Forecasting risk of bankruptcy for machine-building plants

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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-debtors 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.](image-url)
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.

| 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 $x_{1,t}$-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.

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 enterprises2.

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 binary3, as the result risk level is underestimated.

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, Ishimbay 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.

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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.
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.

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, Electrostat 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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| Enterprise                  | Time period | Altman's model | Taffler's model | Fulmer's model | Springate's model | Davydova-Belikov's model | Fuzzy logic model |
|-----------------------------|-------------|----------------|-----------------|----------------|-------------------|--------------------------|------------------|
|                             |             | Z   | Z                | H              | Z                | Z                         | G                |
|                             |             |     | Linguistic      |                | Linguistic      | Interpretation         |      |
|                             |             |     | interpretation |                | Interpretation |                            |      |
|                             |             |     |                  |                |                  |                           |      |
| OJSC “Izhevsk               | 1qtr 2010   | 2.231 | uncertain       | 0.093          | high             | -3.574                   | bankrupt         |
| machine-building plant”     |             | 1qtr 2011 | 0.801 | bankrupt       | 0.100          | high                 | -5.956           | bankrupt         |
|                             |             | 1qtr 2012 | 0.179 | bankrupt       | 0.136          | high                 | -10.391          | bankrupt         |
|                             |             | 1 qtr 2011 | 1.778 | uncertain       | 0.496          | low                  | 3.209             | low              |
|                             |             | 1 qtr 2011 | 1.694 | uncertain       | 0.534          | low                  | 3.453             | low              |
|                             |             | 1 qtr 2012 | 2.031 | uncertain       | 0.590          | low                  | 4.337             | low              |
|                             |             | 1 qtr 2011 | 0.392 | bankrupt       | 0.289          | average             | 0.812             | low              |
|                             |             | 1 qtr 2011 | 0.319 | bankrupt       | 0.263          | average             | 1.688             | low              |
|                             |             | 1qtr 2012 | 0.264 | bankrupt       | 0.237          | average             | 1.120             | low              |
|                             |             | 1 qtr 2011 | 2.774 | uncertain       | 0.819          | low                  | 5.713             | low              |
|                             |             | 1 qtr 2011 | 1.974 | uncertain       | 0.362          | low                  | 5.513             | low              |
|                             |             | 1qtr 2012 | 2.275 | uncertain       | 0.343          | low                  | 5.369             | low              |
|                             |             | 1 qtr 2011 | -0.661 | bankrupt       | 0.216          | average             | -3.547            | bankrupt         |
|                             |             | 1 qtr 2011 | -0.456 | bankrupt       | 0.297          | average             | -2.923            | bankrupt         |
|                             |             | 1qtr 2012 | -1.617 | bankrupt       | 0.349          | low                  | -6.494            | bankrupt         |
|                             |             | 1 qtr 2011 | 1.937 | uncertain       | 0.386          | low                  | 1.448             | low              |
|                             |             | 1 qtr 2011 | 0.826 | bankrupt       | 0.286          | average             | 0.851             | low              |
|                             |             | 1qtr 2012 | 0.280 | bankrupt       | 0.256          | average             | -0.025            | bankrupt         |
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 |
| $x_8$ – tum-round of float          | 0.363 | 0.514 | 0.032 | 0.065 | 0.476 | 0.392 | 1.726 | 1.958 |
| $x_9$ – tum-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% | Acceptable 17.5% | Low 23.5% | Acceptable 76.5% | Low 29.5% | Acceptable 70.5% | Low 77% | Acceptable 23% | Low 81.5% | Acceptable 18.5% |