



Innovative Analysis of Models for Evaluating the Probability of Enterprises Bankruptcy

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Abstract: *The article is devoted to the relevant topic which is assessment of the insolvency (bankruptcy) of enterprises. The instability of a complex socioeconomic system is intensifying in the market economy, which is difficult to fully study and understand. Modern business is being run in a highly competitive environment. Adequate decision-making requires a deep, comprehensive assessment of the situation and a reliable forecast of events. A firm that has managed to correctly forecast the situation receives more profit than a firm that abstained from forecasting. The firm that made the wrong forecast loses the most. The main types of models for assessment of the bankruptcy probability for enterprises and the factors influencing them in the course of making decisions have been considered in this article, and the bankruptcy probability for Megafon PJSC based on various models has been studied. A comparative analysis of the models for assessment of the bankruptcy probability for enterprises has been conducted. The methods of cognition, retrospective and documentary analysis, as well as synthesis, generalization, and systematization were used in the article.*

Index Terms: *bankruptcy, enterprise, model, risk.*

I. INTRODUCTION

As market relations develop, entrepreneurial activity faces growing uncertainty. The uncertainty of the external and internal environment forces entrepreneurs to accept risk, which can cause both gains and losses [1, p. 46], [2]. Lack of complete information, existence of opposing trends, elements of randomness and other new economic conditions make it difficult to forecast the management process, since most of the managerial decisions at an enterprise are made under risk [3]-[6]. Various individuals and legal entities constantly emerge and disappear in the market, conducting independent risky activities, which are aimed at making a profit from the sale of goods or the provision of services. Market players are in constant interaction and enter into

various relationships. Inability of some market entity to fulfill the assumed obligations is an important part of the system of these relations. Risk of the entrepreneur is manifested in such a situation.

In other words, sometimes there are situations where the interaction party has a small profit or, in the worst case, no profit at all, i.e., goes bankrupt.

Bankruptcy is a rather urgent problem today. It aggravated when the global crisis began, as many companies faced financial problems [7, p. 35], [8].

In fact, only the arbitration court can establish the fact of the enterprise insolvency, i.e., its bankruptcy. At the same time, the company itself may officially declare its bankruptcy or liquidation that occurs during the bankruptcy proceedings. These proceedings are aimed at meeting creditors' claims and announcing this company clean from debts.

The purpose of the article is to unveil the bankruptcy problem, analyze the most common models for assessing the bankruptcy probability, and demonstrate them by the example of a particular company.

II. ENTERPRISE BANKRUPTCY (INSOLVENCY): BASIC CONCEPTS AND ESSENCE

1. Essence of bankruptcy

The law on the enterprise bankruptcy is in a constant process of improvement in accordance with the law enforcement. The Federal Law "On insolvency (bankruptcy)" dated October 26, 2002 [9] was created to minimize the costs of bankruptcy processes, tighten control over the activities of bankruptcy commissioners, and reduce the benefits of the deliberate bankruptcy. All legal entities are subject to this law, except for state enterprises, political parties, and religious organizations. Insolvency (bankruptcy) of an enterprise is the inability of the debtor to meet the creditors' claims for monetary obligations and (or) to meet the obligation to make mandatory payments in full, recognized by the arbitrage court. The law identifies a particular attribute of the enterprise insolvency: the inability to meet the creditors' claims for monetary obligations and (or) to meet obligations to make obligatory payments, if the corresponding obligations and (or) obligation have not been met by it within three months from the due date. No minimum amount of monetary obligations required for filing an application to the arbitration court to declare the company bankrupt is set in this law. The size and composition of the financial obligations required to start bankruptcy proceedings are to be defined by the arbitrage court.

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The bankrupt companies identified by the above attributes should be distinguished from:

- *Fraudulent bankruptcy* – an intentionally false declaration by an enterprise that is able to meet the creditors' claims in full of its insolvency in order to mislead creditors and force them to allow a deferment or installment payments, or a discount on debts; and
- *Deliberate bankruptcy* – a purposeful creation or exaggeration of the enterprise insolvency by the management or the owner, causing damage to the company in their personal interests, deliberately not competent management [10, p. 142].

The responsibility for the company's insolvency is defined by the Criminal Code of the Russian Federation in these situations.

In this case, the law specifies two external attributes of bankruptcy:

- Monetary obligations or obligations to make obligatory payments have not been met within three months from the due date; and
- The minimum amount of monetary obligations and obligatory payments is at least 500 times the minimum monthly wage approved by the Government of the Russian Federation.

The process of the enterprise insolvency consists of three stages: hidden financial instability, obvious financial instability, and legally obvious bankruptcy. At the hidden stage, the "enterprise value" falls. This means that its profits have fallen, or the volume of liabilities has increased.

The stage of the financial instability is defined by the appearance of problems with meeting short-term liabilities. The second stage is financial instability, which is described by the occurrence of difficulties with meeting short-term liabilities. The last stage is legally obvious bankruptcy, when the enterprise cannot pay its debts on time.

III. PROPOSED METHODOLOGY

A. Factors Influencing Bankruptcy of Enterprises

Factors that influence the core activities of the enterprise also influence its insolvency, i.e., they are subjective (internal) and objective (external). The objective factors define the conditions that have formed at the macro level for the companies' existence. They are divided into favorable and unfavorable for enterprises, which depends on the level of efficiency of the state, legislative and executive bodies, i.e., how well the state performs its duties [11], [12].

The objective factors include the following:

- *Economic* – size of income and savings of the population (purchasing power), solvency of counterparties, credit and tax policy of the country, changing consumer market preferences, and inflation;
- *Social* – change in the political situation inside and outside the country, international competition, level of the entrepreneurs' and consumers' culture, moral preferences and religious norms that determine the way of life, and demographic situation;
- *Legal* – existence of laws regulating business activities, protection from the state bureaucracy, development of tax

legislation, accounting methodologies and reporting forms, improvement of venture activities with the foreign capital participation; and

- *Climatic and environmental* – availability of material resources, climate conditions, state of nature, etc.

These indicators are interrelated, but they all depend on the same criterion – the level of competence and responsibility of state and municipal authorities, and their ability to reasonably manage the economy of the entire country and individual regions.

The fall in indicators that determine the condition of the state can contribute to the insolvency of enterprises, especially small ones. Medium and large businesses are more resilient in these conditions. Besides, the level of the shadow economy has impact on the failure of small enterprises. Bankruptcy of companies is not rarely carried out purposefully in order to redistribute property in such an economy [13, p. 33].

The subjective factors include the following:

- *Material and technical* – factors associated with the engineering and technology development, introduction of scientific discoveries into the company's operation, and the development of subjects of labor;
- *Organizational* – factors that are determined by the development of the organization of production, labor and management, as well as the choice of the incorporation form; and
- *Socio-economic* – factors associated with the staff, their level of competence, and attitude to property and working conditions.

The following company types are defined based on the reasons for the insolvency appearance [14], [15]:

- Bankrupt enterprise that operates in a balanced economy is an enterprise that failed to meet its obligations for subjective reasons; and
- Bankrupt enterprise that operates in a mass bankruptcy economy is an enterprise that is not suitable for solving economic problems in the future.

B. Criteria for Bankruptcy

The financial strength (FS) is an indicator of the financial stability of an enterprise [16], [17]. The FS is most often found using the following formula:

$$FS = \text{Revenue} - \text{Breakeven point}$$

Or as a percentage:

$$FS = \frac{\text{Revenue} - \text{Breakeven point}}{\text{Revenue}} \times 100\%.$$

An increase in the FS allows to evaluate options for further reducing revenue from sales of products within the breakeven point.

There are three conditions that influence the revenue and the FS differently:

1. sales volume is equal to production volume;
2. sales volume is less than production volume; and
3. sales volume exceeds production volume.

There is a system of indicators that allows to determine the unsatisfactory structure of the insolvent companies' balance.



It is based on the current liquidity, self-sufficiency, etc. These figures influence the assessment of the balance structure quality, and hence the level of the enterprise solvency.

The *current liquidity ratio* reflects the overall provision of the enterprise with working capital for its operation and timely repayment of accounts payable. It is found using the following formula:

$$R_{CL} = \frac{\text{Current assets}}{\text{Current liabilities}}$$

The ratio of the provision of the enterprise with equity capital is found using the following formula:

$$R_{PEC} = \frac{\text{Equity capital}}{\text{Working capital}}$$

When the current liquidity ratio at the end of the reporting period is less than 2 and ratio of the provision with equity capital is less than 0.1, the balance structure can be called unsatisfactory and the company can be called bankrupt.

Then, the *solvency recovery (loss) ratio* is found. It is found for six months using the following formula:

$$R_{PEC} = \frac{\text{Current liquidity ratio at the beginning of the period} + \frac{+6/\text{Period, months} \times (\text{Current liquidity ratio at the beginning of the period} - \text{Current liquidity ratio at the end of the period})}{\text{Normative value of the current liquidity ratio (2)}}$$

If this indicator for six months is greater than 1, then it is recognized that the company can restore its solvency.

When the current liquidity ratio is greater than or equal to 2, and the ratio of the provision with equity capital is greater than or equal to 0.1, then the *solvency loss ratio for three months* is found using the following formula:

$$R_{PEC} = \frac{\text{Current liquidity ratio at the beginning of the period} + \frac{+6/\text{Period, months} \times (\text{Current liquidity ratio at the beginning of the period} - \text{Current liquidity ratio at the end of the period})}{\text{Normative value of the current liquidity ratio (2)}}$$

When the value of this indicator for three months is greater than 1, it indicates real possibility for the company not to lose solvency.

If there are indicators that the balance structure is unsatisfactory but at the same time there is a chance that the company solvency can be restored within certain periods, then a decision is taken to postpone the enterprise bankruptcy for six months.

The study of the bankruptcy proceedings reveals that they can exist only within the boundaries of one method of financial support for business operation that meet the conditions of the market economy [18, p. 42].

C. Models for Assessing the Bankruptcy Probability for Enterprises

The need to predict bankruptcy first appeared in capitalist countries after the Second World War. The enterprises went bankrupt due to shrinking state orders, falling demand, and a

general economic crisis. The bankruptcy assessment initially implied the allocation of the common reasons leading to it, and the first mathematical models for assessment of the bankruptcy probability for enterprises emerged in the 1960s due to the development of information and computing technologies. There are two key approaches to the bankruptcy assessment [19], [20]. The first approach can be considered comparative, since it is based on a comparison of the financial statements of companies that have gone bankrupt in the industry with the figures of the company under study. The second approach lies with various mathematical models based on a combination of the company's efficiency factors and the rationality of using its resources. They are based on the financial statements as well. There are many similar models – all of them are developed with due consideration for the specifics of the industry or country in which the company operates [21, p. 1617]. Below are the most well-known and important:

- two-factor model;
- Altman Z-score;
- Taffler model;
- Beaver model; and
- Zaitseva model.

A two-factor model is the first and the easiest bankruptcy assessment model. The model is based on two indicators that largely determine the bankruptcy probability for the enterprise [22, p. 145]. The indicators have a certain empirically weighting coefficient, and an experimentally obtained constant value is added to them. For example, the following type of equation is characteristic of American companies:

$$C_1 = -0.3877 + R_{CL} \times (-1.0736) + R_B \times 0.057^9,$$

where R_B is the proportion of borrowed funds in the liabilities of the company,

R_{CL} is the current liquidity ratio.

The resulting values can be interpreted as follows: if $C_1 < 0$, then the bankruptcy probability is low. In the opposite case, it can be concluded that there is high probability of bankruptcy.

Of course, this model cannot be used for an objective assessment of the bankruptcy probability due to a small number of input variables.

Altman Z-score is perhaps the most well-known model. It was established by the famous American economist Edward Altman in 1968. The model is based on multiplicative analysis and allows to conditionally divide companies into bankrupts and nonbankrupts [23].

The Altman model (Z-score) was based on a study of 66 enterprises, half of which went bankrupt in the 1940s, and the other half was efficiently operating. The study was based on 22 analytical factors, five of which were selected as the most statistically significant. They were included in the equation of multifactor regression, which describes the possible economic potential of the company and the efficiency of its operation:



Innovative Analysis of Models for Evaluating the Probability of Enterprises Bankruptcy

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + X_5,$$

where X_1 is the working capital/total assets;

X_2 is the retained earnings/total assets;

X_3 is the operating profit/total assets;

X_4 is the market value of shares/debt; and

X_5 is the revenue/total assets.

Following the results of empirical studies, it was found that an acceptable value of the Z ratio should have been included in the interval [-14, +22]. A more accurate interpretation can be given:

- if $Z > 2.99$, the company is financially sustainable;
- if $Z < 1.81$, the company is assessed as insolvent; and
- the interval [1.81 – 2.99] constitutes an area of uncertainty.

This model is only applicable for companies whose stocks are listed on the exchange. This is why Altman adjusted the model for companies that do not have stocks traded in the stock market in 1983:

$$K = 8.38K_1 + K_2 + 0.054K_3 + 0.63K_4,$$

where X_4 is the book value rather than the market value of stocks.

Unfortunately, despite its popularity, this indicator still has disadvantages. According to the equation describing the model, there is a certain margin of the company's profitability, where the bankruptcy risk is almost zero, which is not applicable to the Russian practice, where profits

depend on many external factors.

The Taffler four-factor model, created in 1977 by British scientists R. Taffler and G. Tisshaw, determines the frequent ratios of bankrupt enterprises and sustainable companies. It is done in order to show the two groups of companies and their corresponding ratios (for example, profitability, working capital turnover, liquidity, etc.) [24, p.157].

As such, the model for companies whose stocks are listed on the exchange looks as follows:

$$Z = C_0 + C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4 + \dots,$$

where X_1 is the profit before tax/current liabilities;

X_2 is the current assets/total liabilities;

X_3 is the current liabilities/total assets;

X_4 is no lending interval; and

$C_0 \dots C_4$ are the coefficients that determine the model proportions,

William Beaver created another remarkable bankruptcy assessment model. He developed a system of indicators for which it was true that the ratio of net cash flow to debt allowed to determine the bankruptcy probability. The model is not a regression equation but rather compares several coefficients with standard values [25, p.22]. Depending on this, three possible assessments of the financial condition of the company can be made (Table I):

1. Financially sustainable
2. Probable bankruptcy within five years
3. Probable bankruptcy within one year

Table I. Beaver model

Financial indicator	Coefficient formula	1	2	3
Beaver's coefficient	$(Net\ profit + Depreciation) / (Long-term + current\ liabilities)$	0.4 – 0.45	0.17	-0.15
Return on assets, %	$Net\ profit * 100 / Assets$	6 – 8	4	-22
Ratio of financial leverage	$(Long-term + current\ liabilities) / Assets$	<0.37	<0.5	<0.8
Net current assets ratio	$(Equity - Noncurrent\ assets) / Assets$	0.4	<0.3	-0.06
Cover ratio	$Current\ assets / Current\ liabilities$	<3.2	<2	<1

Finally, let us consider the model created in Russia in the 90s. The regression equation includes six variables that significantly influence the bankruptcy probability (Table II):

$$K = 0.25K_1 + 0.1K_2 + 0.2K_3 + 0.24K_4 + 0.1K_5 + 0.1K_6,$$

where K_1 is the loss ratio of the enterprise (net loss / equity);

K_2 is the payables / receivables;

K_3 is the short-term liabilities / most liquid assets, the ratio is the reciprocal of the absolute liquidity ratio;

K_4 is the loss ratio for sales of goods (net loss / sales volume);

K_5 is the borrowed capital / equity;

K_6 is the assets load factor, inverse of the asset turnover ratio.

Table II. Zaitseva model

Coefficient	Formula	Standard
K_1	$K_1 = Profit\ (loss)\ before\ tax / equity$	$K_1 = 0$
K_2	$K_2 = Payables / Receivables$	$K_2 = 1$
K_3	$K_3 = Short-term\ liabilities / Most\ liquid\ assets$	$K_3 = 7$
K_4	$K_4 = Profit\ before\ tax / Revenue$	$K_4 = 0$
K_5	$K_5 = Borrowed\ capital / Equity$	$K_5 = 0,7$
K_6	$K_6 = Assets / Revenue$	$K_6 = K_6\ of\ the\ past\ year$

The weights for the coefficients were found by experts. The obtained values of the variables are compared with the

corresponding standard

values, for which the minimum values of the coefficients in the model should be replaced: $K_1=0$; $K_2=1$; $K_3=7$; $K_4=0$; $K_5=0.7$; $K_6=K_6$ value in the previous period.

If this problem is considered from the standpoint of applying these models in the modern Russian practice, the authors suggest paying attention to the models of Zaitseva, Altman and Beaver, and also compare them.

IV. RESULT ANALYSIS

ASSESSMENT OF THE BANKRUPTCY PROBABILITY FOR MEGAFON PJSC BASED ON VARIOUS MODELS

Calculations for several bankruptcy models should be made and the results obtained should be compared. Megafon PJSC was chosen as an object of research and the financial statements for 2007 – 2016 of this company were analyzed.

A. Altman model

Table III. Altman model for Megafon PJSC

Coefficient	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
X_1	0.27	0.43	0.34	0.29	0.31	0.15	0.20	0.22	0.16	0.16
X_2	0.28	0.43	0.75	0.75	0.72	0.39	0.38	0.36	0.35	0.32
X_3	0.07	0.22	0.14	0.20	0.14	0.14	0.16	0.10	0.12	0.10
X_4	0.42	0.81	3.15	3.06	2.60	0.66	0.62	0.58	0.54	0.48
X_5	0.39	0.37	0.50	0.67	0.63	0.66	0.61	0.63	0.62	0.62
Z	1.21	2.05	3.12	3.43	2.98	1.82	1.84	1.67	1.64	1.52
Bankruptcy probability	80–100 %	35–50 %	35–50 %	35–50 %	35–50 %	35–50 %	35–50 %	80–100 %	80–100 %	80–100 %
<i>Upper boundary</i>	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81	1.81
<i>Lower boundary</i>	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77	2.77

The five-factor Altman model indicates a very high bankruptcy probability during the crisis, as well as in the last four years. However, it must be noted that this model is

aimed at foreign enterprises, thus, there may be differences with domestic models.

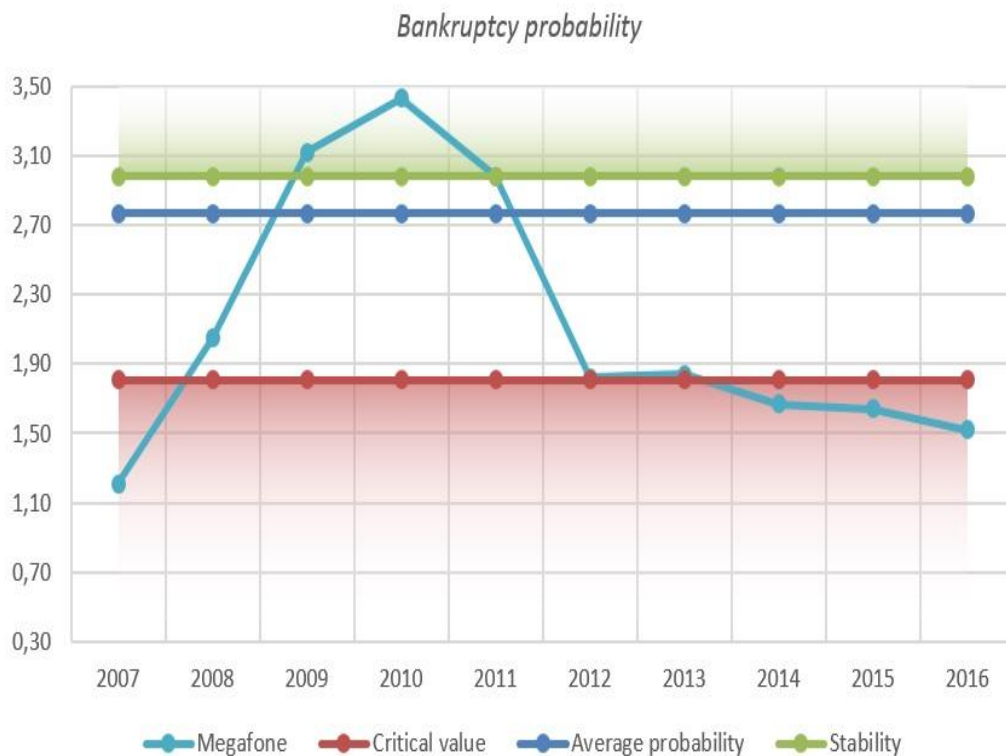


Fig. 1. Graphic interpretation of the Altman model

B. Beaver model

Table IV. Beaver model for Megafon PJSC

Indicator	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Beaver ratio	0.07	0.37	0.46	0.67	0.44	0.19	0.21	0.12	0.15	0.12
Current liquidity ratio	2.85	1.17	2.38	2.68	3.30	2.62	3.40	2.17	2.17	2.27
Economic profitability	4.60 %	20.65 %	11.08 %	16.40 %	12.36 %	11.29 %	12.99 %	7.80 %	9.73 %	7.88 %
Financial leverage	70.30 %	55.27 %	24.09 %	24.64 %	27.80 %	60.30 %	61.67 %	63.13 %	64.79 %	67.78 %
Net current assets ratio	-0.43	-0.12	0.10	0.04	0.03	-0.46	-0.42	-0.41	-0.49	-0.51
Bankruptcy risk group	II	II	I	I	I	II	II	II	II	II

According to this model, the net current assets ratio and financial leverage represent the greatest risk, but Megafon PJSC is at an average risk level due to the high return on assets and current liquidity, which corresponds to the total Beaver ratio.

C. Zaitseva model

The actual value of the coefficient does not exceed the standard – according to this model, Megafon PJSC has an extremely low probability of going bankrupt.

Table V. Zaitseva model for Megafon PJSC

indicator	Standard value	2008	2009	2010	2011	2012	2013	2014	2015	2016
X_1	0	0.46	0.15	0.22	0.17	0.28	0.34	0.21	0.28	0.24
X_2	1	0.51	1.85	1.91	3.04	2.97	3.63	3.15	2.52	2.28
X_3	7	1.24	0.58	0.72	0.53	2.80	0.74	1.41	2.47	2.09
X_4	0	0.55	0.22	0.24	0.20	0.17	0.21	0.12	0.16	0.13
X_5	0.7	1.24	0.32	0.33	0.39	1.52	1.61	1.71	1.84	2.10
X_6	2.57	2.68	2.00	1.49	1.60	1.51	1.64	1.58	1.60	1.62
To standard		1.83	1.84	1.77	1.72	1.73	1.72	1.73	1.73	1.73
To actual		0.95	0.62	0.63	0.70	1.27	0.97	1.01	1.20	1.11
Bankruptcy probability		Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Minor

The authors believe that this model the most objectively assesses the bankruptcy probability for Megafon PJSC, since most of the performance indicators of this company lie within acceptable limits in combination with a high financial result.

V. CONCLUSION

The theoretical aspect of bankruptcy has been analyzed, along with the regulatory framework and the indicators that influence it. As a result, it can be said that the bankruptcy risk is an extremely difficult situation for an enterprise, which can occur in case of lack of competent financial management. Many models of the bankruptcy risk assessment are used today. However, they all use a limited number of indicators. This may lead to the fact that the influence of other important indicators on the financial condition is not taken into account. As such, bankruptcy risk should be systematically assessed by various methods to predict all kinds of situations, taking external conditions into account.

The specifics of the Russian market should be taken into account when choosing models to assess bankruptcy. It has been demonstrated that the widely used Altman model yields

in not only inaccurate, but almost the opposite result in the Russian realities. Therefore, great attention should be paid to the models developed by Russian scientists.

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