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

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Abstract

Firms' survival is often seen as crucial for economic growth and competitiveness. This paper focuses on business demography of Italian firms, using an original database, obtained by matching and merging to gain the intersection three firm level datasets. This database allows us to simultaneously consider the effect of size, technology, trade, foreign direct investments, and innovation on firms' survival probability. We show that size and technological level positively affect the likelihood of survival. Internationalized firms show higher failure risk: on average competition is stronger in international markets, forcing firms to be more efficient. However, large internationalized firms are more likely to 'survive'. An Italian internationalized firm to be successful and to survive, should be high-tech, large and innovative.

Keywords: Business Demography, Survival, Competitiveness, Internationalization
JEL: C41, L11, L25, F21

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1. Introduction

Several 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 economic and social cohesion". Priority actions were designed to encourage an entrepreneurial culture, create additional jobs, promote high technology and knowledge-intensive sectors of the economy, and stimulate internationalization both through exports and foreign direct investment (FDI). These goals are still far from being achieved, especially in Italy, which seems to lag behind other EU countries in terms of the Lisbon targets, therefore representing an interesting case to focus on.

Data from ISTAT (2005) and Eurostat (2006) highlight 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 and their productivity is 10% lower. Italian firms specialize in traditional low tech sectors characterized, in general, by lower productivity. Their specialization is, therefore, far from being the knowledge-intensive kind promoted by the European Council. Moreover, the international demand for traditional goods such as those produced in Italy is low and grows less than the average demand for manufacturing. These characteristics help explain the incredibly high turnover of Italian firms: 4 years after birth, only 60% of Italian firms survive, and the figure is even less for those that operate in international markets.

A recent and increasing literature has pointed out the importance of firms' survival, as well as turnover, entry of new firms, start up, incubators etc. for growth and competitiveness of a country (see for instance Bartelsman *et al*., 2003, Bartelsman *et al.* 2004). A different strand of literature emphasizes that firms involved in international activities through export or FDI are "different" from purely domestic firms in several respect, productivity, wages, skill intensity (see for all Mayer and Ottaviano, 2008). In this paper we draw on these two so far unrelated strands of the literature and assess the relationships among firms' characteristics and their competitiveness by analyzing demographic dynamics and survival of Italian firms. More specifically, we show how the probability of survival is related to firms' size, innovation and technological level (in line with Agarwal e Audretsch, 2001) but also to firms' presence in foreign markets, both as exporters and foreign direct investors (in line with Mayer and Ottaviano, 2008).

We rely on an innovative dataset obtained by matching and merging three different firm level databases for Italy which allows us to analyze the effect of exports, FDI, innovation, size, technological level and R&D expenditures on the firms' probability of survival for the period 2001-2005 in Italy. We find that size and technological level reduce the risk of failure (exit). Furthermore, the positive impact of technology increases with size: large firms that operate in high-tech sectors, on average, have a higher probability of survival than small firms in traditional sectors. Internationalized firms, on the other hand, show higher failure risk since, in general, competition in international markets is stronger. Our results also show that, for innovative firms, the failure risk is reduced if they operate in high-tech sectors, while non-innovative firms can survive longer if they are large enough to exploit their market power. Hence, in Italy, a successful and long-lived internationalized firm should be high-tech, large and innovative. After a brief overview of two strand of the literature (Gibrat's Law and business demography on the one and internationalization on the other hand), we sketch the econometric techniques used (Section 3) and then we present, in Section 4, our results. Section 5 concludes.

2. From Gibrat's Law to firms' demography: domestic versus "international" firms

Back in 1931, Robert Gibrat proposed an explanation for skew size distributions in a number of different environments, ranging from biology to astronomy. In particular, describing manufacturing industries, he showed that the firms' size distribution is well approximated by a Log Normal: "the probability of a given proportionate change in size during a specified period is the same for all firms in a given industry – regardless of their size at the beginning of the period" (Mansfield, 1962, p. 1031). This regularity is known as the Law of Proportionate Effect or Gibrat's Law.

Until the 1970s this Law was popular, not only because it was coherent with dynamic patterns of manufacturing firms in different countries but also because of its compatibility with different theoretical models. However, empirical testing soon became controversial, while theoretical models started developing different lines of research (cf. Santarelli et al, 2006), the most promising of which emphasized the existence of a strong relationship between the likelihood of survival and firm size.[2] "Because small firms have a lower likelihood of survival than their larger counterparts, and the likelihood of small firms' survival is directly related to growth, firms' size is found to be negatively related to growth, thereby refuting Gibrat's Law" (Agarwal and Audretsch, 2001, pp 22). Hence, the greater is the "entry size" in a given industry, the higher the likelihood of survival of new entrants. On average, therefore, smaller firms have a lower probability of survival; however those who survive grow proportionately faster than larger firms (Jovanovic, 1982; Evans, 1987; Hall, 1987, Agarwal and Audretsch, 2001). Furthermore, "entry appears to be relatively easy, but survival is not" (Geroski, 1995), so that turnover can be high, especially in highly competitive markets.

A vast number of recent empirical studies, covering different time periods and countries,[3] finds that size increases the likelihood of survival in the more technological advanced industries, but not in traditional sectors. Most of these studies are consistent with theories of industry evolution (Agarwal and Gort, 1996, Agarwal, 1998, Audretsch,

[2] See the influential surveys by Geroski, 1995, Sutton, 1997 , Caves, 1998 and the paper by Holmes et al., 2008.

[3] See, for instance, Dunne, Roberts and Samuelson, 1988, 1989 (US); Audretsch, 1991, 1995 (US); Agarwal, 1997 (US); Mata, Portugal, 1994 (Portugal); Agarwal and Audretsch, 2001 (US); Eurostat, 2006 (EU); Bartelsman et al., 2003 (OECD); Bartelsman et al., 2004 (EU and Americas). There are several applications to the service sector pointing to the positive effect of size and diversification (see Santarelli, 1998 and Leong et al., 2003).

1995) and with the theory of strategic niches (Caves and Porter, 1977; Porter, 1979). According to the latter, firms remain small because they occupy product niches that are not easily accessible or profitable for their larger counterparts. A different strand of the literature has emphasized firms' heterogeneity and focused on the existence of substantial differences between domestic and internationalized firms.

The underlying idea is that there are relatively few firms 'fit' to cope with the more competitive international markets and these firms are more productive, pay higher wages, employ more skilled workers, invest more in R&D.[4] In a seminal paper, Melitz (2003) maintains that firms with different level of international involvement, which are randomly allocated a productivity level, are clearly ranked: exporters are more productive than domestic firms, foreign investors more productive than exporters and so on. Our purpose is to link the literature on survival with that on mode of internationalization. To the best of our knowledge there are few studies, if any, that look simultaneously at the role of size, technology and internationalization on firms' survival rates. As will be emphasized below, some of our results are in line with the theoretical findings of the recent literature on internationalization (see Mayer and Ottaviano, 2007).

4 More precisely, this literature can be split in two: on the one side the seminal paper by Melitz, 2003 and the papers surveyed in Meyer and Ottaviano, 2008, which focus on the ranking and on the different productivity levels of firms with different international involvement. On the other hand, a large literature on learning by exporting, pioneered by Clerides, Lach and Tybout, 1998. Only some of our results, as will be emphasized below, are in line with the theoretical findings.

3. The Econometric Techniques

To analyze whether the likelihood of survival is invariant to firm size, international involvement and to technological intensity we use the *Analysis of Duration* (Lancaster, 1990) that allows us to estimate the *length of the time until failure.*[5] The variable of interest in the analysis of survival is the length of time that elapses from the beginning of some events either until "their" end or until the end of the analysis. 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 continuous), and for this type of data the analysis of duration allows one to estimate the probability that the event "failure" occurs next period. In this paper the dependent variable is the span of survival and is calculated as the difference between time *t* and the firm's set up year while the "failure" event includes winding-up, failure or end of activity (Agarwal and Audretsch, 2001). The process observed may have started at different points in time and, because its length is not constant over time, the random variable *T* is unavoidably censored.

Let *T* be a random variable with a cumulative probability

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

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*

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

[5] 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.

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

$$l(t,\Delta) = \Pr(t \le T \le t + \Delta \,|\, T \ge t).$$

The Hazard Rate, i.e. the rate at which spells are completed after duration *t*, given that they last at least until *t*, is:

$$\lambda(t) = \lim_{\Delta \to 0} \frac{\Pr(t \le T \le t + \Delta \,|\, T \ge t)}{\Delta} = \lim_{\Delta \to 0} \frac{F(t+\Delta) - F(t)}{\Delta S(t)} = \frac{f(t)}{S(t)}$$

To measure the effect of different regressors (in our case entry size and technological level) on the survival probability of the phenomenon, we estimate the parameter λ using Maximum Likelihood by the *Cox Proportional Hazard Regressions.*

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 *t* 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 t years. To check for significance of differences between groups, tests of homogeneity are usually run (in the following we use the nonparametric Log-Rank, Wilcoxon, Tarone-West and Peto-Peto-Prentice tests). At each failure time t, the test statistics is obtained as a weighted standardized sum of the difference between the observed and expected number of exit in each of the k-groups. The null hypothesis is no difference between the survival functions of the k-groups. The weights functions used determine the test statistics (see Klein and Moeschenberger, 2003).

4. Data and Results

We match and merge to gain the intersection of three different datasets: Capitalia, ICE-Reprint and AIDA.[6] AIDA provides standard data on budgets of Italian companies, Capitalia's Observatory on Small and Medium Size Firms is a survey on a representative sample of over 4000 Italian firms, providing information on R&D, innovation, destination markets for exports etc. The sample includes all firms with more than 500 employees and firms with less than 500 employees selected using a stratified design on location, industrial activity and size. Finally, the ICE-Reprint database is the census of foreign affiliates of Italian firms and provides information on number of employees and sales (for details, see Mariotti and Mutinelli, 2005). In this paper, we use ICE-Reprint for information on foreign direct investment. Hence, our consolidated

6 Capitalia (9th survey, 2005) has data for the period 2001-2003, ICE-Reprint provides information for the period 2001-2003. See De Benedictis and Giovannetti (2008) for further information on the dataset and for the main characteristics of ICE-Reprint database. AIDA provides the budget and entrepreneurs' data for the period 2001-2005. See below for the exact source of each variable.

dataset provides information on firms' processes 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 end of activity. In the survival analysis, S_t represents the "failure" variable on which the exit probability is worked out. Hence, we can avoid biased estimates by distinguishing firms that failed during 2005 from those still alive in 2005 that are no longer included in the dataset as a result of falling outside the sample frame.

The technological dummy is built on the Pavitt taxonomy. It is equal zero when the firm works in traditional or in scale sectors and one otherwise.[7]

Size is generated from firm's total sales. Because of the high skewness of the Italian firms' distribution, we use 5 equally represented classes, 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)*. Hence, we do not use *equally sized* classes but we define a number of classes n

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

such that the proportion of the population[8] (asset size of the firms) in each class *j,* for each *t,* is constant and equal to n^{-1}*.* This allows us to avoid classifying most firms as “small”.

We use a specific question of the Capitalia survey to define the dummy variable capturing innovative capacity. The dummy is equal one if in the period 2001-2003 the firm has introduced into the market an innovative product or it has set up either a new production process or an innovation in labor organization. Finally, dichotomous variables are also defined on whether firms export, invest abroad and/or invest in R&D activities. Innovation, exports, R&D, technology and FDI variables are drawn from the Capitalia and ICE-Reprint databases. Table 1 reports summary statistics on the whole sample. We show that 74.6% of our sample firms export, while only 10.5% invest abroad. Moreover, in the period 2001-2003, 62% of firms reported at least one innovation,[9] while only 44% of them spent on R&D[10]. The sample average firms’ age is 24.78 years, which is quite high if compared to the average age of the Italian firms. However, the sample standard deviation is very high[11].

Table 1 around here

Table 2 presents the estimation results for the entire sample[12] and some sub-samples selected by splitting the sample to single out small (class 1) and medium-large (classes 2-5), exporters and non-exporters, and innovative and non-innovative firms. Table 3 reports the homogeneity

8 $\forall t$ and $\forall j$: 1, 2,…, n, $\pi_{j,t} = n^{-1}$, t is time, j are the n classes and $\pi_{j,t}$ in class j at time t.
9 Because of lack of data, we cannot distinguish between product, process and organizational innovations.
10 Life Tables analysis confirm our results; it is not reported for reasons of space but is available on request.
11 Further analysis shows that eliminating the outliers does not alter the sample average firms’ age. For instance, sample including firms less than 50 years old, have an average age of 22.
12 We also run the regressions including only size (not reported), size and technology (cf. Table 2) and size, technology R&D and innovation. The coefficients of those variables are stable but the explanatory power in our preferred regression, which includes even internationalization variables, is higher.

tests (Log-Rank, Wilcoxon, Peto-Peto Prentice and Tarone Ware) for sub groups.

Table 2 around here

Table 3 around here

Size is always statistically significant and has a positive effect in increasing survival probability. It means that, independently of the main characteristics of the economic system, larger firms have a higher probability to survive. However, its magnitude is different among the various specifications.

Considering the whole sample, all variables except innovation are significant. Larger size and higher tech increase the survival probability, while internationalizing (either by exporting or 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%)[13]. In Figure 1 we report the smooth hazard function for the whole sample; as can be seen, the risk of failure is relatively low (on average around 0.2%) but keeps increasing until almost 30 years after birth and, after a short period of reduction (around ten years), starts increasing again.

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

[13] This result is in line with the theoretical model of Melitz and Ottaviano, 2008.

risk for innovative firms but by 22% for non-innovative firms. Producing in high-tech sectors reduces the risk of 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 exporters is to operate in high-tech sectors and, secondly, to become 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 result 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 they produce (mainly low tech), advantage that can disappear if/when the size increases. 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 produces 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.

5. Conclusions

Our empirical analysis suggests that, for Italian firms: 1) size and technological level reduce failure risk: the larger the firm, the greater the positive effect of technology on survival probability; 2) being an exporter or investing abroad reduces the survival probability of a firm: on average, the exposure to the strong competition in international markets increases the firms' risk of failure. Moreover, competitive firms in international markets tend to be bigger and in high-tech sectors. 3) Comparing exporting and non-exporting firms, size and technology have a stronger impact on the former than on 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-lived successful firm is big and innovative, operates in high-tech sectors, and is a key player on international markets. This has a clear implication for economic policy and makes it essential to fulfil the Lisbon goals.

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Table 1 – Descriptive Statistics (average and standard errors of the sample, 2001-2005)

Variables	Exporter	Non-Exporter	Small	Medium – Large	Innovative	Non – Innovative	Whole 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**

Table 2 – Cox-Regressions

	Whole Sample			**Exporter**	**Non – Exporter**	**Small**	**Medium – Large**	**Innovative**	**Non – Innovative**
	Baseline	Baseline + Innovation	General Model						
Size	0.802	0.784	0.756	0.77	0.836			0.807	0.786
	[0.023]***	[0.023]***	[0.024]***	[0.025]***	[0.057]***			[0.030]***	[0.037]***
Technology	0.745	0.684	0.652	0.668	0.98	0.805	0.693	0.578	1.15
	[0.0608]***	[0.057]***	[0.055]***	[0.060]***	[0.195]	[0.105]*	[0.073]***	[0.061]***	[0.148]
Innovation		0.912	0.898						
		[0.071]	[0.069]						
Export			1.32						
			[0.116]***						
FDI			1.38						
			[0.160]***						
R&D		1.537	1.448						
		[0.117]***	[0.112]***						
Observations	21055	21055	21055	15710	5345	4241	16814	13055	8000
Exits	832	832	832	645	187	317	515	517	315
Log Likelihood	-7589.76	-7574.39	-7564.68	-5666.549	-1469.31	-2345.577	-4627.032	-4431.377	-2596.965
Chi-square	76.24	105.45	117.75	83.33	7.14	2.79	12.24	64.01	26.42
p-value	(0.000)	(0.000)	(0.000)	(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%

Table 3 – Homogeneity tests: test of equality of survival functions

	Whole Sample vs. Baseline	Exporter vs. Non-exporter	Small vs. Medium-Large	Innovative vs. Non-Innovative
Wilcoxson	635.61	22.12	30.02	42.23
p-value	(0.000)	(0.008)	(0.000)	(0.000)
Log-Rank	941.57	45.31	29.88	89.41
p-value	(0.000)	(0.000)	(0.000)	(0.000)
Peto-Peto Prentice	922.32	44.13	30.01	86.71
p-value	(0.000)	(0.000)	(0.000)	(0.000)
Tarone Ware	747.91	31.12	29.01	59.22
p-value	(0.000)	(0.000)	(0.000)	(0.000)

Note: Null hypothesis is that groups survival functions are equal. The difference among the tests is related to the weight at each distinct failure time t_i. See Klein and Moeschberger, 2003

Figure 1 Hazard Function Whole Sample

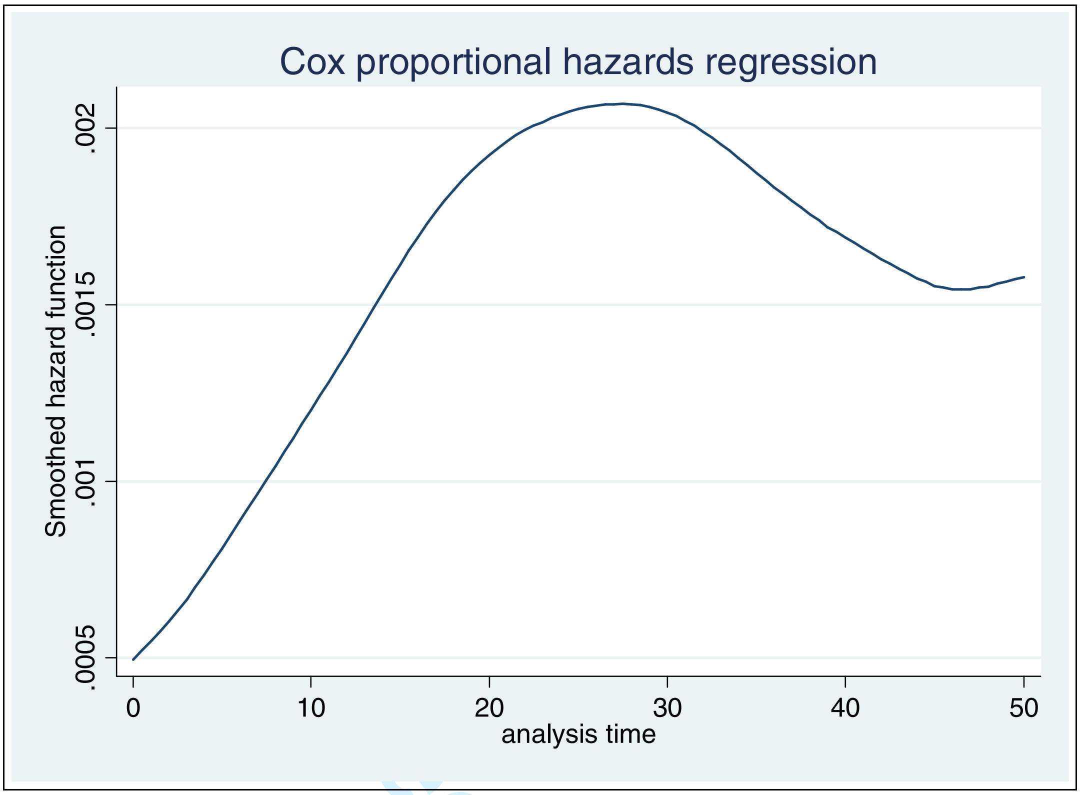

Figure 2 Hazard Functions for smallest and biggest firms

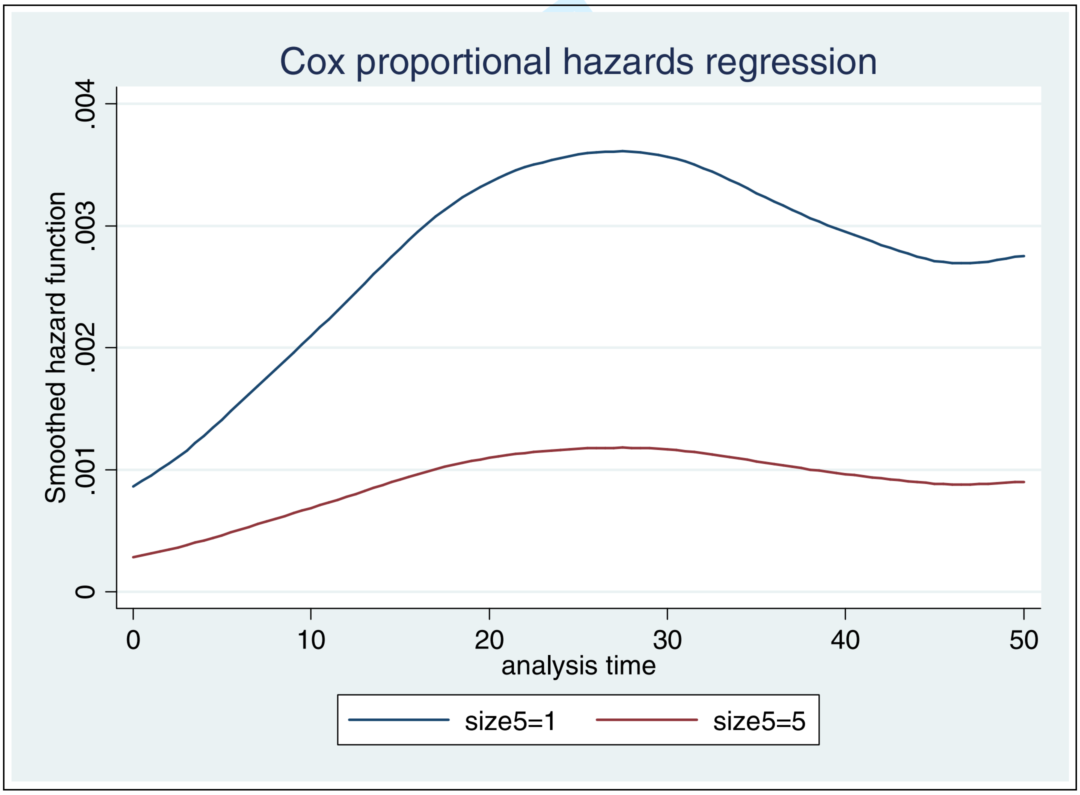

Figure 3 Hazard Function for Low and High Tech Firms

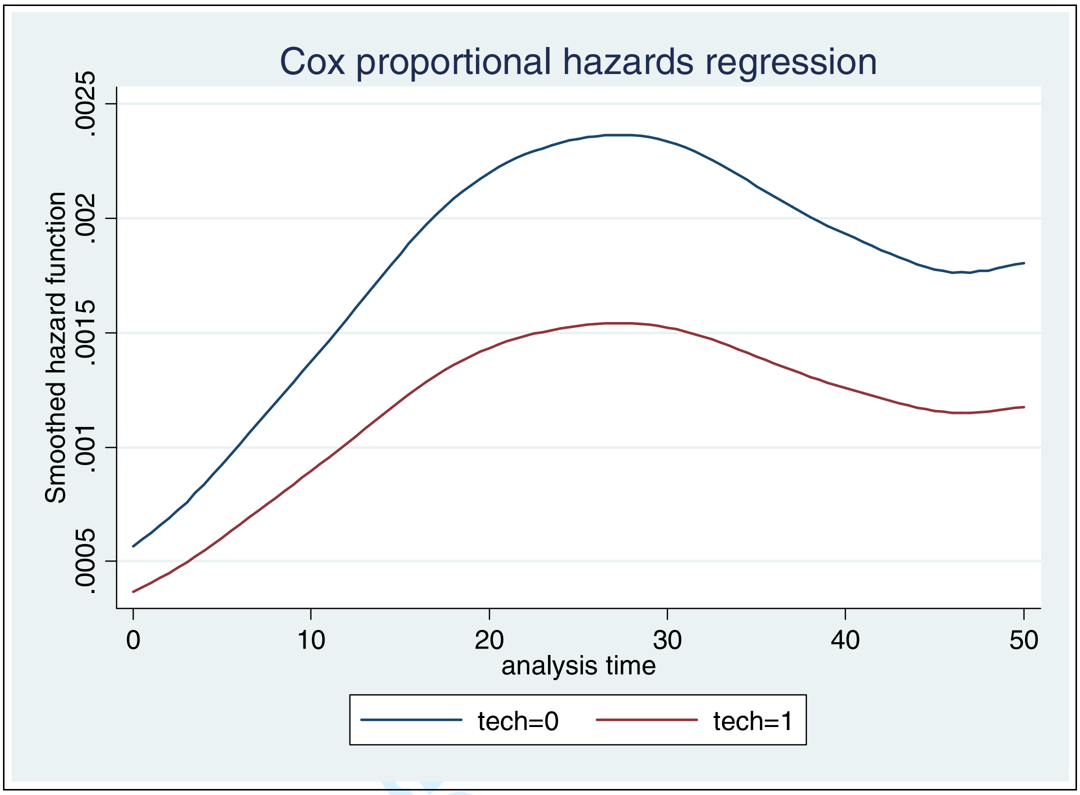

Figure 4 Hazard Function for FDI and Non-FDI Makers

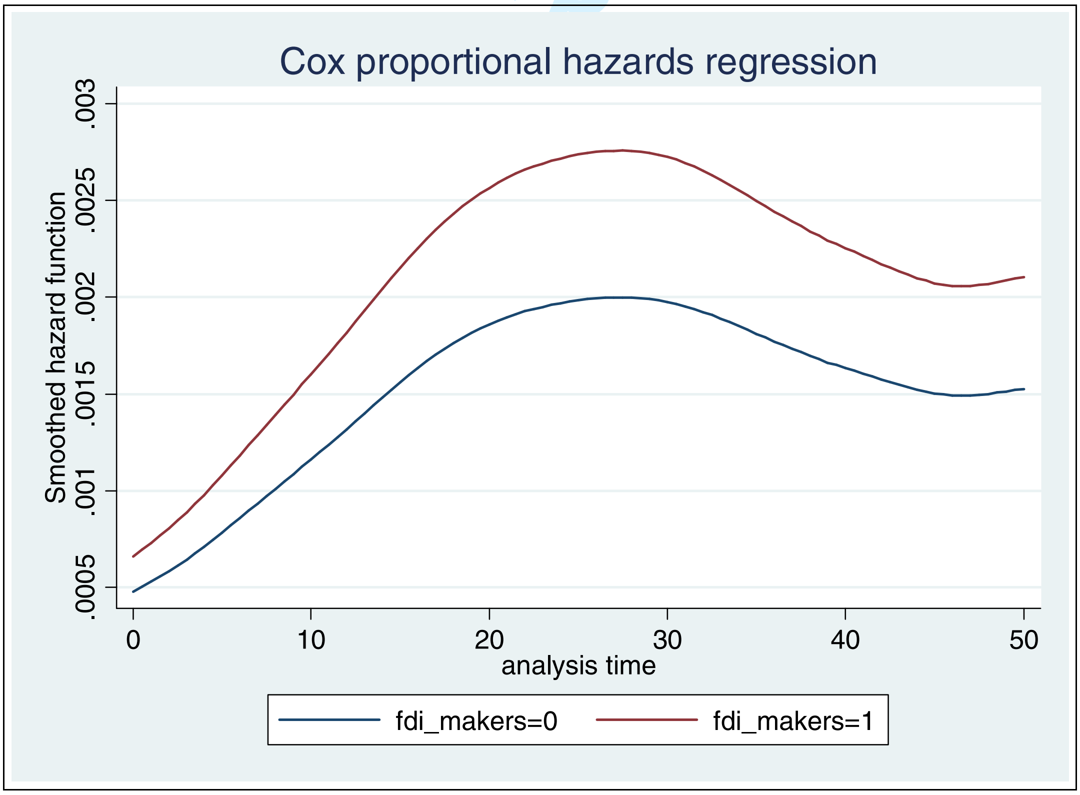

Figure 5 Hazard Function for Exporting and Non-Exporting Firms

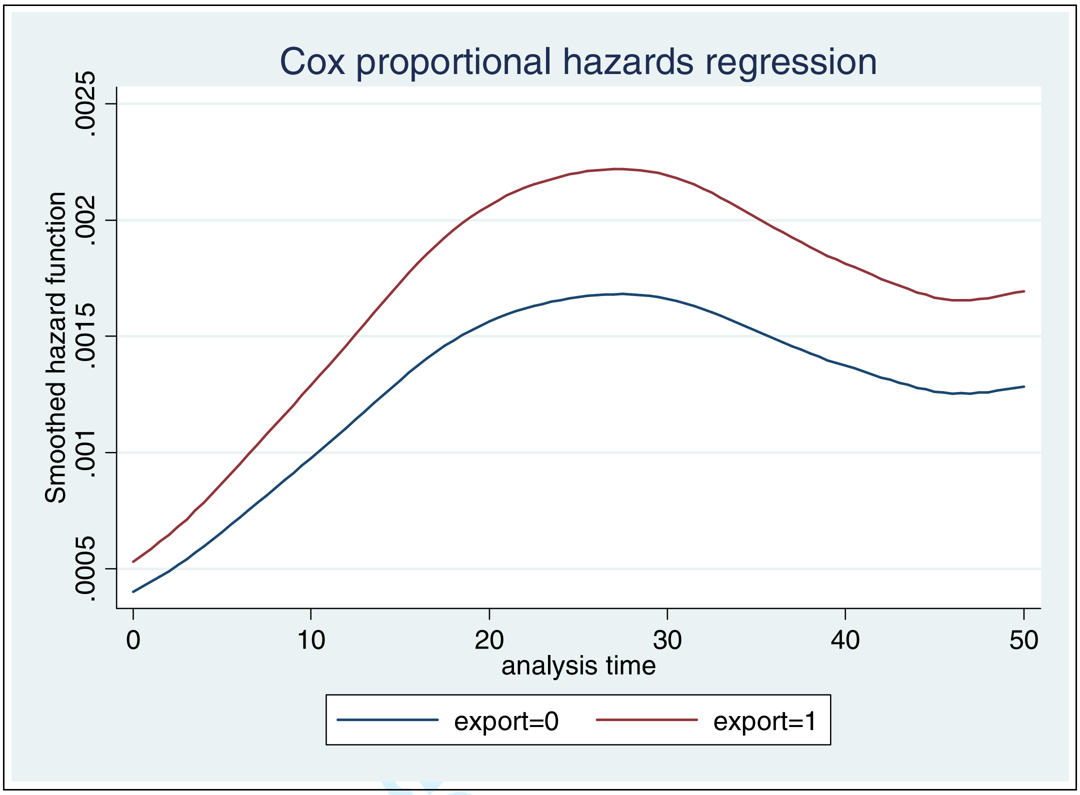

Figure 6 Hazard Function for Innovative and Non-Innovative Firms