

THE DYNAMIC MODEL OF BIRTH AND DEATH OF ENTERPRISES

Henryk Gurgul¹, Paweł Zając¹

ABSTRACT

The aim of this article is to define the model describing the dynamics of bankruptcy and foundation of new enterprises. In the first part we try to answer what bankruptcy in law, economic and social sense is. It results from the overview of literature that bankruptcy is as natural as growth, and both of these contradictions are complementary. Moreover, an important inference is the need for improving the bankruptcy mechanism, because the more efficient it is, the healthier market surrounds us. On the basis of bankruptcy new firms emerge. We derived a procedure in order to forecast the number of new firms. The conclusion is that dynamic mathematical models may be a useful tool of prediction of a number of new firms founded.

Key words: bankruptcy of enterprises, foundation of enterprises, dynamics of foundation and bankruptcy, forecasts.

JEL Classification: C02, L25.

1. Introduction

In recent years, the increasing risk and uncertainty has been the most important feature of companies and the whole economy's activity. Various firms, their groups and the whole country's economy encounter various unpredicted, negative results of events and processes located often in distant parts of the globe.

The latest example of the aforementioned is the current financial crisis and the following economic crisis which have stricken first the United States in 2007, and different countries across the whole world a year later. It proves the strength of mutual connotations between companies and diverse economics in the era of globalization. The growing uncertainty in world economy is the result of sliding of the industrial civilization towards a knowledge-based economy. These radical,

¹ Department of Applications of Mathematics in Economics, AGH University of Science and Technology, Cracow, Poland. Email addresses: henryk.gurgul@gmail.com, pzajac@zarz.agh.edu.pl.

groundbreaking changes lead to the replacement of currently used models of economy by new ones, applying to investments, production, trade, education, management, work, employment and consumption. This process of changes is accompanied by essential social and moral alterations including the modifications in the existing model of the family. Various professions, jobs, firms but also different branches of economy are becoming more vulnerable to bankruptcy of which the main cause is the unprecedented pace of technological progress, bringing equally positive and destructive changes. As a consequence, more often the 'old' ideas, solutions and even companies are replaced by the 'new' ones. This process regards also economic theories, even those awarded in the past by the Nobel Prize. The rapid changes are accompanied by increasing lack of security, the results of which are clearly visible in companies situated in Poland. The uncertainty affecting Polish companies is additionally inflamed by transformations and the necessity of adapting to the European Union's regulations. It is also a significant obstruction in formulating long-term strategies concerning growth, which can provoke management errors, or even in extreme cases, bankruptcy.

Problems concerning the uncertainty and risk, despite frequent occurrence in many papers, are comparatively hardly ever recognized in economic literature. The situation is even worse when it comes to insolvency. Usually used while referring to business, insolvency refers to the company's inability to pay off its debts. Business insolvency is defined in two different ways: cash flow insolvency concerning inability to pay debts as they fall due and balance sheet insolvency meaning that liabilities exceed assets. Another term commonly used in this context is bankruptcy. In colloquial language, the lately mentioned terms are used as synonyms. In fact the difference between them is significant as bankruptcy is a law term and insolvency belongs to the economical terminology. The insolvent company is a company unable to continue an individual activity without outside help. The most frequent source of such situation is the lost of trust among trading partners, clients, essential impairment of financial indicators, inability in implementation of commitments, or even financing its own current activity. It can possibly lead towards arrestment of the company, and eventually to its end. Detailed reasons of such cases in Poland are described in Zdyb (2008).

Insolvency on the other hand (which is the result of either law regulations or the court judgment) can take place despite the economic reasons, leading to the cessation of company. Company's liquidation regardless of its size, sphere of interest, territory or trade partners is the source of confusion and, more importantly, distress on the market. The consequences of this phenomenon are often unpaid debts and taxes or undone services for recent orders. The worst social outcome of the aforementioned is redundancy of employees, which negatively affects the unemployment rate. Other results of bankruptcy are often unexploited resources, frustration and discontent among the fired employees, employers, but also investors and shareholders who devoted their savings, assets and ideas in order to increase production or improve service. In the economic

literature bankruptcy is described as harmful to the business entity and the surrounding form of destruction bringing seriously fatal consequences in a short period of time.

However, in the long run the positive elements which are the result of closure of the ineffective company which does not bring fair remuneration to the owners, may dominate. Especially, the threat of shutting down the company immobilizes the entrepreneurs, encouraging them to undertake effective actions and daunt the continuous borrowings.

The market itself usually does not have the ability to eliminate the unsuccessful entrepreneurs. Therefore, certain protection procedures from disastrous outcomes of their activity are described in the bankruptcy law regulations which help to minimize the negative results which may affect the surrounding as a result of insolvency of the debtor. The obligation of existence of such regulations comes from the fact that no restrictions describe the conditions of setting up any business activity. In particular, this problem applies to suitability of candidates to become entrepreneurs. Hence, certain percentage of them is destined to fail as a result of the lack of competence, management errors, exterior conditions or other unrelated circumstances.

2. Literature overview

Although the problems of bankruptcy and insolvency are still not satisfactorily described, there is a significant number of contributions in English for example by Bebchuk (2002), Hurst (1995), Schonfelder (2003) or in Polish literature among them those by Białasiewicz and Buczkowski (1996), Bratnicki (2001), Czajka (1999), Durlík (1998), Osbert-Pociecha (2004), Perechuda (1999) and Zimmiewicz (2000) which deal with reasons and implications of these problems in economy as a whole and individuals.

In the opinion of the eminent Austrian economist Joseph Schumpeter (1982) failure of the company is a consequence of coexisting processes of destruction and creation. The same point of view is expressed by Foster and Kaplan (2001). According to their theory inspiration, directing and controlling the processes of creative obliteration is stimulated by the financial markets supplying and financially reinforcing the possibilities of the companies as well as withdrawing the support along with decreasing competitiveness of the company. The developing company is offered financial resources, although almost immediately after the appearance of the symptoms of reduction in competitiveness and regression this support is removed. In case of bankruptcy the company not only needs to deal with its current activity, but also with the mutually connected processes of destruction and creation.

Greiner and Schein (1988) (compare Koźmiński and Piotrowski (1999)) claim that flexibility of the company depends on the abilities and creativity of the owner. Further improvements are results of problems which company encounters

in its later existence and the methods it implies to overcome them. If the managements do not notice the problems soon enough, the company is certainly heading to an end. Undertaking the activity in the conditions of uncertainty, rapidly changing situation characterized by frequently occurring problems and new goals, considerably affects the immune to changes businesses' lives cycles which, as a result, are usually seriously shorten. The companies adherent to old, uncompetitive solutions are swiftly eliminated from the market. The lack of alterations inside the company leads to its closure.

Similar subjects lie in the area of interest of Handy (1995), the author of the so-called shape of 's' letter. In the core of his theory lies the idea that entrepreneurs should prepare the company for the crisis period already in the time of its prosperity, by provoking artificial symptoms and undertaking adequate countermeasures. Although such actions weaken the organization in the short term, eventually changes developed by the fake crisis strengthen and immunize the company.

According to Frederick et al. (1988) as well as Davies and Blomstrom (compare Majchrzak (2003)) the companies' activities are always connected with executing social functions, using the resources given to them by the society. If the organization stops responding to those functions by not using those resources in a way that is desired by the society, it starts heading towards failure. This situation is connected with retrieving property, financial and human resources which are indispensable for the proper functioning and existence of the company. Therefore, the elimination of the company is the result of social desire to improve the effectiveness of economic activity.

Apart from the aforementioned advantages of insolvency, as the removal of unprofitable firms and the protection of debtors against dishonest debtors, the bankruptcy based on the certain rules and regulations allows one to eliminate from the market the companies functioning on the verge of cost-effectiveness. Those rules give also the opportunity to eradicate encumbrances which are caused by the prolonged existence of such firms.

In many cases, certain inability to refrain from engaging social sources into businesses which are destined to fail from the very beginning, for example in Poland where it applies mainly to post-communist companies such as mines and shipyards, is well visible.

In practice bankruptcy is mainly a tool of control and protection of the market (Zedler (2003)). After the increase phase the company which encounters the changing circumstances that it cannot deal with is exposed to the pressure from the side of the market that may lead at first to its (bankruptcy) insolvency and then to bankruptcy proceedings protecting debtors, employees and the whole country. Moreover, as a result of this proceedings such company is either reorganized or disposed, which is suppose to protect and give the possibility of better usage of the social resources.

The interesting interpretation of the theory of development and bankruptcy of the firms is based on the biologic theory developed by Darwin (Encyklopedia Biologiczna (1998)).

Darwin wrote that all living beings without any exception, have the tendency to numerous growth in such a big extent that no environment, not even the whole area of the earth or the whole ocean are not able to accommodate offspring of one couple after some generations. The unavoidable result of this process is the continuous fight of existence. It appears that the similar tendency is exhibited by the companies heading towards expansion which leads to competitive fight resembling the one between biological beings.

This process is the realization of natural selection. Its result is the survival of the best individuals possessing the most developed ability to adapt to the surrounding. This theory corresponds also to the companies.

Since the late sixties of the twentieth century quantitative methods became commonly used to predict the risk of bankruptcy and the progenitor of such research was Altman (1968). In his work he used discrimination methods. By working on those methods he was able to divide the analyzed firms into two groups: the ones vulnerable to bankruptcy and those not. The grouping was done on the basis of financial indicators defined earlier for those companies. The following belonged to those markers (ratios): working capital to total assets ratio, retained earnings to total assets ratio (retained earnings - profits which have not been paid out in dividends and which can be re-invested in the business), EBIT (Earnings Before Interest and Taxes) to total assets ratio, market value of equity to book value of total liabilities and sales to total assets. Using these methods allowed Altman to correctly classify up to 95 percent of companies the year before their bankruptcy and 83 percent two years before.

Studies initiated by Altman and continued by others led to foundation of the American Bankruptcy Institute (ABI) in USA in 1982. It delivers to the Congress and public opinion expertises describing the cases concerning companies bankruptcy, analyzes its causes and results. It integrates people of various professions starting from attorneys, accountants, auctioneers, assignees, bankers, lenders to professors. ABI is engaged in numerous educational and research activities concerning bankruptcy in the USA. The institute possesses numerous empirical data related to insolvency and regularly cooperates with the media. Analysis concerning the future of companies is a significant part of Institute's works. It is important, because companies' surroundings and connections become more and more complicated, which provides difficulties in formulating long-term, evolutionary strategy. Although the Institute participates in researching past events as the source of prognoses, its studies of company's future are an essential part of the ABI's mission.

As it was emphasized by Matschke and Broesel (2007) the deciding factor of the company's worth and position on the market is not its past but the profits it can bring in the future. In this context, the plausible scenarios of the future development of the situation inside the company, branch or even the whole

economy are being created. The chances and risks of the expansion possibilities are being analyzed. The purpose is to obtain immediate evaluation of the influence of social and economic decisions basing on the company's results. The Institute concentrates on detecting symptoms threatening companies in order to warn them of insolvency. Only fast enough information may direct towards the restraint of the emerging threat. The Institute also examines cases of fraud in accountancy, for example the so-called creative accountancy.

Early researches on insolvency of Polish firms have been conducted using discrimination methods introduced by Altman. Hadasik (1998) conducted research on the basis of financial statements of 39 companies from 1991 to 1997. She estimated parameters of models containing from 4 to 7 variables. Efficiency of those models was high as it reached from 88,52 percent to 96,72 percent. The most important variables were: debt to equity ratio, accounts receivable turnover ratio, inventory turnover ratio, inventory profitability.

In his research Hołda (2001) in order to estimate discrimination function used 40 statements of companies which declared bankruptcy between 1993 and 1996 and 40 statements of different firms that did not experience insolvency at that time. Using this date he built a model whose efficiency was estimated by the author at 92,5 percent. It included the following variables: current liquidity ratio, debt to equity ratio, return on assets (ROA), accounts payable turnover ratio (average payment period) and total assets turnover ratio.

The results of research on the insolvency which uses discrimination methods can significantly differ from one another according to the country and time period, as the proneness to bankruptcy is different in various periods. In relation to those variables diverse indicators are important. Therefore, it is pointless to conduct researches using the same set of variables not only for companies from different countries, but also for different time periods within single company. It causes that results of even a wide range of papers are not comparable. Hence, some new attempts to form models are applied in order to allow to predict the bankruptcy.

The model which is illustrated here and used in the empirical examinations does not refer to financial indicators. It is a model describing biological phenomenon of creation and degradation of red cells developed by Ważewska-Czyżewska and Lasota (1976). We extended and adjusted this model in order to describe the process of insolvency and creation of companies.

3. The general model

Let $N(t, a)$ be a number of companies which in moment t are not older than a . Then, $N(t) = \lim_{a \rightarrow \infty} N(t, a)$ is a general number of companies at time t .

Function $n(t, a) = \frac{\partial}{\partial a} N(t, a)$ would express density of age distribution for firms. In short time periods $n(t, a)$ represents number of companies which in moment t are in age a .

This function fulfils the condition:

$$\int_0^{\infty} n(t, s) ds = N(t) \quad (1)$$

Companies which in the moment t were aged a are in the moment $t+h$ at age $a+h$. Difference $n(t, a) - n(t+h, a+h)$ means number of firms at age a which went bankrupt in the time period $(t, t+h)$. Destruction intensity $i(t, a)$ of companies at age a in moment t can be specified as:

$$i(t, a) = \lim_{h \rightarrow 0} \frac{n(t, a) - n(t+h, a+h)}{h}.$$

In that situation $\lambda(t, a) = \frac{i(t, a)}{n(t, a)}$ is the empirical probability that company which in the moment t is at the age a will bankrupt to moment $t+1$. $\lambda(t, a)$ will be called destruction coefficient.

The mean value theorem leads to:

$$n(t+h, a+h) - n(t, a) = h \frac{\partial}{\partial t} n(\bar{t}, \bar{a}) + h \frac{\partial}{\partial a} n(\bar{t}, \bar{a}), \quad \bar{t} \in (t, t+h), \quad \bar{a} \in (a, a+h),$$

and therefore

$$\frac{\partial n}{\partial t} + \frac{\partial n}{\partial a} = -\lambda n \quad (2)$$

This equation is used in theorems about creation and degradation of red cells. It was found by von Forster in 1959. It appears that (2) is only a consequence of the destruction's coefficient definition and can be applied to the description of creation and insolvency of companies.

If we assume that $a=0$, function $n(t, a)$ can be interpreted as a number of firms which were created in the moment t :

$$p(t) = n(t, 0). \quad (3)$$

Equation (2) with initial condition (3) allows one to calculate function $n(t, a)$. In order to find reverse relation let us introduce the term of the stimulation

process of firms creation. Derivative $\frac{dp(t)}{dt}$ represents increment of the number of newly created companies in the time unit (for instance year). Quotient

$$S(t) = \frac{1}{p(t)} \frac{dp}{dt} \quad (4)$$

represents the increment rate of new firms in the time unit. We can now say more about the stimulation process of firms creation. It is known that change of the amount of companies is the impulse stimulating (or slowing down) the process of creating new ones.

Because our goal is to build possibly simple model, we assume that the stimulation process of firm's creation $S(t)$ is proportional to the general amount of companies on the market in previous moments.

$$S(t) = -\frac{d}{dt} \gamma N(t-h), \quad (5)$$

where γ is proportional coefficient, and by h we understand the lag (time delay) with which, after changing the general number of companies, new firms are established. Equation (5) implicates that the decreasing amount of companies is related to the increasing number of new ones and that the increasing amount of companies is connected with the decrease of newly created number.

Combining (4) and (5) provides to

$$\frac{dp(t)}{dt} = -p(t) \frac{d}{dt} \gamma N(t-h), \quad (6)$$

which can be solved as:

$$p(t) = \rho e^{-\gamma N(t-h)} \quad (7)$$

where ρ is integration constant. Collating (1), (2), (3) and (7) gives us:

$$\left. \begin{aligned} \frac{\partial n}{\partial t} + \frac{\partial n}{\partial a} &= -\lambda n \\ n(t,0) &= p(t) \end{aligned} \right\} \quad (8)$$

$$p(t) = \rho \exp \left\{ -\gamma \int_0^{\infty} n(t-h, a) da \right\}$$

We can observe in that set of equation three coefficients λ, ρ, γ . Coefficient λ was mentioned before while we were revealing equation (2) and it represents the empirical probability that companies which in moment t were at

age a would bankrupt until moment $t+1$. Coefficient γ characterizes the stimulation of the firm establishing process. Its meaning implies from equation (6). It is the growth rate of companies caused by the unitary change of the general number of companies on the market. The meaning of coefficient ρ is connected with the requirement of new companies on the market. If the requirement is bigger, then coefficient ρ gets higher values. Later in this paper we will try to explain detailed character of this relation.

4. The stationary model solution

Let us consider the simplified (independent from time) problem. Because $n(t,a)$, $p(t)$ and $\lambda(t,a)$ do not depend on time t in stationary model, let us put

$$n(t,a) = \bar{n}(a), \quad p(t) = \bar{p} \quad \lambda(t,a) = \bar{\lambda}(a).$$

Then, we get

$$\bar{n}(a) = \bar{p} \exp \left\{ - \int_0^a \bar{\lambda}(s) ds \right\}, \quad (9)$$

and

$$\bar{p} = \rho \exp \left\{ - \bar{p} \int_0^{\infty} \exp \left[- \int_0^a \lambda(s) ds \right] da \right\}. \quad (10)$$

Let us denote by $E(\sigma)$ solution of equation

$$\sigma E + e^{-E} = 0, \quad \sigma > 0.$$

Using $E(\sigma)$ function we can denote the stationary solution of (10) as:

$$\bar{n}(a) = \frac{1}{\gamma c} E \left(\frac{1}{\rho \gamma c} \right) \exp \left\{ - \int_0^a \bar{\lambda}(s) ds \right\}, \quad (11)$$

where

$$c = \int_0^{\infty} \exp \left\{ - \int_0^a \lambda(s) ds \right\} da.$$

The formula for $\bar{\lambda}(a)$ is important to the upcoming search of stationary solutions. From the analytical point of view the Gompertz curve, well-known and used in the reliability theory, appears to be correct. The curve is in the form:

$$\bar{\lambda}(a) = K e^{a\alpha}. \quad (12)$$

The family of functions (14) allows a good data estimation. Figure 1 shows data from the years 1999-2004 with estimated decomposition curves using the Least Square Method. Table 2 includes estimated values of parameters K and α . Computation have been made using R computer program.

Figure 1. Data from the years 1999-2004 with fitted decomposition curves

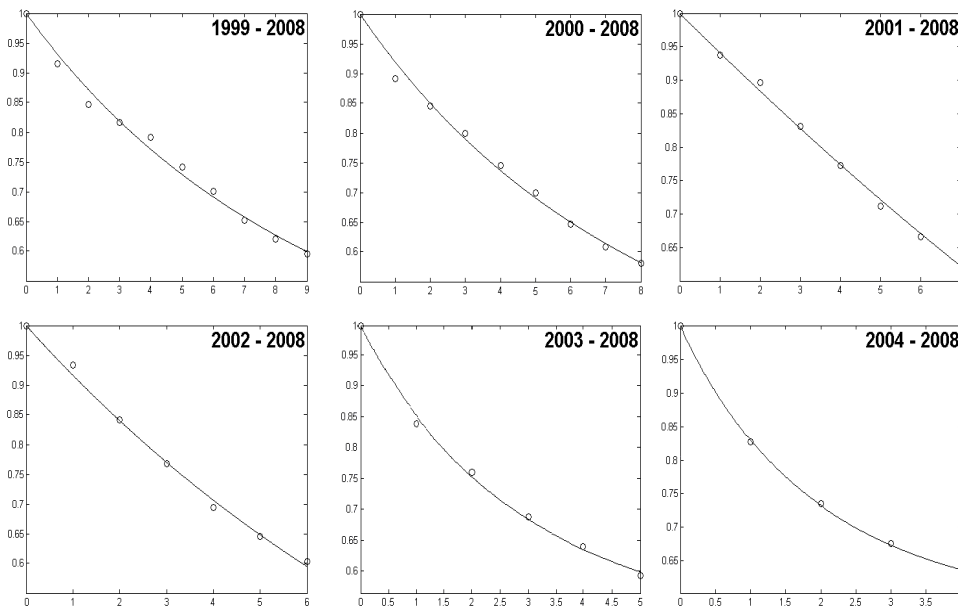


Table 2. Parameters K and α values computed using Least Square Method

	1999	2000	2001	2002	2003	2004
K	0.07256	0.086376	0.059350	0.087438	0.18182	0.227559
α	-0.0566	-0.06399	0.03684	-0.00342	-0.2559	-0.40269

As it can be observed parameters present different values for particular years. It is clear that values received for the period between 1999 and 2002 are similar, whereas since the year 2003 a significant change for both K and α took place. Having in mind that K applies to destructive coefficient, at the beginning the results from the years 1999 till 2002 should be treated as acceptable. In other cases, too high parameters are probably connected with too small number of observations.

The interpretation of the achieved results for K showed that about 7-8 percent of the companies finished their activity soon after the registration to the REGON

system. Values received for the parameter α are, as expected, negative. It means that we get an inequality $\bar{\lambda}(a+1) < \bar{\lambda}(a)$, what shows that the probability of the failure of the company is decreasing with time. According to these calculations the year 2001 seems to be the exception from this rule. On the figure presenting data from 2001 the linearity can be observed. Moreover, the disturbance developed probably on the basis of introducing the new GDP system can also be noticed.

Computation of K and α while accepting the correctness of the given model allows one to predict the survival rate of firms in the following years.

5. The reduced model

In this model our special attention will be focused on the behaviour of the general number of companies in time, the formula for $N(t)$. Let's define a new coefficient:

$$\mu = \frac{1}{N(t)} \int_0^{\infty} \lambda(t, a) n(t, a) da = \frac{\int_0^{\infty} \lambda(t, a) n(t, a) da}{\int_0^{\infty} n(t, a) da}. \quad (15)$$

The numerator tells us about the number of companies liquidated in the time unit and the denominator expresses the general amount of firms active in the time unit. The letter μ expresses empirical probability of bankruptcy announced in the time unit.

Integrating by a equation (2) in interval $[0, \infty)$ we receive:

$$\int_0^{\infty} \frac{\partial}{\partial t} n(t, a) da + \int_0^{\infty} \frac{\partial}{\partial a} n(t, a) da = - \int_0^{\infty} \lambda(t, a) n(t, a) da. \quad (16)$$

Considering equation (1) we can write the first component in the form:

$$\int_0^{\infty} \frac{\partial}{\partial t} n(t, a) da = \frac{\partial}{\partial t} \int_0^{\infty} n(t, a) da = \frac{\partial}{\partial t} N(t). \quad (17)$$

Assuming that all companies would go bankrupt with time ($\lim_{a \rightarrow \infty} n(t, a) = 0$) we can integrate the second component and get:

$$\int_0^{\infty} \frac{\partial}{\partial a} n(t, a) da = n(t, \infty) - n(t, 0) = 0 - p(t) = -\rho e^{-\gamma N(t-h)}. \quad (18)$$

From previous equations (16), (17), (18) and the definition of μ (15) we finally obtain:

$$\frac{\partial}{\partial t} N(t) = -\mu N(t) + \rho e^{-\gamma N(t-h)}. \quad (19)$$

It is the wanted equation for the general amount of companies on the market, including four coefficients.

6. The experimental verification of the reduced model

In our computation we use data concerning Poland gained from the Department of Central Statistical Office in Cracow. Numbers categorized in sections (A-Q) are taken from the Statistical Classification of Economic Activities (Polska Klasyfikacja Działalności - PKD2004). Data used below include only private companies. Table 3 contains the area of interest of companies categorized by PKD2004 sections. For each section, the amount of newly created companies is given in table 4. Table 5 holds the general number of companies in Poland between 2003 and 2009.

Table 3. PKD2004 sections

PKD section	Area of companies activity
A	Agriculture, hunting and forestry
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Manufacturing and electricity, gas and water supply
F	Construction
G	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods
H	Hotels and restaurants
I	Transport, storage and communications
J	Financial intermediation
K	Real estate, renting and business activities
L	Public administration and defence; compulsory social and health security
M	Education
N	Health and social work
O	Other community, social and personal service activities
P	Private households with employed persons
Q	Extra-territorial organisations and bodies

Table 4. Private business entity registered in Poland by PKD2004 sections

PKD section / Year	2003	2004	2005	2006	2007	2008	2009
A	9696	4878	4990	5172	4863	4748	5296
B	163	141	156	126	118	146	186
C	119	131	187	163	207	256	359
D	19401	19369	22926	25985	25391	24252	30 408
E	129	155	185	227	337	597	721
F	18086	19542	27456	39113	49833	57585	46912
G	86450	76045	86339	87585	80106	82495	100229
H	11110	9807	10641	10515	11900	12508	16137
I	13725	12884	13555	15899	18225	20289	20469
J	9823	9756	9739	11614	13433	15695	15179
K	43491	42862	46167	55207	48515	52164	59679
L	917	605	294	731	309	240	229
M	3847	3432	4392	5125	5538	6131	7728
N	6673	8260	8893	9262	10739	13955	17374
O	17609	16668	18550	26532	21842	23007	25975
P	2	5	8	5	3	6	7
Q	0	27	9	10	10	8	26

Table 5. General number of private companies registered in Poland by PKD2004 sections

PKD section/ Year	2003	2004	2005	2006	2007	2008	2009
A	99337	82883	86039	89011	91459	92954	93168
B	2027	2108	2037	1961	1955	1983	2007
C	1944	1998	2124	2190	2352	2544	2929
D	379731	375662	376043	373562	373680	370812	363885
E	2111	2177	2269	2338	2609	3176	3838
F	359569	354658	357169	366705	392112	424371	428235
G	1198978	1188549	1184713	1160369	1149307	1135963	1096819
H	111200	112188	113955	111853	112379	114274	117566
I	269035	262332	260748	258662	262696	268459	267999
J	127519	128890	129239	129480	132896	137018	130196
K	490884	506628	523701	542086	549543	585702	599189
L	14138	14719	14993	15718	16018	16213	16416
M	42242	43671	45788	47259	48998	51848	55595
N	138488	143915	149000	152729	158132	167059	176261
O	214876	221726	229979	243266	251877	260080	267925
P	192	180	179	20	20	27	31
Q	7	33	48	61	70	82	126

In the year 2003 reorganization in the Statistical Classification of Economic Activities was made. The reorganization caused logging out of companies which ended their activity before but have not been logged out from REGON system yet. For that reason our simulation is based on data from the years 2003-2009.

A significant role in the experimental verification of equation (19) is played by parameter h , which stands for interval between the death of the old company and the birth of the new one. Because we possess yearly data, we will consider only the case $h = 1$. Values of parameters ρ and γ are estimated using the nonlinear least squares method applied to the computer program R. Model (19) includes constant μ expressing empirical probability of bankruptcy announcement in the time unit. The mean value for years 2003-2009 of μ is taken to our computation. Applying the computed values of parameters to the model (19) allows us to predict the amount of newly created, as well as the general number of private companies in year 2010 (actual values are not available yet).

Table 6. Estimated values of parameters from the model (19) and predictions about year 2010

PKD section	ρ	γ	μ	Business entity prediction 2010	General number prediction 2010
A	5624.975	0.000001324436	0.043605	4972	94039
B	84.62812	-0.0002693095	0.072086	145	2008
C	7.140696	-0.001533788	0.04073	638	3427
D	554.2193	-0.00000440886	0.065337	27573	368972
E	22.97401	-0.001104265	0.046393	1592	5189
F	3.757.165	-0.00000626922	0.070624	55057	451411
G	0.01901632	-0.00000759622	0.077149	79	1018335
H	0.2324422	-0.00009622672	0.089583	19032	125367
I	58461.39	0.000004710672	0.059661	16542	268521
J	44.62851	-0.00004303992	0.081616	12113	131570
K	10178.98	-0.000003.00623	0.061743	61659	622418
L	180625.6	0.0004020162	0.001499	246	16637
M	158.6318	-0.00007498634	0.069748	10254	61556
N	126.8506	-0.00002943065	0.033525	22708	192515
O	4352.547	-0.00000683107	0.049436	27139	281164
P	5.253919	-0.0007181747	0.698264	5	21
Q	21.20412	0.007387905	0.021459	8	131

While analyzing results of this prediction we can observe that the general number of private companies seems to be acceptable, as well as the predicted number of the newly created private business entities. Estimated values are acceptable and fit correctly to previous data.

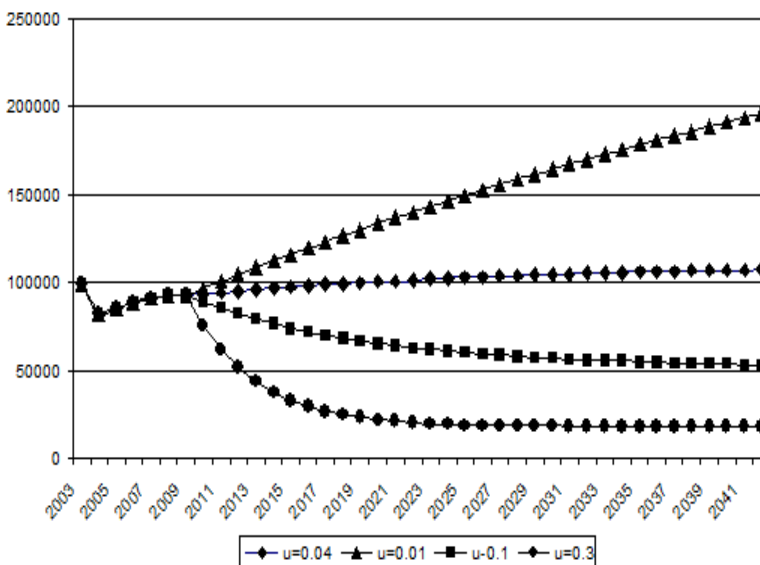
7. Long-term forecast

The limited sample size that is available is not sufficient to predict the number of registered companies in the long perspective. While examining data, it can be observed that in most cases in the given period of time in Poland the number of private companies in the REGON system, as well as of those recently registered in each section, increased. It may be the result of a considerable economic growth that has lately taken place in Poland. What we often get is the situation where we predict the constantly increasing trend. It leads to the conclusion that our model gets more interesting application in relation to more stable markets in which the decreasing number of companies leads to the increase in the amount of newly created ones and vice versa. This dependency was proved only for sections A, I, L and Q.

Let us take a closer look on the data from the A section. According to the model, the amount of private companies in the section A will constantly increase and is going to stabilize on the level of 111315.

Another application of the model (19) is a simulation of behaviour of the amount of companies related to the changing values of the parameter μ . Recall that μ represents empirical probability of bankruptcy announcement in the time unit. This kind of prediction can be applied to a situation where risk of bankruptcy is increasing (for example caused by global crisis) or decreasing (for example caused by decreasing taxes). Figure 2 illustrates long-term forecasts for different values of μ .

Figure 2. Long-term forecasts for section A for different values of μ



Our computations show that if empirical probability of bankruptcy decreases from 4.3 percent to 1 percent, the general amount of private companies in the section A in the long-term will increase to the level of 352613. In case the empirical probability of liquidation increases to 10 percent, the general number heads to 52473, and in case of probability 30 percent to 18301.

8. Final remarks

The creation and bankruptcy of companies is an inherent part of the market economy. Among the newly set up firms only those manage to endure which are flexible enough to respond in time to the changing circumstances. The remaining firms not meeting the demands of the market, by means of their insolvency release work force and resources, which can be and, in most of the cases, are used by newly created companies. The bankruptcy process of ineffective companies is harmful to employees, employers, creditors and related firms, but it improves innovativeness, creativity and efficiency of both recently started and already existing companies that have not failed. The consequence of this practice is the acceleration of the socio-economic development of different countries. However, this process of creative destruction should be monitored so as to maintain certain control over it. Therefore, the attempts of predicting insolvency of companies using financial indicators or certain models, including econometric ones, are of much significance in this context. The above presented author's model, which is a differential equation, applies to the last mentioned conception.

The undeniable advantage of the presented model is the fact that it is based on plausible, simple assumptions and it leads to interesting dependences. The verification of this model based on data from Poland proved correspondence of the model with the existing reality. Using the stationary model we can predict empirical probability of announcing bankruptcy for firms depending on their age. The used model allows one also to predict the future amount of newly created and the general number of companies on the market. As presented for data from the Statistical Classification of Economic Activities, the model can be applied to simulations of changes in the amount of companies for different empirical probability of companies death.

These introductory, encouraging results motivate to conduct further researches on the implementation of this model and creating its versions in order to respond to new scientific aims.

Further research ought to concentrate on the application of this model to other regions of Poland in order to compare obtained results. However, the main problem is too short time series of data available to particular provinces of Poland. Therefore, much value would be attributed to the application of this model to countries which have stable market economies, so that larger samples concerning births and deaths of companies can be extracted.

REFERENCES

- AGIAKOGLU, C. & NEWBOLD, P., 1992, Empirical Evidence on Dickey–Fuller Type Tests, *Journal of Time Series Analysis*, 13, pp. 471–483.
- ANWAR, M.S., DAVIES, S. & SAMPATH, R.K., 1996, Causality between Government Expenditures and Economic Growth: An Examination Using Cointegration Techniques, *Public Finance*, 51, pp. 166–184.
- ALTMAN, E., 1968, Financial Ratios, Discriminant Analysis and the Prediction of the Corporate Bankruptcy, *The Journal of Finance*, 23, pp. 589–609.
- BEBCHUK, L.A., 2002, Ex Ante Costs of Violating Absolute Priority in Bankruptcy, *The Journal of Finance*, 57, pp. 445–460.
- BIALASIEWICZ, M. AND BUCZKOWSKI, T., 1996, Restrukturyzacja przedsiębiorstw i jej skutki na przykładzie niektórych przedsiębiorstw Szczecina, in: *Przedsiębiorstwo w procesie transformacji*, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.
- BRATNICKI, M., 2001, Pułapki i problemy zarządzania strategicznego, in: *Instrumenty Zarządzania we współczesnym przedsiębiorstwie*, Akademia Ekonomiczna w Poznaniu.
- CZAJKA, D., 1999, Przedsiębiorstwo w kryzysie, upadłość lub układ, *Wydawnictwo Zrzeszenia Prawników Polskich*, pp. 17–19.
- DURLIK, I., 1998, Restrukturyzacja procesów gospodarczych: reengineering, teoria i praktyka, *Agencja Wydawnicza Placet*.
- ENCYKLOPEDIA BIOLOGICZNA, 1998, Otałęga (Ed), *Opress*, pp. 341.
- FOSTER, R. AND KAPLAN, S., 2001, Creative Destruction, *Financial Times*.

- FREDERICK, W.C. AND DAVIS, K. AND POST, J.E., 1988, Corporate Social Responsibility and Business Ethics, *McGraw-Hill Publishing Company, New York*, pp. 28-29.
- GREINER, L.E. AND SCHEIN, V.E., 1988, Power and Organization Development, *Addison-Wesley*.
- HADASIK, P., 1988, Upadłość przedsiębiorstw w Polsce i metody jej prognozowania, *Zeszyty Naukowe – seria II*, 153, AE Poznań, pp. 81-91.
- HANDY, CH., 1995, 'THE AGE OF PARADOX', HARVARD BUSINESS SCHOOL PRESS.
- HOLDA, A., 2001, Prognozowanie bankructwa jednostki w warunkach gospodarki polskiej z wykorzystaniem funkcji dyskryminacyjnej ZH, *Rachunkowość*, 5, pp. 306-310.
- HURST, D.K., 1995, Crisis and renewal: meeting the challenge of organizational change, *Harvard Business School Press*, Boston.
- KOŹMIŃSKI, A.K. AND PIOTROWSKI, W., 1999, Zarządzanie teoria i praktyka, *Wydawnictwo Naukowe PWN*.
- MAJCHRZAK, J., 2003, Społeczny wymiar zarządzania przedsiębiorstwem. Mit czy konieczność?, in: Współczesne tendencje w zarządzaniu, *Zeszyty Naukowe*, 33, Wydawnictwo Akademii Ekonomicznej w Poznaniu.
- MATSCHKE, J.M. AND BROESEL, G., 2007, Unternehmensbewertung, *Gabler-Verlag*.
- OSBERT-POCIECHA, G., 2004, Twórcza destrukcja jako uwarunkowanie innowacyjnego rozwoju przedsiębiorstwa, *Prace Naukowe Akademii Ekonomicznej im. Oskara Langego we Wrocławiu*, 1045, pp. 273-278.
- PERECHUDA, K., 1999, Metody zarządzania przedsiębiorstwem, *Wydawnictwo Akademii Ekonomicznej we Wrocławiu*.
- SHONFELDER, B., 2003, Death or Survival. Post-Communist Bankruptcy Law in Action, *A Survey*, Freiberg, 2003, pp. 3.
- SHUMPETER, J., 1982, The Theory of Economic Development: An inquiry into profits, capital, credit, interest and the business cycle, *Transaction Publisher*.

- WAŻEWSKA-CZYŻEWSKA, M. AND LASOTA, A., 1976, Matematyczne problemy dynamiki układu krwinek czerwonych, *Roczniki Polskiego Towarzystwa Matematycznego*, Seria III. Matematyka Stosowana VI, pp. 24-40.
- ZDYB, M., 2008, Jakie czynniki generują upadłości przedsiębiorstw w Polsce? Przyczyny upadłości przedsiębiorstw w Polsce, *Biuletyn E-rachunkowość*.
- ZEDLER, F., 2003, Prawo upadłościowe i naprawcze–wprowadzenie, *Zakamycze*, Kraków.
- ZIMNIEWICZ, K., 2000, Współczesne koncepcje i metody zarządzania, *Polskie Wydawnictwo Ekonomiczne*, Warszawa.

