
ANALYSIS OF THE RISK OF LIQUIDATION DEPENDING ON THE AGE OF THE COMPANY: A STUDY OF ENTITIES ESTABLISHED IN SZCZECIN IN PERIOD 1990-2010

Iwona Markowicz

Univeristy of Szczecin, Szczecin, Poland

e-mail: iwona.markowicz@usz.edu.pl

ORCID: 0000-0003-1119-0789

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Abstract: The aim of the research was an assessment of the relative risk of liquidation of a company depending on its age. The research covered economic entities established in Szczecin in the period 1990-2010. The analysis was carried out with the use of a logit model. The risk of company liquidation was examined depending on the entity's age expressed both in months (continuous variable) and in grouped intervals (year, half-year). In this way, attention was drawn to the benefits of continuous variable coding (rank and 0-1 coding). The research covered companies established during 1990-2010 in total (over 120 thousand) and in time periods resulting from the cyclical character of liquidation of companies (in accordance with the earlier research findings). The research showed that the risk of company liquidation decreases as the company grows older (the use of a continuous variable and a rank variable). On the other hand, the risk of subsequent age groups (using the 0-1 variable) prevents the risk from being monotonous.

Keywords: survival analysis, firms' duration, risk of liquidation.

1. Introduction

According to the literature, the age of a company is important for its prospects of survival in the subsequent periods. According to the *liability of newness* – one of the concepts of company survival derived from the theory of company organization [Poznańska 2008], the most important factor of survival is the longevity of business activity on the market (start-ups tend to leave the market quickly). The importance of company longevity is also emphasized by the *theoretical model of learning* which assumes that the entrepreneur needs time to determine whether their company will be able to operate in the market [Ericson, Pakes 1998; Bhattacharjee 2005]. The results of many studies [Caves 1998; Carroll, Hannan 2000; Praag 2003] suggest that

the age, size and duration of enterprises are interlinked. In the Polish literature one can find the results of research concerning the survival time of entities established in different cities or voivodships [Dehnel 2010; Markowicz 2012; Nehrebecka, Dzik 2013; Jackowska 2015; Ptak-Chmielewska 2016; Gurgul, Zajac 2016; Mikulec 2018; Markowicz, Mikulec 2018].

The aim of the research was an assessment of the relative risk of liquidation of a company depending on its age. The research covered economic entities established in Szczecin in 1990-2010. The analysis was carried out with the use of a logit model. The risk of company liquidation was examined depending on the entity's age expressed both in months (continuous variable) and in grouped intervals. In this way, attention was drawn to the benefits of continuous variable coding. The research covered companies established in the period 1990-2010 and in time periods resulting from the cyclical character of liquidation of companies [Markowicz 2018]. The results of earlier research pointed to the cyclicity of the relative risk of non-survival of the first year of activity by entities from subsequent cohorts (entities established in subsequent years from 1990 to 2010).

2. Statistical data and research methodology

The survey used individual data for 120,115 companies established in Szczecin between 1990-2010 and observed for up to four years. Data on the lifespan of companies liquidated during the observation period were considered to be complete data, while censored data refer to companies operating until the end of the observation period.

The risk of liquidation of the company was assessed using a logit model. The model explained the impact of specific variables on the occurrence or absence of the event under investigation. Transformation of the logistic model into a logit model caused a change of the scale for probability from 0 to 1 to the scale from minus to plus infinity [Wiśniewski 1989; Jajuga 1990; Gatnar, Walesiak (eds.) 2004].

The analysis of the risk is conducted by means of the logit model written as [Kleinbaum, Klein 2005; Gruszczyński (ed.) 2012]:

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right) = \alpha_0 + \sum_{i=1}^k \alpha_i x_i,$$

where: $p = P(Y = 1 | x_1, x_2, \dots, x_k)$ – conditional probability of an event occurring with k independent variables x_1, x_2, \dots, x_k ; $\alpha_1, \alpha_2, \dots, \alpha_k$ – model coefficients.

The value p refers to the probability of failure (the company's liquidation), and the expression $\frac{p}{1-p}$ means the risk for a specific event to occur. The bigger the value of the regression coefficient α_i , the stronger the impact of the explanatory variable on the probability of the event occurring.

The resulting parameter estimates and their interpretation depend on the way the explanatory variables are written. We may use quantitative variables (continuous and discrete variables), suitably dimensioned qualitative characteristics and grouped values or variants of one characteristic [Bednarski, Mocarska, 2006; Bieszk-Stolorz, Markowicz 2017].

The study used three ways to define an independent variable, i.e. the age of the company: a continuous variable x_i expressed in months, a k -variant (rank) variable x expressed in years ($k = 1, \dots, 4$) or half-years ($k = 1, \dots, 8$) and dummy dichotomous variables x_i representing age groups.

For the k -variant variable x , the rank coding was used, as follows:

- for age groups in years (groups 1, ..., 4) – $x = 1$ for company age from the interval $<0-1$), $x = 2$ for company age from the interval $<1-2$), $x = 3$ for company age from the interval $<2-3$), $x = 4$ for company age from the interval $<3-4$),
- for age groups in half-years (groups 1, ..., 8) – $x = 1$ for company age from the interval $<0-6$) months, $x = 2$ for company age from the interval $<6-12$) months, ..., $x = 8$ for company age from the interval $<42-48$) months.

In the third approach to the coding of explanatory variables, the dummy dichotomous variables x_i were created taking values of 0 or 1 according to the definition presented in Table 1.

Table 1. Defining of dichotomous explanatory variables

Variables	Value 1	Value 0
Age groups in years		
x_1	the reference point, age from the interval $<0-1$)	In other incidentals
x_2	for age from the interval $<1-2$)	
x_3	for age from the interval $<2-3$)	
x_4	for age from the interval $<3-4$)	
Age groups in months (half-years)		
x_1	the reference point, age from the interval $<0-6$)	In other incidentals
x_2	for age from the interval $<6-12$)	
x_3	for age from the interval $<12-18$)	
\vdots	\vdots	
x_8	for age from the interval $<42-48$)	

Source: own elaboration.

The variable with k variants was transformed into $k - 1$ so-called design variables or dummy variables. One of the variants was a variable which had not been introduced into the model (due to its collinearity), but which was the reference point for other dummy variables.

The survey was conducted in three stages. The first one covered companies established in the entire period under examination, i.e. the years between 1990-2010. The subsequent stages were identified on the basis of earlier research [Markowicz 2018], which showed that the risk of liquidation of companies runs in cycles. Taking into consideration the risk of liquidation in the first (most difficult) year of operation, two cycles covering the years 1990-2001 and 2002-2010 and four phases were determined: the rise in the years 1990-1997 (increasing risk of liquidation in subsequent cohorts of companies), the decrease in 1998-2001 (declining risk), the rise in 2002-2006 followed by the downward phase in 2007-2010. The results of the study are shown in a sequence of three stages. In each stage the results of the application of the explanatory variable (company age) in the form of a continuous variable, the rank variable and binary (0-1) variables are presented.

3. Research results

3.1. The period of company establishment: 1990-2010

When the continuous variable (the company's age in months) was used in the logit model, we obtained: ($\chi^2 = 110513.1$; $p = 0.0000$):

$$\text{logit}(p) = 19.4237 - 0.5661 \cdot x_i$$

(0.2004) (0.0054)

The risk ratio ($\exp(\alpha_i)$) was 0.5678 ($p = 0.0000$), which should be interpreted as: with the increase in the age of the company by one month, the risk of liquidation decreases by 43.22%. This result was too general, averaged and did not indicate the differences in the risk of companies of different ages. Then, models for the rank variable (groups 1 to 4) and the 0-1 variables were estimated (Table 2, Figure 1). As a result of using a rank variable defining four groups of companies (one, two, three and four-year-old), the risk of each successive group was found to be lower by 24.29%. This is how much the risk of liquidation dropped with the increase in the age of the company by one year. At this point it should be noted that that was still an average result. In order to indicate the differences in the risk of individual groups, the variables 0-1 should be used. Therefore, the rank variable with k variants was transformed into k dichotomous variables. The first one was considered the reference group. It turned out that in relation to one-year-old companies (liquidation in the first year of operation) the risk of liquidation of two-year-old companies (liquidation at the age of 1 to 2 years) was lower by 6.27%, of three-year-old companies by 15.40%, and of four-year-old companies by as much as 68.87%. Accordingly, the use of the artificial dummy variable (0-1) as an explanatory variable makes it possible to differentiate company groups according to their age in terms of the risk of liquidation.

Table 2. Results of the logit model estimation for the period 1990-2010 using the rank variable and 0-1 variables (age in years)

Variables	Parameters estimator	Standard error	p-value	Risk ratio
Rank variable x				
x	-0.2782	0.0053	0.0000	0.7571
0-1 variables x_i				
x_1				1
x_2	-0.0648	0.0141	0.0000	0.9373
x_3	-0.1673	0.0148	0.0000	0.8460
x_4	-1.1669	0.0208	0.0000	0.3113

Source: own research.

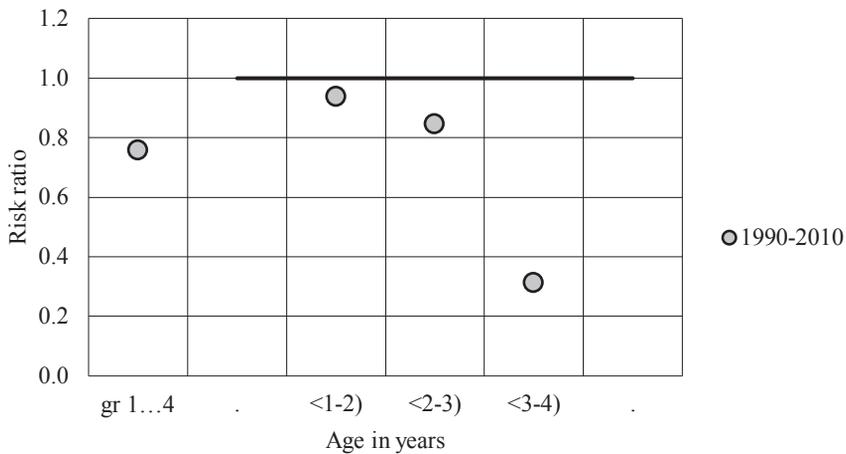


Fig. 1. Risk ratio of company liquidation for variables: rank and 0-1 (age in years)

Source: own research.

Models were also estimated for the rank variable (groups 1-8) and the 0-1 variables, where age was expressed in half-years (Table 3, Figure 2). As a result of using a rank variable which defined eight groups of companies (in age sequence: <0-6), <6-12), ..., <42-48) months), it was found that the risk of each successive group was on average 2.22% lower. In the dichotomous variables approach, companies that were liquidated before reaching six months of operation were used as a reference group. For the subsequent groups (companies aged 6-12 and 12-18 months) the risk of liquidation was 13.80% and 5.29% higher than the risk of the reference group, respectively. The risk born by the next two groups of companies (aged 18-24 and 24-30 months) slightly differed from the risk of the youngest companies (4.59% lower and 1.23% higher respectively). The parameters of the two

variables were insignificant (Table 3). However, this is not a reason to remove these variables from the model, as they have an informative value [Markowicz 2012]. The results indicate that the differences between the risk of liquidation of companies aged 6 months or younger and companies aged 18-24 and 24-30 months were not significant. Therefore, the risk in these groups was similar. The risk ratio for the three oldest groups of companies was below one, which indicates that the risk of these companies was lower than that of the youngest companies by 19.59%, 49.41% and 82.66%, respectively. Therefore, the risk of liquidation in ageing companies was not monotonous, and decreased only in groups of companies over 30 months of age.

Table 3. Results of the logit model estimation for the period 1990-2010 using the rank variable and 0-1 variables (age in half-years)

Variables	Parameters estimator	Standard error	<i>p</i> -value	Risk ratio
Rank variable <i>x</i>				
<i>x</i>	-0.0224	0.0004	0.0000	0.9778
0-1 variables <i>x_i</i>				
<i>x₁</i>				1
<i>x₂</i>	0.1293	0.0186	0.0000	1.1380
<i>x₃</i>	0.0516	0.0192	0.0073	1.0529
<i>x₄</i>	-0.0470	0.2000	0.0186	0.9541
<i>x₅</i>	0.0122	0.0199	0.5414	1.0123
<i>x₆</i>	-0.2181	0.0215	0.0000	0.8041
<i>x₇</i>	-0.6814	0.0252	0.0000	0.5059
<i>x₈</i>	-1.7522	0.0387	0.0000	0.1734

Source: own research.

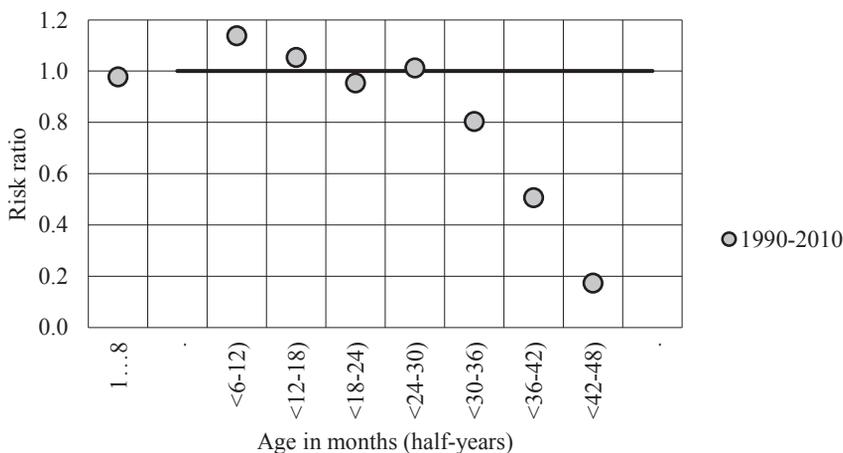


Fig. 2. Risk ratio of company liquidation for variables: rank and 0-1 (age in half-years)

Source: own research.

3.2. The period of company establishment: 1990-2001 and 2002-2010 (two cycles)

Due to the cyclical character of the risk of company liquidation, the period of observation was divided into two (according to the determined cycles): 1990-2001 and 2002-2010. The procedure of using continuous rank and 0-1 variables was repeated as in Chapter 3.1. When the continuous variable was used in the logit model we obtained:

- for the period 1990-2001 ($\chi^2 = 66024.0$; $p = 0.0000$):

$$\text{logit}(p) = 19.5762 - 0.5751 \cdot x_i$$

(0.2752) (0.0074)

- for the period 2002-2010 ($\chi^2 = 43544.0$; $p = 0.0000$):

$$\text{logit}(p) = 19.0658 - 0.5493 \cdot x_i$$

(0.2921) (0.0078)

The risk ratios were 0.5627 ($p = 0.0000$) and 0.5773 ($p = 0.0000$), respectively, which means that with the increase in company age by one month, the risk of liquidation decreased on average by 43.73% in the first period and by 42.27% in the second period. Thereafter, models for the ranked variable (groups 1-4) and the 0-1 variables (Table 4, Figure 3) were estimated. The risk of liquidation in companies

Table 4. Results of the logit model estimation for the periods 1990-2001 and 2002-2010 using the rank variable and 0-1 variables (age in years)

Periods	Variables	Parameters estimator	Standard error	<i>p</i> -value	Risk ratio
Rank variable <i>x</i>					
1990-2001	<i>x</i>	-0.3616	0.0073	0.0000	0.6965
2002-2010		-0.1702	0.0079	0.0000	0.8435
0-1 variables <i>x_i</i>					
1990-2001	<i>x₁</i>				1
	<i>x₂</i>	-0.1734	0.0185	0.0000	0.8339
	<i>x₃</i>	-0.4317	0.0203	0.0000	0.6494
	<i>x₄</i>	-1.3583	0.0283	0.0000	0.2571
2002-2010	<i>x₁</i>				1
	<i>x₂</i>	0.0916	0.0219	0.0000	1.0959
	<i>x₃</i>	0.1706	0.0222	0.0000	1.1861
	<i>x₄</i>	-0.8965	0.0310	0.0000	0.4080

Source: own research.

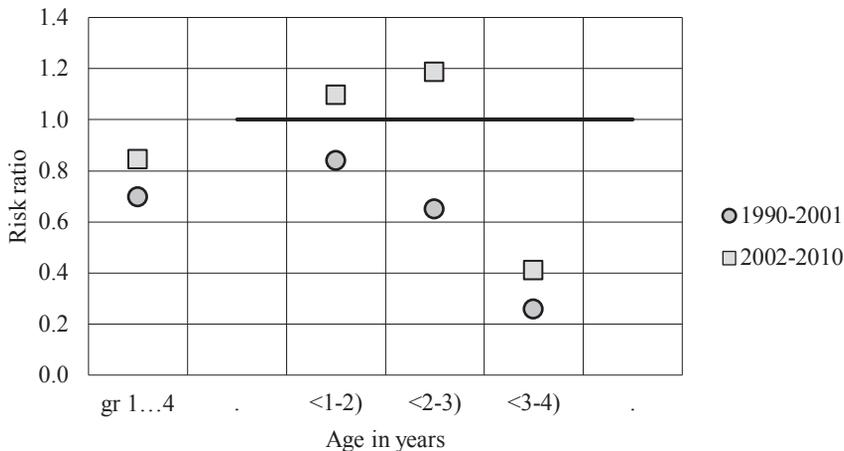


Fig. 3. Risk ratio of company liquidation for variables: rank and 0-1 (age in years) for the periods 1990-2001 and 2002-2010

Source: own research.

ageing by one year decreased by 30.35% in the first period and by 15.65% in the second period. When analysing the results of modelling with the use of dichotomous variables, it should be noted that in the period 1990-2001 the risk of liquidation in subsequent age groups was decreasing in comparison to the companies liquidated in the first year of their activity. On the other hand, in the period between 2002-2010, the risk initially increased to drop only in the group of the oldest companies. Therefore, the conditions of running a business activity were more favourable for entrepreneurs in the first period of study, when the risk of liquidation was systematically decreasing together with the company age.

Models for the rank variable (groups 1-8) and the 0-1 variables where age was expressed in half-years were also re-estimated (Table 5, Figure 4). As a result of using a rank variable that defined eight groups of companies (age <0-6), <6-12), ..., <42-48 months), it was found that in each successive group the risk was on average 2.83% lower in the first period and 1.41% lower in the second period. In the model with 0-1 variables, companies that were liquidated before reaching six months of age were again accepted as the reference group. In the first cycle, the risk of liquidation was higher than for the youngest companies only in the case of entities aged from 6 to 12 months. For all other groups the value of relative risk was below one (in the case of the variable x_3 the parameter was insignificant, i.e. the risk of liquidation for companies aged from 12 to 18 months did not differ significantly from the risk in the reference group). In the second analysed cycle (2002-2010), the risk of groups 2-5 was higher than that of the youngest companies (even by as much as 54.95% in the case of entities aged 24-30 months). The risk of liquidation of the next group

Table 5. Results of the logit model estimation for the periods 1990-2001 and 2002-2010 using the rank variable and 0-1 variables (age in half-years)

Periods	Variables	Parameters estimator	Standard error	p-value	Risk ratio
Rank variable x					
1990-2001	x	-0.0287	0.0006	0.0000	0.9717
2002-2010	x	-0.0142	0.0006	0.0000	0.9859
0-1 variables x_i					
1990-2001	x_1				1
	x_2	0.1021	0.0239	0.0000	1.1075
	x_3	-0.0351	0.0250	0.1597	0.9655
	x_4	-0.2102	0.0265	0.0000	0.8104
	x_5	-0.3498	0.0279	0.0000	0.7049
	x_6	-0.3916	0.0286	0.0000	0.6760
	x_7	-0.9366	0.0347	0.0000	0.3920
	x_8	-1.8423	0.0503	0.0000	0.1585
2002-2010	x_1				1
	x_2	0.1716	0.0298	0.0000	1.1872
	x_3	0.1789	0.0302	0.0000	1.1959
	x_4	0.1776	0.0306	0.0000	1.1943
	x_5	0.4379	0.0295	0.0000	1.5495
	x_6	0.0338	0.0329	0.3042	1.0342
	x_7	-0.3370	0.0372	0.0000	0.7139
	x_8	-1.6032	0.0605	0.0000	0.2013

Source: own research.

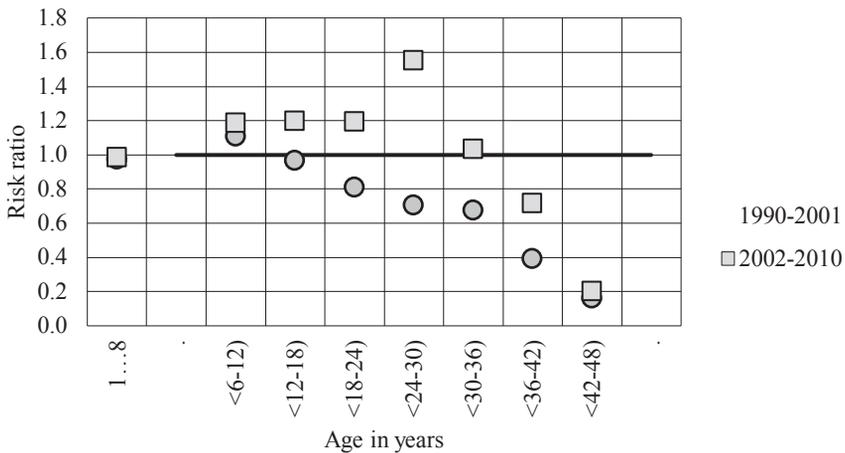


Fig. 4. Risk ratio of company liquidation for variables: rank and 0-1 (age in half-years) for the periods 1990-2001 and 2002-2010

Source: own research.

(x_6) did not differ significantly from the youngest group. On the other hand, once the company reached the age of three years, the risk decreased.

3.3. The period of company establishment: 1990-1997, 1998-2001, 2002-2006 and 2007-2010 (four phases)

Since the results of earlier surveys indicated that there were four phases of change in the risk of liquidation in the first year of business operation, the analysed period was also divided into four parts. The procedure of using continuous rank and 0-1 variables was repeated again. When the continuous variable was used in the logit model, we obtained:

- for the period 1990-1997 ($\chi^2 = 2112.9$; $p = 0.0000$):

$$\text{logit}(p) = -1.7075 - 0.4016 \cdot x_i$$

(0.0203) (0.0091)

- for the period 1998-2001 ($\chi^2 = 574.5$; $p = 0.0000$):

$$\text{logit}(p) = -1.9058 - 0.2867 \cdot x_i$$

(0.0287) (0.0122)

- for the period 2002-2006 ($\chi^2 = 368.3$; $p = 0.0000$):

$$\text{logit}(p) = -1.7247 - 0.2145 \cdot x_i$$

(0.0272) (0.0113)

- for the period 2007-2010 ($\chi^2 = 136.5$; $p = 0.0000$):

$$\text{logit}(p) = -1.8727 - 0.1277 \cdot x_i$$

(0.0273) (0.0110)

The risk ratios ($\exp(\alpha_i)$) in the individual phases were as follows: 0.5707 ($p = 0.0000$), 0.5470 ($p = 0.0000$), 0.5764 ($p = 0.0000$) and 0.5784 ($p = 0.0000$), which means that along with an increase in the age of the company by one month, the risk of liquidation decreased on average by 42.93% in the first period, by 45.30% in the second period, by 42.36% in the third period and by 42.16% in the fourth one. The models for the ranked variable (groups 1 to 4) and the 0-1 variables were then estimated (Table 6, Figure 5). The risk of liquidation was decreasing with a company ageing by one year in the first phase by 33.07%, in the second phase by 24.92%, in the third by 19.30%, and in the fourth by 11.99%. When analysing the results of modelling with the use of dichotomous variables, it should be noted that in the first two phases (1990-1997 and 1998-2001) the risk of liquidation decreased in subsequent age groups in comparison to the companies liquidated in the first year

Table 6. Results of the logit model estimation for the periods 1990-1997, 1998-2001, 2002-2006 and 2007-2010 using the rank variable and 0-1 variables (age in years)

Periods	Variables	Parameters estimator	Standard error	p-value	Risk ratio
Rank variable x					
1990-1997	x	-0.4016	0.0091	0.0000	0.6693
1998-2001	x			0.0000	0.7508
2002-2006	x			0.0000	0.8070
2007-2010	x			0.0000	0.8801
0-1 variables x_i					
1990-1997	x_1				1
	x_2	-0.2138	0.0226	0.0000	0.8075
	x_3	-0.5847	0.0256	0.0000	0.5572
	x_4	-1.4161	0.0348	0.0000	0.2427
1998-2001	x_1				1
	x_2	-0.0949	0.0325	0.0035	0.9095
	x_3	-0.1535	0.0337	0.0000	0.8577
	x_4	-1.2400	0.0487	0.0000	0.2894
2002-2006	x_1				1
	x_2	0.1476	0.0304	0.0000	1.1591
	x_3	0.0286	0.0323	0.3758	1.0290
	x_4	-0.9814	0.0448	0.0000	0.3748
2007-2010	x_1				1
	x_2	0.0320	0.0314	0.3087	1.0325
	x_3	0.2993	0.0307	0.0000	1.3489
	x_4	-0.8151	0.0430	0.0000	0.4426

Source: own research.

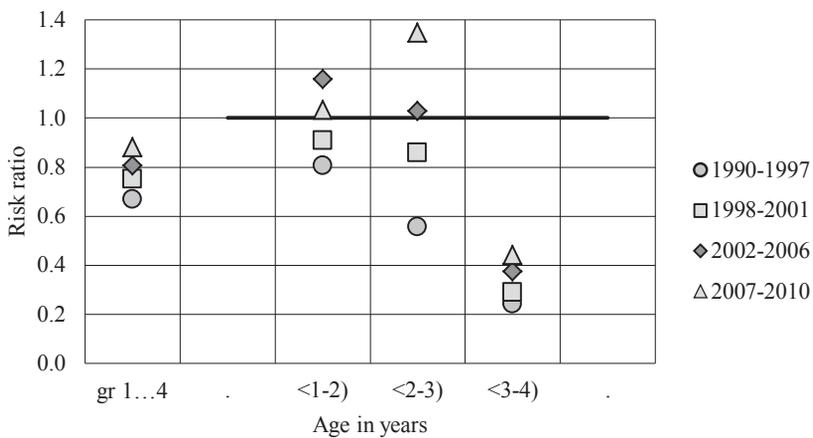


Fig. 5. Risk ratio of company liquidation for variables: rank and 0-1 (age in years) for the periods 1990-1997, 1998-2001, 2002-2006 and 2007-2010

Source: own research.

of operation (to a greater extent in the first phase), while in the third and fourth phase (2002-2006 and 2007-2010) the risk initially grew and was smaller only in the oldest group.

4. Conclusions

Wiśniewski [1989] stresses that the possibilities of econometric modelling are greater when the 0-1 measurement is used rather than the rank measurement. The author refers this observation to qualitative endogenous variables. The results of the research presented in this article allow for a similar reference to quantitative explanatory variables. Better results in the sense of interpretation of the estimated parameters are obtained from the use of exogenous 0-1 variables than the rank or continuous variables.

The main conclusions of the research are as follows:

1. For companies established in Szczecin between 1990-2010:

- as the company aged by one month, the risk of its liquidation dropped on average by 43.22% (age as a continuous variable),
- as the company aged by one year, the risk of its liquidation dropped on average by 24.29% (rank variable),
- in comparison to companies aged one year, the risk of liquidation for two-year-old companies was lower by 6.27%, for a three-year-old one – by 15.40%, and for four-year-old ones – by as much as 68.87% (0-1 variable),
- in groups 1-8 (age expressed in half-years) the risk of liquidation in each subsequent group was lower by an average of 2.22% (rank variable),
- in comparison to the groups liquidated before reaching six months of age, the risk of liquidation was higher by 13.80% in group 2, higher by 5.29% in group 3, lower by 4.59% in group 4, higher by 1.23% in group 5, lower by 19.59% in group 6, lower by 49.41% in group 7 and lower by 82.66% in group 8 (0-1 variable).

2. For companies established in Szczecin in the cycles of 1990-2001 and 2002-2010:

- as the company aged by one month, the risk of its liquidation dropped on average by 43.73% in the first cycle and by 42.27% in the second cycle (age as a continuous variable),
- as the company aged by one year, the risk of its liquidation dropped on average by 30.35% in the first cycle and by 15.65% in the second cycle (rank variable),
- in the first cycle the risk of liquidation in subsequent age groups was lower in comparison to the companies liquidated in their first year of operation, while in the second cycle it initially increased to fall only in the group of oldest companies (0-1 variable).

3. For companies established in Szczecin in 4 phases: 1990-1997, 1998-2001, 2002-2006, 2007-2010:

- as the company aged by one month, the risk of its liquidation dropped on average by 42.93% in the first phase, by 45.30% in the second, by 42.36% in the third and by 42.16% in the fourth phase (age as a continuous variable),
- as the company aged by one year, the risk of its liquidation dropped in the four phases on average by 33.07%, 24.92%, 19.30%, 11.99% respectively (rank variable),
- in the two initial phases the risk of liquidation in subsequent groups was lower in comparison to the companies liquidated in their first year of operation, while in the third and fourth phases it initially rose to fall only in the group of oldest companies (0-1 variable).

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ANALIZA RYZYKA LIKWIDACJI W ZALEŻNOŚCI OD WIEKU FIRMY NA PRZYKŁADZIE PODMIOTÓW POWSTAŁYCH W SZCZECINIE W LATACH 1990-2010

Streszczenie: Celem przeprowadzonych badań była ocena ryzyka względnego likwidacji firmy w zależności od jej wieku. Ich przedmiotem były podmioty gospodarcze powstałe w Szczecinie w latach 1990-2010. Analizę przeprowadzono z wykorzystaniem modelu logitowego. Ryzyko likwidacji firmy zbadano zarówno w zależności od wieku wyrażonego w miesiącach (zmienna ciągła), jak i w pogrupowanych przedziałach (rok, półrocze). Zwrócono w ten sposób uwagę na korzyści wynikające z kodowania zmiennych ciągłych (kodowanie rangowe i 0-1). Badania przeprowadzono dla firm powstałych w latach 1990-2010 ogółem (ponad 120 tys.) oraz w okresach wynikających z cykliczności likwidacji firm (wyniki poprzednich badań). Z badań wynika, że ryzyko likwidacji firmy wraz ze wzrostem wieku maleje (zastosowanie zmiennej ciągłej i zmiennej rangowej). Natomiast wartości ryzyka dla kolejnych grup wieku wskazują na to, że ryzyko nie przebiega monotonicznie.

Słowa kluczowe: analiza przeżycia, trwanie firm, ryzyko likwidacji.