



Iwona Markowicz

University of Szczecin, Faculty of Economics and Management, Institute of Econometrics and Statistics, iwona.markowicz@wneiz.pl

Modeling the Survival Time of Trading Companies in the Zachodniopomorskie Voivodship

Abstract: The aim of this study was to construct models of trading companies' lifespan, in individual districts of Zachodniopomorskie Voivodship. The author verified whether the impact of the survival time of trading companies on the survival function in general is the same in individual districts. This may inform potential entrepreneurs' decisions on whether to set up a trading or other company. The Kaplan-Meier estimator was calculated and a tests verifying similarities of functions of trading companies within the districts was used. Districts were then divided into groups, according to trading companies' lifespan. Further on, the functions of the intensity of companies' liquidation for particular districts were analysed. The rankings of districts were compared in terms of the lifespan of trading companies and businesses in total. In the study, the author used REGON registry, containing data about companies established in Zachodniopomorskie Voivodship in 2009–2011. These entities were observed until the end of 2013. It is something to be considered by both decision makers and entrepreneurs, that the probability of liquidation of a trading company is greater than of any other company. Trading activity is prevailing (the highest percentage of all newly established companies are trading companies), however, trading companies are also most in danger of liquidation.

Keywords: models of firms' lifespan, intensity function of firms' liquidation, trading companies

JEL: C10, C14, C41

1. Introduction

Survival analysis is increasingly used in business demography (and other research areas). The survival analysis is a collection of methods for modelling of processes, i.e. the survival of the phenomena under study, from the initial event (business establishment) to the final event (business liquidation). Methodology adopted in business demography is defined by such scientific disciplines as statistics, econometrics, demography, or survival analysis. In the literature on the subject, one may come across publications presenting the results of analysis of enterprises based on phenomena modelling methods. A good example of such publication is *Business Demography in Spain: Determinants of Firm Survival*. Its authors adopt procedures for phenomena analysis to examine companies operating in Spain (López-García, Puente, 2006: 1–44).

The most interesting publications, containing results of scientific research, include:

- 1) Hannan and Freeman (1989: 3–27), Carroll and Hannan (2000), Caves (1998: 1947–1982) – age, size, growth and mortality of enterprises are inter-related,
- 2) Santarelli (2000: 315–325) – analysis of newly established enterprises offering financial intermediation in Italy,
- 3) Bhattacharjee (2005: 1–29) – research of quoted companies functioning in Great Britain throughout the period 1965–2002,
- 4) Geroski, Mata and Portugal (2007: 1–38) – survival analysis with reference to new firms established in Portugal,
- 5) Kaniowski and Peneder (2008: 41–58) – parametric analysis for determining the lifespan of Austrian firms during the period 1975–2004,
- 6) Nunes and de Morais Sarmento (2012: 260–272) – survival function for firms founded in Portugal during the period 1987–2005.

Parametric, semi-parametric and non-parametric models are used for the purpose of the survival analysis. The construction of parametric models requires adoption of a theoretical distribution of the examined variable (Frątczak, Gach-Ciepiela, Babiker, 2005), which is difficult in the case of studies on the companies' lifespan (Markowicz, 2012; 2014). Therefore, in this study, continuous-time non-parametric models were used: the Kaplan-Meier estimator, the Gehan (Gehan-Wilcoxon) test and the lifespan table (probability of survival, intensity of liquidation). Those methods were employed to model the survival time of trading firms in the districts of Zachodniopomorskie Voivodship.

The purpose of this study was to rank and group districts in Zachodniopomorskie Voivodship according to the declining trading company's survival function and to compare the district rankings in terms of the survival time of trading companies with the survival time of the companies in total. In the first stage of the study

a model was constructed, representing the survival time of trading companies in the districts (K-M estimator). The subsequent stages were as follows: Stage II – ranking of the districts according to the declining trading company survival function (Gehan test; verification statistics sign); Stage III – identification of groups of districts with similar models of trading company’s survival function (Gehan test; significance of differences); Stage IV – analysis of the course of the trading companies’ survival function in the groups of districts (tables of lifespans); and Stage V – comparison of the districts’ ranking in terms of the survival time of trading companies with the districts’ ranking in terms of the survival time of companies in general (Markowicz, 2017a).

In the study, the author used the REGON registry containing data about trading companies established in Zachodniopomorskie Voivodship in 2009–2011 (21 districts). The entities were observed until the end of 2013.

2. Statistical data

The article presents the results of the cohort analysis. The cohorts comprise of the trading enterprises set up in the districts of Zachodniopomorskie in 2009–2011, observed until the end of 2013 (conduct activity classified according to the NACE Rev. 2: G – trade and repair of motor vehicles). The information about the number of established and closed-down businesses (trading companies and companies in general) is shown in Table 1, while Figure 1 shows the number of liquidated and censored (not liquidated by the end of the observation period) trading companies. 14182 trading companies were established in Zachodniopomorskie throughout 2009–2011. By the end of 2013 the number of liquidated companies reached 6018 (42%).

Table 1. The number of firms established in 2009–2011 and liquidated by the end of 2013 in the districts of Zachodniopomorskie Voivodship (firms in general and G section)

NTS4	Districts	Firms in general		G section firms	
		Number of established	Percentage of liquidated	Number of established	Percentage of liquidated
01	białogardzki	1485	42.0	383	52.7
02	choszczeński	1389	41.2	308	44.2
03	drawski	1381	36.1	373	44.5
04	goleniowski	2638	40.0	632	44.8
05	gryficki	2415	45.4	590	52.7
06	gryfiński	2643	38.0	672	38.2
07	kamieński	1857	37.9	369	47.2
08	kołobrzeczki	3049	36.5	731	45.0

NTS4	Districts	Firms in general		G section firms	
		Number of established	Percentage of liquidated	Number of established	Percentage of liquidated
09	koszaliński	2088	39.6	445	41.6
10	myśliborski	2070	38.1	474	43.5
11	policki	3076	34.3	688	36.9
12	pyrzycki	1220	41.6	297	43.1
13	ślawieński	1788	43.2	407	45.7
14	stargardzki	3983	41.7	913	42.8
15	szczecinecki	1968	41.4	597	47.1
16	świdwiński	1102	40.8	317	44.5
17	wałecki	1366	39.2	391	41.9
18	łobeski	1059	43.8	267	47.9
61	Koszalin (city)	3999	32.6	1047	43.3
62	Szczecin (city)	17398	33.3	3928	38.0
63	Świnoujście (city)	1613	36.9	359	42.1
	Voivodship	59587	37.3	14188	42.4

Source: own study (REGON data)

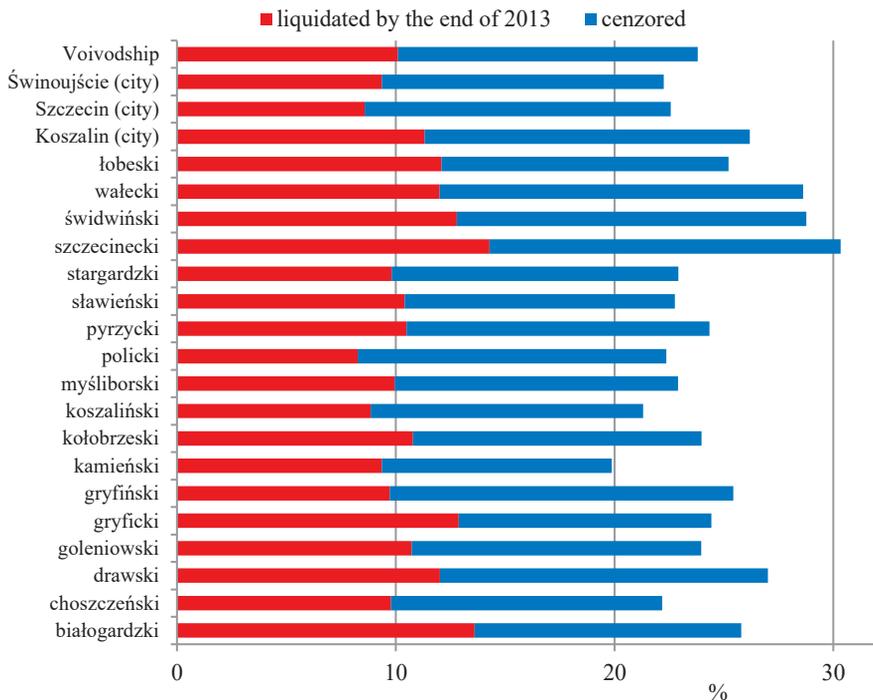


Figure 1. The trading companies as a percentage of total number of enterprises established in 2009–2011, (division into liquidated and censored) in the districts of Zachodniopomorskie Voivodship

Source: own study

3. Ranking and grouping of districts

A non-parametric model of trading companies' survival in the districts of Zachodniopomorskie can be built by means of the Kaplan-Meier method (Product-Limit-Estimation), provided that we assume the presence of censored observations. In contrast to the survival tables, this method does not require the grouping of the observation times into class intervals. The companies' survival time is the realisation of the random variable $(T; \delta)$:

$$T = \begin{cases} T_z & \text{for } \delta = 1 \\ T_c & \text{for } \delta = 0 \end{cases} \quad (1)$$

where: T_z – the survival time of a liquidated company; T_c – the survival time of a censored company; δ – the random variable adopting 1 for a complete observation and 0 for a censored observation.

The Kaplan-Meier estimator can be calculated as (Kaplan, Meier, 1958; Markowicz, 2012):

$$\hat{S}(t_i) = \prod_{t \leq t_i} \left(1 - \frac{z_i}{n_i} \right) \text{ for } i = 1, \dots, k, \quad (2)$$

where: t_i – the moment in which there was at least one event (company liquidation), z_i – the number of events in time t_i (complete observations), n_i – the number of units of observation at time t_i .

The Kaplan-Meier estimator is a function that is non-increasing, periodically constant, with leaps at random time points determined by complete observations (liquidation of at least one company). The estimator adopts the values:

$$\hat{S}(t_i) = \begin{cases} 1 & \text{for } t_0 \\ \prod_{t \leq t_i} \left(1 - \frac{z_i}{n_i} \right) & \text{for } t_1 \leq t \leq t_k \\ 0 & \text{for } t > t_k \text{ if } \delta_n = 1 \\ \text{unidentified} & \text{for } t > t_k \text{ if } \delta_n = 0 \end{cases} \quad (3)$$

The initial value of the survival function is 1 and it decreases at subsequent points of time t_p , at which at least one analysed event has occurred. According to the literature, the statistical properties of the Kaplan-Meier estimator are regarded as good when the sample is large¹. When using the Kaplan-Meier estimator, the probability of survival can be estimated at any time. The statistical rele-

¹ The modification of the Kaplan-Meier estimator for small samples was proposed by (Rossa, 2005).

vance of the differences in survival models built for groups can be measured with an adequate non-parametric statistical test, taking into consideration the presence of censored data. The hypothesis that the survival functions for groups are equal (Gehan, 1965; Klainbaum, Klein, 2005) is verified by means of the Gehan test, whose statistics are written (Domański et al., 2014) as follows:

$$Z = \frac{W}{D(W)}. \quad (4)$$

The Gehan test was used in Stage II (ranking of the districts according to the declining trading company survival function; verification statistics sign) and Stage III (identification of groups of districts with similar models of trading company survival; significance of differences).

Table 2. Groups of districts with similar trading company's duration model

Group	Districts	Number of districts
1	policki, Szczecin (city), gryfiński	3
2	świdwiński, koszaliński, wałecki, myśliborski, stargardzki, Świnoujście (city), choszczeński, drawski, goleniowski, pyrzycki, kołobrzegi, Koszalin (city), sławieński, łobeski, szczecinecki, kamieński	16
3	białogardzki, gryficki	2

Source: own study

In order to distinguish the groups of districts with similar company survival times, the relevance of differences in the survival times of trading companies established in 2009–2011 was examined. The Kaplan-Meier estimators were calculated for each district and compared pair-wise. The groups were separated in such a way as to ensure that each of them contains districts where the differences among survival time models were not statistically significant. For each pair of districts the hypothesis $H_0: S_1(t) = S_2(t)$, was tested. The differences were considered significant when $p \leq 0,05$. Therefore, each group contained only the districts with similar survival functions. The functions in the districts of one group can be significantly or irrelevantly different from the functions in the districts of other groups. Moreover, the groups and districts were ordered according to the decreasing probability of the analysed companies' survival over time. The groups are shown in Table 2. In keeping with the above scheme, three groups of districts with similar company's survival time models were distinguished. The first group consists of districts: policki (adjacent to Szczecin), Szczecin (city) and gryfiński, where the probability of companies' survival in the successive months was the highest. The second group comprised of 16 districts. It needs to be noted that in the last group (białogardzki and gryficki districts), the probability of companies' survival in the successive months was the lowest.

4. Survival function and intensity of trading companies' liquidation

The IV and V Stages of the analysis involved the construction of cohort tables of companies' survival in individual districts (21 areas). The tabular model (Balicki, 2006) was built for the three-month models (Markowicz, 2015). The enterprises that did not go into liquidation by the end of 2013 were considered censored. Based on the elements of the table, the survival function and the intensity function of company liquidation (hazard function) were analysed.

The author presents lifespan tables in actuarial version (Markowicz, 2017b). Therefore, the second column contains the number of units at risk of liquidation. This value is represented by means of the formula: $n_t^* = n_t - c_t / 2$. The next two values in the cohort survival table were estimated according to the discrete approach because they can be calculated only for the time interval. The first one is the probability of an enterprise being liquidated in the time interval \hat{f}_t^* and the second is the probability of the company's survival in the time interval. The distribution of the business survival cannot be assigned to any known type of probability distribution. This is why the functions describing the process of the enterprises' survival are not known, and the tables of survival contain the estimates calculated on the basis of empirical data. The probability estimator of business liquidation in the time interval \hat{f}_t^* is a ratio of the number of liquidated economic entities in a given interval of time z_t to the number of enterprises at risk of liquidation by the interval n_t^* . Opposite to the probability of business liquidation in the time interval is the probability of business survival in the time interval: $\hat{p}_t^* = 1 - \hat{f}_t^* = \frac{n_t^* - z_t}{n_t^*}$. The probability of survival and the hazard intensity are functions continuous in their nature, but in the tables they are presented in a discrete approach. The probability of survival when calculated for interval $\langle t, t + 1 \rangle$, is the probability that the enterprise will be liquidated after the time $t + 1$:

$$\hat{S}_t^* = \prod_{k=1}^t p_k^* \quad (5)$$

In the moment $t = 0$ (the moment of setting up of an economic entity) $S_t = 1$ and this function is decreasing over time. The rate at which the survival function is decreasing depends on the value of t and is defined as a hazard function (a_t – length of time interval):

$$\hat{h}_t^* = \frac{z_t}{\left(n_t^* - \frac{z_t}{2}\right) a_t} \quad (6)$$

The survival time is analysed in intervals (Figures 2 and 3 – beginning of the time interval).

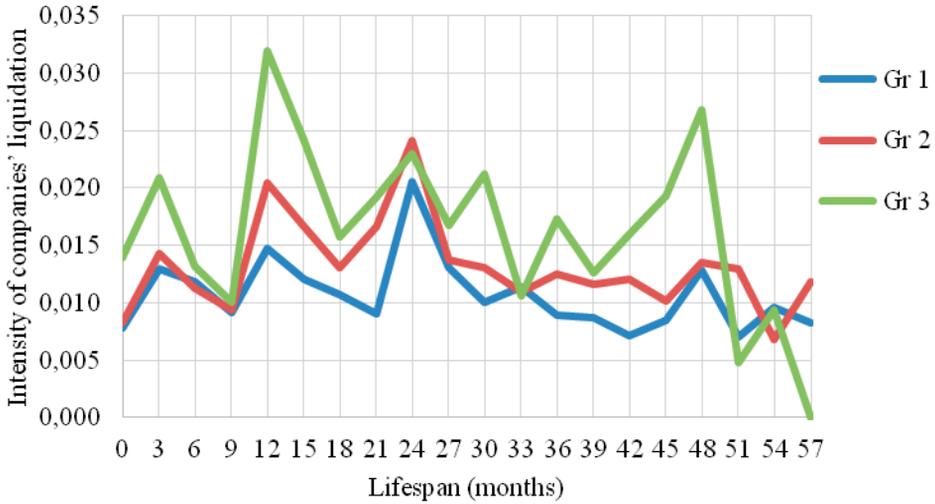


Figure 2. Estimation of the survival function of trading companies (three groups of districts)

Source: own study

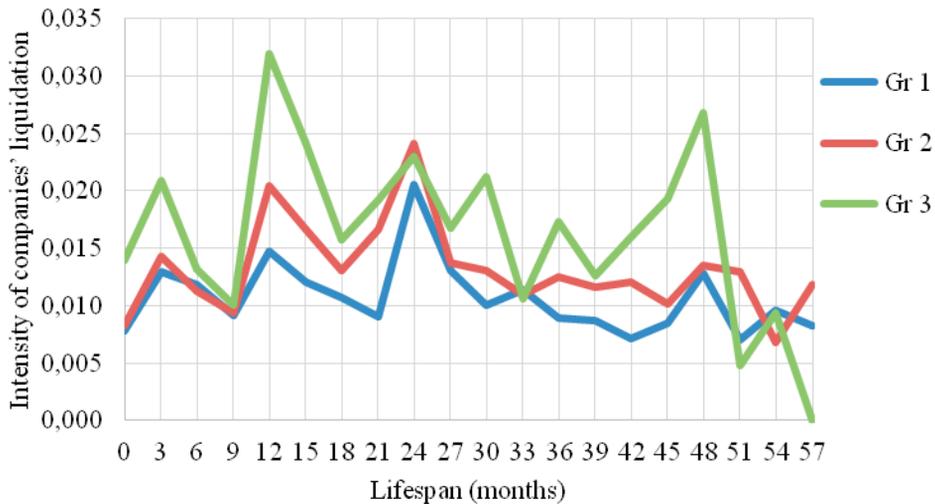


Figure 3. Estimation of the intensity of companies' liquidation

Source: own study

Survival functions in Groups from 1 to 3 were continually declining. After 60 months 53,9% of trading companies survived in Group 1; 47,0% – in Group 2 and 38,6% in Group 3.

Many studies have confirmed that the intensity function of companies' liquidation adopts the inverted U -shape with a fixed maximum, which is in keeping with the theoretical learning model (Markowicz, 2012; 2016).

Figure 3 shows the intensity function of trading companies' liquidation for three groups of districts. The functions of individual groups take a specific shape. Having analysed the shape of the intensity function of companies' liquidation in individual groups of districts, which has been built according to the survival models, the following observations have been made:

- 1) the intensity function of companies' liquidation for Groups 1 and 2 takes approximately the typical inverted U -shape with the maximum marked within 24–27 months; the function adopts low values,
- 2) when comparing Groups 1, 2 and 3, we can see as follows: a less and less distinct pattern of the intensity function that takes an inverted U -shape, the increasingly higher intensities of companies' liquidation and the increasingly stronger fluctuations of this intensity over time.

5. Analysis of survival time of trading companies and survival time of companies in general. Comparison of districts

Trading companies (Section G) are most common among companies in general. The comparison of the survival models led to the following results: trading companies were liquidated faster than companies in general (Figure 4); the intensity of liquidation in subsequent time intervals was higher in the case of trading companies (Figure 5). The positions in the rankings and the groups of districts differ between the trading companies and companies in general (Table 3; Spearman coefficient 0.4786). Trading companies are the most common. However, other entities also influence the companies' lifespan in the districts. This influence is not the same in every district.

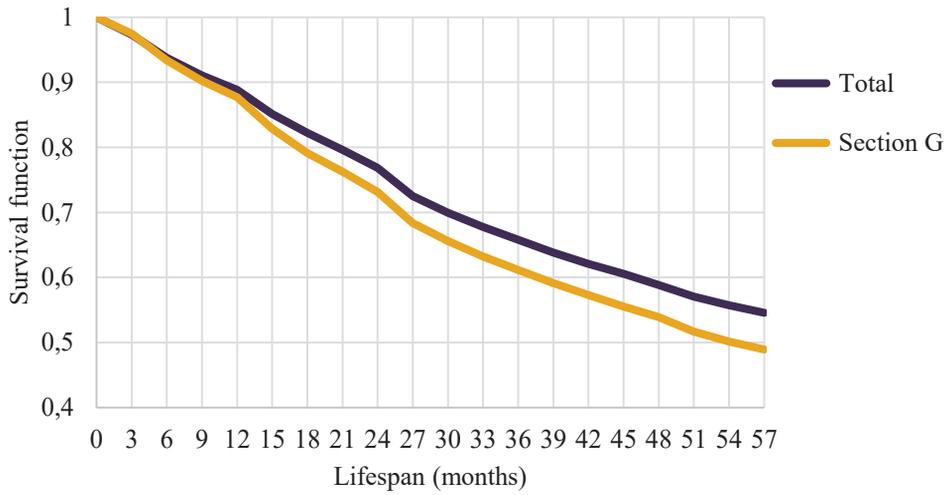


Figure 4. Estimation of the survival function of trading (section G) companies and companies in general

Source: own study

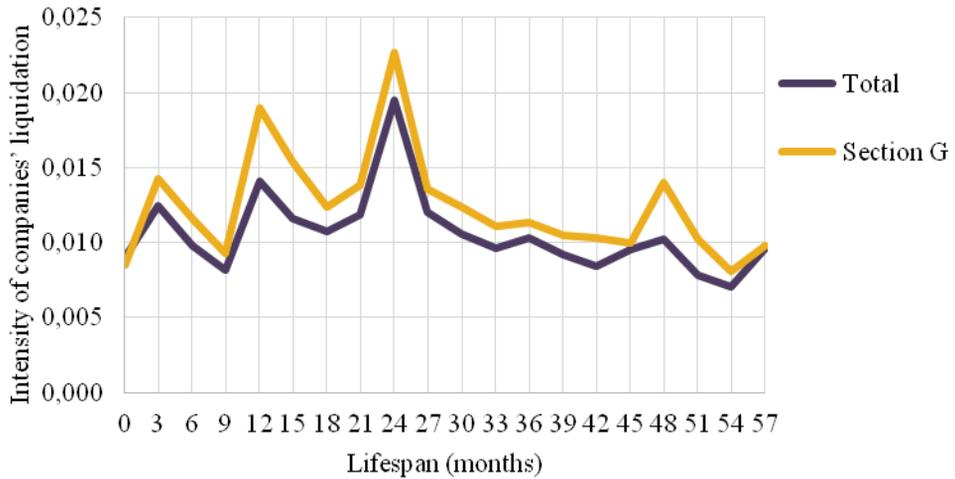


Figure 5. Estimation of the intensity of companies' liquidation – trading (section G) companies and companies in general

Source: own study

Table 3. Districts according to the lifespan model of the companies in general and of trading companies (section G)

Rank	Companies in general	Section G
	districts	districts
1	Koszalin (city)	policki
2	Szczecin (city)	Szczecin (city)
3	policki	gryfiński
4	drawski	świdwiński
5	kołobrzesci	koszaliński
6	myśliborski	wałecki
7	Świnoujście (city)	myśliborski
8	gryfiński	stargardzki
9	wałecki	Świnoujście (city)
10	goleniowski	choszczeński
11	kamieński	drawski
12	świdwiński	goleniowski
13	szczecinecki	pyrzycki
14	białogardzki	kołobrzesci
14	koszaliński	Koszalin (city)
16	choszczeński	sławieński
17	stargardzki	łobeski
18	pyrzycki	szczecinecki
19	sławieński	kamieński
20	łobeski	białogardzki
21	gryficki	gryficki

Source: own study

6. Conclusions

The study results presented in this article reveal the survival models of trading companies in the districts of Zachodniopomorskie Voivodship. Three groups of districts were distinguished. The groups (for 1 to 3) were characterised by:

- 1) decreasing time of companies' liquidation (decreasing survival functions),
- 2) less and less distinct shape of the intensity function (inverted *U*-shape),
- 3) growing intensity of companies' liquidation,
- 4) increasingly stronger fluctuations of intensity in time.

In the paper, the author compared the groups of districts formed according to survival models of the trading companies and companies in general. The companies in Section G were liquidated faster than companies in general and their intensity of liquidation was higher as well. This finding may be used by both decision makers and entrepreneurs in decision making processes: that the probability

of liquidation of a trading company is greater than that of any other entity. Trading activity is prevailing (the largest percentage of new entities) and is the most exposed to liquidation.

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Modelowanie czasu trwania firm handlowych w województwie zachodniopomorskim

Streszczenie: Celem przeprowadzonych badań była budowa modelu czasu trwania firm handlowych dla poszczególnych powiatów województwa zachodniopomorskiego. Oszacowano estymator Kaplana-Meiera oraz zastosowano test weryfikujący podobieństwo funkcji firm handlowych w powiatach. Utworzono grupy powiatów. Zbadano funkcję intensywności likwidacji firm w grupach. Porównano uszeregowania powiatów pod względem czasu trwania firm handlowych i firm ogółem. W badaniu wykorzystano dane z rejestru REGON, dotyczące firm powstałych w województwie zachodniopomorskim w latach 2009–2011 (21 powiatów). Obserwacja trwała do końca 2013 roku. Jest to sugestia zarówno dla decydentów, jak i dla przedsiębiorców, że prawdopodobieństwo likwidacji firmy handlowej jest większe niż innych firm. Działalność handlowa jest przeważająca (największy udział w nowych firmach) i najbardziej narażona na likwidację.

Słowa kluczowe: model trwania firm, funkcja intensywności likwidacji firm, firmy handlowe

JEL: C10, C14, C41

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