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ANALYSIS OF MODELS FOR PREDICTING INSOLVENCY (BANKRUPTCY) OF BUSINESS ENTITIES

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Abstract
This article presents the concept of insolvency (bankruptcy) and its content, analysis methodology. The article describes the foreign models of bankruptcy prediction and the indicators used in them. As a result of research, was formed the author's approach to preventing insolvency (bankruptcy).

Keywords: Insolvency, bankruptcy, crisis, assets, equity, liabilities, sales, sales revenue, working capital.

Introduction

Today, business entities frequently encounter crisis situations during their operations, which may lead them to the stage of insolvency (bankruptcy). It becomes necessary to assess their current financial condition and diagnose the probability of insolvency (bankruptcy) by applying relevant methods and models for forecasting. This approach makes it possible to prevent negative consequences in advance. There is no universally optimal model for predicting insolvency (bankruptcy); each method has its own advantages and limitations.
The purpose of diagnosing insolvency (bankruptcy) is to identify early signs of crisis conditions. In such circumstances, it is crucial for business entities to make timely, effective, and scientifically grounded management decisions.

Literature Review

On April 12, 2022, according to the Law "On Insolvency," based on the previous Law "On Bankruptcy," the term "bankruptcy" was replaced with the term "insolvency." According to Article 3 of the Law, "insolvency is the inability of a debtor, as recognized by a court, to fully satisfy the claims of creditors regarding monetary obligations and/or to fully fulfill tax and levy obligations." [1]
In scientific literature and publications, the term "insolvency" is often used interchangeably with the term "bankruptcy."
According to V. Masaev, bankruptcy is a condition in which an arbitration court or property owners of an organization acknowledge the debtor's inability to fully settle mandatory payments and monetary obligations arising from creditors' claims. [3]
S. E. Zhilinskiy interprets that instability is the cause, while bankruptcy is its consequence. He believes that instability arises when a legal entity is unable to fulfill its obligations to creditors, employees, and the state. Bankruptcy, in his opinion, is the final state of the debtor. The authority to define this state of the debtor belongs to administrative courts. [2]

Research Methodology

During the research process, the theoretical foundations of forecasting the insolvency (bankruptcy) of business entities were studied, and numerous scientific publications related to the topic were analyzed. Based on existing scientific research, methods such as scientific observation, logical reasoning, and a systematic approach were widely applied.

Analysis and Results

In assessing insolvency risk (bankruptcy) both domestic and international practices rely on a large number of quantitative methods. The most commonly applied models include Altman, Lis, Taffler, and Tishou.

The well-known Z-Altman model for evaluating bankruptcy probability and creditworthiness is calculated as follows: $Z = 1.2\ X1 + 1.4\ X2 + 3.3\ X3 + 0.6\ X4 + 0.999\ X5$

Where:

X1 – net working capital / total assets (net working capital = current assets minus current liabilities);

X2 – retained earnings / total assets;

X3 – earnings before taxes and interest / total assets (EBIT / total assets);

X4 – market value of equity / total liabilities;

X5 – net income / total assets;

According to the Altman model, numerous calculations show that the Z indicator spans the range [-14, 22]. A $Z > 2.99$ indicates financial stability, a $Z < 1.81$ indicates financial instability, and the interval (1.81–2.99) is a gray/indeterminate zone.

Table 1. Analysis of bankruptcy risk using Altman's five-factor model

Indicators	O'zmetkombinat JSC	Kvarts JSC
X_1 – Net working capital / Total assets	0	0
X_2 – Retained earnings / Total assets	0,29	0,05
X_3 – Earnings before taxes / Total assets	0,22	0,05
X_4 – Market value of equity / Total liabilities	0,0000018	0,0000044
X_5 – Net sales / Total assets	1,04	0,43
Z- Altman model	2,17	0,66

So, O'zmetkombinat JSC (Z = 2.17) lies in the gray zone; Kvarts JSC (Z = 0.66) indicates higher insolvency risk.

However, since the fourth coefficient includes the indicator of the market value of shares, this model can be applied only to companies whose shares are listed on the stock exchange. Therefore, Altman later developed a special version of the model for companies whose shares are not publicly traded (Table 2).

Table 2 KEY INDICATORS OF ALTMAN'S FIVE-FACTOR MODEL FOR COMPANIES WHOSE SHARES ARE NOT PUBLICLY TRADED

Bankruptcy Probability ratio	$Z=0,717X_1+0,847X_2+3,1X_3+0,42X_4+0,995X_5$
Notation	Z – discriminant function that diagnoses the presence of a crisis based on quantitative indicators.
	X_1 = Working Capital / Total Assets
	X_2 = Retained Earnings / Total Assets
	X_3 = Earnings Before Taxes / Total Assets
	X_4 = Equity / Debt Capital
	X_5 = Net Sales / Total Assets
Differentiation by Bankruptcy Probability Level	**Z < 1.23** – high probability of bankruptcy **1.23 < Z < 2.9** – zone of uncertainty **Z > 2.9** – low probability of bankruptcy

When calculating the fourth coefficient, the balance sheet value of the shares is used instead of their market value.

Studies conducted by American analysts have proven that calculations based on the Altman model make it possible to diagnose a company's bankruptcy with 95% accuracy one year in advance and with 83% accuracy at the moment of bankruptcy.

Later, Altman developed a seven-factor model that enables forecasting bankruptcy five years ahead with 70% accuracy. This model includes the following indicators: return on assets, profit growth rate, interest coverage ratio, current liquidity ratio, financial independence ratio, and asset value ratio.

The Lis model (United Kingdom) makes it possible to determine bankruptcy probability based on indicators such as liquidity, profitability, and financial stability (Table 3).

Table 3 KEY INDICATORS OF THE FOUR-FACTOR LIS MODEL

Bankruptcy Probability ratio	$Z=0,063X_1+0,092X_2+0,057X_3+0,001X_4$
Notation	Z – discriminant function whose quantitative values diagnose the presence of a crisis state
	X_1 = Current assets / Total assets
	X_2 = Operating profit (profit from sales) / Total assets
	X_3 = Retained earnings / Total assets
	X_4 = Equity / Debt capital
Bankruptcy probability classification	Z < 0.037 — high probability of bankruptcy; Z > 0.037 — low probability of bankruptcy.

Taffler's four-factor predictive model (United Kingdom) makes it possible to determine the probability of bankruptcy based on indicators such as the ratio of profit from sales to current liabilities, the ratio of working capital to liabilities, the ratio of current liabilities to total assets, and the ratio of net revenue to total assets (see Table 4).

Table 4 Key Indicators of the Taffler Four-Factor Model

Final bankruptcy probability ratio	$Z=0,53X_1+0,13X_2+0,18X_3+0,16X_4$
Notation	Z – discriminant function whose numerical value diagnoses the presence of a crisis condition
	X_1 = Profit from sales / Current liabilities
	X_2 = Current assets / Debt capital
	X_3 = Current liabilities / Total assets
	X_4 = Sales revenue / Total assets
Differentiation by bankruptcy probability level	Z < 0.2 – bankruptcy risk exists; Z > 0.3 – positive long-term outlook.

The Springate model provides the following formula for determining bankruptcy risk (Table 5):

Table 5 Springate Model

Final bankruptcy probability ratio	$Z=1,03X_1+3,07X_2+0,66X_3+0,4X_4$
Notation	Z – discriminant function whose numerical value diagnoses the presence of a crisis condition
	X_1 = Working Capital / Total Assets
	X_2 = Earnings Before Taxes / Total Assets
	X_3 = Earnings Before Taxes / Current Liabilities
	X_4 = Net sales / Total assets
Differentiation by bankruptcy probability level	Z<0,862 – bankruptcy risk exists.

The accuracy of forecasting using the Springate model is 92.5%. A.D. Sheremet developed a bankruptcy forecasting coefficient calculated using the following formula:

BFC = (SRA + SFI + CS – SSL – SCL) / TB

where:

- **SRA** – short-term accounts receivable;
- **SFI** – short-term financial investments;
- **CS** – cash funds;
- **SSL** – short-term borrowed funds;
- **SCL** – short-term accounts payable;
- **TB** – total balance.

Sheremet's bankruptcy forecasting coefficient characterizes the share of net working assets in the total balance sheet assets. Therefore, financially unstable companies demonstrate a negative trend of this coefficient.

Under conditions of high bankruptcy risk, G.V. Savitskaya's scoring and rating methodology (Table 6) can be used to forecast a company's financial condition and assess credit risk. According to this methodology, companies may belong to one of the following classes:

Class I – a company with a strong reserve of financial stability, allowing confidence in the repayment of borrowed funds;

Class II – a company with a certain level of risk regarding its obligations, but not yet considered high-risk;

Class III – a problematic company with no risk of losing principal funds, but with questionable prospects of receiving full interest payments;

Class IV – a company with a high risk of bankruptcy, where creditors may lose both principal and interest;

Class V – a company with extremely high risk, almost financially unstable;

Class VI – a bankrupt company.

Table 6 G.V. Savitskaya's Scoring and Rating Methodology

Indicators	Class boundaries according to criteria											
	Class **I**		Class **II**		Class **III**		Class **IV**		Class **V**		Class **VI**	
	Criterion value	Score	Criterion value	Score	Criterion value	Score	Criterion value	Score	Criterion value	Score	Criterion value	Score
Absolute liquidity ratio	>=0,25	20	0,2	16	0,15	12	0,1	8	0,05	4	<=0,05	0
Quick liquidity ratio	>=1	18	0,9	15	0,8	12	0,7	9	0,6	6	<=0,5	0
Current liquidity ratio	>=2	16,5	1,9-1,7	15-12	1,6-1,4	10,5-7,5	1,3-1,1	6-3	1	1,5	<=0,5	0
Financial independence ratio	>=0,6	17	0,59-0,54	15-12	0,53-0,43	11,4-7,4	0,42-0,41	6,6-1,8	0,4	1	<=0,4	0
Working capital adequacy ratio	>=0,5	15	0,4	12	0,3	9	0,2	6	0,1	3	0,1	0
Inventory coverage with working capital	>=1	15	0,9	12	0,8	9	0,79	6	0,6	3	<=0,5	0
Total score class boundaries	100		85-64		63-57		56-42		28-8		0	

Based on these models, we assess the bankruptcy probability of joint-stock companies (Table 7):

Table 7 Bankruptcy Probability Analysis Based on Various Models

Models	Indicators	"O‘zmetkombinat" JSC	"Kvarts" JSC
Model of Lis	X_1 = Current assets / Total assets	0,74	0,19
	X_2 = Profit from sales / Total assets	0,34	0,15
	X_3 = Retained earnings / Total assets	0,29	0,05
	X_4 = Equity / Debt capital	0,64	0,52
Result: $Z=0,063X_1+0,092X_2+0,057X_3+0,001X_4$		0,0951	0,0548
		low bankruptcy probability	low bankruptcy probability
Model of Taffler	X_1 = Profit from sales / Current liabilities	0,78	0,52
	X_2 = Current assets / Debt capital	1,22	0,29
	X_3 = Current liabilities / Total assets	0,44	0,85
	X_4 = Net sales / Total assets	1,05	0,43
Result: $Z=0,53X_1+0,13X_2+0,18X_3+0,16X_4$		0,8192	0,5351
		positive long-term outlook	positive long-term outlook
Model of Springate	X_1 = Working capital / Total assets	0	0
	X_2 = EBIT / Total assets	0,22	0,05
	X_3 = EBIT / Current liabilities	0,50	0,05
	X_4 = Net sales / Total assets	1,05	0,19
Result: $Z=1,03X_1+3,07X_2+0,66X_3+0,4X_4$		1,4254	0,2625
		healthy (no bankruptcy risk)	bankruptcy probability exists
Method of G.V.Savitskaya	Absolute liquidity ratio	0,60	0,02
	Quick liquidity ratio	1,34	0,15
	Current liquidity ratio	1,69	0,65
	Financial stability ratio	0,39	0,34
	Working capital adequacy ratio	0	0
	Inventory coverage by working capital	0	0
Result		48,5	1,5
		Class IV (high bankruptcy risk)	Class VI (company is bankrupt)

The data presented in the table show that, based on the financial statements of joint-stock companies and the application of various bankruptcy prediction models, it is possible to obtain different results. In particular, according to the Lis model, **“O‘zmetkombinat” JSC** has a low probability of bankruptcy; according to the Taffler model, it has a positive long-term outlook; according to the Springate model, no bankruptcy risk is observed; while according to the G.V. Savitskaya model, it falls under Class IV — a company with a high level of bankruptcy risk. Similarly, for **“Kvarts” JSC**, the Lis model indicates a low probability of bankruptcy, the Taffler model shows a positive long-term outlook, the Springate model confirms the existence of bankruptcy risk, and the G.V. Savitskaya model classifies the company as Class VI — an enterprise at the bankruptcy level.

Since each business entity has its own specific characteristics, none of the methodologies discussed can be considered universally applicable. Moreover, the causes of insolvency (bankruptcy) may be associated with various types of crises.

Based on the conducted research, the following measures can be recommended to prevent business entities from falling into insolvency (bankruptcy) (Table 8):

Table 8 Measures to Prevent Insolvency (Bankruptcy)

№	Area of Activity	Proposed Measures
1.	Operational Activity	Ensuring the efficiency of operational activities
		Reducing finished goods inventory by optimizing production volume
		Ensuring the competitiveness of produced goods (or provided services)
		Increasing the share of innovative products within the total output (services)
		Achieving a positive trend in sales volume
2.	Financial Situation	Increasing the share of equity within total sources of financing
		Developing an optimal asset structure (taking into account the specifics of each business entity and its industry)
		Ensuring a positive level of working capital
		Improving the mechanism for forecasting the instability of a business entity's operations
		Balancing accounts receivable and payable, ensuring the absence of overdue debts in their structure
3.	Financial Results	Achieving positive financial performance across all types of activities
		Ensuring positive profitability indicators
4.	Management	Ability to make optimal managerial decisions
		Development of a financial strategy
		Strengthening staff capacity (human capital)
		Conducting strategic analysis based on strategic management models

Conclusion

The continuous financial instability of a business entity leads to an increased risk of insolvency (bankruptcy). A systematic analysis of insolvency makes it possible to identify the "pain points" of economic and financial activities in a timely manner. Understanding the causes of insolvency (bankruptcy) at a high probability level facilitates the development of effective anti-crisis measures.

Efficient asset management, sufficient working capital to cover inventories, constant control over liabilities, and stable positive financial results are essential factors ensuring the financial soundness of an enterprise.

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