Forecasting risk of bankruptcy for machine-building plants[1]

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Abstract. The paper presents an overview of well-known bankruptcy risk forecasting models, elaborated as by Russian so by foreign authors, on the basis of the data about financial and business activities of the biggest machine-building Russian plants. The authors substantiate and confirm appropriateness of a fuzzy set model to the problem of bankruptcy risk forecasting. This model is worked out on the basis of 10 most important factors, which have the greatest influence on sales proceeds as the main financial source for a production plant.

1. Introduction

One of the most important market system institutes, which allow attracting bailout money and encouraging redeployment of production resources from inefficient economy sectors to efficient ones, is corporate bankruptcy. In any developed economy of market type bankruptcy is used not only for indicated purposes but also on behalf of agents-debtees and owners of a problem enterprise. It is a comparatively young institute in Russia, which had first legal confirmation in RF Law, dated 19 November, 1992, N 3929-1 “About Business Failure (Bankruptcy)”. During this time it showed some ambiguity from the point of view of its fitness for the “right” purpose. In Russia corporate bankruptcy very often had a raider character and was used as an instrument for business take-over.

In this context tested, mathematically sound ways for bankruptcy risk forecasting have extrinsic value, because their elaboration and application is aimed at self-insurance system development of an enterprise for eventual bankruptcy.

2. Main results

2.1 Selection of the most important factors, which have an influence on sales proceeds as the main financial source for an enterprise, for bankruptcy risk forecasting by means of a principal components method

The method of principal components is meant for data structuring through the medium of reduction of many test variables to fewer number of variables (components or factors), which would explain most of studied data value variability.

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For the analysis the authors selected 33 components (including sales proceeds), which characterize more precisely all aspects of enterprise financial and business activities. Selected indicator values were calculated for 33 machine-building plants on the basis of financial statements (Bookkeeping balance sheet (form №1), Supplement to the Bookkeeping balance sheet (form №5), Profit and loss account (form №2)) by 1st quarter 2010.

Then according to the main steps of the principal components method everything was calculated. In the result 5 basic components were worked out. They explain 73,607 % of all variables dispersion. It is necessary to notice that indicator selection was done with a glance to their influence on sales proceeds as the main financial source for a production plant.

After analyzing component eigen-vectors with the help of information coefficient the authors clarified which varieties contributed the most to their formation: x_5 – working capital ratio; x_6 – acid test ratio; x_8 – absolute liquidity ratio; x_9 – liquid capital ratio in assets; x_{14} – concentration ratio of capital loans; x_{16} – long term fund raising ratio; x_{17} – borrowed and own funds ratio; x_{21} – turn-round of float; x_{24} – turn-round of owned capital; x_{25} – product profitability.

Other variables can be excluded.

Therefore application of the principal components method allows diminishing feature space and moving from 33 factors, influencing sales proceeds as the main financial source for an enterprise, to 10 the most important, which explain most of studied data value variability [1].

2.2 Application of machinery of a possibility theory for bankruptcy risk forecasting of an enterprise

Bankruptcy risk assessment with the help of fuzzy sets includes 9 basic steps. You may see a simplified method description in Figure 1.

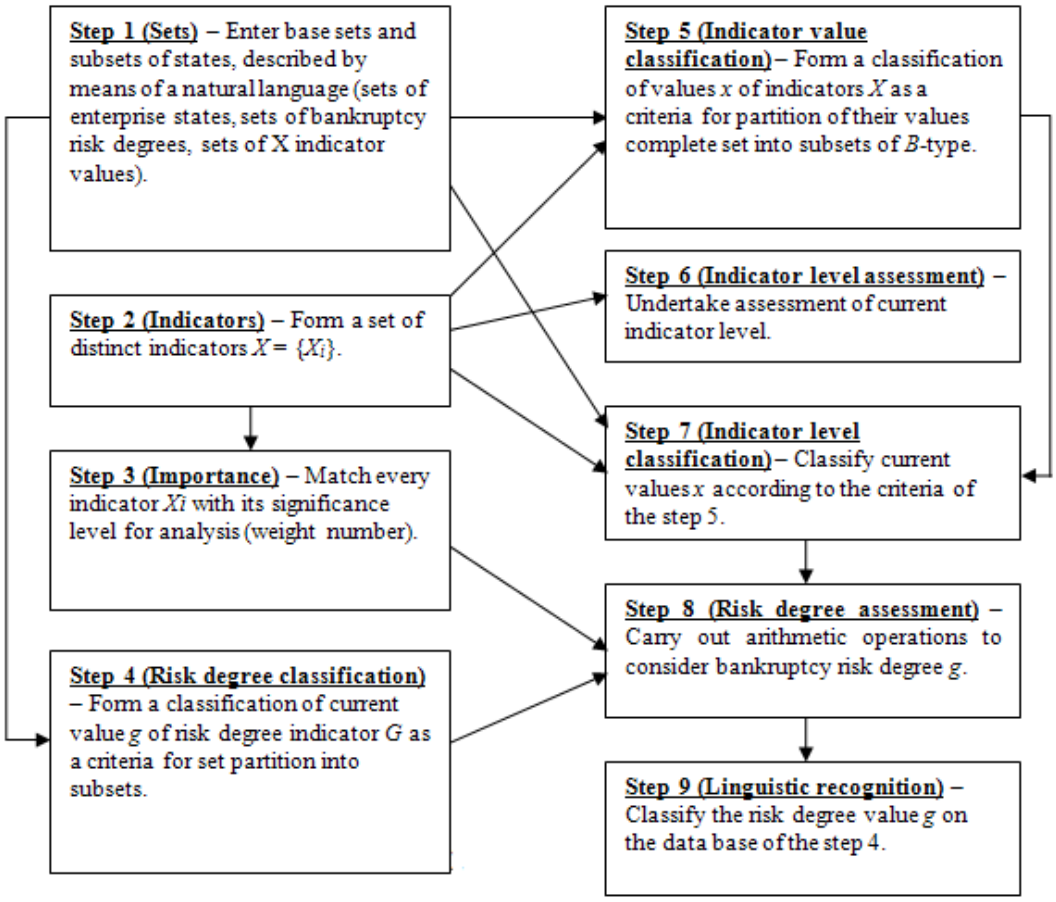

Figure 1. Simplified description of a fuzzy logical method.

Application of machinery of a possibility theory to the problem of bankruptcy risk forecasting allows:

- considering quantitative and qualitative indicators, which could be as standardized so non-standardized;
- considering an acceptable risk level for an enterprise and its property;
- recognizing in time possible beginning of bankruptcy risk.

2.3 Forecasting models for basic indicator evaluations of enterprise financial and business activities

To manage effectively bankruptcy risk of an enterprise it is necessary to be oriented not only onto current enterprise state assessment, but also onto its time history.

To calculate forecasting indicator values it is supposed to use a time-series forecasting method on the basis of polynomial growth curves. For 10 statistically based factors they form data selections over some periods, and then forecasting models are developed on this basis. Obtained models are needed to forecast indicator values for some periods of time, and also for time lag calculation before they take their critical values.

For example, there is a forecasting model for the factor - working capital ratio for open joint-stock company "Ishimbaiskiy Machine-building Plant" with the data from the table 2.

Table 2. Values of working capital ratio over 2007-2011. Open joint-stock company "Ishimbaiskiy Machine-building Plant"

Year	1 quarter	2 quarter	3 quarter	4 quarter
2007	2,65	2,2	2,17	1,7
2008	1,6	2,6	1,95	1,9
2009	1,9	2,2	2,3	2,7
2010	2,2	2,4	2,2	1,9
2011	1,4	1,1	0,96	0,84

Construct x_1-t diagram (fig. 3). It is evident from the diagram in fig. 2 the coefficient has a downward trend. Polynomial regression is the best in this case to characterize the trend.

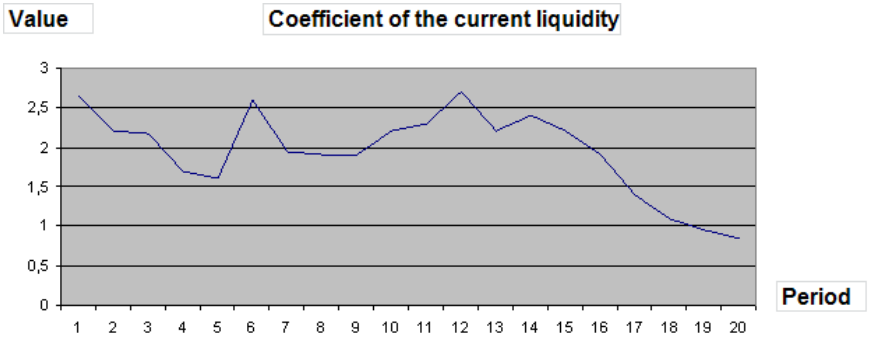

Figure 2. Changes trend of working capital ratio.

Then according to finite-difference method (Tintner method) a polynomial degree is defined, and with the help of least-square method one finds equation coefficients:

$\hat{y}_t = 1,92 + 0,107 \cdot t - 0,008 \cdot t^2$, where *"t"* is time in quarters.

It is possible to assess quality of the model by means of a relative approximation error, which is 14,96% in this case. An average approximation error is in interval 10-20%, consequently the model fidelity is quite good.

In a similar way one can form forecasting models for the rest factors.

On the basis of deduced equations it is possible to define forecasting factor values by 1 quarter 2012 (tab. 4).

2.4 Application of a model on the basis of fuzzy logic for enterprise bankruptcy risk forecasting

The authors calculated bankruptcy risk level of 27 enterprises on the basis of financial accounting data over the first quarter 2010-2012 with the help of six models: Altman's, Taffler's, Fulmer's, Springate's, Davydova-Belikov's, Telipenko's fuzzy set model (using 10 factors) [2-5]. A part of the calculations for the most prominent selected factors is presented in tab. 3.

At the result of analysis the authors drew a conclusion:

1) All reviewed models define precisely bankruptcy risk level of financially troubled enterprises[2]. Fig. 4 presents results of the models application which help to assess bankruptcy risk level of the enterprises, against which they instituted bankruptcy proceedings in 2012.

2) Assessments of bankruptcy risk level obtained after Altman's model application are very pessimistic: 20 enterprises out of 27 are bankrupts following the results of 1 quarter 2012, but it is not true. This fact is confirmed by quarterly enterprises reports.

3) Calculations of bankruptcy risk level by Fulmer's model are binary[3], as the result risk level is underestimated.

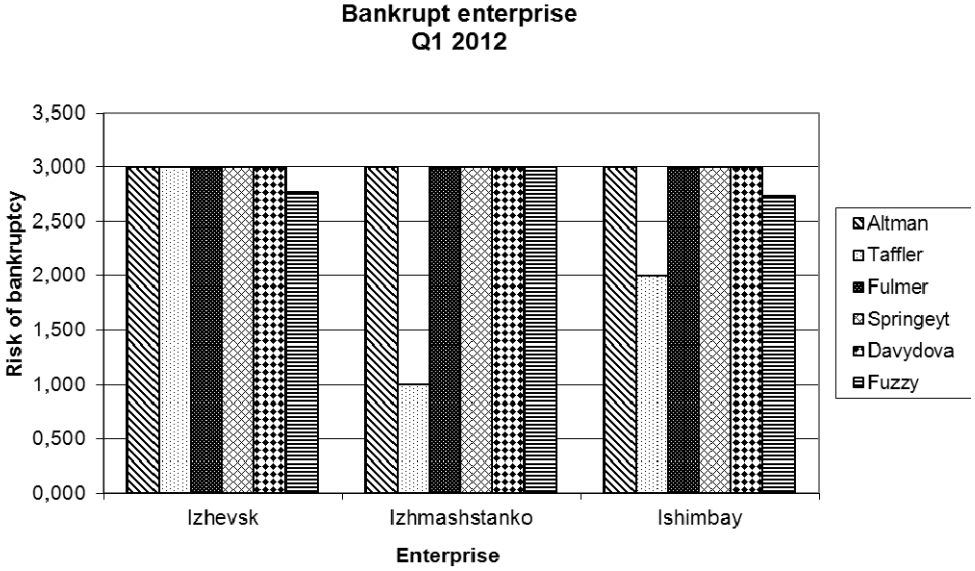

Figure 3. Results of the models application which help to assess bankruptcy risk level of the enterprises over 1 quarter 2012.

4) Fuzzy model gave appropriate assessments of bankruptcy risk level in respect of all analyzed enterprises. It is confirmed by quarterly enterprises reports.

For example, the method of fuzzy logic helped to correctly assess enterprise state (open joint-stock company "Ishimbaiskiy Machine-building Plant", Russia, Ishinbay city) not only in the time of crisis, but long before it (fig. 4). Against the plant they instituted bankruptcy proceedings in 1 quarter 2012.

You can see gradual degradation of the situation on the enterprise (fig. 4), the fuzzy model fairly presented it.

[2] Against these enterprises they instituted bankruptcy proceedings in different times in 2011-2012.
[3] Assessment of risk level has only two linguistic interpretations: either low or high without intermediate result.

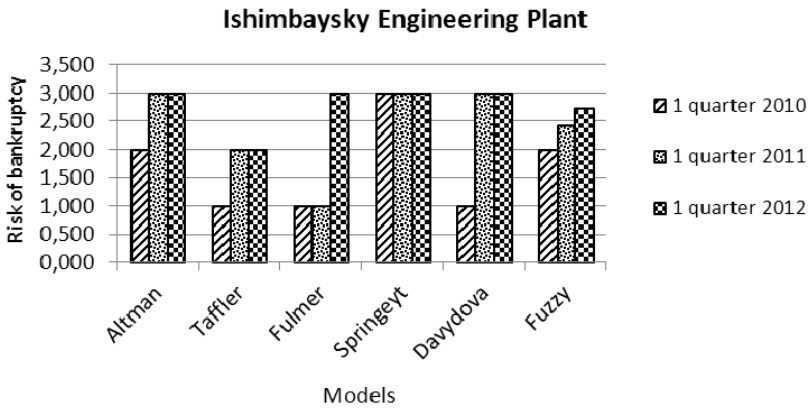

Figure 4. Bankruptcy risk assessment results of Open joint-stock company "Ishimbaiskiy Machine-building Plant".

Advantages of a fuzzy model are evident even when analyzing a successful enterprise (fig. 5).

Four models out of six assessed bankruptcy risk level of closed joint-stock company "Sibkabel" (Russia, Tomsk city) as low. But it is known that since 2000 financial condition of the enterprise has changed for the worse because of downswing of production output and serious contraction of market channels. Situation gradually improved when closed joint-stock company "Sibkabel" merged into Ural mining and metallurgical company (Russia, Verkhnaya Pyshma city). It was adequately shown by means of a fuzzy model of risk assessment and it is clearly seen in a block diagram.

Therefore most preferable model for bankruptcy risk forecasting of an enterprise is a fuzzy set model, because it is most sensitive to enterprise state changes and it gives a reliable assessment not only in the time of crisis but long before it.

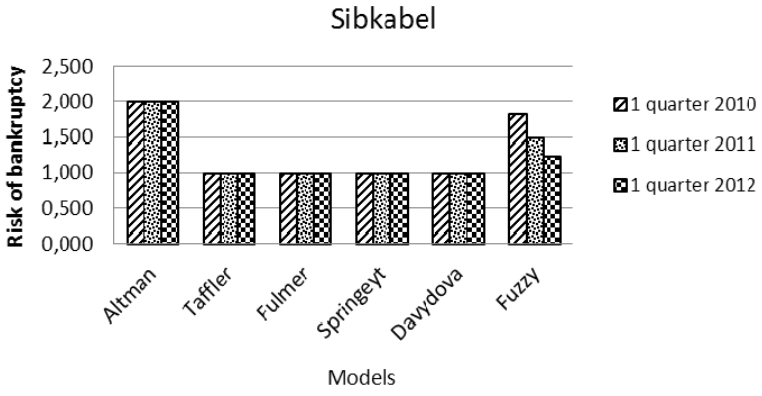

Figure 5. Bankruptcy risk assessment results of closed joint-stock company "Sibkabel".

2.5 Verification of forecasting model application on the basis of polynomial growth curves for calculation of indicator values in the future and with their help bankruptcy risk forecasting

For verification the authors made calculations for four enterprises, two of which were bankrupts.

10 indicators of enterprise financial and business activity over 2010-2011 were calculated to conduct analysis. They had been selected on the first step by means of the principal components method. On the base of obtained data forecasting models were formed and forecasting indicator values were calculated for 1 quarter, 2012.

Then on the basis of real and forecasting indicator values over 1 quarter, 2012, enterprises bankruptcy risk level was assessed and obtained results were compared (tab. 4).

Analysis of the table 4 shows:

1) assessment results of bankruptcy risk level with the help of a matrix method based on forecasting indicator values of enterprise financial and business activity almost coincide with assessment results based on real values; and when one classifies them they are in the same interval and have relatively equal assessment reliance;

2) assessment results of bankruptcy risk level confirm real situation of analyzed enterprises at 1 quarter 2012, i.e.: Commercial Court decision of the Udmurtian Republic as of 02.20.2012 was to declare OJSC "Izhmashctanko" (Russia, Izhevsk city) a bankrupt; Commercial Court decision of the Udmurtian Republic as of 04.06.2012 was to declare OJSC "Izhevsk machine-building plant" (Russia, Izhevsk city) a bankrupt; OJSC "Machine-building plant" (Russia, Electrostal city) and CJSC "Sibkabel" (Russia, Tomsk city) function today.

3. Conclusion

Taking into consideration everything what was said it is necessary to point out some advantages of a fuzzy set model for enterprise bankruptcy risk forecasting:

1. Application of 10 factors selected by means of the principal components method for analysis and bankruptcy risk level forecasting allows obtaining adequate results for machine-building enterprises, and it is confirmed by real situation in analyzed enterprises.
2. Application of forecasting models for indicator values calculation at a particular moment in the future allows fairly forecasting of situation development and identifying forecasted bankruptcy risk level.
3. Application of a matrix (fuzzy set) method at the step of assessment and forecasting of enterprise bankruptcy risk allows not only classifying risk level values as low or high but also considering their percentage. It helps to more fully comprehend the situation and come to the right management decision. Matrix method is also graphical, that is why it allows following dynamics of indicator values changes.
4. Regular application of a forecasting model for enterprise state monitoring will help to come to management decisions well-timed, but not post factum. It will help to reduce or escape bankruptcy risk.
5. Presented in the paper fuzzy set model has software support now, it is a module part of "Information system of bankruptcy risk management for an enterprise". This module can be used by owners, creditors, investors, and others for enterprise bankruptcy risk forecasting. More information about "Information system of bankruptcy risk management for an enterprise" is in [6-8].

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Table 3. Model approbation and comparison results for bankruptcy risk level determination.

Enterprise	Period of time	Altman's model		Taffler's model		Fulmer's model		Springate's model		Davydova-Belikov's model		Fuzzy logic model	
		Z	Linguistic interpretation	Z	Linguistic interpretation	H	Linguistic interpretation	Z	Linguistic interpretation	Z	Linguistic interpretation	G	Linguistic interpretation
OJSC "Izhevsk machine-building plant"	1qtr 2010	2.231	uncertain	0.093	high	-3.574	bankrupt	-0.040	high	-1.546	maximum (90-100%)	0.524	100% acceptable
	1 qtr 2011	0.801	bankrupt	0.100	high	-5.956	bankrupt	0.180	high	-1.257	maximum (90-100%)	0.687	56.5% acceptable; 43.5% high
	1qtr 2012	0.179	bankrupt	0.136	high	-10.391	bankrupt	0.186	high	-3.368	maximum (90-100%)	0.754	23% acceptable; 77% high
CJSC "Sibkabel"	1 qtr 2010	1.778	uncertain	0.496	low	3.209	low	1.444	low	4.041	insignificant (до 10%)	0.367	16.5% low; 83.5% acceptable
	1 qtr 2011	1.694	uncertain	0.534	low	3.453	low	1.224	low	2.043	insignificant (до 10%)	0.299	50.5% low; 49.5% acceptable
	1 qtr 2012	2.031	uncertain	0.590	low	4.337	low	1.151	low	2.357	insignificant (до 10%)	0.246	77% low; 23% acceptable
OJSC "Machine-building plant Zio-Podolsk"	1 qtr 2010	0.392	bankrupt	0.289	average	0.812	low	0.789	high	1.689	insignificant (до 10%)	0.699	50.5% acceptable; 49.5% high
	1 qtr 2011	0.319	bankrupt	0.263	average	1.688	low	0.881	low	1.802	insignificant (до 10%)	0.616	80% acceptable; 20% high
	1qtr 2012	0.264	bankrupt	0.237	average	1.120	low	0.846	high	1.768	insignificant (до 10%)	0.746	27% acceptable; 73% high
OJSC "Machine-building Plant", Electrostal city	1 qtr 2010	2.774	uncertain	0.819	low	5.713	low	0.833	high	3.577	insignificant (до 10%)	0.238	81% low; 19% acceptable
	1 qtr 2011	1.974	uncertain	0.362	low	5.513	low	0.502	high	1.948	insignificant (до 10%)	0.395	100% acceptable
	1qtr 2012	2.275	uncertain	0.343	low	5.369	low	0.399	high	2.729	insignificant (до 10%)	0.353	23.5% low; 76.5% acceptable
OJSC "IZHMASH-Stanko"	1 qtr 2010	-0.661	bankrupt	0.216	average	-3.547	bankrupt	0.101	high	-4.506	maximum (90-100%)	0.837	100% high
	1 qtr 2011	-0.456	bankrupt	0.297	average	-2.923	bankrupt	0.654	high	-6.845	maximum (90-100%)	0.891	100% high
	1qtr 2012	-1.617	bankrupt	0.349	low	-6.494	bankrupt	0.167	high	-9.117	maximum (90-100%)	0.819	100% high
OJSC "Ishimbaiskiy Machine-building Plant"	1 qtr 2010	1.937	uncertain	0.386	low	1.448	low	0.496	high	2.937	insignificant (до 10%)	0.469	100% acceptable
	1 qtr 2011	0.826	bankrupt	0.286	average	0.851	low	0.581	high	-1.918	maximum (90-100%)	0.684	58% acceptable; 42% hihg
	1qtr 2012	0.280	bankrupt	0.256	average	-0.025	bankrupt	0.513	high	-3.882	maximum (90-100%)	0.747	26.5% acceptable; 73.5% high

Table 4. Assessment results of enterprise bankruptcy risk level on the basis of real and forecasted indicator values over 1 quarter, 2012.

Indicator name	OJSC "Izhmashstanko", Izhevsk city		OJSC "Izhevsk machine-building plant", Izhevsk city		OJSC "Machine-building plant", Elektrostal city		CJSC "Sibkabel", Tomsk city	
	fact	forecast	fact	forecast	fact	forecast	fact	forecast
x_1 – working capital ratio	0.123	0.126	0.387	0.419	3.000	3.15	2.98	2.83
x_2 – acid test ratio	0.21	0.24	0.0059	0.0055	1.293	2.44	1.41	1.9
x_3 – absolute liquidity ratio	0.0003	0.0002	0.00016	0.00023	0.394	0.444	0.00223	0.00198
x_4 – liquid capital ratio in assets	0.188	0.201	0.089	0.129	0.503	0.492	0.771	0.757
x_5 – concentration ratio of capital loans	1.783	1.813	0.481	0.605	0.170	0.100	0.251	0.264
x_6 – long term fund raising ratio	0.063	0.049	0.0184	0.0203	0.026	0.019	0.0199	0.0201
x_7 – borrowed and own funds ratio	2.276	2.571	0.925	0.981	0.205	0.199	0.334	0.381
x_8 – turn-round of float	0.363	0.514	0.032	0.065	0.476	0.392	1.726	1.958
x_9 – turn-round of owned capital	0.219	0.322	0.006	0.012	0.059	0.057	0.621	0.786
x_{10} – product profitability, %	0.563	0.478	0.03	0.01	32.9	27.2	6.25	6.13
Generalized estimator of a risk level	**0.819**	**0.843**	**0.754**	**0.765**	**0.403**	**0.301**	**0.246**	**0.237**
Linguistic interpretation	**High 100%**	**High 100%**	**Acceptable 23% High 77%**	**Acceptable 17,5% High 82,5%**	**Low 23,5% Acceptable 76,5%**	**Low 29,5% Acceptable 70,5%**	**Low 77% Acceptable 23%**	**Low 81,5% Acceptable 18,5%**