

SEMPARAMETRIC COX REGRESSION MODEL IN ESTIMATION OF SMALL AND MICRO ENTERPRISES' SURVIVAL IN THE MALOPOLSKA VOIVODESHIP¹

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Abstract: This paper aims at identifying factors (external and internal) affecting the ability of an enterprise to survive on the market. The analysis is based on the results of a retrospective study conducted in 2012 on a sample of enterprises from Malopolska voivodeship. Methods and models of event history analysis, including semiparametric Cox's model were applied to analyse enterprises' survival. The approach based on the event history analysis allows us to include dynamics of the process. The results provided extensive data on how factors such as size, activity sector, market range, legal form and internal conditions like: owner characteristics, investments, profits, reported barriers affect the survival of enterprises.

Keywords: survival analysis, Cox's model, enterprises' survival

BACKGROUND – LITERATURE REVIEW

Enterprises dynamics account for a high percent of total productivity growth, supporting the idea that entrepreneurs are among the driving forces of economic growth and structural change. In the context of enterprises population dynamics, three aspects and areas must be considered: the entry, the exit and survival of entities. This paper aims at identifying factors (external and internal) affecting the ability of an enterprise to survive on the market.

Entry may be motivated by possibilities of higher earnings as self-employed, which supports start-up decision process [Creedy and Johnson 1983, Audretsch

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1995, Geroski 1995, Vivarelli 2004] as well as escape from unemployment as push factor. Barriers of entry like financial constraints on business start-ups [Evans and Jovanovic 1989, Cabral and Mata 2003] also play a significant role. Some characteristics of entrepreneurs may also be important such as self-realization, fulfillment of aspiration, better social status [Creedy and Johnson 1983, Vivarelli 2004]. Some market mechanisms may be assessed by macro-models but human behavioural decisions are not always fully predictable and measurable.

More than 50% of new firms exit the market within the first five years of activity, which is due to just a mistake according to the true Schumpeterian displacement-replacement effect [Geroski and Mazzucato 2001]. Exit is the effect of self-decisions (behavioural) or due to financial difficulties. The big role play loan constraints [Becchetti and Trovato 2002, Hurst and Lusardi 2004]. The internal factor is human capital of workforce and skills of entrepreneur [Lazear 2004, Silva 2006], and also sex of entrepreneur, but this is mixed effect [Cooper et al. 1994], not confirmed. The sector heterogeneity of survival [Marsili 2002] also plays a significant role.

The initial papers regarding the survival of enterprises have appeared in recent years in Poland. In her paper dedicated to survival of enterprises, Markowicz [2012] applies the Cox model for the analysis of enterprises from Szczecin region (only one city region) based on REGON register (not adjusted for non-active enterprises). Dehnel [2010] applies small area estimation techniques for basic business demography ratios for small and micro enterprises in Poland (active before 2001). Nehrebecka and Dzik [2013] apply logistic regression and distinguish between liquidation and bankruptcy as different ways of exiting the market. Some works of Ptak-Chmielewska [2010, 2012c] apply non-parametric (Kaplan-Meier) and semi-parametric (Cox regression) methods for retrospective data for one of regions in Poland.

According to the group of theories connected with management in an enterprise [Poznańska, 2008]: “Liability of Smallness”, “Liability of Newness” and “Ecological Economy”, the position of a small enterprise (as far as the number of employees and turnover are concerned) on the competitive market is much weaker in comparison with large enterprises. The reasons can be traced to the fact that small enterprises are put at a disadvantage with regard to economy of scale, distribution chains or market research. They employ managers with lower skills. On the other hand, according to the market niche theory, a small size can create many opportunities [Porter 1979]. Such enterprises will retain their size at a given level in order to be able to reach the market niches which are not accessible for large companies. Liability of Newness links the success of an enterprise with the time it functions on the market. The probability of exiting the market is much higher for new enterprises than for those with at least one year history. Ecological economy refers to biological theories [Hannan and Freeman 1989, Freeman et al. 1983] focusing on three groups of enterprises: new, developing and shrinking (end

of life). The ecological theory is focused then on the life cycle of an enterprise: determinants of birth, survival and death.

DATA AND METHODS

Event history analysis (survival analysis) is defined as a set of different statistical techniques used for describing and analysing the life course of an individual: number of events, sequence of events, timing and time spent in different states of the process. The subject of this analysis is a stochastic process with events (states). This process is described by survival time defined as the time from the start of observation till the end of process or the end of survey if it is completed before the end of the process. The subject of this kind of research is a time span between events known as time of the process or episode.

There are many different models used in the survival analysis. Models are differentiated according to assumptions on their functional form of hazard rate and its variability in time. The description of different models – nonparametric, parametric and semi-parametric – may be found in Frątczak [2005, chapters 7, 8, 9]. In practice, the proportional hazards Cox regression model is most frequently used. For this reason this model was presented in more details in this paper. For the Cox regression model the hazard function is given by a formula:

$$h(t | x_1, \dots, x_k) = h_0(t) \exp(\alpha_1 x_1 + \dots + \alpha_k x_k) \quad (1)$$

where: h_0 – base hazard, parametrically non-specified function of time and x_1, x_2, \dots, x_k – explanatory variables (including time dependent variables).

Cox also proposed a special type of estimation method called pseudo-likelihood [Cox, 1972]. This method divides the likelihood function for the proportional hazards model into two parts: first including only information on parameters and second including information on parameters and hazard function. This division into two components is justified because the former depends only on the sequence of events and does not depend on the exact time of occurrence, while the latter is 0 and is omitted.

The main advantage of Cox's model (and other semiparametric models) is the ability to assess the influence of many variables (including time dependent variables) on the process with no need for base hazard $h_0(t)$ specification. The main disadvantage of Cox's model is hazard proportionality assumption. This assumption imposes a fixed hazard rate for each pair of individuals at any time. Relative hazard (ranking) for individuals is stable. Despite this limitation of Cox's model, it is particularly attractive for researchers as in the case of Blossfeld and Rohwer [2002]:

- unknown shape of hazard in time;
- no theoretical basis for parametrisation;
- no possibility of specifying the functional shape of hazard;

- main interest focused on the influence of explanatory variables on hazard.

The abovementioned advantages of the application of Cox regression model make this model useful in modelling the risk of enterprises' liquidation. The only disadvantage of this model is a proportionality assumption which implies a fixed proportion of hazard for individuals during the observation period. This problem may be solved by including additional time dependent variables to the model such as the interaction between a variable and time. This model is known as non-proportional hazards Cox regression model. The results of Cox model estimation are parameters describing the influence of explanatory variables on the probability of event occurrence and on the base hazard (the same for all individuals, dependent only on time).

The analysis of enterprises' survival requires information on the exact date of the start and exact date of the end of their activity. Data concerning this information that are available in administrative registers such as REGON and cover all enterprises are not up-to-date and thus seem useless in the analysis of enterprises' survival. This requires the application of representative surveys. A panel representative survey on the sample of micro and small enterprises that has been conducted by CSO since 2002 is a good source of data [Warunki... 2010]. However a panel character of the survey leads to a significant information loss in subsequent waves and poses the necessity of missing data imputation. More details on data sources can be found in [Ptak-Chmielewska 2012a]. In 2012 a retrospective survey on the sample of enterprises from the Malopolska voivodeship registered in 2006 was conducted. The survey covered basic information on a given enterprise, activity status (after a five-year period) and type of activity, legal form, number of workers, range of market activity, and changes observed during its five-year activity. Additionally socio-demographic characteristics of the main owner of enterprise and reported barriers were collected.

The calendar time was not analyzed because all enterprises were existing in the same macroeconomic conditions. Time in survival analysis was defined as time in months since the start of the business (different from the date of registration) till the end date of the business: liquidation or suspension. Right censoring was set at the date of the survey 31.12.2011 for enterprises that survived till the end of a five-year period. For these enterprises (censored) time was measured as time in months since the start of the business till its end in 2011 (survey). In overall sample of 1077 enterprises 667 were censored (62%), means still active at the date of survey.

RESULTS OF COX REGRESSION MODEL ESTIMATION

The semiparametric Cox regression model was estimated in three steps. As the first step univariate models were estimated using the variables listed below and insignificant variables were deleted. In the second step, the multivariate model was

estimated using significant variables and checking for correlation between independent variables. In the last step, the proportionality assumption was verified and the model, including interaction over time for variables for which assumption was not satisfied, was estimated.

Variables used in Cox's regression model:

1. legal form –1 if companies (legal persons), including companies without special legal form, and 0 – for sole traders;
2. number of workers –1 if an enterprise had 10-49 workers at the start, and 0 – if an enterprise had 0-9 workers employed at the start;
3. sector of activity-group –1 if sectors were from a low risk group: industry, education, wholesale, hotels and restaurants, repairs, health care, other activity, and 0 – if sectors belonged to a high risk group: construction, retail, financial intermediation, real estate and business activities, transport;
4. change in the sector of activity –1 if during an enterprise activity some changes of the sector took place, and 0 – no changes;
5. geographical area of activity –1 if the area of activity was a cross-national or international market and 0 – if an enterprise was active only on a local or regional market;
6. change of geographical area – 1 if any change in the geographical area took place and 0 – if there was no change;
7. source of financing –1 if funds for starting the business came from a bank loan and 0 if they came from other sources (mainly own funds or family support);
8. export of goods and services –1 if an enterprise has ever exported their goods or services and 0 – if a respondent answered „no”;
9. change in the number of workers –1 if a change in the number of workers took place (measured by a positive parameter in linear trend for a five-year period) and 0 – if this trend was negative or there was no growth;
10. owner as the only employee –1 if during the whole period of activity only the owner worked in an enterprise and there was no change and 0 in any other case;
11. profit in the first year –1 if over the first year of activity an enterprise made profits and 0 if it made a loss or suspended its activity (vulnerable or forced);
12. age of the owner –1 if the owner was 35 years old and older or it was a company and 0 if the owner was younger than 35 or the age of the owner was missing;
13. educational level of the owner –1 if the owner had higher education (post-secondary) or it was a company and 0 in other cases;
14. sex of the owner – 1 if the owner was a man or it was a company and 0 if the owner was a woman;
15. source of maintenance – 1 if the employment in this enterprise was the main source of maintenance for the owner or it was a company and 0 in other cases;
16. type of previous job –1 if the previous job of the owner was a job from the low risk group (engineering, white collar, manager, other) or it was a company and 0 if it was a job from the high risk group (farmer, craftsman, seller, student, unemployed);

17. investments –1 if an enterprise invested in the first year of activity and 0 if there were no investments or an enterprise was suspended or no information;
18. barriers –1 if an enterprise (respondent) did not report any barriers in selling their goods or services in the first year of activity and 0 if barriers were reported.

The results of this univariate analysis confirmed the lack of significance of the following variables: source of maintenance and age of the owner. In the multivariate analysis 16 variables were used. The assumption of proportionality was tested and verified with martingale residuals – supremum test (details in Allison 2010, pp. 173 and further). The correlation between explanatory variables was also investigated but there were no significant correlations. In the multivariate model variables such as sector of activity-group, export of goods and services, sex of the owner, education of the owner were not significant.

Enterprises registered and operating as companies had 65% lower risk of liquidation compared to enterprises of sole traders (see table 1). Enterprises with 10-49 workers at the start had 67% lower risk of liquidation compared to enterprises with 0-9 workers at the start. In many cases it turned out that the owner was the only employee working in an enterprise (self-employment).

Table 1. Results for Cox regression model

Variable	Parameter	Std. error	Chi-square	Pr. > chi-sq.	Hazard ratio
Legal form	-1.03945	0.21673	23.0016	<.0001	0.354
Number of workers	-1.12391	0.36727	9.3644	0.0022	0.325
Sector of activity-group	0.12674	0.10842	1.3664	0.2424	1.135
Change of sector of activity	-1.24947	0.45612	7.5039	0.0062	0.287
Geographical area of activity	-0.29889	0.13047	5.2483	0.0220	0.742
Change of geographical area	-0.92062	0.51144	3.2403	0.0718	0.398
Source of financing	-0.75325	0.29621	6.4669	0.0110	0.471
Export of goods and services	-0.52834	0.33484	2.4897	0.1146	0.590
Change in number of workers	-0.22728	0.02763	67.6391	<.0001	0.797
Owner as only employee	-2.28942	0.20973	119.1544	<.0001	0.101
Profit in the first year	-0.68265	0.10342	43.5683	<.0001	0.505
Sex of the owner	-0.04531	0.10337	0.1921	0.6612	0.956
Education of the owner	-0.10960	0.11582	0.8955	0.3440	0.896
Type of the previous job	-0.38199	0.10645	12.8767	0.0003	0.682
Investments	-0.60068	0.10316	33.9060	<.0001	0.548
Barriers	-0.53033	0.10760	24.2919	<.0001	0.588

Source: own calculations based on the results of a retrospective survey on enterprises' survival in Malopolska voivodeship using SAS system

Enterprises with only the owner working and without any changes during the observation period had about 90% lower risk of liquidation in comparison to enterprises that changed the employment (most cases those enterprises employed

people at start and after 1-2 years limited employment). For the variable sector of activity-group the parameter was positive, which seems to be counter-intuitive. This aggregation could be too strong to reveal any differences between risk for different sectors of activity. If an enterprise was flexible and could change the sector of activity according to a market demand it had 60-70% lower risk of liquidation compared to enterprises that did not change their sector of activity. Enterprises operating on cross-national or international markets had 26% lower risk of liquidation compared to enterprises operating only on regional and local markets. Changes in the area of activity (wider markets) were also significant and lowered the risk of liquidation by about 60%. If an enterprise was able to get bank loans to finance the start of the business it had about 53% lower risk of liquidation compared to enterprises that started the business basing only on own funds or family help. Enterprises that exported their goods or services had higher chances for survival (but this influence was not significant). A key risk factor was also the profit gained during the first years of activity. Enterprises that gained profits during the first year of activity had 50% lower risk of liquidation as compared to enterprises that made a loss or suspended their activity. Enterprises with a male owner (or company) and enterprises with an owner with high education had lower risk of liquidation but the effect of these variables was not statistically significant. Higher importance was attributed to enterprise development and barriers on the market. If an enterprise invested during the first year of activity it had about 45% lower risk of liquidation. Enterprises (respondents) that did not report any demand barriers during the first year of activity had 41% lower risk of liquidation compared to enterprises that reported some kinds of barriers.

In the case of variables such as: change in the number of workers, owner as the only employee and profit in the first year and investments or barriers the proportionality assumption was violated (based on results of supremum test). For these variables the interaction over time was included (see table 2).

Table 2. Interaction over time for variables with a violated proportionality assumption

Variable	Parameter	Std. error	Chi-square	Pr. > chi-sq.
Change in the number of workers*time	-0.00311	0.0003667	71.8844	<.0001
Owner as the only employee *time	-0.02507	0.00292	73.6585	<.0001
Profit in the first year*time	-0.02111	0.00169	155.5539	<.0001
Investments*time	-0.01707	0.00175	95.4634	<.0001
Barriers *time	-0.01638	0.00185	78.6185	<.0001

Source: own calculations based on the results of a retrospective survey on enterprises' survival in Malopolska voivodeship using SAS system.

A negative and significant parameter for interaction reveals a substantial and increasing in time effect of a given variable. For example, the effect of a change in the number of workers measured by a positive increase in the number of workers in

time is negative and additionally accelerates with time (negative significant interaction effect). If an increase in the number of workers was observed the risk of liquidation was lower about 22.7% compared to enterprises for which no increase in the number of workers was observed. This effect accelerated with the time of enterprise activity because the estimated parameter for interaction was -0.00311. For example after 12 months of activity the effect of this variable accelerates up to $-0.22728 + (-0.00311) \cdot 12 = -0.2646$. The results for other variables were very similar but the effect of acceleration was weak.

CONCLUSIONS AND DISCUSSION

Discussion of the results may be divided into two areas: internal and external factors driving the process of enterprises' survival.

The first internal factor important for firms survival is the size and age of a company, numerous investigations have found that larger and older firms have lower hazard rates than smaller and younger ones. However, this effect is not uniform. The size-age effects are only significant for single-person firms, and there is no size effect in new branches and subsidiaries of existing firms [Audretsch and Mahmood 1994, Mahmood 2000]. This means that the effect of "liability of adolescence" differs across different types and sectors of activity. According to the ecological theory of firms [Hannan 2005], smaller firms have a higher risk of failure - "liability of smallness" [Freeman et al. 1983], younger firms have the higher risk of failure - "liability of newness" [Stinchcombe 1965]. Enterprises that employed workers at the very beginning of activity were generally more successful and this effect in Cox model was significant. Also a change (growing number) of workforce of the enterprise plays a significant role.

Second, we have those studies that focus on differences in the legal structure of the firm [Mata and Portugal 2002, Esteve et al. 2004, Esteve-Pérez and Mañez-Castillejo 2008]. However, limited liability firms are more likely to exit through voluntary liquidation. In our model (for one of the regions in Poland) the evidence shows that sole traders are the most risky group, and any form of partnership decreases the risk of failure.

Other strategic activities that influence the survival are advertising and exporting [Kimura and Fujii 2003, Esteve et al. 2004, Esteve-Pérez and Mañez-Castillejo 2008]. Firms engaging in these activities seem to have lower hazard rates of exit [Mata and Portugal 2002]. In our sample we considered dummy: exported in first year or not exported, but this effect was not significant. More important was gaining a profit during the first period of activity.

Considering the socio-demographic profile of an entrepreneur as the most deterministic in enterprise failure we describe below the demography of owners. Those are the main internal factors determining the success and failure.

Only 12% of owners were unemployed before starting their own business which means that the influence of the market "push factor" was not significant (see

also [Ptak–Chmielewska 2012b]). In 70% of cases the employment in the own enterprise is the main source of maintenance of the main owner. In our model the effects of sex of the owner, education of the owner were not significant. The type of professional experience of the owner was significant. If the previous job of the owner was a job from the low risk group (engineering, white collar, manager, other) or it was a company the risk of liquidation was lower comparing to the situation where the owner had previously a job from the high risk group (farmer, craftsman, seller, student, unemployed).

The evaluation of the situation and conditions helping or disturbing the enterprises' development was focused on the environment and barriers existing on the market. 40% of enterprises did not invest in their first year of activity. Almost 48% of enterprises form investing group used their own funds, only 10% used loans or subsidies. Half of entrepreneurs did not report any barriers in sales of goods and services and production development. In subsequent years the share of enterprises that did not report barriers decreased slightly. The most important was the first year because this was the main driver of being on the market. 26% of enterprises reported too high competition on the market, other barriers were not significant.

Among external factors, the most important role is played by: the industry, the geographical space, the business cycle [Manjon–Antoli and Arauzo–Carod 2008]. First, the industry-specific characteristics such as technology, entry rates and scale economies seem to explain differences in survival rates across firms. In our research we controlled for sector of activity group. We divided sectors of activity into two groups: low risk group (industry, education, wholesale, hotels and restaurants, repairs, health care, other activity) and high risk group (construction, retail, financial intermediation, real estate and business activities, transport) but the difference was not significant. The change in the sector of activity was significant, confirming that elasticity of an enterprise plays significant role.

The second, the geographical space, according to New Economic Geography factors such as agglomeration economies, affects firm performance [Fujita et al. 1999]. In Poland enterprises registered in urban areas have higher chances for survival [Ptak–Chmielewska 2010]. More important are cross-border activities. According to our results, enterprises running activities on local or regional markets had lower chances for survival compared to enterprises with activities run on cross-national or international markets. Enterprises that succeeded in expanding outside regional and local markets had lower risk of liquidation.

The third, the business cycle, the chances of survival tend to be closely related to the evolution of the business cycle, being higher in the upswings and lower in the downturns. Business cycle upturn, shows negative and statistically significant coefficients in most research results with evidence that firms founded in periods of low unemployment rates have longer time of survival [Audretsch and Mahmood 1995, Mahmood 2000, Disney et al. 2003, Görgand Strobl 2003, Ptak–Chmielewska 2012b]. Macroeconomic conditions at the time of entry into the

market determine the probability of survival during the whole life of the enterprise [Mata et al. 1995]. However, using macroeconomic conditions must be combined with additional control variables.

In conclusion, we found that some internal factors such as previous experience of the owner or motivation play significant role in firms successes. Also, the external situation and barriers on the market matter considerably. Some of our results confirmed basic findings from previous research but some of detailed results gave new insight into the process of start-ups failure or success. The results for one region are generally consistent with results for the country. Expanding the activity into cross-national and international markets plays a significant role and increases the probability of survival. Surviving the first year is crucial, and this is strongly connected to gaining profits, investing in assets and barriers (demand side). Those effects accelerate in time. Research in this area including methods with time varying effect of characteristics was very rare and our work gives more light into this area. The application of event history methods and models rather than traditional methods in the analysis of enterprises' survival opens up opportunities for a better and wider use of the results in supporting enterprises by public policy.

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