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Size, Innovation and Internationalization: A Survival Analysis of Italian Firms[1]

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Abstract

The birth of new firms and their survival in the market are often seen as crucial for economic growth and competitiveness in a modern economy. This paper focuses on business demography of Italian firms, using an original dataset obtained by merging Capitalia-Reprint and AIDA, to identify the relationships among firms' characteristics their demographic dynamics and survival. We show that size and technological level affect survival probability. Internationalized firms show higher failure risk: on average competition is stronger on international markets, forcing firms to be more efficient. An Italian long lasting successful internationalized firm is a high-tech, large and innovating firm.

Keywords: Business Demography, Survival, Competitiveness, Internationalization

JEL: C41, L11, L25, F21

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Introduction

Seven Years ago, the Lisbon European Council (2000) set the (ten-year goal) of making the European Union “the most dynamic, competitive, sustainable knowledge-based economy in the world, enjoying full employment and strengthen economic and social cohesion”. Priority actions were to encourage an entrepreneurial culture, create additional jobs, promote high technology and knowledge-intensive sectors of the economy, stimulate internationalization both trough exports and direct investments.

These goals are still far from being achieved especially in Italy, which lags behind other EU countries. ISTAT Annual Report (2005) and Eurostat (2006) point out, for instance, that 22% of the EU25 firms are Italian, but their weight in terms of employment is only 11%. The size of Italian firms is half the European average size; their productivity is 10% lower. Italian firms specialize in traditional sectors with a low productivity and a low technology. Hence, their specialization is far from the knowledge-intensive sectors promoted by the European Council, furthermore the international demand for traditional goods is low and grows less than the average demand for manufacturing. Finally, the turnover in Italy is incredibly high: 4 years after birth, only 60% of Italian firms survive.

The birth of new firms and their survival in the market are often seen as crucial for economic growth and competitiveness (see, Bartelsman, Scarpetta and Schivardi, 2003, Bartelsman, Haltiwanger and Scarpetta, 2004). New firms increase the competitive pressure on incumbents, therefore increasing efficiency. They stimulate innovation and make it easier to adopt new technologies, while helping to increase overall productivity, shifting resources from less to more productive activities and pushing the process of internationalization (export and FDI). This process has been described as the Schumpeterian *creative destruction*: technological innovations and new ideas about how to manage business continually reshuffle firms, giving rise to new enterprises competing with established ones and eventually driving-out old technologies.

This paper focuses on business demography of Italian firms to identify the relationships among firms’ characteristics and their competitiveness using, as a proxy, their demographic dynamics and survival. The aim of the paper is to show whether the firms' survival probability is related to their size, innovation, technological level (cf. Agarval e Audretsch, 2001) and their presence on foreign markets. To this aim we merge three dataset: Capitalia, ICE-Reprint, and AIDA. We define the span of survival as the difference between the year 2005 and the firm birth year. We analyze, firstly, the effect of export, FDI, innovation, size and technological level and R&D expenditures on the firms' probability of survival. Secondly, we estimate the differences in the likelihood of survival between large and small, exporting and non-exporting and innovating and non-innovating firms.

We show that size and technological level reduce the failure risk. The positive impact of technology increases with size: large firms that operate in high-tech sectors, on average, have higher probability of survival than small firms in traditional sectors. Internationalized firms, on the other hand, show higher failure risk: on average the competition on international markets is stronger. For innovating firms, the failure risk is reduced if they operate in high-tech sectors. On the contrary, non-innovating firms can survive only if they are large enough to exploit their market power. Hence, a successful internationalized firm is a high-tech, large and innovating firm.

The demography of firms: an overview

In 1931 a French engineer, Robert Gibrat, proposed an explanation for skew size distributions in a number of environments ranging from biology to income distributions[2]. He also described the size distribution of firms in manufacturing industries and showed that firms distribution is well approximated by a Log Normal, hence, a firm's absolute rate of growth could be represented by a random variable whose mean is proportionate to the current firm size or, equivalently, that the proportionate rate of growth is represented by a random variable with mean independent of the current firm size, the so called *Law of Proportionate Effects.* According to the law, the expected value of the

[2] He traced the origin of this thinking to the work of Jacobus Kapteyn (1916), an astronomer who was interested in the evidence of skew distributions in various settings, especially in biology. Kapteyn assumed that underlying a skewed distribution was a simple Gaussian process: many small additive elements independent of each other generate a normally distributed random variable *z*. An observed skew distribution of some *z* could be modelled assuming that some underlying function of *x* was normally distributed. Gibrat used the simplest of such processes suggesting that the logarithm of *x* developed as Kapteyn described.

increment to a firm's size in each period is proportional to the current size of the firm[3]. In the 1960s the so called ''golden age for stochastic models of the size distribution'' various models relied on Gibrat's approach to explain firm's dynamics (Steindl, 1965) and started to relax some stringent assumptions on entry and exit of firms; but, in general maintained the Gibrat's Law to specify the size-growth relationship for surviving and successful firms (Simon and Bonini 1958, Bottazzi et al., 2007).

This literature on firm dynamics and industry evolution, however, tends to reject the *Law*. Both Geroski (1995) and Sutton (1997, 1998) emphasize the existence of strong relationship between the likelihood of survival and the firm size, and almost all empirical studies find that the firm size is positively related to the likelihood of survival. More specifically, Sutton (1997) shows that size at time *t* is linked to the growth in the subsequent period[4]. Geroski (1995) shows that, because small firms have a lower likelihood of survival than larger firms and the likelihood of small-firm survival is directly related to growth, firms' size is negatively related to growth. This implies that the greater the "entry size" in a given industry, the greater the likelihood of survival confronting the new entrants; i.e. "entry appears to be relatively easy, but survival is not" (Geroski, 1995). In this line, some studies suggest that, on average, smaller firms have a lower probability of survival but those who survive grow proportionately faster than larger firms (Evans, 1987; Hall, 1987, Agarval and Audretsch, 2001).

Empirical research on the size-growth relation covers different time periods and countries and generally supports a positive relationship between firms'

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[3] Size can be measured in several ways and the Gibrat's observations have applied to measures of annual sales, of current employment and of total assets. There are in principle systematic differences between these measures but this is not the focus of interest in this literature. We can sketch the argument proposed by Gibrat following Steindl (1965): let *x* be the size of the firm at time *t* and let ε_t be the random variable denoting the proportionate rate of growth between *t-1* and *t* so that

$$x_t - x_{t-1} = \varepsilon_t x_{t-1}$$

hence

$$x_t = (1+\varepsilon_t)x_{t-1} = x_0(1+\varepsilon_1)(1+\varepsilon_2)...(1+\varepsilon_t)$$

if we choose a short time period, if ε_t is small, then $\log(1+\varepsilon_t) \cong \varepsilon_t$. Taking logs, we obtain

$$\log x_t \cong \log x_0 + \varepsilon_1 + \varepsilon_2 + ... + \varepsilon_t$$

By assuming the increments ε_t to be independent random variables with mean μ_t and variance σ^2, we have that if $t \to \infty$, the term $\log x_0$ will be small if compared to $\log x_t$, hence $\log x_t$ can be approximated by a normal distribution with mean μ_t and variance σ_t^2, that is the limiting distribution of X_t is lognormal.

[4] This specification follows from the assumption that the probability that the next opportunity is taken by a firm is proportional to the current size of the firm, which is the assumption underlying the Gibrat's Law.

size and likelihood of survival[5]. These empirical studies are consistent with theories on industry evolution suggesting that the number and the evolution of entrants in an industry may not be invariant to the stage of life cycle (Agarval and Gort, 1996, Agarval, 1998): the number of entrants can be a proxy for the number of innovations in an industry and evolves over the life-cycle; moreover, the role of innovation in entries changes in the "entrepreneurial" and in "routinized" technological regimes (Audretsch, 1995). According to the theory of strategic niches (Caves and Porter, 1977; Porter, 1979), firms remain small because they occupy product niches that are not accessible to their larger counterparts. Hence, size represents an advantage in increasing the likelihood of survival in the formative, more technological advanced stage of the industry, but not in a mature stage and in traditional sectors in which the size advantage should not be statistically significant.

The Econometric Techniques

To analyze whether the likelihood of survival is invariant to firm size and to technological intensity we use the *Analysis of Duration* (Lancaster, 1990) that allows to estimate the *length of the time until failure*[6]. The variables of interest in the analysis of survival are the length of time that elapses from the beginning of some events either until their end or until the measurement are taken which may precede termination. Observations will typically consist of a cross section of durations $t_1, t_2, \ldots, t_n \in T$, where T is a random variable (discrete or continue), and for this type of data the analysis of duration allows to estimate the probability that the event "failure" appears next period. In this paper the variable of interest is called span (span of survival) and is calculated as the difference between time t and the firm's set up year while the "failure" event starts with a procedure of insolvency (Agarval and Audretsch, 2001). The process being observed may have begun at different points in time and, because its length is not constant over time, the random variable T is unavoidably censored.

[5] See for instance Dunne, Roberts and Samuelson, 1988,1989; Audretsch, 1991, 1995, Agarval, 1997; Mata, Portugal, 1994, Agarval and Audretsch, 2001, Eurostat, 2006; Bartelsman, Scarpetta and Schivardi, 2003; Bartelsman, Haltiwanger and Scarpetta, 2004.

[6] Simple examples are the length of a strike, the durability of electric and electronic components, the length of survival after the diagnosis of a disease or after an operation and time until business failure.

Let T be a random variable with a cumulative probability

$$F(t) = \int_0^t f(s)ds = \Pr(T \leq t)$$

where *f(t)* is the continuous probability distribution. We are interested in the probability that the period is of length at least *t*, which is given by the *survival function*

$$S(t) = 1 - F(t) = \Pr(T \geq t)$$

and the probability that the phenomenon will end the next short interval of time Δ is

$$l(t,\Delta) = \Pr(t \leq T \leq t + \Delta \mid T \geq t)$$

To describe this we use the *Hazard Rate:*

$$\lambda(t) = \lim_{\Delta \to 0} \frac{\Pr(t \leq T \leq t + \Delta \mid T \geq t)}{\Delta} = \lim_{\Delta \to 0} \frac{F(t+\Delta) - F(t)}{\Delta S(t)} = \frac{f(t)}{S(t)}$$

which is the rate at which spells are completed after duration *t*, given that they last at least until *t*. We estimate the parameter λ using Maximum Likelihood by the *Cox Proportional Hazard Regressions* to measure the effect of different regressors (in our case entry size and technological level) on the survival probability of the phenomenon, estimating the regressors *hazard rates.*

The *hazard function* $h_i(t)$ of a firm *i* is expressed as

$$h_i(t) = h(t, x_i) = h_0(t)\exp(x_i^{'}\beta)$$

$h_0(t)$ being an arbitrary and unspecified baseline hazard function representing the probability of failure conditional on the fact that the firm has survived until time *t*, x_i is a vector of measured explanatory variables for the *i-th* firm and β is the vector of unknown parameters to be estimated. Negative coefficients or risk ratios less than one imply that the hazard rate decreases and the corresponding probability of survival increases.

Life-table analysis, estimating the survival rate at time *s*, where s is defined as the fraction of the total number of firms that survived at least *s* years, can also be used to show firms survival and failure rates. Life tables give the number of firms that die conditional on their age, i.e. they represent the probability of failure given that the firm has survived *s* years. We run two tests of homogeneity (the parametric Likelihood Test and the nonparametric Log-Rank) to check for significance of differences between large and small entry size survival rates within the different environments based on the technological level.

Data and Results

We use a merge of a dataset provided by Capitalia (2005) the ICE-Reprint database 2000-2003, and AIDA[7]. The merge provides information on firms' process of internationalization, economic performance, innovative capacity and growth for 4289 manufacturing firms.

The independent variable (span of survival) is calculated as:

$$S_t = A_t - A_0 + 1$$

where A_t is the year corresponding to the balance sheet at year t and A_0 is the firms' birth year. S_t is a censored variable because the exit from the market can happen during or before 2005 due to winding-up, failure or the end of the activity. In the survival analysis, S_t represents the "failure" variable on which the exit probability is worked out. Hence, biased estimates can be avoided distinguishing firms that failed during 2005 from those still alive during 2005 that are not followed anymore because of the dataset structure.

The technological dummy is built on the Pavitt taxonomy[8]. It is equal zero when the firm works either in traditional or in scale sectors and one otherwise.

Size is generated from firm's total sales: we use 5 equally represented classes which, because of the high skewness of the Italian firms' distribution, allow us to avoid classifying most firms as "small". Following the procedure introduced by Geweke, Marshall and Zarkin (1986), to avoid inconsistency problems in the axioms at the basis of the discrete Markov Chains theory (*Fractile Markov Chains)*, we do not use *equally sized* but *equally represented* classes; in other words, $\forall t$ and $\forall j: 1, 2, \ldots, n$, $\pi_{j,t} = n^{-1}$, t being time, j are the n classes and $\pi_{j,t}$ denotes the proportion of the population in class j at time t. Hence, we define a number of classes such that the proportion of the population (asset size of the firms) in each class j, for each t, is constant and equal to n^{-1}.

We use a specific question of the Capitalia survey to define the dummy on the innovative capacity. It is equal one if in the period 2001-2003 the firm has introduced into the market any kind of innovative product or it has set up either a new production

7 Cf. De Benedictis and Giovannetti (2008) also explain the construction of ICE-Reprint database.

8 The Pavitt taxonomy distinguishes between traditional, specialized, scale and high-tech sectors. Since in the scale sectors there are some firms that cannot classified as "low tech", we run the models using (1) a dummy assuming 0 only for traditional sectors and 1 otherwise and (2) the 4 Pavitt classes. Results, available upon request, are robust.

process or an innovation in the labor organization. Finally, dichotomic variables are also defined on whether firms export, invest abroad and/or invest on R&D activities.

Innovation, export, R&D, technology and FDI variables are drawn from Capitalia and ICE-Reprint database (2001-2003) to show the effects of internationalization and innovation on firms' size and their probability of survival.

Table 1 reports summary statistics, showing that the firms' average age is 24.78 years, which is quite high if compared to the corresponding age of the Italian firms (even if standard deviation is very high). 74.6% of sample exports, only 10.5% makes FDIs. Moreover, in the period 2001-2003, 62% of firms reported at least one innovation[9], while only 44% of them spent on R&D.

Table 1 around here

Table 2 presents results for both the entire sample and for sub-samples. We split the sample looking at small (class 1) and medium-large (classes 2-5), export and non-export, and innovative and non-innovative enterprises.

Size is always relevant and has a positive effect in increasing survival probability. It means that independently from the main characteristics of the economic system, larger enterprises have a higher probability to survive. However, the variable presents different effects among the various specifications.

Considering the whole sample, all variables but innovation are significant. Larger size and operating in high-tech sectors increase the survival probability, while internationalizing (either by exporting or making FDI) has the opposite effect: competition in international markets is harder and increases the risk of failure (more specifically, to export increases the risk of failure by 32% and to invest abroad by 38%). In Figure 1 we report the smooth hazard function for the whole sample.

Figure 1 around here

It is worth noting that size plays a more important role for exporting that for non-exporting firms. Moreover, size reduces by 20% the failure risk for innovative firms but 22% for non-innovative firms. Producing in high-tech sectors reduces the risk of

[9] We do not distinguish between product, process and organizational innovations.

failure. Particularly, firms that export high-tech goods are less vulnerable and their probability of survival increases by roughly 33%. It seems that the best strategy for this kind of firms is to operate in high-tech sectors and secondly to grow larger.

If we split small from medium and large firms, we notice that for the former technology has a weakly (significant) effect while for the latter a huge (-30%) impact on failure risk. This seems to support somehow the theory of strategic niches: some firms remain small because they have a comparative advantage due to the peculiar nature of the goods produced (mainly with a low degree of technology), advantage that can disappear if the enterprise grows in dimension. Finally, in the sample considered, the innovative firms have higher survival probability (+42.2%). On the contrary, for non-innovative firms operating in traditional sectors, the technological level of the goods produced does not have any effect on the failure risk. Figures 2 to 6 report sub-sample smoothed hazard functions.

Figures 2 to 6 around here

In summary, we can say that exporting and innovative activity are (on average) more risky if the firm is small and produce traditional goods. On the other hand, size plays a crucial role for those firms operating only in Italy and for non-innovative firms; in these cases, technology does not have significant effects on survival probability.

Conclusions

Our empirical application to the Italian economy suggest that for Italian firms: 1) size and technological level reduce the Italian firms' failure risk: the larger the firm, the greater the positive effect of technology on survival probability; 2) being an exporter and investing abroad reduce their survival probability: on average, the exposure to the strong competition on international markets increases the firms' risk of failure. Moreover, competitive firms on international markets tend to be bigger and operating in high-tech sectors. 3) Comparing exporting and non-exporting firms, size and technology have a stronger impact for the former than for the latter. Similarly, for innovative firms it is crucial to operate in high-tech sectors, while non-innovative firms can survive longer exploiting the market power (proxied by size).

Hence, we can claim that, in Italy in the last few years a long lasting successful firm is big and innovative, operates in high-tech sectors, and is a key player on international markets. This a clear implication for economic policy.

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Table 1 – Descriptive Statistics (average and standard errors of the sample)

Variables	Export	Non-Export	Small	Medium - Large	Innovative	Non - Innovative	All Sample
Size	3.199	2.393	1	3.497	3.128	2.775	2.994
	(1.384)	(1.328)	(0)	(1.117)	(1.391)	(1.424)	(1.414)
Age of the Firm (Span)	24.955	24.265	22.526	25.348	24.809	24.731	24.78
	(15.947)	(14.885)	(13.384)	(16.167)	(15.246)	(16.381)	(15.687)
Technology	0.357	0.182	0.294	0.317	0.354	0.245	0.313
	(0.479)	(0.386)	(0.456)	(0.465)	(0.478)	(0.43)	(0.464)
Innovation	0.671	0.471	0.528	0.643	1	0	0.62
	(0.47)	(0.499)	(0.499)	(0.479)	(0)	(0)	(0.485)
Export	1	0	0.579	0.788	0.807	0.647	0.746
	(0)	(0)	(0.494)	(0.409)	(0.395)	(0.478)	(0.435)
FDI	0.132	0.026	0.037	0.123	0.12	0.081	0.105
	(0.339)	(0.16)	(0.189)	(0.328)	(0.325)	(0.273)	(0.307)
R&D	0.528	0.213	0.318	0.481	0.622	0.163	0.448
	(0.499)	(0.41)	(0.466)	(0.5)	(0.485)	(0.37)	(0.497)
Observations	**15710**	**5345**	**4241**	**16814**	**13055**	**8000**	**21055**

Tabella 2 – Cox-Regressions

	All Sample	Export	Non – Export	Small	Medium - Large	Innovative	Non – Innovative
Size	0.756	0.77	0.836			0.807	0.786
	[0.024]***	[0.025]***	[0.057]***			[0.030]***	[0.037]***
Technology	0.652	0.668	0.98	0.805	0.693	0.578	1.15
	[0.055]***	[0.060]***	[0.195]	[0.105]*	[0.073]***	[0.061]***	[0.148]
Innovation	0.898						
	[0.069]						
Export	1.32						
	[0.116]***						
FDI	1.38						
	[0.160]***						
R&D	1.448						
	[0.112]***						
Observations	21055	15710	5345	4241	16814	13055	8000
Exits	832	645	187	317	515	517	315
Log Likelihood	-7564.68	-5666.549	-1469.31	-2345.577	-4627.032	-4431.377	-2596.965
Chi-square	117.75	83.33	7.14	2.79	12.24	64.01	26.42
p-value	0	[0.000]	[0.028]	[0.095]	[0.001]	[0.000]	[0.000]

Robust Standard Errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1 Hazard Function All Sample

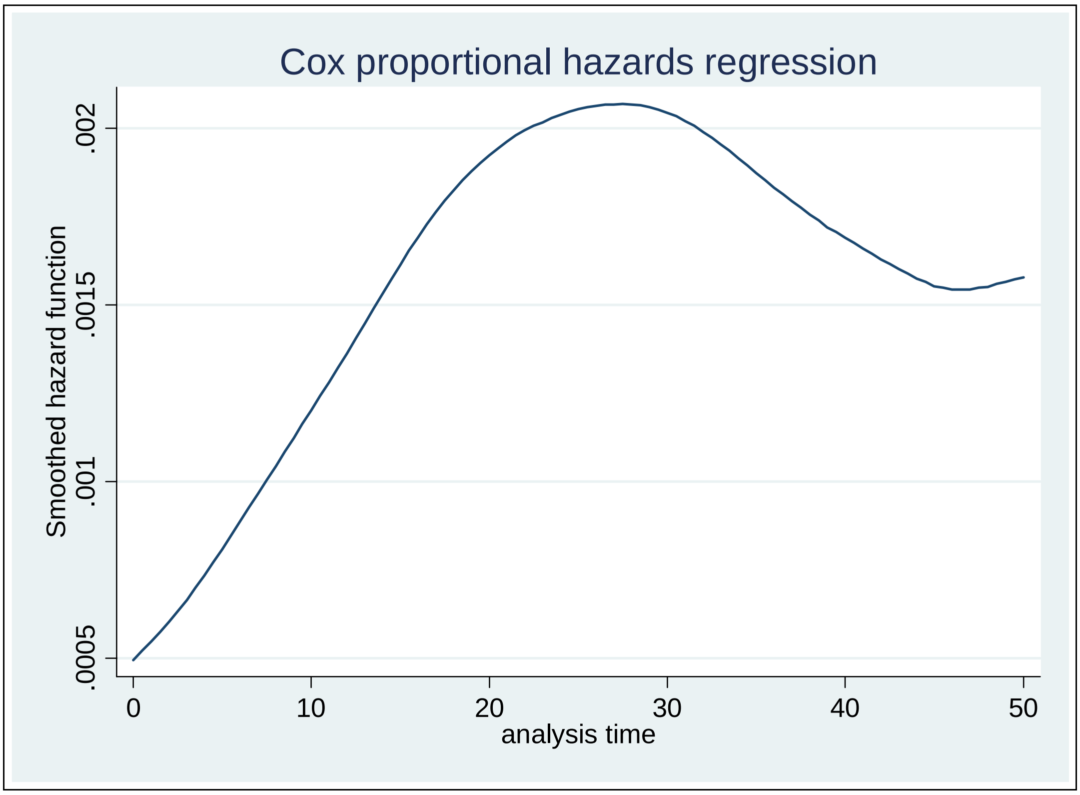

Figure 2 Hazard Functions for smallest and biggest firms

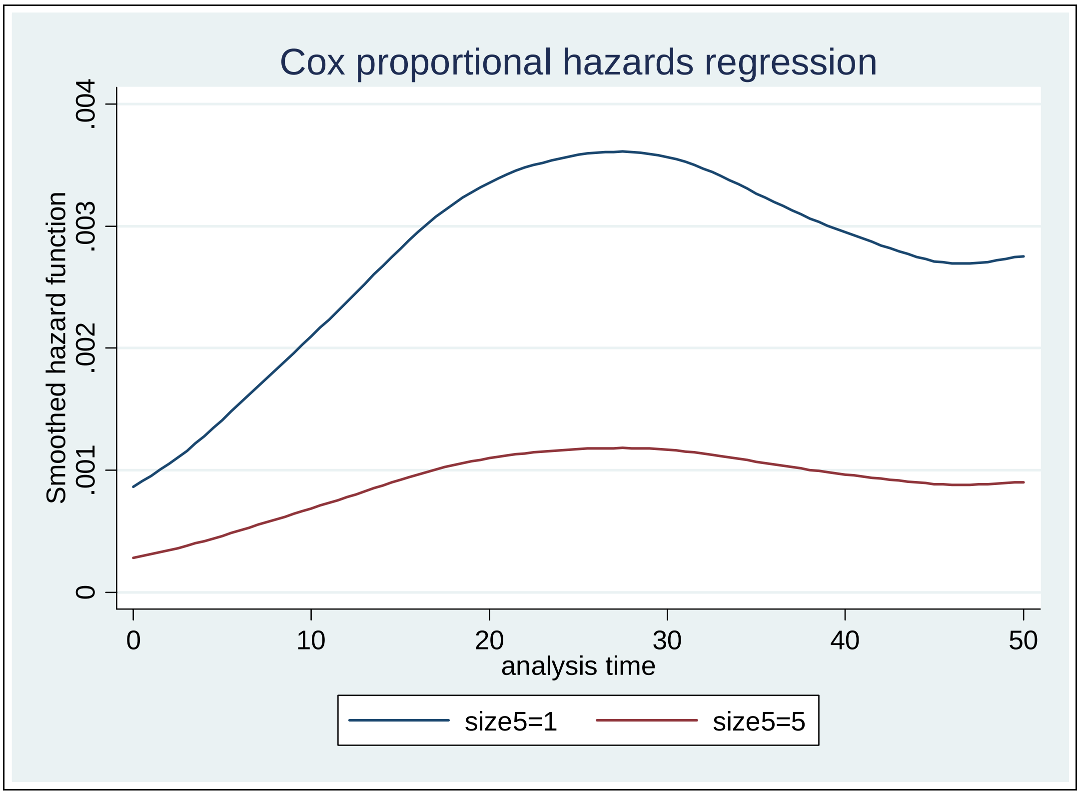

Figure 3 Hazard Function for Low and High Tech Firms

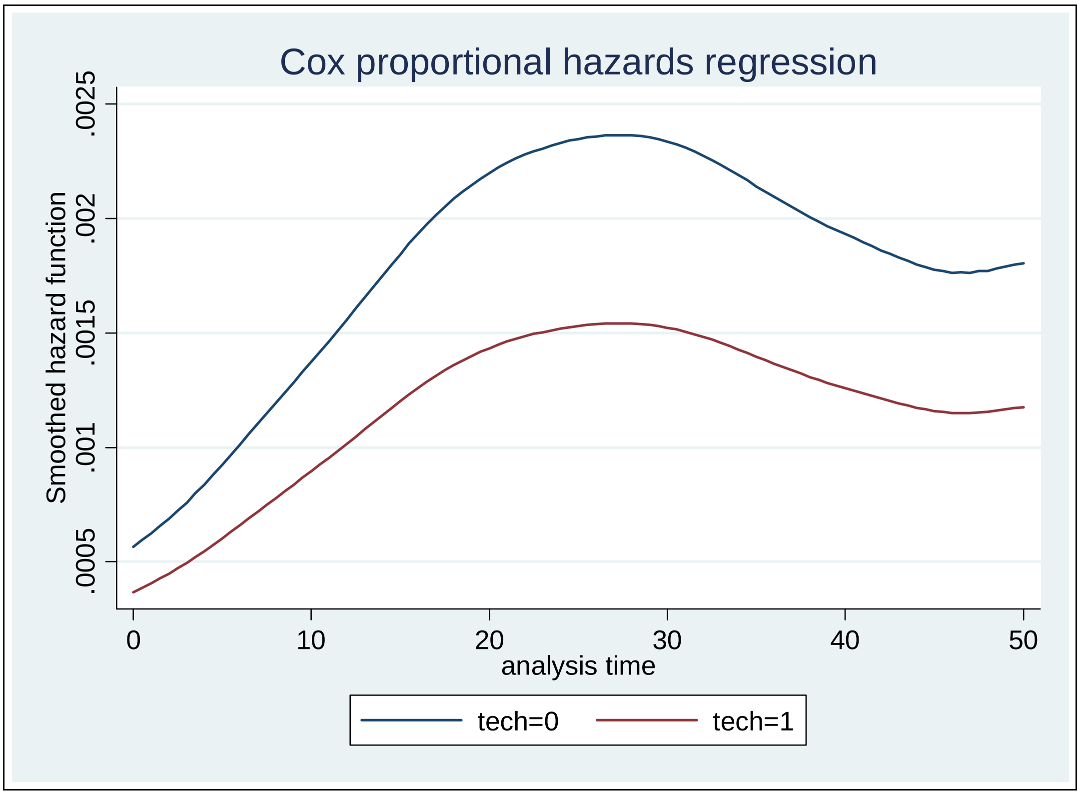

Figure 4 Hazard Function for FDI and Non-FDI Makers

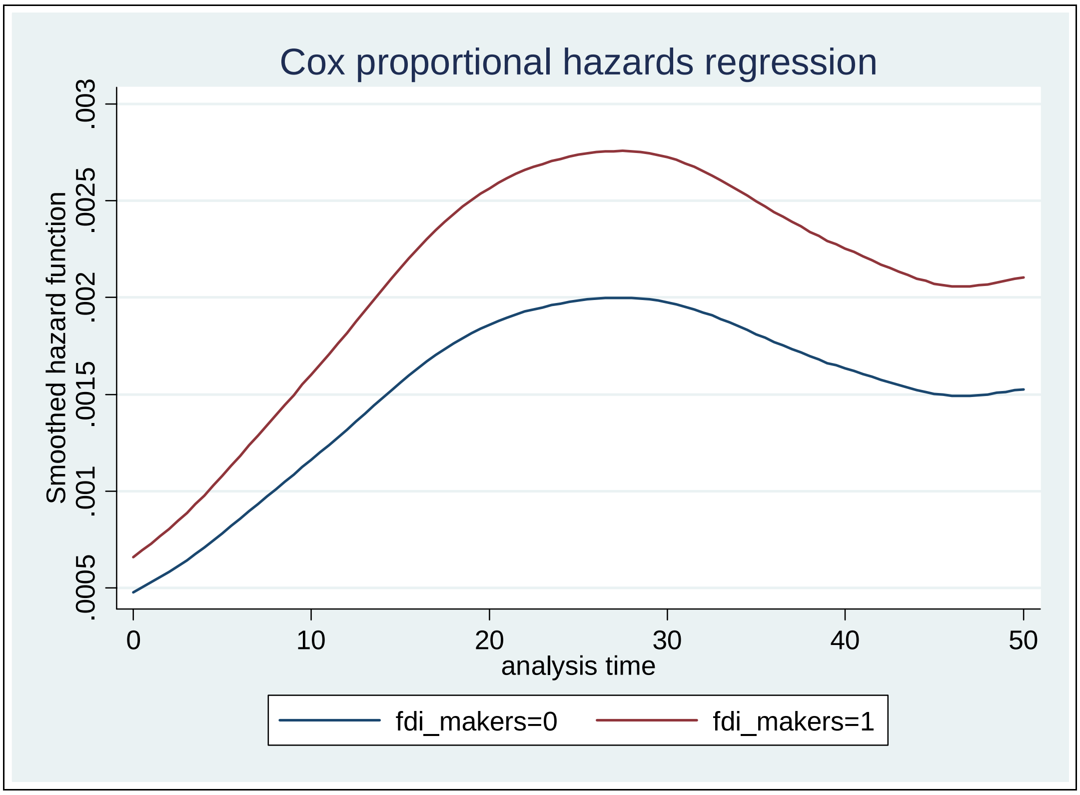

Figure 5 Hazard Function for Exporting and Non-Exporting Firms

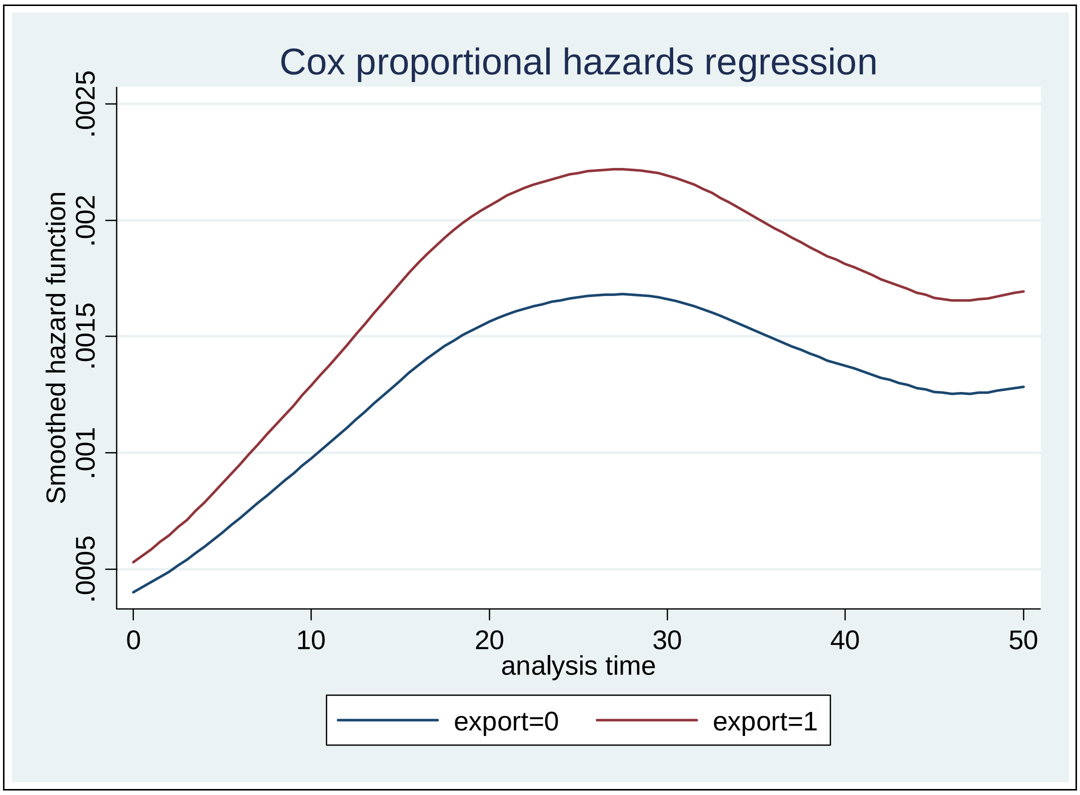

Figure 6 Hazard Function for Innovative and Non-Innovative Firms