Firm Dynamics in the Knowledge-Intensive Services Industry

Nádia Cristina Monteiro da Costa
nadia.costa@tecnico.ulisboa.pt

Instituto Superior Técnico, Lisboa, Portugal

November 2019

Abstract

The service industry has become the main contributor for economic growth and employment in Portugal and worldwide. Since we are moving towards a knowledge-based economy, it is of the utmost importance to research how knowledge-intensity has an influence on the dynamic of entries and closures in the service market. We analyse firm dynamics in the service industry, focusing on the determinants of firm survival, while comparing knowledge-intensive services (KIS) and less knowledge-intensive services (LKIS), using the *Integrated Business Account System* (SCIE) data-set from 2007 to 2015. We apply a semi-parametric duration model (piecewise-constant exponential model), and find that: age, size and start-up size have a negative effect in hazard of exit; innovators have lower hazard of exit than non-innovators; exporters have lower hazard of exit than non-exporters; firms with positive growth rate, in terms of sales per employee, have lower hazard of exit than firms with negative growth rate; and KIS firms have lower hazard of exit than LKIS firms. We also characterise the different impact of these factors between KIS firms and LKIS firms, where we find that their effect is more intense in LKIS firms hazard of exit than KIS firms hazard of exit.

Keywords: Firm dynamics, Firm survival, Service industry, Knowledge-intensive services, Innovation.

1. Introduction

We are progressively moving towards a knowledge-based economy, where technology and knowledge are key production factors to value creation. The Portuguese economy has been gradually shifting from an extensive economic model of growth, that relied on unqualified work and low wages, to an intensive economic model of growth, where it employs technology, innovation and knowledge management, in order to improve productivity and human resources qualification (Amaral, 2008). However, most firms that emerge in the economy never get to reach maturity — hazard rates of closure tend to increase during the first years and decrease afterwards (Mata and Portugal, 1999; Wagner, 1994). For these reasons, studies of firm dynamics in the service sector are of the utmost importance to understand the main factors of entries and closures in this economy. From findings of the literature review, we chose a set of hypotheses related with the variables: type of industry (KIS or LKIS), age, size, start-up size, innovation, exports and growth rate. Through a continuous semi-parametric duration model, the piecewise-constant exponential model, we discuss these hypotheses and possible interactions with knowledge-intensity. We confirm previous findings from the literature, showing that: age, size and start-up size have a negative effect in hazard of exit; innovators have lower hazard of exit than non-innovators; exporters have lower hazard of exit than non-exporters; firms with positive growth rate, in terms of sales per employee, have lower hazard of exit than firms with negative growth rate; and KIS firms have lower hazard of exit than LKIS firms. Additionally, we characterise the different impact of these factors between KIS firms and LKIS firms, concluding that the effect of these variables is more intense in LKIS firms hazard of exit than KIS firms hazard of exit. We suggest that the degree of customization of the service output and proportion of educated and skilled workers may be responsible for the extent of exposure to closure for service firms.

2. Literature Review and Hypotheses

2.1. Knowledge-intensive Service Industry

We may define service as "any act or performance that one party can offer to another, that is essentially intangible and does not result in the ownership of anything“ (Kotler et al., 2000). The service sector is mainly characterised by (Tether and Hipp, 2002; Miles, 2008; Hipp and Grupp, 2005): *intangibility* and *perishability*, they are consumed in place and time, difficult to store and may imply high levels of communication flows; *heterogeneity* and *uniqueness*, since there is a close interaction between production and consumption, being sometimes tailored to a specific client or situation; *process orientation*, it may requires the interaction or active participation of the client; *crucial role of organizational factors*, since there is a close relationship between the technologies employed and the service organizational form; *weak intellectual property protection*, since some innovative activities are easily imitable; and *human capital key role*, since services rely deeply on people skills and knowledge.

With the rise of distribution and utilisation of knowledge, firms related to the production to knowledge started to gain relevance in the economy, playing a role of knowledge intermediaries. We may define knowledge-intensity as "the extent to which a service activity requires highly skilled service operatives who exercise professional or technical capabilities to produce situation specific results" (Miles, 2008). From this definition, service firms are classified according to knowledge-intensity.

According to Tether and Hipp (2002), service firms competitiveness lies on quality and flexibility on meeting users' needs, rather than price, where a large proportion of knowledge-intensive firm's income being earned from customized services. More technical and knowledge-intensive firms tend to invest less in new machinery and equipment per employee. Instead, these services spend more on information communication technologies (ICT) than other services, since they rely on knowledge and expertise of their workforce, hardly replaceable by machines and equipment. Also, Tether and Hipp (2002) suggest that less knowledge-intensive service firms invest more in non-technical ICT technologies, related with their provision of standard services, than knowledge-intensive firms. This is a strategy associated with routinisation and economies of scale, that allows these firms to substitute "high-skill-high-cost" labour for "low-skill-low-cost" labour. Thus, the general characteristics of the workforce have an influence on the performance of the service. Indeed, the experience education level of the general task force has a positive impact on firm's performance as the firm gets older and, consequently, a positive impact on firm's survival (Baptista et al., 2012; Brüderl et al., 1992). Since the characterisation of firms according to knowledge-intensity is based on the degree and proportion of high education level workers, we test if knowledge-intensity has a positive impact on firm's survival as well. Therefore, we explore the following hypothesis.

H1: *KIS firms have lower hazard of exit than LKIS firms.*

2.2. Age and Size

Several studies present findings that show the importance of age and size on firm survival and growth. According to Evans (1987a) and Dunne and Hughes (1994), there is a negative correlation between firm growth and age, suggesting that younger firms grow faster than older firms. According to Evans (1987a), firm growth decreases with firm size, where this relationship is non-linear and vary over size distribution (Evans, 1987b). According to Jovanovic (1982), this is caused by the learning process that firms go through regarding their true efficiency, as they operate in the industry. This is referred as the theory of "noisy" selection, which says that "(...) efficient firms grow and survive (...)", while "(...) inefficient firms decline and fail". However, Cabral and Mata (2003) found no relationship between the selection effect and the evolution of the firm size distribution. In terms of survival, the likelihood of survival increases with firm size and age where, consequently, smaller and younger companies have higher failure rates (Dunne and Hughes, 1994; Evans, 1987a). According to Fritsch et al. (2006), high vulnerability to failure of new firms is mostly due to the initial period without profit, and eventual problems on setting an organisational structure. For these reasons, and to discuss possible interactions with knowledge-intensity, we postulate the following hypotheses.

H2: *Firms that remains longer in the market have lower hazards of exit.*

H2.1: *Age has a negative and higher effect on the hazard of exit of KIS firms than LKIS firms.*

H3: *Larger firms have lower hazards of exit than smaller firms.*

H3.1: *Size has a negative and higher effect on the hazard of exit of KIS firms than LKIS firms.*

2.3. Start-up Size

Start-up size also plays an important role in firm survival. According to Mata and Portugal (1994), survival is higher among firms that initiated their activity with a large start-up size, since it indicates a greater expectation of success. Also, Mata and Portugal (1994) have found that entering the market with large size and multiple establishments increases the chance of survival. However, Brüderl et al. (1992) argue that, even though being small can prevent possible "financial disasters" (related to higher financial requirements and risk by larger firms), it also increases the exposure to failure. Despite that, the advantage of entering at large scale may vary with the competitive environment where the firm operates, such as product life cycle and technological intensity, and it dissipates over the years (Agarwal and Audretsch, 2001). To study these claims, we suggest the following hypotheses.

H4: *Large start-up size lowers the hazard of exit.*

H4.1: *Start-up size has a negative and higher effect on the hazard of exit of KIS firms than LKIS firms.*

2.4. Innovation

Empirical studies have found that innovation has a significant and positive impact on firm's performance and profitability, ultimately translated into a positive effect on the probability of survival, particularly to small and younger firms, since this group is the most exposed to the risk of leaving the market and benefit the most of innovation to survive(Audretsch, 1991, 1995; Cefis and Marsili, 2006). Studies also show that innovation investment has a more unstable effect on younger firms than older firms, since the returns on investment are more unpredictable and riskier, due to the higher amount of financial requirements at early age (Coad et al., 2016). Nonetheless, the risk-reward deal that comes from innovation is much higher for young firms, and its "innovation premium" increases their chance of surviving, when compared with non-innovative firms (Cefis and Marsili, 2006). However, Banbury and Mitchell (1995) argue that mature and well established firms benefit equally from innovation, since innovative activities allows them to cope with new and disruptive technologies while improving their existing capabilities, in order to stay competitive in the market. Therefore, we postulate the follow hypotheses.

H5: *Innovators have lower hazard of exit than non-innovators.*

H5.1: *Innovating has a negative and higher effect on the hazard of exit of KIS firms than LKIS firms.*

2.5. Exports

According to Bernard et al. (1995), exporters have a positive impact for the economy, being more profitable and more competitive than non-exporters. They become larger and more productive. Therefore, they provide better prospects of employment and higher salaries, thus the economic importance of exports for growth and survival. However, there is a causality issue while studying exports since, according to Wagner (1995), exports may lead to growth but, at the same time, its size may lead to invest more in exports. Moreover, exports is a source to overcome underperformance and possible other external factors that may jeopardize firm's growth and consequently, the firm's permanence in the market (Hirsch and Lev, 1971; Hirsch and Adar, 1974). Therefore, we present the following hypotheses.

H6: *Exporters have lower hazard of exit than non-exporters.*

H6.1: *Exporting has a negative and higher effect on the hazard of exit of KIS firms than LKIS firms.*

2.6. Growth Rate

High growth rates are usually associated to better prospects of survival (Audretsch, 1995). Young firms have higher and more variable growth rates than older firms, due to the process of learning their true efficiency. Jovanovic (1982) argues that the main reason for survival is related to the firm's awareness of their efficiency. This is achieved over time as the firm becomes more mature, where they gained knowledge regarding their cost structures and efficiency levels (Dunne et al., 1988; Jovanovic, 1982). As the likelihood of survival for new entrants tends to be lower in industries characterised by high minimum efficient size (Fritsch et al., 2006), not meeting the requirements of the industry may be an obstacle to survival. Moreover, according to Cabral and Mata (2003), some firms are small due to financial constraints while others stay small for efficiency purposes. When financial constraints are surpassed, firms will grow to an optimal size. Therefore, to infer the effect of productivity growth rate, in terms of sales per employee, we propose the following hypotheses.

H7: *Growing firms, in terms of sales per employee, have lower hazards of exit.*

H7.1: *Growing, in terms of sales per employee, has a negative and higher effect on the hazard of exit of KIS firms than LKIS firms.*

3. Data Characterisation

To study the determinants of survival, we use the Integrated Business Accounts System (SCIE) dataset, provided by Statistics Portugal. It presents a full characterisation of the firms' economic and financial behaviour, through a set of relevant variables and financial ratios for the business sector. The population of SCIE in each year n is composed by all firms that perform any goods and/or services activity (sole proprietaries , societies and independent workers), excluding financial, insurances and non-market-oriented companies.

3.1. Sample

Given the context of our study, we classified service firms as knowledge-intensive services (KIS) or less knowledge-intensive services (LKIS) according to CAE Rev.3, the Portuguese Classification of Activities, based on the Statistical Classification of Economic Activities in the European Community (NACE Rev.2) from Eurostat. This classification is based on technological proximity and considers that a sector is knowledge-intensive if at least a third of the number of employees are highly educated, and it is considered less knowledge-intensive otherwise. We restrict our analysis to the period from 2007 to 2015 because of data availability, excluding single individual owned firms and/or with no information regarding their sales. Our sample is composed by 851,148 observations, corresponding to 223,452 unique firms.

We characterise our sample using the following variable definitions: age - number of years of activity; size - number of employees in the current year; start-up size - number of employees in the first year of activity; growth rate - sales per employee annual growth rate; "growing" - dummy variable (1 if growth rate > 0, 0 otherwise); innovation expenditure - sum of R&D, employee training, tangible and intangible assets investment; innovation ratio - ratio between innovation expenditure and sales; innovator - dummy variable (1 if $innovation\ ratio > \overline{innovation\ ratio} - standard\ deviation$, 0 otherwise); total exports - international sales; exports ratio - ratio between international sales and sales; exporter - dummy variable (1 if $exports\ ratio > \overline{exports\ ratio} - standard\ deviation$, 0 otherwise). All dummy variables and ratios are defined by year, region and sector.

Table 1: Summary statistics (whole sample).

Variable	KIS	LKIS
Age	4.14	4.13
	(2.69)	(2.70)
Size	3.44	3.60
	(20.47)	(12.00)
Start-up size	1.98	2.47
	(9.21)	(4.37)
Sales [10^3 €]	185.29	345.26
	(1804.42)	(3580.06)
Sales per employee [10^3 €/emp.]	53.04	92.58
	(292.19)	(543.88)
Growth rate [%]	1.49	3.06
	(120.72)	(248.24)
Growing	0.61	0.60
	(0.49)	(0.49)
Innovation expenditure [10^3 €]	19.96	19.44
	(960.18)	(329.76)
Innovation ratio [%]	57.73	69.70
	(3201.72)	(3399.13)
Innovator	0.51	0.49
	(0.50)	(0.50)
Total exports [10^3 €]	27.85	49.02
	(749.22)	(2823.49)
Exports ratio [%]	5.57	5.00
	(20.23)	(19.31)
Exporter	0.13	0.13
	(0.34)	(0.34)
Number of observations	277,792	573,356
Number of firms	69,604	154,592
Number of closures	16,537	49,734
Proportion of closures [%]	24	32

Note: Mean and standard deviation (in parentheses).

Table 1 shows the summary statistics by knowledge-intensity of the whole sample. In terms of duration, both type of firms have approximatively the same mean with equal variability, with LKIS average age slightly lower than KIS average age. As for size, LKIS firms are larger than KIS firms, with superior variability for KIS firms. The scenario is similar for start-up size, since LKIS firms enter the market in larger scale than KIS firms, with a larger variability for KIS firms than LKIS firms. The amount of sales is much higher for LKIS firms, due to the superior number of LKIS firms with high sales volumes in the service industry, such as, e.g., wholesale and retail firms. The same pattern occurs to the average sales per employee and growth rate, with equally higher variability for LKIS firms, probably for the same reason. The average innovation expenditure is superior for KIS than LKIS firms. However, in terms of innovation ratio, LKIS firms have higher values than KIS firms. Probably LKIS firms need for more investment in innovation than KIS firms in order to survive. Furthermore, LKIS firms, in average, have a larger volume of exports revenue than KIS firms with superior variability but KIS firms have a greater exports ratio.

4. Methodology

To perform this study, we employ a survival analysis method. Its main tool is the hazard function $h(t)$, described as the "instantaneous probability that the duration under study will end in an infinitesimally small time period u after time t, given that the duration has not elapsed until time t"(Bhat, 1996).

$$h(t) = \lim_{u \to 0^+} \frac{P(t \leq T \leq t + u \mid T \geq t)}{u} \quad (1)$$

where T is the firm's life duration. Duration dependence plays a significant role on firm survival theory (Jovanovic, 1982). It exists if $\frac{dh(t)}{dt} \neq 0$ holds, i.e., the hazard rate varies with time. We may interpret the hazard function derivative as follows (Heckman and Singer, 1984).

- If $\frac{dh(t)}{dt} > 0$, at $t = t_0$, there is a positive duration dependence at t_0.
- If $\frac{dh(t)}{dt} < 0$, at $t = t_0$, there is a negative duration dependence at t_0.

For our study, we employ the piecewise-constant exponential proportional model (Eq.(2)), due to its flexibility and explicit estimates of the baseline hazard function. It is a simple generalisation of the standard parametric exponential model, where we split the time axis into smaller time intervals and assume that the hazard rate is constant in each interval, allowing the rate to change across the different intervals (Jenkins, 2005). Generically, it may be written as follows.

$$h(t, X_t) = \begin{cases} h'_1\lambda_1 & t \in [0, \tau_1] \\ h'_2\lambda_2 & t \in [\tau_1, \tau_2] \\ ... & \\ h'_k\lambda_k & t \in [\tau_{k-1}, \tau_k] \end{cases} \quad (2)$$

where the baseline hazard rates (h'_k) are constant, within each k interval, but may be different between intervals, while λ_k is an individual-specific non-negative function of covariates X_t.

5. Results

We study our hypotheses through average marginal effects on the hazard rate. This can be interpreted as the absolute change on the hazard rate in percentage points (p.p.), i.e., it measures the effect on the conditional mean of y of changes in one of the regressors x_j, while keeping all other covariates constant. A positive marginal effects means that increasing x_j is associated with higher hazard rates and shorter survival times, whereas a negative marginal effect means that increasing x_j is associated with lower hazard rates and longer survival times.

5.1. Marginal Effects

Table 2 presents the average marginal effects of six models with the variables related to the set of hypotheses: age, type of industry (KIS or LKIS), growth rate, size, start-up size, innovation and exports. In model 1, we present the impact of size and start-up size categorically. In model 2, we use the logarithm form on size and start-up size to impose a constant percentage effect of both variables on the marginal effect, i.e., it allows us to interpret the impact of 1% increase of size/start-up size on the hazard rate without worrying about firm size scale issues. Models 3, 4, 5 and 6 were developed to analyse the role of size and start-up size separately due to collinearity, i.e., high correlation observed between size and start-up size ($\rho = 0.72$). Variables such as age, innovation, exports and growth rate are present in all models. The differences between the number of observations of each model are related to the information available of start-up size, innovation, exports and growth rate variables. All marginal values are statistically significant.

5.2. Marginal Effects in KIS and LKIS Firms

Table 3 shows the average marginal effect of the firm survival determinants by knowledge-intensity. We chose model 1, 2, 3 and 4, due to the different results caused by high correlation between size and start-up size. For this analysis, we include interactions in our models according with findings of the literature. Since innovation is a key player on firm survival, where KIS firms play a role of innovation carriers (Cefis and Marsili, 2005, 2006; OECD, 2006), and service firms tend to be small for efficiency purposes (Tether and Hipp, 2002), we include the following interactions in all models: type of industry and innovation, type of industry and size; and type of industry and start-up size.

5.3. Discussion

All the hypotheses concerning the determinants of firm survival were confirmed. Even with problems concerning collinearity, it was possible to observe the impact of start-up size in firm survival, resorting to models without the variable related to the current size of the firm. All marginal effects from the remaining variables present coherent results with the literature review. When accounting the sub-hypotheses, the estimates show an opposite scenario where, generally, LKIS firms benefit more from the impact of the firm survival determinants than KIS firms.

Hypothesis 1, related with knowledge-intensity, was confirmed by our estimates. The fact that knowledge-intensity has a negative effect on the hazard may be related with the proportion of educated workers and the demand for knowledge-intensive activities (KIA) involved progressively increasing. According to Brüderl et al. (1992), the number of experienced workers increase the chances of survival and highly educated workforce tend to raise sales productivity. Thus, we suggest that part of the reason for lower hazard of exit on KIS firms may rely on human capital. Moreover, there is a number of studies that relate KIBS firms, an important subset of KIS firms, to the diffusion of innovation in the market, with a crucial role on innovation processes (OECD, 2006; Tether and Hipp, 2002; Muller and Zenker, 2001). The exchange of knowledge and interactivity occurred between KIBS firms and client firms may promote mutual growing, being beneficial for both parties (Muller and Zenker, 2001; OECD, 2006). These benefits lead to an increase on the demand of KIA services, which may improve the prospect of survival. On the other hand, LKIS firms provide services that are more standard and easily reproducible, which may induce into less barriers of entry, turning their markets more competitive.

Hypothesis 2, related with age, was confirmed. According to the decreasing values of marginal effects throughout the categories of age, we were able to conclude that staying in the market lowers the hazard of exit, matching findings from the literature. However, we must be careful while studying the true meaning of this variable. Firstly, age or passage of time per se may not improve the probability of survival. What is implied in this variable is the experience and know-how gained as the firm stays longer in the market. As Jovanovic (1982) selection theory suggest, firms only survive if they become aware of their efficiency levels and cost structures. Another reason may lie on the implications of unobserved heterogeneity (often referred as frailty in the survival analysis context). When we do not account for this issue, the non-frailty model will

Table 2: Average marginal effects (whole sample).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
KIS	-0.028***	-0.028***	-0.027***	-0.026***	-0.027***	-0.027***
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)
Age:						
3 to 4 years	-0.029***	-0.029***	-0.031***	-0.031***	-0.014***	-0.014***
	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
5 to 6 years	-0.051***	-0.051***	-0.052***	-0.053***	-0.031***	-0.032***
	(0.0011)	(0.0011)	(0.0011)	(0.0011)	(0.0010)	(0.0011)
$\geq$ 7 years	-0.063***	-0.063***	-0.064***	-0.065***	-0.053***	-0.054***
	(0.0013)	(0.0013)	(0.0013)	(0.0013)	(0.0009)	(0.0009)
Size:						
2 to 9 employees	-0.054***					-0.033***
	(0.0011)					(0.0006)
$\geq$ 10 employees	-0.073***					-0.045***
	(0.0018)					(0.0013)
Log of size		-0.050***			-0.026***	
		(0.0009)			(0.0005)	
Start-up size:						
2 to 9 employees	0.031***			-0.004***		
	(0.0011)			(0.0008)		
$\geq$ 10 employees	0.066***			-0.011***		
	(0.0066)			(0.0026)		
Log of start-up size		0.032***	-0.0049***			
		(0.0009)	(0.0006)			
Innovator	-0.044***	-0.042***	-0.052***	-0.052***	-0.040***	-0.042***
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)
Exporter	-0.030***	-0.029***	-0.033***	-0.033***	-0.031***	-0.031***
	(0.0010)	(0.0010)	(0.0009)	(0.0009)	(0.0008)	(0.0008)
Growing	-0.105***	-0.107***	-0.099***	-0.099***	-0.082***	-0.082***
	(0.0012)	(0.0012)	(0.0011)	(0.0011)	(0.0008)	(0.0008)
Number of observations	460,242	460,242	460,242	460,242	632,893	632,893
Number of firms	142,534	142,534	142,534	142,534	198,859	198,859
Log likelihood	-71,838	-71,537	-73,181	-73,207	-99,841	-99,960
p-value of the log likelihood test	0.000	0.000	0.000	0.000	0.000	0.000

Note: Standard errors in parentheses. All models control for sector, region, unemployment rate and GDP per capita. For categorical variables, base levels are not presented (age = 1 to 2 years; start-up size = 1 employee; size = 1 employee; non-innovators; non-exporters; not growing). *Significant at 10%, ** Significant at 5%, *** Significant at 1%.

over-estimate (under-estimate) the degree of negative (positive) duration dependence in the baseline hazard (Jenkins, 2005). Since this is a detail that is not considered in our models, the effect of age might be over-estimated. The results related with sub-hypothesis 2.1, i.e., interaction between age and knowledge-intensity typology, indicate that age has more influence on the survival of LKIS firms than KIS firms, and the effect gets stronger for LKIS firms between age categories. Since LKIS firms are more labour intensive, staying in the market may provide them some advantage in comparison to their younger competitors. Due to the higher standardisation and labour-intensity from LKIS firms (Tether and Hipp, 2002), gains in efficiency may have a higher impact in LKIS firms performance than KIS firms, as the firm gets older. Perhaps KIS firms gains in efficiency are more dependable of other factors such as the quality and adequacy of the general workforce qualification, that may or may not be achievable with age.

Hypothesis 3, related with size, was confirmed by the estimates. This is aligned with the literature, where small firms have higher vulnerability to exit than large firms. According to Headd (2003), large firms are more stable and have access to better financing tools, which improves the probability of survival. On the other hand, smaller firms tend to invest more and take less debt, improving their prospects of survival (Cooley and Quadrini, 2001). When accounting with the impact on KIS and LKIS hazard rates (sub-hypothesis 3.1), firm size has a superior and negative effect on LKIS hazard rates, as we may observe from model 1 and 2 from Table 3. This might be related to the fact that LKIS firms activities are more labour intensive and require more workers, while KIS firms activities require qualified employees, not necessarily in larger scale. Plus, some KIS firms struggle to hire workers with the right set of skills and qualifications for the job, due

Table 3: Average marginal effect by knowledge-intensity with interactions (whole sample).

	Model 1	Model 2	Model 3	Model 4
Age: 3 to 4 years				
LKIS	-0.033***	-0.033***	-0.034***	-0.035***
	[-0.036, -0.031]	[-0.035, -0.030]	[-0.037, -0.032]	[-0.037, -0.032]
KIS	-0.022***	-0.022***	-0.023***	-0.024***
	[-0.024, -0.020]	[-0.024, -0.020]	[-0.025, -0.022]	[-0.025, -0.022]
Age: 5 to 6 years				
LKIS	-0.058***	-0.058***	-0.059***	-0.060***
	[-0.061, -0.056]	[-0.061, -0.056]	[-0.062, -0.057]	[-0.062, -0.057]
KIS	-0.039***	-0.038***	-0.040***	-0.040***
	[-0.040, -0.037]	[-0.040, -0.037]	[-0.042, -0.038]	[-0.042, -0.038]
Age: $\geq$ 7 years				
LKIS	-0.072***	-0.072***	-0.073***	-0.073***
	[-0.075, -0.070]	[-0.075, -0.069]	[-0.076, -0.070]	[-0.076, -0.070]
KIS	-0.048***	-0.048***	-0.050***	-0.050***
	[-0.050, -0.046]	[-0.050, -0.046]	[-0.052, -0.047]	[-0.052, -0.047]
Size: 2 to 9 employees				
LKIS	-0.061***			
	[-0.064, -0.060]			
KIS	-0.039***			
	[-0.042, -0.036]			
Size: $\geq$ 10 employees				
LKIS	-0.085***			
	[-0.089, -0.081]			
KIS	-0.053***			
	[-0.059, -0.046]			
Log size				
LKIS		-0.059***		
		[-0.062, -0.057]		
KIS		-0.034***		
		[-0.037, -0.031]		
Start-up size: 2 to 9 employees				
LKIS	0.032***			-0.008***
	[0.029,0.035]			[-0.010, -0.006]
KIS	0.031***			0.004***
	[0.027,0.034]			[0.002,0.007]
Start-up size: $\geq$ 10 employees				
LKIS	0.066***			-0.018***
	[0.051,0.082]			[-0.024, -0.012]
KIS	0.081***			0.010*
	[0.049,0.113]			[-0.001,0.021]
Log of start-up size				
LKIS		0.035***	-0.009***	
		[0.033,0.037]	[-0.010, -0.007]	
KIS		0.029***	0.004***	
		[0.026,0.032]	[0.002,0.006]	
Number of observations	460,242	460,242	460,242	460,242
Number of firms	142,534	142,534	142,534	142,534
Log likelihood	-71,838	-71,537	-73,181	-73,207
p-value of the log likelihood test	0.000	0.000	0.000	0.000

Note: 95% confidence intervals in brackets. All models control for sector, region, unemployment rate and GDP per capita. For categorical variables, base levels are not presented (age = 1 to 2 years; start-up size = 1 employee; size = 1 employee; non-innovators; non-exporters; not growing). *Significant at 10%, ** Significant at 5%, *** Significant at 1%.

Table 3: Average marginal effect by knowledge-intensity with interactions (whole sample)(continued).

	Model 1	Model 2	Model 3	Model 4
Innovator				
LKIS	-0.047***	−0.043***	-0.055***	-0.056***
	[-0.049, -0.045]	[-0.045, -0.041]	[-0.057, -0.054]	[-0.058, -0.054]
KIS	-0.040***	-0.040***	-0.046***	-0.046***
	[-0.043, -0.038]	[-0.042, -0.038]	[-0.049, -0.044]	[-0.048, -0.044]
Exporter				
LKIS	-0.034***	-0.0332***	-0.0376***	-0.0374***
	[-0.037, -0.032]	[-0.035, -0.031]	[-0.040, -0.036]	[-0.040, -0.035]
KIS	-0.023***	-0.022***	-0.025***	-0.025***
	[-0.024, -0.021]	[-0.023, -0.020]	[-0.027, -0.024]	[-0.027, -0.024]
Growing				
LKIS	-0.121***	-0.123***	-0.113***	-0.113***
	[-0.124, -0.119]	[-0.126, -0.120]	[-0.115, -0.110]	[-0.115, -0.110]
KIS	-0.079***	-0.080***	-0.076***	-0.076***
	[-0.081, -0.076]	[-0.082, -0.077]	[-0.078, -0.074]	[-0.078, -0.073]
Number of observations	460,242	460,242	460,242	460,242
Number of firms	142,534	142,534	142,534	142,534
Log likelihood	-71,838	-71,537	-73,181	-73,207
p-value of the log likelihood test	0.000	0.000	0.000	0.000

Note: 95% confidence intervals in brackets. All models control for sector, region, unemployment rate and GDP per capita. For categorical variables, base levels are not presented (age = 1 to 2 years; start-up size = 1 employee; size = 1 employee; non-innovators; non-exporters; not growing). *Significant at 10%, ** Significant at 5%, *** Significant at 1%.

to the low share of highly educated people in Portugal. Additionally, acquiring several high skilled employees is an additional expense for the firm due to higher salaries. Silva and Lima (2017) argue that high-tech firms value human capital more than low-tech firms due to difficulty in acquiring high skill workers able to perform complex tasks of the respective firm's activities, and also as an incentive to retain workers in the company. Thus, this may influence the decision of remaining small, for efficiency purposes.

Hypothesis 4, related to start-up size, was confirmed in model 3 and 4, where the current size was not included. Under those conditions, start-up size seems to improve the prospects of survival. This determinant is also mentioned in the literature, where starting the business with a considerable large size indicates higher expectation of success and likelihood of survival (Mata and Portugal, 1994; Evans, 1987a; Brüderl et al., 1992). While considering knowledge-intensity, there is a negative effect on hazard rates for LKIS firms, while for KIS firms the effect is positive. Here, the justification behind these results is similar to the one related to firm size: KIS firms tend to perform under smaller scale due to the requirements of their internal activities and lowering additional costs, since they are more intensive in knowledge; and LKIS firms benefit more from economies of scale since their activities are more labour intensive (Tether and Hipp, 2002). However, these results may not translate the real influence of start-up size on the long term. According to Audretsch (1991), the existence of economies of scale and high capital labour tends lower the probability of survival for an uncertain period of time, and Agarwal and Audretsch (2001) suggest that this advantage provided by large size entry varies with product life cycle and/or technological intensity of the industry.

Hypothesis 5 related to innovation, was confirmed by all models, consistent with the negative effect that innovation has on hazards of exit. Several findings indicate that innovation has a strong and positive impact on performance and profitability, leading to longer stays in the market (Audretsch, 1991, 1995). Innovation can be a tool to overcome possible scale and/or size disadvantages that young and smaller firms may face at entry, even though it carries some risk to invest capital at early age (Coad et al., 2016; Geroski, 1995; Audretsch, 1995). As for the effect on KIS and LKIS firms, it seems that innovation has a stronger and negative effect in LKIS firms hazard rates than KIS firms hazard rates. However, this difference is only significant for model 1, 3 and 4 (non-overlapped 95% interval confidences)[1]. In first place, LKIS firms are more vulnerable to exit than KIS firms as observed before, thus, this factor can be decisive to remain competitive in the market. Small increments of innovation may have a higher impact for LKIS

[1] In model 2, the 95% confidence intervals do overlap. However, they do not overlap at 90% level of confidence, thus, we may confirm statistically significant differences between the effect of innovation in KIS and LKIS firms at a 90% level of confidence.

firms than KIS firms. Secondly, since KIS firms tend to be more innovative and "diffusors" of innovation (OECD, 2006), resorting to a comparison of an average value may virtually increase/decrease the thresholds used to identify innovators among KIS and LKIS firms. On the other hand, this problem is probably mitigated by the high entrance rates from both type of firms. Another possible explanation may be related to the importance of innovation in firm survival. Innovation may be a determinant of firm survival so powerful and effective, that equally benefits both KIS and LKIS firms.

Hypothesis 6, related to exports, was confirmed. According to Bernard et al. (1995), exporters are more productive, profitable and competitive, which rises the chances of survival. Also, resorting to exports may help small firms to overcome low performance in domestic markets (Hirsch and Lev, 1971), sometimes caused by unfavourable macroeconomic environment such as the Portuguese financial crisis. Regarding the impact in KIS and LKIS separately, same pattern occurs, where LKIS firms benefit more from exporting than KIS firms. International trade for service sectors may require some flexible organizational structure (e.g.: ICT). Perhaps this flexibility is less achievable among LKIS firms, however, they benefit the most from the performance boost that exporting provides (e.g.: e-commerce in the retail sector).

Finally, hypothesis 7 related with growth rate in terms of sales per employee was also confirmed, where growth in terms of sales per employee increases the probability of remaining in the market. According to Audretsch (1995), young firms that are able to adjust to the market requirements may experience high growth rates and higher prospects of survival. Also, improving the sales per worker can be consequence of the rise in productivity and efficiency, which may improve survival (Jovanovic, 1982). The results regarding the average marginal effects of growth on LKIS and KIS hazards rates reveal that the impact is higher for LKIS than KIS, similar to what occurs in most factors. Here, this result can be justified by the greater impact of gains of efficiency for LKIS firms, due to their higher standardisation and labour-intensive services.

6. Conclusions

The main results are aligned with findings of the literature review. There is no doubt of the importance of each determinant of firm survival studied for the service industry. However, our results may have been influenced by frailty, probably caused by omitted variables (e.g. founder's education level, quality of management) and/or unappropriated choice of baseline hazard function. It was also a challenge to find a proper classification of innovators and exporters. We decide to compare the corresponding ratio to an arithmetic mean. This tactic may result for the first few years of duration, however, it starts to be less effective over the years. Since innovators (exporters) tend to survive more years than non-innovators (non-exporters), these "survivors" will rise the average value, leading to unreliable classification. Even though the entrance of new and innovators/exporters firms may appease this effect, we are not certain of the real effectiveness of this classification on the long term.

Despite that, we believe that these results gave us a glance of what factors should service firms invest, in order to survive in this competitive economy. As the knowledge-based economy continues to rapidly evolved, companies must be aware of the new trends in the market and build cope mechanism to surpass possible adversities from the external environment. It is often said that firms that survived periods of economical retrenchment (e.g. Portuguese crisis) become more resilient to unfavourable events. However, this is not enough. Being responsive to market needs, explore new markets, introducing/acquiring innovation products to/from the market, are few generic examples of strategies that firms may utilise to overcome difficulties without shutting down their activities.

We achieve some useful insights and contributions to the KIS and LKIS industry literature. Our suggestion for future investigation is to resort to alternative survival analysis models, such as discrete models, to ensure more robust results, and to perform a more detail analysis into the subgroups of KIS and LKIS to uncover other possible conclusions.

References

Agarwal, R. and Audretsch, D. B. (2001). Does entry size matter? the impact of the life cycle and technology on firm survival. *The Journal of Industrial Economics*, 49(1):21–43.

Amaral, L. M. (2008). *Economiatech: da indústria à sociedade da informação e do conhecimento*. Booknomics.

Audretsch, D. B. (1991). New-firm survival and the technological regime. *The Review of Economics and Statistics*, 73(3):441–450.

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

Banbury, C. M. and Mitchell, W. (1995). The effect of introducing important incremental innovations on market share and business survival. *Strategic Management Journal*, 16(S1):161–182.

Baptista, R., Lima, F., and Mendonça, J. (2012). Human capital and the performance of firms over time. Working Paper, Instituto Superior Técnico, University of Lisbon.

Bernard, A. B., Jensen, J. B., and Lawrence, R. Z. (1995). Exporters, jobs, and wages in US manufacturing: 1976-1987. *Brookings Papers on Economic Activity. Microeconomics*, 1995:67–119.

Bhat, C. R. (1996). A hazard-based duration model of shopping activity with nonparametric baseline specification and nonparametric control for unobserved heterogeneity. *Transportation Research Part B: Methodological*, 30(3):189–207.

Brüderl, J., Preisendörfer, P., and Ziegler, R. (1992). Survival chances of newly founded business organizations. *American Sociological Review*, 57(2):227–242.

Cabral, L. and Mata, J. (2003). On the evolution of the firm size distribution: Facts and theory. *American Economic Review*, 93(4):1075–1090.

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(5):626–641.

Coad, A., Segarra, A., and Teruel, M. (2016). Innovation and firm growth: Does firm age play a role? *Research Policy*, 45(2):387–400.

Cooley, T. F. and Quadrini, V. (2001). Financial markets and firm dynamics. *American Economic Review*, 91(5):1286–1310.

Dunne, P. and Hughes, A. (1994). Age, size, growth and survival: UK companies in the 1980s. *The Journal of Industrial Economics*, 42(2):115–140.

Dunne, T., Roberts, M. J., and Samuelson, L. (1988). Patterns of firm entry and exit in us manufacturing industries. *The RAND Journal of Economics*, 19(2):495–515.

Evans, D. S. (1987a). The relationship between firm growth, size, and age: Estimates for 100 manufacturing industries. *The Journal of Industrial Economics*, 35(4):567–581.

Evans, D. S. (1987b). Tests of alternative theories of firm growth. *Journal of Political Economy*, 95(4):657–674.

Fritsch, M., Brixy, U., and Falck, O. (2006). The effect of industry, region, and time on new business survival–a multi-dimensional analysis. *Review of Industrial Organization*, 28(3):285–306.

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

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

Heckman, J. and Singer, B. (1984). A method for minimizing the impact of distributional assumptions in econometric models for duration data. *Econometrica: Journal of the Econometric Society*, 52(2):271–320.

Hipp, C. and Grupp, H. (2005). Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies. *Research Policy*, 34(4):517–535.

Hirsch, S. and Adar, Z. (1974). Firm size and export performance. *World Development*, 2(7):41–46.

Hirsch, S. and Lev, B. (1971). Sales stabilization through export diversification. *The Review of Economics and Statistics*, 53(3):270–277.

Jenkins, S. P. (2005). Survival analysis. *Unpublished Manuscript, Institute for Social and Economic Research, University of Essex, Colchester, UK*, 42:54–56.

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

Kotler, P. et al. (2000). *Marketing Management*. Millenium Ed. Prentice Hall.

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

Mata, J. and Portugal, P. (1999). Technology intensity, demand conditions, and the longevity of firms. In Audretsch, D. B., Thurik, R., and Thurik, A., editors, *Innovation, industry evolution and employment*, chapter 12, pages 265–279. Cambridge University Press, New York.

Miles, I. (2008). Patterns of innovation in service industries. *IBM Systems Journal*, 47(1):115–128.

Muller, E. and Zenker, A. (2001). Business services as actors of knowledge transformation: the role of KIBS in regional and national innovation systems. *Research Policy*, 30(9):1501–1516.

OECD (2006). *Innovation and Knowledge-Intensive Service Activities*. Paris: OCDE Publishing.

Silva, H. C. and Lima, F. (2017). Technology, employment and skills: A look into job duration. *Research Policy*, 46(8):1519–1530.

Tether, B. S. and Hipp, C. (2002). Technology analysis & strategic management knowledge intensive, technical and other services: patterns of competitiveness and innovation compared knowledge intensive. *Technology Analysis & Strategic Management*, 14(2):163–182.

Wagner, J. (1994). The post-entry performance of new small firms in german manufacturing industries. *The Journal of Industrial Economics*, 42(2):141–154.

Wagner, J. (1995). Exports, firm size, and firm dynamics. *Small Business Economics*, 7(1):29–39.