growth in the Indian IT sector is primarily on the back of high export growth. The IT sector is the spearhead of Indian exports (Hung, 2009). Indian software exports increased from a mere $US 4 million in 1980 to over $US 12 billion in 2003-2004 (Arora & Bagde, 2010). Exports accounted for almost 80 per cent of software sales in 2006 (Altenburg *et al.*, 2008). At present the Indian IT sector gets 60 per cent of its export revenue from the United States, 20 per cent from Europe and 20 per cent from Latin America, the Middle East and other destinations. Initially, the bulk of exports consisted of sending software developers to work at the client site in the United States on short-term assignment. Revenue contributions from the US market continue to rise, due to the large number of IT-enabled services and business process outsourcing projects being outsourced to India (Hung, 2009). According to the WNS '2008 Global Outsourcing 100' survey, 20 Indian companies are among the world's top 100 in terms of outsourcing (Joshi, 2009). It has only been since the mid-1990s that there has been substantial software activity taking place in India locally (Arora & Bagde, 2010). While the Indian IT sector continues to be dominated by routine tasks, in recent years there has been expansion beyond low value-added services by complementing routine activities with innovative niche services. Knowledge-intensive activities - engineering services, R&D and software products - are growing fast (Altenburg *et al.*, 2008). Several multinational companies, including many of the leading ones, have established software development centres in India and are filing for patents in large numbers (Srinivasan & Krueger, 2005).

Literature Review

The theoretical models of Bernard *et al.* (2003) and Melitz (2003) conclude that propensity to export and productivity are correlated. Several empirical studies suggest that firms which export are more productive than firms which do not export (Greenaway & Kneller, 2007). Overall, empirical studies have found that exporters have 10-15 per cent higher productivity than non-exporters (Kimura & Kiyota, 2006). Theoretically, it has been shown that trade liberalisation increases the rate of return to a firm's investment in productivity enhancing activities, such as R&D, and that this generates productivity gains (Atkeson & Burstein, 2010; Constantini & Melitz, 2008). A large empirical literature also exists which suggests that a firm's investment in R&D strengthens the relationship between exports and productivity (Aw *et al.*, 2007, 2008, 2011; Bernard & Jensen, 1997; Baldwin & Gu, 2004). There are a large number of studies which examine the determinants of firm survival. These studies have modelled the effect of age and size on firm survival among other factors. A subset of this literature has modelled the effect of innovation, productivity or technological activity on firm survival (see eg., Agarwal, 1996, 1998; Cefis & Marsili, 2005, 2006; Hall, 1987; Shiferaw, 2009). The findings from these studies generally suggest that firms which invest more in innovation or R&D and have higher productivity levels have higher survival rates.

However, it does not follow necessarily that because exporters have higher productivity and that more productive firms have higher survival rates that exporters will have higher survival rates. According to heterogeneous firm trade models (eg. Bernard *et al.*, 20003; Melitz 2003), while export markets offer growth potential for some firms by increasing the size of their market, trade also increases the productivity thresholds required for survival, thus forcing the least efficient firms to exit. In this sense, export markets represent an additional source of uncertainty for the firm, which make sales more susceptible to international demand shocks. Some studies have found that exporting has a positive effect on firm survival and employment growth, consistent with a productivity effect. For example, Kimura and Kiyota, (2006) found that exporters faced a 7-18 per cent lower hazard than non-exporters. Other studies suggest that exporters have lower survival rates, consistent with exporters facing higher uncertainty with respect to sales. Specifically, Giovannetti *et al.*, (2011) found that in a sample of Italian firms, exporting increased the risk of failure by 32 per cent, which they attribute to tougher competition in international markets in the start-up phase.

Model

The Firm's Problem in an Environment with Uncertain Lifetimes

Here, we follow Chang (2004) in the presentation of an environment with an uncertain lifetime. Specifically, we assume that there is a maximum terminal date, $\bar{T}$, beyond which no firm survives in the market. We can assume that $\bar{T} \to \infty$. However, there is the possibility that the firm might leave the market before the maximum planning horizon is reached. The terminal date of each individual firm is, thus, a stochastic variable, $\tilde{T}$.

Therefore, given the terminal date, the probability of a firm leaving the market at time t is $f(t)$. This implies that $\int_0^{\bar{T}} f(t)dt = 1$. Then

$$F(t) = \int_0^t f(t)dt \, , \tag{1}$$

is the cumulative probability that the firm will leave the market before time t.

We use this to define the survival function,

$$S(t) = 1 - F(t) \, , \tag{2}$$

which measures the probability that the firm will not leave the market until time t. By definition $S(0)=1$ and $S(\bar{T})=0$. Using the cumulative density function, $S(t)$, and probability density function, $f(t)$, we introduce a measure that gauges the rate at which the risk of exit from the market is being accumulated. Denote this measure, the hazard rate.

The hazard rate (function) $h(t)$ is the probability that a firm exits between t and $(t+\Delta)$, divided by the probability that the firm survived beyond time t given by $S(t)$.

$$h(t)=\frac{f(t)}{S(t)}=-\frac{d}{dt}\log S(t). \tag{3}$$

This expression implies that

$$S(t)=\exp\left\{-\int_0^t h(s)ds\right\}. \tag{4}$$

Now, consider the firm's problem. We assume that the firm produces output, $y_i(t)$ using inputs - labour, $l_i(t)$, capital, $k_i(t)$ and other inputs, $x(t)$, given by

$$y(t)=Z(t,d,e)g(k,l,x), \tag{5}$$

where $g(k,l,x)$ is the function that maps the inputs to output function and $Z(t,d,e)$ is the technology coefficient. Z is a function of time, R&D expenditure, $R(t)$, and exports, $e(t)$. Thus, $d(t)$ captures the effect of both R&D and export exposure on productivity. The productivity coefficient $Z(t,i)$ is assumed, similar to Aw *et al.* (2008), to follow the process:

$$Z(t+1)=\rho Z(t)+d(t)+e(t)\zeta(t)\exp(-\rho t)+u(t). \tag{6}$$

However, we differ from Aw *et al.* (2008) as this specification implies that the productivity of IT firms is improved through both R&D expenditure and export exposure. The actual realization of the productivity gain is random as it depends also on the *i.i.d.* shocks, $u(t)$ and, specific to exporting firms only, the *i.i.d.* shock $\xi(t)$. We allow for learning by exporting, where uncertainty related to exporting declines with time. The firm is assumed to maximize its expected net value by choosing its inputs, investment in capital and R&D.

$$V = E\int_0^{\tilde{T}} \exp(-rt)\pi(t)dt\,, \tag{7}$$

where r is the discount rate and $\pi(t)$ is profit at time t.

Using the probability of survival we formulate the above problem as:

$$\max V = \int_0^{\tilde{T}} f(t)\left[\int_0^{t} \exp(-rs)\pi(s)ds\right]dt\,. \tag{8}$$

Using integration by parts and noting that $S'(t) = -f(t)$, we write:

$$-S(t)\left[\int_0^{t} \exp(-rs)\pi(s)ds\right]_{t=0}^{t=\bar{T}} + \int_0^{\bar{T}} \exp(-rt)\pi(t)ds$$

$$= \int_0^{\bar{T}} S(t)\exp(-rs)\pi(t)dt$$

$$= \int_0^{\bar{T}} \exp\left\{-rt - \int_0^{t} h(s)ds\right\}\pi(t)dt\,. \tag{9}$$

The result, given by (9), indicates that the hazard rate adds to the discounting of the cash flows; hence, reducing the net present value of the firm facing an uncertain lifetime. Therefore, the survival of the firm is affected by the factors driving the hazard.

The Factors that Effect Survival of the Firm

Here we consider how the probability of survival at time t depends on different factors. To so do, we relate the probability of survival at time t to some decision criteria employed by the firm. Usually, it is assumed that the firm exits (fails) if the expected net value is less than some reservation value, θ. That is, the probability of exit is given by

$$Pr[V(\pi(t)) < \theta] = F(t)\,. \tag{10}$$

It is worth noting that the reservation value, θ, can also be seen as part of the fixed cost or initial investment in the firm to be recovered at time t. This implies that with a higher debt burden or with a higher fixed cost, the probability of survival decreases. The factors that affect the profit rate of the firm for a given level of debt drive the probability of survival of the firm. We base our analysis on this cut-off rule. Assuming that the reserved value can be represented as cash flow, $\theta = \int_0^t \varphi(s)ds$, and using (9) and (10) we can specify that

$$\exp\left\{-rt - \int_0^t h(s)ds\right\}\pi(t) = \varphi(t). \tag{11}$$

Taking logs and recalling that $H = \int_0^t h(s)ds$ is a cumulative hazard function we derive

$$H = \int_0^t h(s)ds = \log \pi(t) - \log \varphi(t) - rt \tag{12}$$

This equation relates the accumulative hazard function to the factors that drive the exit decision. Here, observing (12) we can conclude that survival of the firm increases with its profitability. Since the accumulative hazard function is just a sum of the instantaneous hazard rate, $h(t)$, in practice, survival analysis focuses on this rate. Therefore, the hazard rate, $h(t)$, is a function of all the variables included on the right hand side of this equation.

$$h(t) = g[\pi(t), \varphi(t), r] \tag{13}$$

Equation (13) can serve as a base for our empirical analysis. For this purpose we need to ascertain what drives $\pi(t)$, $\varphi(t)$, and r. It is known that profits, $\pi(t)$, are determined by the output level and costs related to production. Thus, we need to account for the factors that drive both the output level and the cost level which firms are facing. The output of the firms may also be affected by the size of market that the firm can capture.[1] Since, most IT firms in India target overseas markets, their success depends on how well they are connected to those markets. Thus, we can write that, in general, the profit of a firm is given by:

[1] See Klepper (2002) for the link between the size of firms and their ability to invest in productivity gains, which as a result contributes to their survival.

$$\pi(t) = p(t)[Z(t-1) + d(t-1) + u(t)]g(k,l,x) - c(t) - R(t),$$

where $p(t)$ is the firm's price, $c(t)$ is all production costs assumed to be common across firms and $d(t)$ is the positive effect of R&D expenditure and export exposure on the firm's productivity . The value of nominal sales, $p(t)y(t)$, captures the size of the firm.

As discussed above exporters generally have higher productivity. This property of export firms can be seen either as exporters having additional knowledge spill-over or an additional positive effect of R&D expenditure. The productivity of the firm is formulated as

$$d(t) = (\gamma_1 e(t) + \gamma_2) R(t),$$

where $e(t)$ denotes exports, γ_1 denotes the coefficient that links exports to innovation and γ_2 denotes the coefficient that links R&D to productivity. This formulation of productivity evolution is general. Exports have a positive effect on firm survival through an expected increase in productivity, but simultaneously recognises that export activity leads to additional uncertainty in a more competitive environment, compared to just selling in the domestic market. Hence, exporters may face an increased hazard in the initial stages of their life reflected in Equation (6). However, over time this export-specific hazard declines, and export firms are expected to face a hazard lower than non-export firms.

The profit function can be concisely stated as

$$\pi(t) = \Pi[y(t), c(t), R(t-1), e(t-1)] + \varepsilon(t), \tag{14}$$

where $\varepsilon(t)$ is *i.i.d.* shocks to profits. Further, we recall that the variable $\varphi(t)$ in (13) captures the reservation value of the firm to remain in the market, which depends on credit conditions and outside options available in the economy. First, credit market constraints imposed on the firm depend on its net worth (indebtedness of the firm), cash flow, size of the enterprise and the ownership-type. The ownership form is important as it also may determine the firm's access to credit and borrowing costs. Hence, we state that the credit constraint is a function of net worth, size of the firm, cash flow, and the type of ownership. It is given by

$$credit = g(nw, cf, s, o),$$

where nw is net worth, cf is cash flow, s is size and o is the form of ownership. The outside options in the economy available to the firm are also an important factor that affects the exit decision. The idea is that a positive profit rate may not be enough to keep the firm in the market if there are more profitable business options available. One can capture those options with the average economy wide profit rate, $\tilde{\pi}$, which can be proxied by the market interest rate. Based on this idea we can express the reserved value in a general form as:

$$\varphi(t) = \Phi[nw, cf, s, o, \tilde{\pi},] \qquad (15)$$

Finally, the third term of (12) is captured by the interest rate on loans taken by the firm. Both the industry-wide profit rate and the interest rate affect the investment level of the firm. Hence, we may proxy both of these variables by the investment expenditure of the firm.

The discussion above identifies the structure of the factors ($\pi(t)$, $\varphi(t)$, and (r) that drive the hazard rate facing firms. Since, R&D and export exposure both contribute to the productivity of the firm, the probability of exit falls; hence, the hazard rate effectively decreases.

This logic allows us to state the following hypotheses.

Hypothesis 1 *The hazard rate faced by the firm falls with higher spending on R&D.*

Hypothesis 2. *The hazard rate facing exporters is initially higher than non-exporters, but, over time, the hazard rate facing exporters falls below that of non-exporters.*

Econometric Methodology

Equation (13) can be estimated by imposing a parametric functional form. One way in which this equation can be estimated is employing a parametric proportion hazard (PH) model where the proportional hazard is expressed in the following parameterization:

$$h(t|X_j) = h_0(t)\exp(X_j\beta_x) \qquad (16)$$

where X_j is the vector of all the explanatory variables. $h_0(t)$ is known as the baseline hazard. This model can be estimated, assuming various shapes of the baseline hazard corresponding to the distribution followed by the hazard function. The choice of distributions and corresponding functional form for the above equation for the PH models is as follows:

1. Exponential: $h(t|X_j) = \exp(\beta_0 + X_j\beta_x)$
2. Weibull: $h(t|X_j) = pt^{p-1}\exp(\beta_0 + X_j\beta_x)$
3. Gompertz: $h(t|X_j) = \exp(\gamma t)\exp(\beta_0 + X_j\beta_j)$

Another way to estimate Equation (13) is to employ an accelerated failure time (AFT) model:

$$\ln(t_j) = X_j\beta_j + \ln(\tau_j) \qquad (17)$$

such that the random variable $\ln(\tau_j)$ follows a distribution such as:

1. Exponential: $\tau_j \sim Exponential\{\exp(\beta_0)\}$
2. Weibull: $\tau_j \sim Weibull(\beta_0, p)$
3. Lognormal: $\tau_j \sim lognormal(\beta_0, \sigma)$
4. Loglogistic: $\tau_j \sim loglogistic(\beta_0, \gamma)$
5. Generalized gamma: $\tau_j \sim Gamma(\beta_0, \kappa, \sigma)$

As the theoretical model predicts, exporting firms have different productivity characteristics and hence are expected to face a different hazard than non-exporting firms. We incorporate this aspect of the theoretical model into the empirical methodology by employing a stratified regression, using a dummy variable for exporters as the stratification variable. The assumption that every firm faces the same baseline hazard, multiplied by their relative hazard:

$$h\big(t\big|X_j\big) = h_0(t)\exp(X_j\beta_x)$$

is relaxed in favour of

$$h\big(t\big|X_j\big) = h_{01}(t)\exp(X_j\beta_x), \text{ if j is an exporter}$$

$$h\big(t\big|X_j\big) = h_{02}(t)\exp(X_j\beta_x), \text{ if j is a non-exporter}$$

Specifically, we employ a stratification model, in which the baseline hazards are allowed to differ according to whether the firm is an exporter or non-exporter, but the coefficients, β_x are constrained to be the same. When allowing a different baseline hazard for exporters and non-exporters we allow both the scale and shape of the hazard function to differ, which is the most general form. Alternatives to using a stratification model would have been to employ an unshared frailty model in which unobserved random effects among firms were at the individual level or a shared frailty model, in which exporters (and non-exporters) share common unobserved random effects. We tried using both forms of the frailty model. The estimates of variance when assuming frailty at the individual level were small and not significantly different from zero. With the shared frailty model, the model was not converging; hence, making it impossible to get an estimate of the frailty parameter.

Data and Preliminary Results

The data is taken from the Prowess database provided by the Centre for Monitoring the Indian Economy (CMIE). This is a corporate database compiled from company reports. The raw data consisted of an unbalanced panel 797 IT firms for the period 1991 – 2009, giving us a total of 4940 observations. The IT firms were categorized into 2 sub-categories “Computer Software” and “IT Enabled Services (ITES)”, based on their main business activity. The dataset consisted of a lot of missing observations, outliers, incomplete records and data on firms, which have either merged or been acquired by another firm during the period of study. We removed observations with missing values for the key variables and removed firms subjected to merger or acquisition, as these do not indicate a firm’s exit from the industry.

Moreover the data for 2009 was incomplete. The dataset was last updated in May 2010, and hence it did not contain information for firms which had not released their company reports (containing 2009 figures) by that time. Thus, if a firm was observed missing in 2009, it was not possible to tell that if the firm had exited the industry or it had not yet released its company report for that year. With this in mind we removed the year 2009 from the period of study. Firms for which data were available up to 2008 where treated as censored subjects - i.e. subjects who had not exited the industry during the period of observation.

Following the removal of the missing observation points, we were left with an unbalanced panel of 744 firms for the period 1991-2008, giving a total of 4076 observations. This dataset was then converted into a format, which can used for survival data analysis, leading to further loss of one observation per firm and removal of firms with only one year of data. Finally we were left with data on 655 firms (594 computer software and 61 ITES) for the period 1991-2008, giving a total of 3332 observations for the final analysis.

The variables sales (proxy for size) and entry size (sales in the first year of observation) were employed in log form. Age (year less year of incorporation) and age squared were entered in years. The firm's specific variables - R&D expenses, assets, total expenses, cash flow and investments - were all normalized by firm sales, using the following form:

$$Tx_{ij} = \frac{x_{ij}}{Sales_{ij}} \times 100$$

such that x_{ij} represents the original variable in year i for firm j and Tx_{ij} represents the transformed variable. Due to this transformation the change in variables can be interpreted as change in percentage of sales (revenue) devoted to that variable.

Table 1 provides a basic description of the dataset. There are, on average, five records per firm with minimum 1 and maximum 17 records per firm in the dataset. All the firms enter at time = 0 (the analysis time, defined separately for each firm) and exit any time between 1 to 17 (with mean 6.2 and median 5). There are no gaps i.e. there are no cases where a firm has exited the dataset at one point and re-entered at a later date. There are in total 359 failures in the data with a maximum failure of 1 per subject (i.e. a firm can fail only once when it exits).

Table 2 presents the estimates of the Nelson-Aalen cumulative hazard function**.** The cumulative hazard function is defined as

$$H(t) = \int_0^t h(u)du$$

where $h()$ is the hazard function. The above integral is estimated using the following formula

$$\hat{H}(t) = \sum_{j|t_j \leq t} \frac{d_j}{n_j}$$

where $n_j$is the number at risk at time t_j, d_j is the number of failures at time t_j and the sum is the overall distinct failure times less than or equal to t. At the beginning of time period one there were 655 firms observed; of which, 87 failed at the end of their first year in the sample.

At the beginning of time period two there were 559 firms in the sample; of which, 60 failed at the end of their second year in the sample. The cumulative values for the percentage of fails are in the fourth column, giving an estimate of the cumulative hazard function. The Nelson-Aalen cumulative hazard function is plotted for various subgroups in Figures 1-3. Figure 1 shows that the computer software firms face a lower hazard than ITES firms. There are four ownership forms – foreign, group, private and state. Figure 2 shows that group-owned firms face a lower hazard than other ownership forms. Figure 3 shows that firms with R&D expenditure face a lower hazard than the firms with no R&D expenditure.

Table 3 presents the mean survival times of various subgroups. The mean survival time (μ_T), is defined as an integral from zero to infinity of the survival function $S(t)$. The bottom half of Table 3 presents the results of non-parametric tests for equality of means. The two tests used are the log-rank test for equality of survival functions and Wilcoxon (Breslow) test for equality of survival functions. The mean survival time is higher for computer software firms than ITES firms, group firms have the highest survival time compared to other ownership groups and firms with R&D expenditure have higher mean survival times than firms without R&D expenditure. Both of the tests of equality of means are in close agreement and suggest that the difference in the mean survival times is statistically significant.

Table 4 presents the model selection criteria. The choice of one particular parametric model over another is generally governed either by the underlying theory or from a purely statistical view of finding the model with best fit. As the underlying theoretical model does not predict why we should prefer one distribution over the other, we proceed with using the statistical criteria to choose a model. For choosing the best fitting model one would normally choose the model with the highest log-likelihood value. However, the models with more explanatory variables will give a higher likelihood value. Akaike (1974) proposed penalizing each model's log likelihood to reflect the number of parameters being estimated and then comparing the log likelihoods. Using this rule the preferred model is not the one with the highest log-likelihood value but the one with lowest value for the Akaike Information Criteria (AIC). A similar statistic is the Bayesian Information Criterion (BIC), proposed by Schwarz (1978). Table 4 summarizes the AIC and BIC values for five different specifications (Model 1 – Model 5) of the parametric survival equation, using five different distributions[2]. The exact specifications for the five models correspond to the five models in Tables 5 and 6 below. The distribution with the lowest values for the AIC is presented in bold letters. In each case the AIC and BIC suggest that the lognormal distribution is the preferred distribution.

Given that the lognormal distribution is the preferred distribution, it is to be noted that it can only be estimated for the AFT model. For the lognormal regression we assume that τ_j in (17) is distributed as lognormal with parameters (β_o, σ) and cumulative distribution function:

$$F(\tau) = \Phi\left(\frac{\ln \tau - \beta_0}{\sigma}\right) \quad (18)$$

such that $\Phi()$ is the cumulative distribution function for the standard Gaussian (Normal) distribution. This gives us the following linear model to estimate:

$$\ln(t_j) = \beta_0 + X_j\beta_x + u_j \qquad (19)$$

The baseline survivor function is given as

$$S_0(t_j) = 1 - \Phi\left(\frac{\ln t_j - \beta_0}{\sigma}\right) \qquad (20)$$

and the survivor function is given as

[2] We could not estimate the generalized gamma distribution for our data, as the log-likelihood function hit a dis-continuous region and failed to converge. The failure of the log-likelihood function to converge with the generalized gamma distribution indicates that this distribution is not a good fit for our data.

$$S(t_j|X_j) = 1 - \Phi\left\{\frac{\ln t_j - (\beta_0 + X_j\beta_x}{\sigma}\right\} \tag{21}$$

While this model has no natural PH interpretation, the hazard function of X_j can be estimated:

$$h(t|X_j) = \frac{-\frac{d}{dt}S(t|X_j)}{S(t|X_j)} \tag{22}$$

Multivariate Regression Results

Tables 5 and 6 present the main parametric estimates of the analysis. The only difference is that R&D intensity is used as a continuous variable in Table 5 and a dummy variable in Table 6. In both the tables the dependent variable is ln(survival time). We begin with the control variables. The coefficients on ln(Sales) can be interpreted as elasticities. Hence, a 1 per cent increase in sales leads to a 27 per cent increase in survival time. This is consistent with many previous studies which have found a positive relationship between size and firm survival (eg. Cefis & Marsili, 2005, 2006; Esteve-Perez *et al.,* 2010). The rationale is that larger firms are more likely to have levels of output close to the minimum efficient scale (Holmes *et al.,* 2010). Another possible explanation is that larger firms may have better access to capital and labour markets which, in turn, increase their chances of survival (Esteve-Perez *et al.*, 2010).

The coefficients on ln(Entry size) can also be interpreted as elasticities. Thus, a 1 per cent increase in entry size leads to a 14-16 per cent decrease in survival time, depending on the specification. The effect of entry size on firm survival in previous studies is mixed (see eg. Audretsch & Mahmood, 1994; Das & Srinivasan, 1997; Mata & Portugal, 1994). Das and Srinivasan (1997) also found that larger entry size hastened firm exit in the Indian computer hardware industry. Their explanation was that a large entry size, for a given post-entry size, is indicative of a slow growing firm that is more vulnerable to industry-wide shocks and this, in turn, hastens exit. In developing countries, such as India, fluctuations in industry-wide shocks are more common than in the mature environment of developed countries. With the existence of various rigidities in countries such as India often magnified, large entry size becomes a liability. The reason is that it hampers flexibility in responding to new information, which is critical in the start-up phase of a business (see Das & Srinivasan, 1997).

Age and age squared are in years. A one year increase in age reduces the survival time by roughly 5 per cent. The relationship between age and survival time is non-linear with the turning point occurring between 12 and 14 years of age depending upon the exact specification. This result is consistent with a number of studies which have found exit rates have an inverted U-shaped relationship with age (eg. Geroski, 1995; Strotmann, 2007; Wagner, 1994). Following establishment, the risk of failure is comparatively low because new firms are protected by initial resource endowments. The risk of failure subsequently increases as firm endowments erode and then decreases as learning reduces the risk of exit.

Several studies suggest that poor performance will have a negative effect on firm survival (Altman, 1968; Heiss & Koke, 2004; Koke, 2002). Of the firm performance variables, we find assets have a positive effect on firm survival and expenses have a negative effect on firm survival. However, cash flow has a statistically insignificant effect on firm survival. Generally, this is also true for the debt structure; however, in Model 5 in Tables 5 and 6, the debt-equity ratio has a positive effect on firm survival at the 10 per cent level. While only weakly significant, the result in Model 5 is consistent with agency theory, which suggests a high debt-equity ratio limits the free cash-flows available to managers who would otherwise invest them in dubious projects (Jensen, 1986). It is also consistent with Caves and Porter's (1976) argument that in the initial phase following entry, a high debt ratio is a barrier to competitors entering the market and simultaneously firms exiting the market.

Finally, a number of studies have pointed to the importance of ownership in accessing funding (eg Esteve-Perez *et al.*, 2010; Shiferaw, 2009). We find that group ownership has a positive effect on firm survival. In the Indian IT boom, it was common for conglomerates in other sectors to diversify into the IT sector. Our findings reflect the fact that group-owned firms can draw on resources from subsidiaries in other fields to support their IT activities.

Turning to the hypotheses from the model, there is support for the first hypothesis. An extra 1 per cent of sales revenue spent on R&D, increases the firm's survival time by 12 – 13 per cent in Table 5. When we do not take into account variation in R&D values, but instead treat expenditure on R&D as a dummy variable in Table 6, the transition from a firm without R&D expenditure to a firm with R&D expenditure almost doubles the survival time. This result is consistent with the findings from extant studies that firms which invest more in innovation or R&D have higher survival rates (see eg., Cefis & Marsili, 2005, 2006; Hall, 1987).

To examine hypothesis 1 further, as well as hypothesis 2, we turn to the results of the stratification model. When a variable enters only as a covariate in the regression model it affects only the scale of the hazard function; however, when a variable is used as a stratification variable it affects the scale as well as shape of the hazard function. This provides an extra level of generality in the model. In the absence of stratification the effect of exports on firm survival is constrained to be only on the scale of the hazard function and hence the estimation will suffer from misspecification bias. As there is no natural baseline hazard specification for the lognormal distribution, stratification enters the regression equation through the specification of the shape parameter σ in equations (20) and (21).

σ is specified by the following linear form:

$$\ln \sigma = \alpha_0 + z\alpha_z \qquad (23)$$

This is instead of a constant (in the absence of stratification). Here z is the stratification variable (export dummy) and this equation is known as an ancillary equation. The coefficient on z in the main equation effects the scale of the hazard function whereas the coefficient on z in the ancillary equation effets the shape of the hazard function. The estimates of the ancillary equation are presented below the estimates of the main equation in Tables 5 and 6.

The coefficient of stratification (entering through the ancillary equation) cannot be directly interpreted, as it not only effects the scale of the hazard function but also changes the shape of the hazard function. The stratification results can be better interpreted through Figures 4-6. Several observations can be made about Figures 4-6. First, the shape of the hazard function is different for exporting and non-exporting firms, which confirms the need to treat exporting and non-exporting firms differently in modelling the hazard function. Second, firms with R&D expenditure (or higher R&D expenditure in the case of Figure 5) face a lower hazard than firms without R&D spending, irrespective of whether they belong to the exporting or non-exporting group. This result is further evidence consistent with hypothesis 1.

Turning to hypothesis 2, exporting firms face a higher hazard in the initial years than non-exporting firms. The initial period for which the exporting firm faces a higher hazard than the non-exporting firm depends upon the exact specification and the assumptions regarding the values of other covariates. For example when all the covariates take their mean value (including R&D intensity) the exporting firm faces a higher hazard than non-exporting firm for the first two years (see Figure 4). Thereafter, exporting firms face a lower hazard than non-exporting firms. This finding is consistent with hypothesis 2. Specifically, this finding is consistent with the notion that in the initial entry period exporters have a lower prospect of survival than non-exporters because of the high level of uncertainty associated with entering into international markets, but over time the productivity benefits of being in international markets kick in and this reduces the hazard of exporters relative to non-exporters. To put it differently, if exporters can survive the initial period in international markets in which there is uncertainty, they stand to benefit from the productivity gains associated with exporting and the productivity gains to exporting, relative to non-exporting, increase over time.

This result is consistent with several observations from the recent literature on the exporting-productivity nexus. The first is that the sunk cost of exporting is higher than the fixed cost of continuing to export (Aw *et al.,* 2011). Second, firm-specific export market shocks play an important role in the decision to export, given the high hazard exporters face, relative to non-exporters in the initial period following entry into international markets. For example, see Aw *et al.'*s (2011) study employing data from the Taiwanese electronic industry, and Das *et al.'*s, (2007) findings using Columbian manufacturing data. Third, the results are consistent with the notion of learning by exporting (see eg. Aw *et al.,* 2007, 2008). Illmakunnas and Nurmi (2010) found that firms which exhibited the highest level of learning by exporting had the highest survival rates in export markets. Specifically, firm productivity evolves endogenously in response to a firm's decision to export (Aw *et al.,* 2011) and firms which experience productivity evolution have higher survival rates (Aw *et al.,* 2007).

Conclusion

This paper has examined the effect of exporting on firm survival for a panel of Indian IT firms. A contribution of the paper has been to highlight that internationalisation via exporting has competing effects on firm survival. On the one hand, exporting and investing in productivity are complementary activities, while, on the other, exporting activity also makes firms more susceptible to international demand shocks, meaning that exporting activity is an additional source of uncertainty for the firm. These competing effects are reflected in the mixed evidence on the relationship between exporting and firm survival found in previous studies. Our results shed light on the reasons for the mixed evidence in previous studies. We show that both effects are influencing survival, but operate at different points in time. Specifically, the hazard facing exporters is higher than non-exporters in the initial phase following entry, reflecting the fact that exporters are particularly vulnerable to shocks in the start-up phase. However, over time, exporters benefit more from productivity gains than non-exporters and the hazard facing exporters falls below that confronting non-exporters.

One of the limitations is that measuring R&D in a high-tech service industry, in which the boundaries between production and research activities are blurred, is a difficult task. Much research takes place within the production process, which may or may not be captured by measuring expenditure on R&D. A better measure of R&D could be the number of research staff employed by the firm. Prowess does not provide this data, but a primary survey could reveal this information. Another potential limitation is that we use an input based R&D measure (R&D expenditure). R&D expenditure has an uncertain outcome and an argument can be made that R&D helps increase the probability of survival only when it is successful.

An extension of this study could be to use output based measures of R&D such as number of patents attained by the firm in a given year (for which Prowess provides no data). Using an input based measure of R&D we have concluded that firms with higher R&D investment have higher survival rates. A study which also employed an output-based measure of R&D, could explore if there is a difference between the survival rates of successful innovators and non-successful innovators, after controlling for R&D inputs (i.e. between firms with higher R&D output, but similar levels of R&D investment). Most likely, such a study would find that successful innovators have higher survival rates than non-successful innovators. One could also compare the survival rates of unsuccessful innovators (R&D input > 0, R&D output = 0) to that of non-innovators (R&D input = 0, R&D output = 0). If it turns out that the cost (in terms of survival time) of doing R&D and failing is greater than the cost of not doing R&D, this might explain that, given the uncertain nature of R&D outcomes, risk averse firms will not engage in R&D in spite of knowing that successful R&D increases survival.

Yet another extension to this paper could be to look at sub-industries within computer software. It could be possible that the results hold (or more strongly hold) for one sub industry over others. For example, for a particular kind of product/service within computer software, the productivity gains from exporting might be higher than others. If more detail were available on the uses of R&D, it might be possible to examine how different uses effect firm survival. It might also be possible to examine whether the complementarities between exporting and R&D, and hence effects on firm survival, were greater for particular uses of R&D, which, in turn, might differ across sub-industries (see also Aw *et al.*, 2011).

References

Agarwal, R. (1996) 'Technological Activity and Survival of Firms', *Economics Letters,* 52, 101-108.

Agarwal, R. (1998) 'Small Firm Survival and Technological Activity', *Small Business Economics*, 11, 215-224.

Akaike, H. (1974). 'A New Look at the Statistical Model Identification', IEEE Transactions on Automatic Control 19(6): 716–723.

Altman, E. (1968) 'Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy', *Journal of Finance*, 23, 580-609.

Altenburg, T., Schmitz, H. and Stamm, A. (2008) 'Breakthrough? China's and India's Transition from Production to Innovation', *World Development,* 36(2): 325-344.

Arora, A. and Bagde, S. (2010) 'Human Capital and the Indian Software Industry', National Bureau of Economic Research, Working Paper 16167.

Atkeson, A. and Burstein, A. (2010) 'Innovation, Firm Dynamics and International Trade', *Journal of Political Economy*, 118(3): 433-488.

Audretsch, D.B. and Mahmood, T. (1994) 'Firm Selection and Industry Evolution: The Post Entry Performance of New Firms', *Journal of Evolutionary Economics,* 4(3): 243-260.

Aw, B.Y., Roberts, M. and Winston, T. (2008) 'Export Market Participation, Investments in R&D and Worker Training, and the Evolution of Firm Productivity', *The World Economy,* 14(1): 83-104.

Aw, B.Y., Roberts, M. and Xu, D.Y. (2008) 'R&D Investments, Exporting and the Evolution of Firm Productivity', *American Economic Review, Papers & Proceedings,* 98(2): 451-456.

Aw, B.Y., Roberts, M. and Xu, D.Y. (2011) 'R&D Investment, Exporting and Productivity Dynamics', *American Economic Review,* 101(4): 312-344.

Baldwin, J.R. and Gu, W. (2004) 'Export Market Participation and Productivity Performance in Canadian Manufacturing', *Canadian Journal of Economics,* 36: 634-657.

Bernard, A.B., Eaton, J., Jensen, J.B. and Kortum, S. (2003) 'Plants and Productivity in International Trade', *American Economic Review,* 93(4): 1268-1290.

Bernard, A.B. and Jensen, J.B. (1997) ‚Exporters, Skill Upgrading and the Wage Gap', *Journal of International Economics,* 42(1)*:* 3-31.

Bhide, A. (2008) 'What Holds Back Bangalore Businesses?' *Asian Economic Papers,* 7(1): 120-153

Bustos, P. (2011) 'Multilateral Trade Liberalisation, Exports and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms', *American Economic Review,* 101(1): 304-340.

Caves, R. and Porter, M. (1976) ‘Barriers to Exit’ in R.T. Masson and P.D. Qualls (Eds.) *Essays in Industrial Organisation in Honour of Joe S. Bain* (Cambridge, MA.: Ballinger).

Cefis, E. and Marsili, O. (2005) ‘A Matter of Life and Death: Innovation and Firm Survival’, *Industrial and Corporate Change,* 14(6): 1167-1192.

Cefis, E. and Marsili, O. (2006) ‘Survivor: The Role of Innovation in Firms’ Survival’, *Research Policy,* 35, 626-641.

Chang, F-R., (2004). *Stochastic Optimization in Continuous Time.* Cambridge University Press, Cambridge, UK.

Constantini, J. and Melitz, M. (2008) ‘The Dynamics of Firm-level Adjustment to Trade Liberalisation’ in E. Helpman, D. Marin and T. Verdier (Eds.) *The Organization of Firms in a Global Economy* (Cambridge: Harvard University Press).

Das, S., Roberts, M. and Tybout, J. (2007) ‘Market Entry Costs, Producer Heterogeneity and Export Dynamics’, *Econometrica,* 75(3), 837-873.

Das, S. and Srinivasan, K. (1997) ‘Duration of Firms in an Infant Industry: The Case of Indian Computer Hardware’, *Journal of Development Economics,* 53: 157-167.

Esteve-Perez, S., Sanchis-Llopis, A. and Sanchis-Llopis, J.A. (2010) ‘A Competing Risks Analysis of Firm Exit’, *Empirical Economics,* 38: 281-304.

Geroski, P. (1995) ‘What Do We Know About Entry?’ *International Journal of Industrial Organization,* 13(4), 421-440.

Giovannetti, G., Ricchiuti, G. and Velucchi, M. (2011) ‘Size, Innovation and Internationalization: A Survival Analysis of Italian Firms’, *Applied Economics,* 43, 1511-1520.

Gorg, H. and Strobl, E. (2003) ‘Footloose Multinationals?’ *Manchester School,* 71, 1-19.

Greenaway, D. and Kneller, R. (2007) ‘Firm Heterogeneity, Exporting and Foreign Direct Investment’, *Economic Journal,* 117: F134-F161.

Hall, B. (1987) ‘The Relationship Between Firm Size and Firm Growth in the US Manufacturing Sector’, *Journal of Industrial Economics,* 35, 583-606.

Heiss, F and Koke, J. (2004) ‘Dynamics in Ownership and Firm Survival: Evidence From Corporate Germany’, *European Financial Management,* 10, 167-195.

Holmes, P., Hunt, A. and Stone, I. (2010) ‘An Analysis of New Firm Survival Using a Hazard Function’, *Applied Economics,* 42, 185-195.

Hung, S-W. (2009) ‘Development and Innovation in the IT Industries of India and China’, *Technology in Society,* 31, 29-41

Ilmakunnas, P. and Nurmi, S. (2010) 'Dynamics of Export Market Entry and Exit', *Scandinavian Journal of Economics,* 112(1): 101-126.

Jensen, M. (1986) 'The Agency Costs of Free Cash Flows, Corporate Finance and Takeovers', *American Economic Review,* 75, 234-256.

Joshi, S. (2009) 'IT and ITES as an Engine for Growth: An Exploration into the Indian Experience', Institute for Economic Growth, University of Delhi, Delhi, India.

Kimura, F. and Kiyota, K. (2006) 'Exports, FDI and Productivity: Dynamic Evidence From Japanese Firms', *Weltwirtschaftliches Archiv/Review of World Economics,* 142(4): 695-719.

Klepper, S. (2002) 'Firm Survival and the Evolution of Oligopoly', *RAND Journal of Economics,* 33(1): 37-61.

Koke, J. (2002) 'Determinants of Acquisition and Failure: Evidence From Corporate Germany', *Structural Change and Economic Dynamics,* 13, 457-484.

Lileeva, A. and Trefler, D. (2010) 'Improved Access to Foreign Markets Raises Plant Level Productivity …. for Some Plants', *Quarterly Journal of Economics,* 125(3): 1051-1099.

Mata, J. and Portugal, P. (1994) 'Life Duration of New Firms', *Journal of Industrial Economics,* 62, 227-245.

Melitz, M. (2003) 'The Impact of Trade on Aggregate Industry Productivity and Intra-Industry Reallocations', *Econometrica,* 71(6): 1695-1725.

Nafziger, E.W. and Terrell, D. (1996) 'Entrepreneurial Human Capital and the Long-run Survival of Firms in India', *World Development,* 24(4): 689-696.

Schwartz, G. (1978) 'Estimating the Dimension of a Model', *Annals of Statistics* 6 (2): 461–464.

Shiferaw, A. (2000) 'Survival of Private Sector Manufacturing Establishments in Africa: The Role of Productivity and Ownership', *World Development,* 37(3): 572-584.

Srinivasan, R., Lilien, G.L. and Rangaswamy, A. (2008) 'Survival of High-tech Firms: The Effects of Diversity of Product-Market Portfolios, Patents and Trademarks', *International Journal of Research Marketing,* 25, 119-128.

Srinivasan, T.N. and Krueger, A. (2005) 'Information Technology Enabled Services and India's Growth Prospects', *Brookings Trade Forum,* 203-240.

Wagner, J. (1994) 'The Post-Entry Performance of New Firms in German Manufacturing Industries', *Journal of Industrial Economics,* 42: 141-154.

Table 1: Description of survival data

		Per subject			
Category	Total	Mean	Min	Median	Max
No. of Firms	655				
No. of Records	3332	5.087	1	4	17
(First) entry time		0	0	0	0
(Final) exit time		6.198	1	5	17
Firms with gap	0				
Time on gap if gap	0	-	-	-	-
Time at risk	4060	6.198	1	5	17
Failures	359	0.548	0	1	1

Table 2: Nelson-Aalen cumulative hazard estimates

Time	Beg. Total	Fail	Net Lost	Nelson-Aalen Cum. Haz.	Std. Error	95% Conf. Int.	
1	655	87	9	0.133	0.014	0.108	0.164
2	559	60	16	0.240	0.020	0.204	0.282
3	483	45	16	0.333	0.024	0.289	0.384
4	422	35	23	0.416	0.028	0.365	0.475
5	364	31	23	0.501	0.032	0.443	0.568
6	310	17	13	0.556	0.035	0.493	0.628
7	280	27	17	0.653	0.039	0.580	0.734
8	236	6	26	0.678	0.041	0.603	0.763
9	204	16	32	0.757	0.045	0.673	0.850
10	156	8	19	0.808	0.049	0.718	0.909
11	129	10	10	0.885	0.054	0.785	0.999
12	109	10	19	0.977	0.062	0.863	1.106
13	80	4	41	1.027	0.067	0.905	1.166
14	35	1	12	1.056	0.072	0.923	1.208
15	22	1	11	1.101	0.086	0.946	1.282
16	10	1	3	1.201	0.132	0.969	1.489
17	6	0	6	1.201	0.132	0.969	1.489

Table 3: Mean survival times by various subgroups and hypothesis tests for equality of means

Mean Survival Times					
Category	No. of Firms	Restricted mean*	Std. Error.	95% Conf. Int.	
Industry					
Computer	594	9.162	0.282	8.609	9.715
ITES	61	7.628	0.964	5.739	9.516
Ownership					
Foreign	40	8.416	1.026	6.405	10.427
Group	136	10.781	0.574	9.655	11.906
Private	471	8.569	0.324	7.935	9.204
State	8	6.629	0.916	4.833	8.424
R&D Expenditure					
R&D Expenditure = 0	649	8.812	0.275	8.273	9.351
R&D Expenditure > 0	55	14.031	1.096	11.883	16.179
Test of equality of survival functions					
Category		DF	Chi-square	Pr > Chi-square	
Industry					
Log-rank test		1	3.40	0.065	
Wilcoxon test		1	4.07	0.044	
Ownership					
Log-rank test		3	10.70	0.013	
Wilcoxon test		3	11.91	0.007	
R&D Expenses					
Log-rank test		1	11.04	0.0009	
Wilcoxon test		1	9.42	0.002	

Notes: (*) largest observed analysis time is censored, mean is underestimated

Table 4: Selection of distribution for Parametric Estimation

Distribution	Observations	ll(null)	ll(model)	DF	AIC	BIC
Model 1						
Exponential	3332	-824.097	-799.212	6	1610.425	1647.093
Weibull	3332	-811.952	-794.871	8	1605.742	1654.633
Gompertz	3332	-811.927	-796.785	8	1609.570	1658.461
Log-Normal	**3332**	**-795.539**	**-770.796**	**8**	**1557.592**	**1606.483**
Log-Logistic	3332	-807.229	-782.440	8	1580.880	1629.770
Model 2						
Exponential	3332	-824.097	-792.107	9	1602.213	1657.215
Weibull	3332	-811.952	-787.232	11	1596.464	1663.689
Gompertz	3332	-811.927	-789.855	11	1601.711	1668.935
Log-Normal	**3332**	**-795.539**	**-761.230**	**11**	**1544.460**	**1611.685**
Log-Logistic	3332	-807.229	-772.537	11	1567.075	1634.299
Model 3						
Exponential	3332	-824.097	-790.912	11	1603.823	1671.048
Weibull	3332	-811.952	-786.132	13	1598.264	1677.711
Gompertz	3332	-811.927	-788.623	13	1603.246	1682.694
Log-Normal	**3332**	**-795.539**	**-759.131**	**13**	**1544.262**	**1623.709**
Log-Logistic	3332	-807.229	-770.405	13	1566.810	1646.258
Model 4						
Exponential	3332	-824.097	-784.515	13	1595.029	1674.476
Weibull	3332	-811.952	-779.021	15	1588.043	1679.713
Gompertz	3332	-811.927	-781.843	15	1593.687	1685.357
Log-Normal	**3332**	**-795.539**	**-753.282**	**15**	**1536.564**	**1628.234**
Log-Logistic	3332	-807.229	-762.953	15	1555.906	1647.576
Model 5						
Exponential	3332	-824.097	-780.355	17	1594.710	1698.602
Weibull	3332	-811.952	-774.808	19	1587.615	1703.731
Gompertz	3332	-811.927	-777.532	19	1593.064	1709.180
Log-Normal	**3332**	**-795.539**	**-749.346**	**19**	**1536.692**	**1652.808**
Log-Logistic	3332	-807.229	-762.953	15	1555.906	1647.576

Notes: Selected distribution in Bold.

Table 5: Determinants of Firm survival [Lognormal AFT model; R&D continuous variable]

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Main Equation: Dependent variable = $\ln(t)$					
ln(Sales)	0.266***	0.278***	0.274***	0.278***	0.270***
	(5.502)	(5.640)	(5.537)	(5.664)	(5.534)
Age	-0.047**	-0.052**	-0.051**	-0.050**	-0.056**
	(-1.979)	(-2.155)	(-2.089)	(-2.064)	(-2.198)
Age Squared	0.002*	0.002*	0.002*	0.002*	0.002**
	(1.752)	(1.918)	(1.857)	(1.892)	(1.990)
ln(Entry Size)	-0.147***	-0.157***	-0.156***	-0.163***	-0.161***
	(-2.845)	(-3.090)	(-3.069)	(-3.239)	(-3.246)
R&D expenses		0.129**	0.129**	0.128**	0.119**
		(2.087)	(2.076)	(2.074)	(2.047)
Assets		0.0001**	0.0001**	0.0002***	0.0002***
		(2.262)	(2.229)	(3.082)	(3.106)
Total Expenses		-0.002***	-0.002***	-0.003***	-0.003***
		(-2.862)	(-2.954)	(-3.127)	(-3.027)
Cash Flow			-0.001	-0.001	-0.001
			(-1.229)	(-1.091)	(-1.159)
Debt Equity Ratio			0.194	0.188	0.225*
			(1.605)	(1.563)	(1.844)
Investments				-0.0003**	-0.0003**
				(-2.131)	(-2.168)
Export Dummy	0.051	0.104	0.101	0.108	0.098
	(0.357)	(0.714)	(0.695)	(0.748)	(0.684)
Industry Dummy (CS =0)					-0.395**
					(-2.235)
Ownership Dummies (Foreign =0)					
Group					0.483**
					(1.979)
Private					0.240
					(1.054)
State					0.254
					(0.487)
Constant	2.045***	2.169***	2.144***	2.131***	1.918***
	(13.26)	(12.90)	(12.68)	(12.65)	(7.207)
Ancillary Equation: Dependent variable = $\ln(\sigma)$					
Export Dummy	0.232**	0.245***	0.238***	0.240***	0.186**
	(2.561)	(2.732)	(2.672)	(2.693)	(2.073)
Constant	0.089*	0.072	0.074	0.068	0.077
	(1.814)	(1.458)	(1.503)	(1.369)	(1.541)
Observations	3,332	3,332	3,332	3,332	3,332
Log Likelihood	-770.8	-761.2	-759.1	-756.8	-752.0

Notes: (1.) z-statistics in parentheses (2.) *** p<0.01, ** p<0.05, * p<0.1 (3.) The variables R&D expenses, Assets, Total expenses, Cash flow, Investments were normalized by sales before entering into the regression.

Table 6: Determinants of Firm survival [Lognormal AFT model; R&D dummy variable]

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Main Equation: Dependent variable = $\ln(t)$					
ln(Sales)	0.266***	0.270***	0.265***	0.269***	0.262***
	(5.502)	(5.413)	(5.313)	(5.441)	(5.322)
Age	-0.047**	-0.051**	-0.050**	-0.049**	-0.055**
	(-1.979)	(-2.129)	(-2.063)	(-2.039)	(-2.176)
Age Squared	0.001*	0.001*	0.001*	0.002*	0.002*
	(1.752)	(1.819)	(1.761)	(1.798)	(1.906)
ln(Entry Size)	-0.147***	-0.154***	-0.153***	-0.161***	-0.159***
	(-2.845)	(-3.029)	(-3.008)	(-3.179)	(-3.183)
R&D Dummy		1.014***	1.009***	0.999***	0.929**
		(2.691)	(2.681)	(2.675)	(2.554)
Assets		0.0001**	0.0001**	0.0002***	0.0002***
		(2.209)	(2.174)	(3.034)	(3.061)
Total Expenses		-0.002***	-0.002***	-0.003***	-0.002***
		(-2.807)	(-2.898)	(-3.071)	(-2.973)
Cash Flow			-0.002	-0.001	-0.001
			(-1.246)	(-1.109)	(-1.176)
Debt Equity Ratio			0.194	0.187	0.224*
			(1.596)	(1.555)	(1.831)
Investments				-0.0003**	-0.0003**
				(-2.127)	(-2.165)
Export Dummy	0.051	0.098	0.095	0.102	0.094
	(0.357)	(0.672)	(0.650)	(0.703)	(0.657)
Industry Dummy (CS =0)					-0.391**
					(-2.207)
Ownership Dummies (Foreign =0)					
Group					0.492**
					(2.006)
Private					0.252
					(1.106)
State					0.281
					(0.536)
Constant	2.045***	2.171***	2.147***	2.134***	1.908***
	(13.26)	(12.88)	(12.66)	(12.63)	(7.145)
Ancillary Equation: Dependent variable = $\ln(\sigma)$					
Export Dummy	0.232**	0.251***	0.244***	0.245***	0.192**
	(2.561)	(2.794)	(2.725)	(2.746)	(2.130)
Constant	0.089*	0.072	0.074	0.067	0.077
	(1.814)	(1.449)	(1.498)	(1.364)	(1.531)
Observations	3,332	3,332	3,332	3,332	3,332
Log Likelihood	-770.8	-761.7	-759.6	-757.2	-752.5

Notes: (1.) z-statistics in parentheses (2.) *** p<0.01, ** p<0.05, * p<0.1 (3.) The variables R&D expenses, Assets, Total expenses, Cash flow, Investments and Forex Income were normalized by sales before entering into the regression.

Figure 1: Nelson-Aalen cumulative hazard estimates by Industry

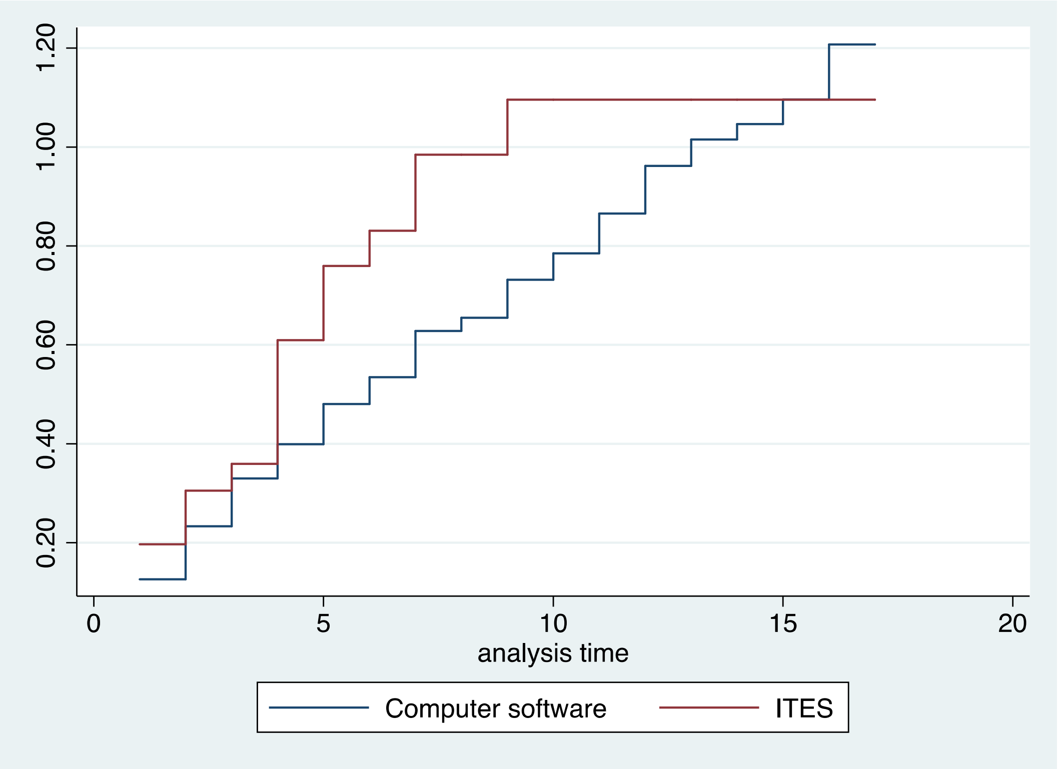

Figure 2: Nelson-Aalen cumulative hazard estimates by Ownership

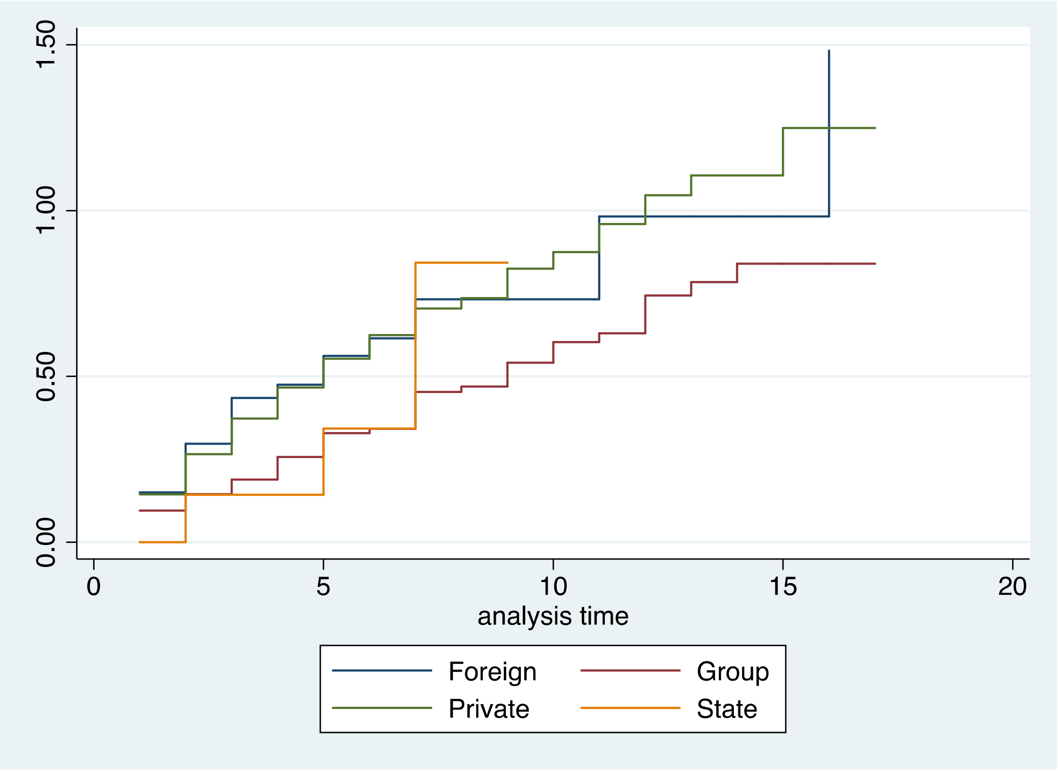

Figure 3: Nelson-Aalen cumulative hazard estimates by R&D expenditure

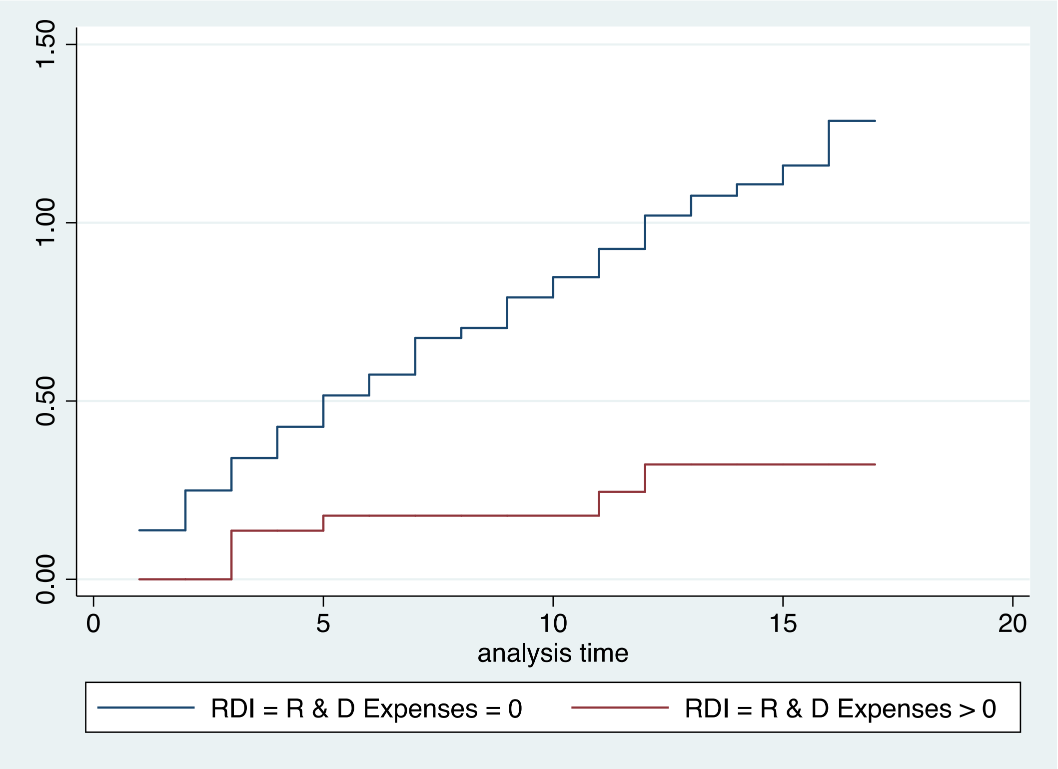

Figure 4: Estimated hazard function using mean values of all explanatory variables [based on Model 5, Table 5]

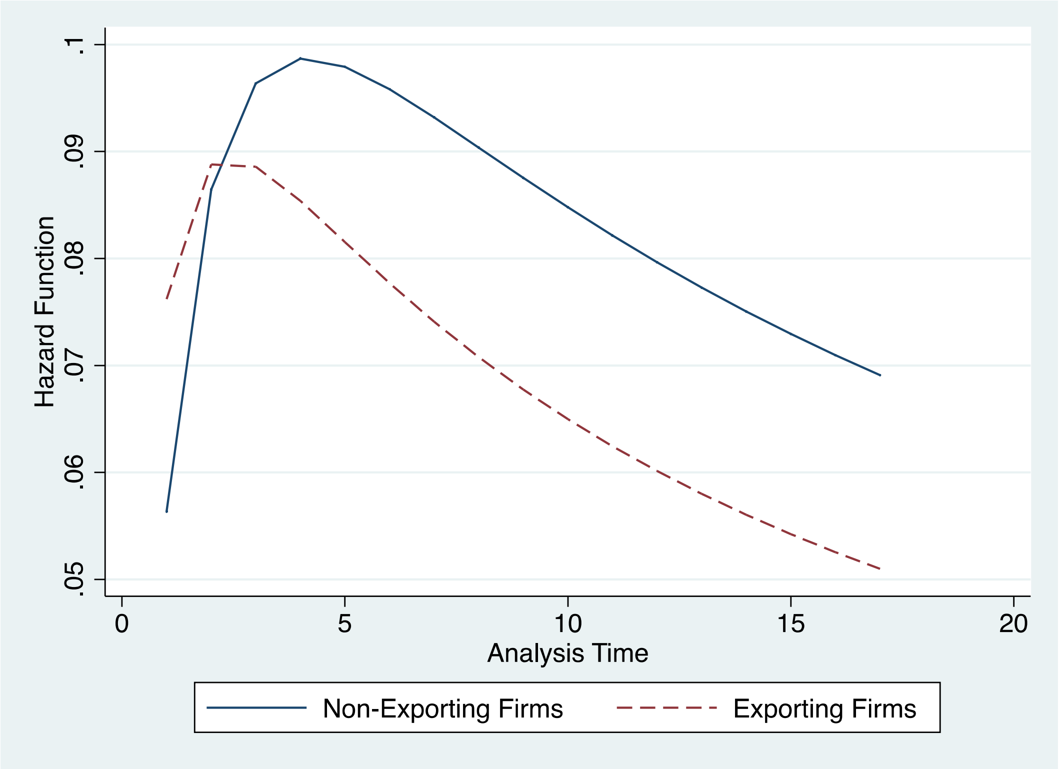

Figure 5: Estimated hazard function for different levels of R&D expenditure and mean values of all other explanatory variables [based on Model 5, Table 5]

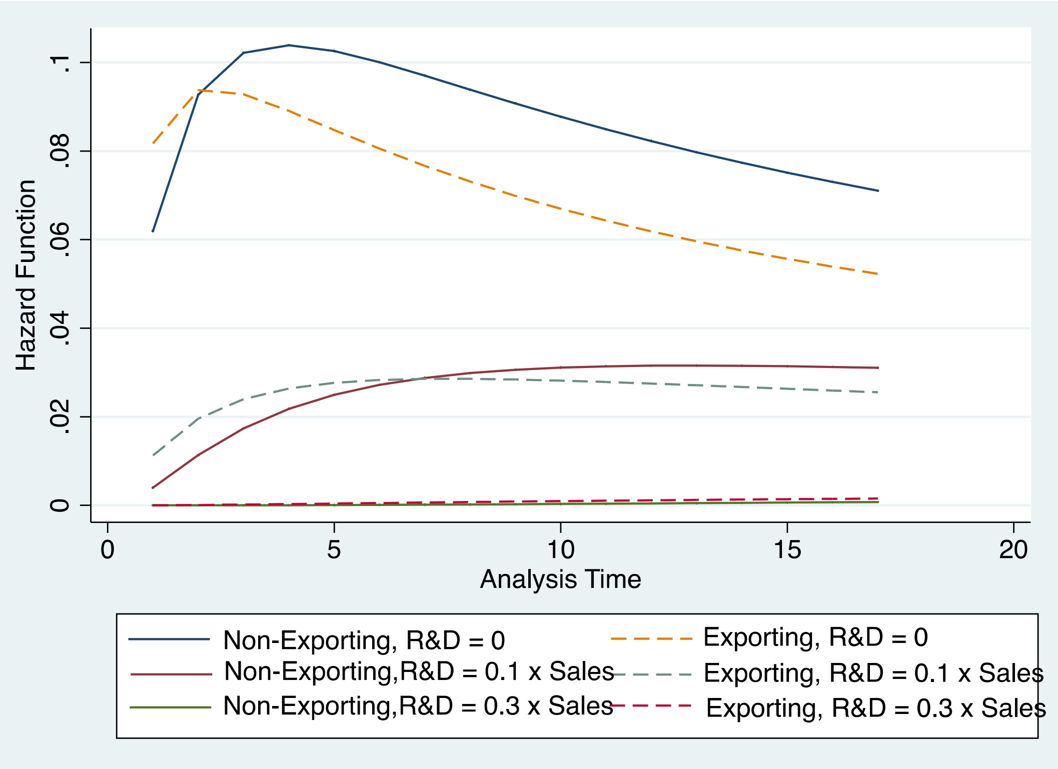

Figure 5: Estimated hazard function for different levels of R&D expenditure [dummy variable] and mean values of all other explanatory variables [based on Model 5, Table 6]