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Comparative Analysis of Corporate Bankruptcy Prediction Models

Muhammad Kiki Januar[1], Rida Perwita Sari[2]
[1,2]Universitas Pembangunan Nasional "Veteran" Jawa Timur/Jl. Rungkut Madya No. 1, Gn. Anyar, Surabaya, Jawa Timur/Indonesia
Email: 22013010042@student.upnjatim.ac.id[1], ridaps.ak@upnjatim.ac.id[2]

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Abstract. *This study aims to analyze the differences in bankruptcy prediction results, accuracy rates, and error rates of the Altman Z-Score Model, Springate Model, Zmijewski Model, and Grover Model, as well as to determine the best model. The study employed a comparative quantitative method using purposive sampling, resulting in a sample of 8 companies that had their shares suspended for more than six months by the Indonesia Stock Exchange. Data were analyzed using descriptive statistics, normality tests, homogeneity tests, the Kruskal-Wallis test, and a confusion matrix. The results indicate significant differences among the four models, with a significance level of <0.001. The Altman Z-Score Model has the highest accuracy rate of 70% and the lowest error rate of 30%, followed by the Zmijewski Model at 65%, the Grover Model at 62.5%, and the Springate Model at 47.5%. These results indicate that the Altman Z-Score Model is the best model for predicting the potential bankruptcy of companies whose securities have been suspended for more than six months by the Indonesia Stock Exchange.*

Abstrak. Penelitian ini bertujuan menganalisis perbedaan hasil prediksi kebangkrutan, tingkat akurasi, dan tingkat kesalahan Model Altman Z-Score, Model Springate, Model Zmijewski, dan Model Grover serta menentukan model terbaik. Penelitian menggunakan metode kuantitatif komparatif dengan teknik purposive sampling sehingga diperoleh 8 perusahaan yang mengalami suspensi efek lebih dari enam bulan oleh Bursa Efek Indonesia sebagai sampel. Data dianalisis menggunakan statistik deskriptif, uji normalitas, uji homogenitas, uji Kruskal–Wallis, dan confusion matrix. Hasil penelitian menunjukkan terdapat perbedaan signifikan antara keempat model dengan nilai signifikansi <0,001. Model Altman Z-Score memiliki tingkat akurasi tertinggi sebesar 70% dan tingkat kesalahan terendah sebesar 30%, diikuti Model Zmijewski sebesar 65%, Model Grover sebesar 62.5%, dan Model Springate sebesar 47.5%. Hasil tersebut menunjukkan bahwa Model Altman Z-Score merupakan model terbaik dalam memprediksi potensi kebangkrutan perusahaan yang mengalami suspensi efek lebih dari enam bulan oleh Bursa Efek Indonesia.

Keywords:
Bankruptcy Prediction Model; Suspension Effect; Best Model

Corresponding author:
ridaps.ak@upnjatim.ac.id

Introduction

Bankruptcy is a condition that all companies seek to avoid because it contradicts the primary purpose of establishing a company, namely to generate profits and ensure the long-term sustainability of the business (Khairally, 2025). The potential for bankruptcy can be caused by both internal and external factors. Internal factors include management weaknesses in resource management, funding structure errors, and poor corporate governance. Meanwhile, external factors include economic slowdowns, changes in government policy, and increased business competition, which can worsen a company's financial condition (Santoso, 2025). The combination of these two factors can accelerate the deterioration of a company's financial condition to the point where it loses the ability to maintain its existence in the market.

In recent years, corporate bankruptcy cases in Indonesia have shown an upward trend. According to data from the Case Tracking Information System (SIPP), the number of bankruptcy petitions and Debt Payment Moratorium (PKPU) cases rose from 435 cases in 2019 to 726 cases in 2021. Although there was a decline in 2022 and 2023, the number remains higher than in 2019 (Kiki Safitri, 2023). Additionally, the number of bankruptcy and PKPU cases handled by the five Commercial Courts in Indonesia from January to December 2024 reached 630 cases (Heriani, 2025). This situation indicates that the risk of corporate bankruptcy remains a problem that requires serious attention.

The increasing risk of bankruptcy is also reflected in the growing number of companies whose securities have been suspended for more than six months by the Indonesia Stock Exchange. A stock suspension is a temporary halt in the trading of listed companies' securities imposed by the Indonesia Stock Exchange (BEI, 2023). Based on the Board of Directors' Decision of PT Bursa Efek Indonesia No. Kep-00077/BEI/05-2023, there are nine categories of reasons for stock suspension. However, this study focuses on two categories directly related to indications of potential corporate bankruptcy, namely category III.1.2 regarding companies filing for bankruptcy or PKPU, and category III.1.5 regarding indications of doubt regarding the company's ability to maintain its going concern. As of June 30, 2025, the Indonesia Stock Exchange recorded 55 companies that had experienced a trading suspension of more than six months, spanning various industrial sectors.

The number of companies experiencing prolonged trading suspensions has shown significant fluctuations from year to year. In 2018, there was only one company with a prolonged suspension, which increased to eight companies in 2019 and fourteen companies in 2020. After a decline in 2021, the number rose again to seventeen companies in 2024. This trend indicates an increase in issues related to financial performance, business sustainability, compliance, and information disclosure among listed companies. Additionally, category III.1.5 regarding doubts about business sustainability was the most common suspension category, involving 27 companies. These findings suggest that companies facing prolonged suspensions have a relatively high risk of bankruptcy, making them relevant for study in the context of bankruptcy prediction.

This bankruptcy risk is also reflected in the financial performance of companies that have been suspended for more than six months. Several companies showed a decline in profits and even incurred consecutive losses during the 2020-2024 period. According to Salim & Ismudjoko (2021), a company can be categorized as potentially

facing bankruptcy if it experiences negative profits for three or more consecutive years, a decline in dividend payments, and an increase in the debt-to-equity ratio. These conditions indicate ongoing operational pressure and the likelihood that the company will enter a deeper stage of financial distress if corrective actions are not taken. Financial distress reflects a condition in which a company experiences financial difficulties and faces challenges in meeting its short-term obligations, which may increase the risk of bankruptcy if not addressed appropriately (Romadhina, 2023).

Pressure on corporate financial conditions has intensified since the 2020 COVID-19 pandemic, which caused economic contraction, a decline in demand for goods and services, and disruptions to global supply chains. Economic pressures resurfaced in 2022 due to the Russia-Ukraine conflict, which triggered rising energy and food prices. Although the national economy began showing signs of recovery during the 2023–2024 period, global economic uncertainty and financial pressures still have the potential to increase the risk of corporate bankruptcy in Indonesia (Melati, 2023). Under these conditions, financial statement analysis serves as a crucial tool for detecting potential corporate bankruptcy at an early stage. Persistent financial pressure can not only trigger bankruptcy but also drive financial statement manipulation, making financial ratio analysis an effective early warning system for financial distress and potential corporate bankruptcy (Muawanah & Sari, 2023). Research by Musmini et al. (2025) also explains that financial ratio analysis can help predict potential bankruptcy and provide an early warning for companies to take corrective action.

Various bankruptcy prediction models have been widely used in previous research, including the Altman Z-Score, Springate, Zmijewski, and Grover models. These four models use financial ratios as the basis for prediction but yield different accuracy rates and error rates across various industrial sectors. The study by Seto & Trisnaningsih (2021) found that the Altman Z-Score Model had the highest accuracy rate of 84.48%, followed by the Zmijewski Model at 79.61% and the Springate Model at 75.00% for companies in the retail trade subsector. Conversely, Hertina & Dari (2022) showed that the Springate Model had the lowest accuracy rate. The study by Ristati et al. (2025) also found that the Grover Model has the highest accuracy rate of 95% in the food and beverage sector. These findings indicate inconsistencies in accuracy rates and error rates among bankruptcy prediction models.

The inconsistencies in previous research findings suggest that there are still unanswered issues in research on bankruptcy prediction models. Most previous studies have focused on specific industrial sectors and rarely compared the Altman Z-Score, Springate, Zmijewski, and Grover models simultaneously. Furthermore, no study has specifically examined companies that have been suspended from trading for more than six months by the Indonesia Stock Exchange. Consequently, there is no comprehensive understanding of which bankruptcy prediction model has the highest accuracy and the lowest error rate for companies experiencing prolonged suspension.

This study employs the perspectives of Signaling Theory and Agency Theory to explain the importance of bankruptcy prediction models. Signaling Theory explains that the financial information disclosed by a company can serve as a signal to investors and creditors regarding the company's financial condition and future prospects (Firlianti & Mildawati, 2021). Bankruptcy prediction results indicating high risk will send a negative signal regarding the company's prospects. On the other hand, Agency Theory explains the existence of information asymmetry between management and shareholders, which may prompt management to conceal financial difficulties or manipulate financial statements (Yanti & Munari, 2021). Therefore,

bankruptcy prediction models can serve as an objective monitoring tool to reduce information asymmetry and provide early warnings regarding a company's potential bankruptcy.

Given the rising incidence of bankruptcy cases, the large number of companies facing prolonged trading suspensions, and the inconsistencies in previous research findings, this study was conducted to analyze differences in bankruptcy prediction results using the Altman Z-Score, Springate, Zmijewski, and Grover models for companies that have been suspended from trading for more than six months by the Indonesia Stock Exchange. Additionally, this study aims to identify the model with the highest accuracy rate and the lowest error rate as the best estimate for predicting a company's potential bankruptcy. The uniqueness of this study compared to previous research lies in the simultaneous use of four bankruptcy prediction models, as well as the research focus specifically on companies that have experienced a trading suspension of more than six months by the Indonesia Stock Exchange.

Differences in Bankruptcy Prediction Models

Based on Signaling Theory and Agency Theory, bankruptcy prediction models function as an early warning system capable of detecting potential bankruptcy while reducing information asymmetry. Differences in the characteristics and formulas of each model allow for variations in prediction results for companies experiencing prolonged trading suspensions. Previous research findings by Seto & Trisnaningsih (2021), Hertina & Dari (2022), and Ristati et al. (2025) also indicate variations in accuracy and error rates across models. Therefore, the first hypothesis of this study is formulated as follows:

H1: There is a significant difference between the Altman Z-Score Model, the Springate Model, the Zmijewski Model, and the Grover Model in predicting the potential for bankruptcy in companies that have had their shares suspended for more than six months by the Indonesia Stock Exchange.

Comparison of Accuracy and Error Rates of Bankruptcy Prediction Models

Based on Signaling Theory, the model with the highest accuracy rate is considered more capable of providing accurate signals regarding a company's potential for bankruptcy. Previous studies indicate that each model has different accuracy and error rates depending on sector characteristics and the research subject. The study by Seto & Trisnaningsih (2021) shows that the Altman Z-Score Model is the most accurate in the retail trade subsector, while Ristati et al. (2025) found that the Grover Model has the highest accuracy rate in the food and beverage sector. These differing findings suggest that there is a possibility that one model outperforms the others for companies experiencing prolonged trading suspensions. Thus, the second hypothesis of this study is formulated as follows:

H2: There are differences in accuracy and error rates among bankruptcy prediction models, and there is one model that has the highest accuracy and the lowest error rate as the best estimate for predicting potential bankruptcy in companies experiencing a trading suspension of more than six months by the Indonesia Stock Exchange.

Research Method

This study employs a quantitative method with a comparative approach to compare the prediction results, accuracy rates, and error rates of the Altman Z-Score, Springate, Zmijewski, and Grover models in predicting a company's potential bankruptcy. The research subjects are companies that have experienced a trading suspension of more than six months by the Indonesia Stock Exchange (IDX). The data used consists of secondary data from financial statements, annual reports, and announcements regarding the suspension of a company's securities obtained

through the official IDX website and the relevant companies during the 2020–2024 period. The study population consists of 55 companies that experienced a suspension of trading for more than six months as of June 30, 2025. The sample was selected using purposive sampling based on specific criteria, resulting in 8 companies as the research sample.

The independent variables in this study are bankruptcy prediction models (Altman Z-Score, Springate, Zmijewski, and Grover), while the dependent variables consist of the scores calculated by each model used to assess a company's potential for bankruptcy based on cutoff values. The operational definitions of the variables are presented in Table 1.

Table 1. Operational Definitions and Measurement of Variables

Independent Variables (X)		
Variable Name and Formula	**Model Variables**	**Cut-Off Value**
	Altman Z-Score Model (X1)	
Z-Score = 6.56 X_1 + 3.26 X_2 + 6.72 X_3 + 1.05 X_4	X_1 = Working Capital / Total Assets X_2 = Retained Earnings / Total Assets X_3 = Earnings Before Interest and Taxes / Total Assets X_4 = Book Value of Total Equity / Book Value of Total Debt	Z-Score < 1.10: Potentially Bankrupt. Z-score 1.23 < Z < 2.6: Grey Area (cannot be determined whether the company is healthy or insolvent). Z-score > 2.6: Company is Healthy.
	Springate Model (X2)	
S-Score = 1.03 X_1 + 3.07 X_2 + 0.66 X_3 +0.4 X_4	X_1 = *Working Capital/Total Assets* X_2 = *Net Profit Before Interest and Taxes/Total Assets* X_3 = *Net Profit Before Taxes/Current Liability* X_4 = *Sales/Total Assets*	S-Score < 0.862: Potentially Bankrupt. S-Score > 0.862: Not at Risk of Bankruptcy.
	Zmijewski Model (X3)	
X-Score = -4.3 – 4.5 X_1 + 5.7 X_2 - 0.004 X_3	X_1 = Net Income / Total Assets X_2 = Total Liabilities / Total Assets X_3 = Current Assets / Current Liabilities	X-Score > 0: Potentially Bankrupt. X-Score < 0: Not at Risk of Bankruptcy.
	Grover Model (X4)	
G-Score = 1.650 X_1 + 3.404 X_3 – 0.016 ROA + 0.057	X_1 = Working capital / Total assets X_3 = Earnings Before Interest and Taxes / Total Assets ROA = Net Income / Total Assets	G-Score ≤ -0.02: Potentially Bankrupt. G-Score ≥ 0.01: Not at risk of bankruptcy.
Dependent Variable (Y)		
	Bankruptcy Prediction	
Z, S, X, and G Scores	1. Continuous Decline in Profit 2. Decline in Sales 3. Increase in Operating Costs 4. Negative Cash Flow (Operating) 5. Total Liabilities > Total Assets	A company is categorized as potentially bankrupt if it meets at least three of the indicators established in this study.

Data were collected through documentation. Data analysis was conducted by calculating the score for each model, followed by descriptive statistical analysis, normality tests, and homogeneity tests. Hypothesis testing used One-Way ANOVA or the Kruskal-Wallis test depending on the data characteristics. The accuracy rate and error rate of each model were measured using a confusion matrix with the following formula:

Accuracy Rate = ((True Positive + True Negative) / Total Data) × 100%

Error Rate = ((False Positive + False Negative) / Total Data) × 100%

The model with the highest accuracy rate and the lowest error rate was designated as the best model.

Results and Discussion

The initial stage of the study involved calculating bankruptcy prediction scores using the Altman Z-Score, Springate, Zmijewski, and Grover models for eight companies whose shares were suspended for more than six months on the Indonesia Stock Exchange during the 2020–2024 period. The scores obtained were then compared with the cut-off values of each model to classify the companies as potentially bankrupt or not potentially bankrupt. After the classification process was completed, data analysis and hypothesis testing were performed to test the hypotheses in this study.

Descriptive Statistical Analysis

Descriptive statistics were used to describe the characteristics of the data in each bankruptcy prediction model. The analysis results showed differences in mean values and data variability across models. The Altman Z-Score model had the highest data variability, while the Springate model exhibited relatively lower data variability. These differences indicate that each model has different sensitivity in detecting a company's potential for bankruptcy.

Table 2. Descriptive Statistics Results

Descriptive Statistics					
	N	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Altman Z-Score	40	-533.67	14.21	-35.7633	105.14540
Springate	40	-40.82	1.32	-4.0753	8.71220
Zmijewski	40	-3.73	277.95	23.6165	64.79757
Grover	40	-79.24	0.69	-4.9205	15.02095
Valid N (listwise)	40				

Source: SPSS output processed by the researcher (2026)

Based on Table 2, the Altman Z-Score Model has a mean value of -35.7633 with a standard deviation of 105.14540. The Springate Model has a mean value of -4.0753 with a standard deviation of 8.71220. The Zmijewski model has a mean value of 23.6165 with a standard deviation of 64.79757, while the Grover model has a mean value of -4.9205 with a standard deviation of 15.02095. These results indicate differences in data characteristics among the respective bankruptcy prediction models.

Normality Test

A normality test was conducted to determine whether the research data are normally distributed. The results of the normality test are presented in Table 3.

Table 3. Results of the Normality Test

Tests of Normality							
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Model	Statistic	df	Sig.	Statistic	df	Sig.
Score	Altman Z-Score	.407	40	<.001	.435	40	<.001
	Springate	.335	40	<.001	.596	40	<.001
	Zmijewski	.437	40	<.001	.440	40	<.001
	Grover	.398	40	<.001	.391	40	<.001
a. *Lilliefors Significance Correction*							

Source: SPSS output processed by the researcher (2026)

Based on Table 3, all models had significance values of less than 0.05 in both the Kolmogorov-Smirnov and Shapiro-Wilk tests. In this study, the Shapiro-Wilk test was the primary test used because the sample size was less than 50 (n = 40). Thus, the research data were not normally distributed and did not meet the assumption of normality.

Homogeneity Test

The homogeneity test was conducted to determine the equality of variances among the data groups. The results of the homogeneity test are presented in Table 4.

Table 4. Results of the Homogeneity Test

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Score	Based on Mean	9.904	3	156	<.001
	Based on Median	2.899	3	156	.037
	Based on Median and with adjusted df	2.899	3	67.620	.041
	Based on trimmed mean	4.595	3	156	.004

Source: SPSS output processed by the researcher (2026)

Based on Table 4, the significance value of Levene's Test (Based on Mean) is less than 0.05. This result indicates that the data variance across groups is not homogeneous, so the assumption of homogeneity is not met.

Kruskal-Wallis Test

Since the data did not meet the assumptions of normality and homogeneity, hypothesis testing was conducted using the Kruskal-Wallis test as an alternative to the One-Way ANOVA. The test results are presented in Table 5.

Table 5. Results of the Kruskal-Wallis Test

Test Statistics[a,b]	
	Score
Kruskal-Wallis H	23.888
df	3
Asymp. Sig.	<.001
a. Kruskal-Wallis Test	
b. Grouping Variable: Model	

Source: SPSS output processed by the researcher (2026)

Based on Table 5, the significance value (Asymp. Sig.) is less than 0.05, indicating a significant difference between the Altman Z-Score, Springate, Zmijewski, and Grover models in predicting a company's bankruptcy risk.

Confusion Matrix

The Confusion Matrix is used to evaluate the performance of predictive models by measuring accuracy and error rates. A summary of the Confusion Matrix results is presented in Table 6.

Table 6. Summary of the Confusion Matrix

	Altman Z-Score Model	Springate Model	Zmijewski Model	Grover Model
True Positive (TP)	17	18	17	13
True Negative (TN)	11	1	9	12
False Positive (FP)	10	20	12	9
False Negative (FN)	2	1	2	6
Total	40	40	40	40

Source: Compiled by the researcher (2026)

Based on the results of the Confusion Matrix, the accuracy and error rates of each model were calculated and are presented in Table 7.

Table 7. Accuracy Rate and Error Rate

	Altman Z-Score Model	Springate Model	Zmijewski Model	Grover Model
Accuracy Rate	70%	47.5%	65%	62.5%
Error Rate	30%	52.5%	35%	37.5%

Source: Compiled by the researcher (2026)

The analysis results show that the Altman Z-Score Model has the highest accuracy rate of 70% with an error rate of 30%. The Springate model has an accuracy rate of 47.5% with an error rate of 52.5%. The Zmijewski model has an accuracy rate of 65% with an error rate of 35%. The Grover model has an accuracy rate of 62.5% with an error rate of 37.5%.

Discussion

Differences Between the Altman Z-Score, Springate, Zmijewski, and Grover Models

Based on the results of the normality and homogeneity tests, the data in this study had a significance value < 0.001, meaning it did not meet the assumptions of a parametric distribution. Therefore, the comparison of differences was conducted using the Kruskal-Wallis test. The test results show a significance value (Asymp. Sig.) < 0.001 (< 0.05), indicating a significant difference between the Altman Z-Score, Springate, Zmijewski, and Grover models in predicting the potential bankruptcy of companies whose securities have been suspended for more than six months by the Indonesia Stock Exchange. These results indicate that each model produces different predictions because they use different financial ratios, formulas, and classification criteria. Thus, the first hypothesis (H1) is accepted.

This finding aligns with the research by Hertina & Dari (2022), which found significant differences among bankruptcy prediction models. However, the results of this study differ from those of Toudas et al. (2024), who stated that bankruptcy prediction models have not shown significant differences due to their relatively low accuracy levels.

Comparison of Accuracy Rates and Error Rates and Determination of the Best Model

Differences in prediction results among models are also reflected in the accuracy and error rates obtained through Confusion Matrix analysis. The Altman Z-Score model showed the highest accuracy rate of 70% with an error rate of 30%. Furthermore, the Zmijewski Model has an accuracy rate of 65% and an error rate of 35%, the Grover Model has an accuracy rate of 62.5% and an error rate of 37.5%, while the Springate Model has the lowest accuracy rate of 47.5% with an error rate of 52.5%.

These results indicate that the Altman Z-Score Model is the most accurate model for predicting the potential bankruptcy of companies whose securities have been suspended for more than six months by the Indonesia Stock Exchange. The high accuracy of this model suggests that the combination of financial ratios used provides a better estimate of a company's financial condition compared to other models. Therefore, the second hypothesis (H2) is accepted.

These findings support the studies by Seto & Trisnaningsih (2021) and Robiansyah et al. (2022), which indicate that the Altman Z-Score model has the highest accuracy rate compared to other bankruptcy prediction models. However, these results are inconsistent with the study by Hartono et al. (2025), which found that the accuracy rate of the Altman Z-Score is relatively low. These differing research results indicate that the performance of bankruptcy prediction models can be influenced by company characteristics, industry sector, economic conditions, and the research period used.

Conclusion and Recommendations

Based on the research findings, it can be concluded that there are significant differences among the Altman Z-Score, Springate, Zmijewski, and Grover models in predicting the bankruptcy potential of companies whose shares have been suspended from trading for more than six months by the Indonesia Stock Exchange. These differences indicate that each model has varying capabilities in identifying companies' financial conditions and bankruptcy potential. Among the four models, the Altman Z-Score demonstrates the highest predictive accuracy, indicating that it is the most appropriate model for predicting bankruptcy potential in the companies examined in this study. These findings also support Signaling Theory and Agency Theory, which emphasize the importance of financial statement information in signaling a company's financial condition and reducing information asymmetry between management and investors. Therefore, bankruptcy prediction models can serve as useful instruments for evaluating corporate financial conditions and supporting economic decision-making.

Based on these findings, companies are encouraged to conduct regular evaluations of their financial conditions by utilizing bankruptcy prediction models as an early warning tool to anticipate potential financial distress. Investors and prospective investors are also advised to consider bankruptcy prediction results as one of the factors in making investment decisions, particularly when assessing companies whose shares have been suspended from trading for an extended period. Although the Altman Z-Score demonstrates better predictive performance in this study, its use should still be supported by an analysis of other financial and non-financial factors. Future researchers are encouraged to extend this study by employing alternative bankruptcy prediction models, increasing the number and characteristics of sample companies, and extending the observation period to obtain

more comprehensive findings and a broader understanding of the ability of different models to predict corporate bankruptcy potential.

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