

Original Research

Testing the Accuracy of Altman, Springate, and Zmijewski Models in the Context of Indonesian Banking

Adi Gunanto¹ 

Department of Accounting, Universitas Muhammadiyah Surakarta, Madiun,
Indonesia

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Abstract

This research aims to identify the most accurate model for predicting bankruptcy in the banking industry in Indonesia. The three models used in this study are the *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score* models. The population used consists of all banks listed on the Indonesia Stock Exchange (IDX). The data used are secondary data in the form of financial reports from 2012 to 2022. The methodology employed includes hypothesis testing using tests for normality, homogeneity, and one-way ANOVA. The research findings indicate that the *Z-Score* model is the most suitable and accurate model for predicting bankruptcy, with an accuracy rate of 85.53%. The *S-Score* model achieved an accuracy rate of 14.47%, while the *X-Score* model did not provide significant accuracy. The implications of the findings are that if the *Z-Score* model can be used to evaluate the financial health of banks and provide concrete preventive actions before bankruptcy occurs.

Keywords: Bankruptcy, *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score* Models.

¹ Corresponding author's Email: adigunamanusia@gmail.com

Introduction

Analysis and prediction of the financial condition of a company has become very important in the era of technological advancement and economic cycle changes that affect intense competition in the business world (Ali, Aysan & Yousef, 2023). The capital market, as a source of funding or alternative financing for publicly traded companies, can reflect the performance and financial condition of the companies. Investors examine the financial condition of the company before deciding to invest their funds (Grikietytė & Šniukienė, 2023). Therefore, companies analysis and prediction of financial conditions of companies is a market demands (Agwata, 2018).

The prediction model of bankruptcy for a company is highly needed by various parties such as lenders, investors, government, accountants, and management due to the uncertain economic conditions in Indonesia, which potentially lead to financial difficulties or even bankruptcy for companies (Ayvaz & Erkan, 2023; Gupta, 2023; and Vu & Tran, 2023). A prediction error regarding the continuity of a company's operations in the future can have consequences, including the loss of revenue or investment that has been invested in a company. However, in addition to the uncertain economic conditions, the phenomenon of the weakening of the rupiah exchange rate is also a concern for the banking industry in Indonesia. If the rupiah continues to weaken to the level of Rp 15,000, it is estimated that five national banks will collapse, similar to the economic crisis in late 1998 that caused many banks to "fall" due to the weakening of the rupiah exchange rate against the US dollar. This means that the Otoritas Jasa Keuangan (OJK) is taking anticipatory steps by calling the bank management related to the depreciation (Fredy, 2018; Agustina, 2022).

The *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score* models have been analyzed in several previous studies. A study conducted by Dailibas (2021) showed strong and significant results in using the *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score* models to analyze bankruptcy. Meanwhile, research conducted by Melina and Kalinggo (2023) on companies listed on the Indonesia Stock Exchange (IDX) showed that the *Altman X-Score* and *Springate S-Score* models provided similarly high bankruptcy prediction rates. This means that both studies indicate that the *Altman X-Score* and *Springate S-Score* models have high and comparable bankruptcy prediction rates.

According to the studies of Siahoe and Kordlouie, (2018); Bansal et al., (2020); Shree and Selvam, (2023), in testing the three bankruptcy prediction models (*Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score*), it was found that the *Altman X-Score* model provided the highest prediction rate in 15 companies, while the Springate model provided a prediction rate for 7 companies. On the other hand, the *Zmijewski Z-Score* model provided the lowest prediction rate, with no companies predicted to go bankrupt. Another study conducted by Sitorus, (2023) on delisted companies in the Indonesia Stock Exchange (IDX) during 2019-2021 showed that the *Altman X-Score* model had the highest accuracy rate, reaching 71%, while the *Springate S-Score* model had an accuracy rate of 70%, and the *Zmijewski Z-Score* model only achieved an accuracy rate of 65%. Thus, both studies show that the *Altman X-Score* model has the highest accuracy rate, followed by the *Springate S-Score* and *Zmijewski Z-Score* models.

Research on corporate bankruptcy has been extensively conducted in Indonesia and other countries. However, research specifically focusing on the banking industry and comparing the accuracy of bankruptcy prediction models remains limited. Therefore, researchers are interested in conducting a study to determine which model is the most accurate in predicting bankruptcy in the banking industry in Indonesia. This is because previous research on the *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score* models has yielded inconsistent results when analyzing corporate bankruptcy or the banking industry. In addition, this study aims to provide empirical evidence regarding the accuracy of the *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score* models in predicting bankruptcy in the banking industry in Indonesia.

In this study, several relevant problem arguments were found. First, there is an urgent need to find the most accurate model in predicting bankruptcy in the Indonesian banking industry. Currently, there is no model that consistently provides accurate predictions, which poses a challenge for researchers and practitioners in identifying bankruptcy risks in the banking sector. Second, the importance of bankruptcy prediction in the banking industry becomes a focal point of attention due to its serious implications for the economic and financial stability of the country. By having a reliable bankruptcy prediction model, financial managers and regulators can evaluate the financial health of the banking industry in Indonesia and take preventive measures before bankruptcy occurs.

Furthermore, this study also demonstrates the need for a comparison between existing bankruptcy prediction models. In this case, the *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score* models are compared to determine the performance and accuracy of each model. The research results show that the *Springate S-Score* model has a higher accuracy rate compared to other models. However, it is also found that the *Altman X-Score* model does not provide adequate accuracy. This highlights the importance of evaluation and improvement of less effective models to enhance bankruptcy prediction capabilities in the future. Taking these arguments into consideration, it can be seen that determining the most accurate model in predicting bankruptcy in the Indonesian banking industry is a major problem that needs to be addressed.

This phenomenon indicates the need for the development of better bankruptcy prediction models in the context of the Indonesian banking industry. Evaluation and improvement of existing models need to be carried out in order to enhance the ability to predict bankruptcies in the future. The development of more reliable and accurate prediction models will provide a positive contribution in identifying bankruptcy risks in the banking sector, maintaining economic and financial stability of the country, and providing a foundation for making more accurate decisions in managing the financial aspects of the Indonesian banking industry.

Literature Review

The theoretical framework for this research consists of the theory of bankruptcy and credit prediction models, Bank Indonesia's policy theory regarding credit monitoring and bankruptcy prevention, and the theory of using bankruptcy and credit prediction models in Bank Indonesia. As a result, researchers can analyze and evaluate the

bankruptcy and credit prediction models used in Bank Indonesia and draw conclusions or recommendations necessary to improve the accuracy of the bankruptcy prediction model in Indonesia's banking industry.

The *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score* bankruptcy prediction models are methods used to assess the bankruptcy potential of a company. The *Altman X-Score* combines several financial ratios such as liquidity, profitability, and leverage to generate a bankruptcy score. The *Springate S-Score* measures the financial health of a company by considering profitability, liquidity, and operational efficiency ratios. Meanwhile, the *Zmijewski Z-Score* uses variables such as profitability, liquidity, leverage, and activity to predict bankruptcy risk. These three models provide important indicators for financial analysts to evaluate the level of bankruptcy risk of a company based on available financial data.

Altman X-Score, *Springate S-Score*, and *Zmijewski Z-Score* are bankruptcy models used to evaluate the financial health of companies. *Altman X-Score* combines ratios such as liquidity, profitability, and leverage, while *Springate S-Score* includes factors like profitability, liquidity, and operational efficiency. *Zmijewski Z-Score* considers external factors such as changes in economic conditions and market. The advantage of *Altman X-Score* lies in its ease of use and interpretation, while *Springate S-Score* provides a more in-depth analysis and can be applied to various types of companies. *Zmijewski Z-Score* takes into account external factors and a company's operational activities. However, these models have some limitations, including their relevance to changing business environments, the use of complex variables, and the dependence on complete historical data.

Thus, it can be concluded that these three models can provide useful methods for financial analysts to evaluate the financial health of banks and identify bankruptcy risks. *Altman X-Score* is easy to use and interpret, while *Springate S-Score* provides more in-depth analysis and can be applied to various types of companies. *Zmijewski Z-Score* considers external factors and the operational activities of the company. By using these models, financial analysts can gain a better understanding of the financial health of a company and the potential bankruptcy risks it faces through a comprehensive and holistic approach that takes into account various interacting factors, including internal aspects of operational efficiency and external factors that can impact the company's financial performance and its financial condition and bankruptcy risk. This helps in making more accurate and thorough decisions.

Altman X-Score

The Altman (1968) model uses the Multiple Discriminant Analysis method with five types of financial ratios, namely working capital to total assets, retained earnings to total assets, earnings before interest and taxes to total assets, market value of equity to book value of total debts, and sales to total assets. To this day, the *Altman X-Score* is still widely used by researchers, practitioners, and academics in the accounting field compared to other prediction models (Irawan, 2023). The results of Altman's developed research are:

$$Z = 1.2 Z_1 + 1.4 Z_2 + 3.3 Z_3 + 0.6 Z_4 + 0.999 Z_5 \quad (1)$$

Where;

Z₁: Working capital

Z₂: Retained earnings

Z₃: Earnings before taxes

Z₄: Book value of equity/book value of debt

Z₅: Sales/total asset

In its development, the Altman model underwent revisions so that it could be used not only for public manufacturing companies but also for private companies (Laitinen & Suvas, 2017; Altman, 2018). The revision was carried out by changing one of the variables used in the previous model.

$$Z' = 0.0717 Z_1 + 0.874 Z_2 + 3.107 Z_3 + 0.420 Z_4 + 0.988 Z_5 \quad (2)$$

Where;

Z'₁ : Working capital/total asset

Z'₂ : Retained earnings/total asset

Z'₃ : Earnings before taxes/total asset

Z'₄ : Book value of equity/book value of debt

Z'₅ : Sales/total asset

The final result in the form of X-Score values for each company will be grouped according to the critical value standards set by Altman (Irawan, 2023), which are :

If the X-Score value is greater than 2.99, the company is in the safe zone, which means the company is healthy or not bankrupt, if the X-Score value is between 1.01 - 2.99, it is in the gray zone, which means the company is in a gray area, where the company may potentially not go bankrupt or go bankrupt and if the X-Score value is less than 1.01, the company is in the distress zone, where the company is unhealthy or potentially facing bankruptcy.

Springate S-Score

This model was developed by Springate (1978) using multidiscriminant analysis. The model can be used to predict bankruptcy with an accuracy rate of 92.5% (Irawan, 2023). The model successfully developed by Springate is :

$$S = 1.03 A + 3.07 B + 0.66 C + 0.4 D \quad (3)$$

Where;

A : Working capital/total asset

B : Earnings before taxes/total asset

C : Earnings before taxes / current liabilities

D : Sales/total asset

The final result in the form of *Springate* X_{score} for each company will be grouped according to the critical value standards set by *Springate* as follows :

If the *Springate* value is greater than 0.862, the company falls into the category of healthy companies and if the *Springate* value is less than 0.862, the company falls into the category of unhealthy companies or potentially bankrupt companies.

Zmijewski Z-Score

Model *Zmijewski* (1984) uses ratio analysis to measure the performance, leverage, and liquidity of a company for its prediction model. *Zmijewski* used probability analysis applied to 40 bankrupt companies and 800 surviving companies at that time (Irawan, 2023; Leisen & Swan, 2023). The successfully developed model is :

$$Z = 1.03 A + 3.07 B + 0.66 C + 0.4 D \quad (4)$$

Where;

A : Return on asset
B : Debt ratio
C : Current ratio

The final result in the form of *Zmijewski* Z_{Score} for each company will be grouped according to the critical value standards set by *Zmijewski* Z_{Score} as follows :

The higher the *Zmijewski* Z_{Score} value (positive value), the more likely the company is classified as bankrupt and the smaller the *Zmijewski* Z_{Score} value (negative value), if the *Zmijewski* Z_{Score} value is also smaller and negative, the company is categorized as healthy.

Methodology

This research focuses on the banking industry in Indonesia listed on the Indonesia Stock Exchange (IDX) within the time range from 2012 to 2022. The population of this study consists of 10 banks that meet the following criteria: Banks listed on the Indonesia Stock Exchange (IDX) for three consecutive years, where the sample is selected from banks listed on the IDX and have met the listing requirements for three consecutive years. This criterion is used to ensure that the selected banks have stability and continuity in operating in the Indonesian stock market, financial statements in Indonesian Rupiah (Rp), where the sample is selected based on financial statements presented in Indonesian Rupiah. This is done to facilitate the comparison and analysis of financial data between different banks. The cut-off period is on December 31 of each year, where the sample is selected based on the cut-off period at the end of the year, namely December 31, for each year within the research period. This ensures that the financial data analyzed is the most up-to-date data at the end of each year and has been audited, where the sample is selected from banks that have undergone the auditing process. Auditing is conducted by independent third parties to verify and assess the accuracy of the banks' financial statements. This criterion ensures that the data used in

this research has been verified and considered reliable. Following are the results of purposive sampling :

Tabel 1. Sample Criteria

IDX Code	Issuer	Presentment
BDMN	PT. Bank Danamon, Tbk.	IDR · IDX
BBRI	PT. Bank Rakyat Indonesia (Persero), Tbk.	IDR · IDX
BMRI	PT. Bank Mandiri, (Persero) Tbk.	IDR · IDX
BBNI	PT. Bank Negara Indonesia, (Persero) Tbk.	IDR · IDX
BRIS	PT. Bank Syariah Indonesia, (Persero) Tbk.	IDR · IDX
BTPN	PT. Bank Tabungan Pensiunan Nasional, Tbk.	IDR · IDX
NISP	PT. Bank OCBC NISP, Tbk.	IDR · IDX
BBTN	PT. Bank Tabungan Negara (Persero), Tbk.	IDR · IDX
BTPS	PT. Bank BTPN Syariah, Tbk.	IDR · IDX
BBCA	PT. Bank Central Asia, Tbk.	IDR · IDX
Research Sample Criteria		Quantity
<i>Banking in Indonesia that is listed on the IDX</i>		36
<i>Banking listed on IDX 10 consecutive years</i>		(23)
<i>Financial statements are presented in Rupiah (Rp)</i>		(3)
<i>Cut-off per December 31 each year and has been audited</i>		(0)
<i>Number of research samples</i>		10

Furthermore, the data used in this research are quantitative secondary data in the form of annual financial reports of banks listed on the Indonesia Stock Exchange (IDX) for the period 2012 to 2022. The data collection method in this study was obtained from documentary data taken through the internet site provided by the official website of the Indonesia Stock Exchange (IDX). The data analysis methodology used includes hypothesis testing using tests for normality, homogeneity, and one-way ANOVA with the assistance of a computer using IBM SPSS 25 for Windows program.

Analysis and Discussions

To assess the suitability of data and analyze factors, it is necessary to perform prerequisite tests that the data must meet. These prerequisite tests are intended to ensure that the data to be used in factor analysis meets the requirements and can be relied upon in generating analysis results.

Tabel 2. Descriptive Statistics of Research Variables

Variable	N	Minimal	Maximal	Mean	S.D
<i>Altman X-Score</i>	100	2.000	963.000	166.72000	178.968824
<i>Springate S-Score</i>	100	4.000	293.000	43.27000	47.503504
<i>Zmijewski Z-Score</i>	100	.000	66.000	13.38000	12.389129

In Table 2, there are several conclusions that can be drawn regarding the three models used in the study, namely *Altman X-Score*, *Springate S-Score*, and *Zmijewski Z-Score*. Firstly, looking at their average values, *Altman X-Score* has an average value of 166.72, followed by *Springate S-Score* with an average value of 43.27, and *Zmijewski Z-Score* with an average value of 13.38. The interpretation of these average values provides a general overview of the relative performance of each model. *Altman X-Score*, with a high average value, indicates that the model tends to provide better results in predicting the financial condition of banks. On the other hand, *Zmijewski Z-Score*, with a negative average value, indicates that the model tends to provide lower results in predicting the financial condition of companies. *Springate S-Score* has an average value between the two, indicating moderate performance in predicting the financial condition of companies. In the context of a more specific research, definitive conclusions can be drawn through a more comprehensive analysis among these models.

Results of the Altman X-Score Bankruptcy Prediction Analysis

The analysis in this study is the *Altman X-Score* discriminant model. This analysis is used to identify and analyze the prediction of bankruptcy in the banking industry in Indonesia for the period of 2018-2022. The *Altman X-Score* formula is as follows :

$$X = 1,2 X_1 + 1,4 X_2 + 3,3 X_3 + 0,6 X_4 + 0,999 X_5 \quad (1)$$

Based on the calculation results using Excel program, the following results were obtained :

Tabel 3. The Calculation Results of *Altman X-Score*

Issuer	Categories									
	1 th	2 th	3 th	4 th	5 th	6 th	7 th	8 th	9 th	10 th
PT. Bank Danamon, Tbk.	G	H	H	G	G	G	H	G	G	G
PT. Bank Rakyat Indonesia (Persero), Tbk.	G	G	H	H	H	H	H	G	H	H
PT. Bank Mandiri, (Persero) Tbk.	G	H	H	H	G	H	H	G	H	H
PT. Bank Negara Indonesia, (Persero) Tbk.	H	G	H	H	G	H	H	H	H	H
PT. Bank Syariah Indonesia, (Persero) Tbk.	G	G	G	G	H	G	G	G	H	H
PT. Bank Tabungan Pensiunan Nasional, Tbk.	G	G	G	G	G	H	G	G	H	G
PT. Bank OCBC NISP, Tbk.	H	G	H	H	G	G	G	G	G	G
PT. Bank Tabungan Negara (Persero), Tbk.	H	G	H	H	H	G	H	H	G	H
PT. Bank BTPN Syariah, Tbk.	G	H	G	G	G	H	G	G	H	G
PT. Bank Central Asia, Tbk.	H	H	H	G	H	G	H	G	H	H

G = Grey Area, H = Healthy

Table 3 shows that there are several healthy banking industries in Indonesia during the predicted period of 2012-2022, namely PT. Bank Rakyat Indonesia (Persero) Tbk, PT. Bank Mandiri (Persero) Tbk, PT. Bank Negara Indonesia (Persero) Tbk, PT. Bank Tabungan Negara (Persero) Tbk, and PT. Bank Central Asia Tbk. However, all banks have experienced Grey Area predictions at various points. During that period, there were five banks consistently classified as Grey Area, namely PT. Bank Danamon Tbk, PT. Bank Syariah Indonesia (Persero) Tbk, PT. Bank Tabungan Pensiunan Nasional

Tbk, PT. Bank OCBC NISP Tbk, and PT. Bank BTPN Syariah Tbk. No banks were predicted to go bankrupt during 2012-2022. The implication of this study is the importance of using the *Altman Z-Score* model to assess the financial health of the banking industry in Indonesia. Banks categorized as Grey Area need to take preventive measures before bankruptcy occurs. Furthermore, the findings of this research also affirm that the *Altman Z-Score* model can be used by financial managers and regulators to evaluate the financial health of the banking industry in Indonesia and implement concrete preventive measures before bankruptcy occurs. These findings are consistent with previous research conducted by (Putri et al., 2020; Tiryaki, 2021; and Ullah et al., 2021).

Results of the Springate S-Score Bankruptcy Prediction Analysis

The analysis in this study is the S-Score discriminant model. This analysis is used to determine and analyze bankruptcy prediction in the banking industry in Indonesia for the period 2018-2022. The following is the formula for the S-Score :

$$S = 1,03A + 3,07B + 0,66C + 0,4D \quad (2)$$

Based on the calculation results using Microsoft Excel, the following results were obtained :

Tabel 4. The Calculation Results of S-Score

Issuer	Categories									
	1 th	2 th	3 th	4 th	5 th	6 th	7 th	8 th	9 th	10 th
PT. Bank Danamon, Tbk.	B	H	H	B	B	B	H	H	B	H
PT. Bank Rakyat Indonesia (Persero), Tbk.	H	H	H	H	H	H	H	H	H	H
PT. Bank Mandiri, (Persero) Tbk.	H	H	B	H	H	H	B	H	H	B
PT. Bank Negara Indonesia, (Persero) Tbk.	H	H	H	H	H	H	H	H	H	H
PT. Bank Syariah Indonesia, (Persero) Tbk.	B	B	B	H	B	H	B	H	B	H
PT. Bank Tabungan Pensiunan Nasional, Tbk.	H	H	H	B	B	H	H	H	B	B
PT. Bank OCBC NISP, Tbk.	B	H	H	B	B	B	B	B	H	H
PT. Bank Tabungan Negara (Persero), Tbk.	H	H	B	H	H	H	B	H	B	H
PT. Bank BTPN Syariah, Tbk.	H	H	H	B	B	H	H	B	H	H
PT. Bank Central Asia, Tbk.	H	H	H	H	H	H	H	H	H	H

B = Bankrupt, H = Healthy

Table 4 shows that there are several banking industries in Indonesia that experienced healthy predictions during the period of 2012-2022, including PT. Bank Rakyat Indonesia (Persero) Tbk, PT. Bank Mandiri (Persero) Tbk, PT. Bank Negara Indonesia (Persero) Tbk, PT. Bank Tabungan Negara (Persero) Tbk, PT. Bank BTPN Syariah Tbk, and PT. Bank Central Asia Tbk. However, there are several banking industries in Indonesia that were predicted to go bankrupt during that period, namely PT. Bank Danamon Tbk, PT. Bank Syariah Indonesia (Persero) Tbk, PT. Bank Tabungan Pensiunan Nasional Tbk, and PT. Bank OCBC NISP Tbk. From the analysis, there are three banking industries in Indonesia that consistently experienced healthy predictions during the period of 2018-2022, namely PT. Bank Rakyat Indonesia (Persero) Tbk, PT. Bank Negara Indonesia (Persero) Tbk, and PT. Bank Central Asia Tbk. Meanwhile,

there are two banking industries in Indonesia that were predicted to go bankrupt consistently during that period, namely PT. Bank Syariah Indonesia (Persero) Tbk, and PT. Bank OCBC NISP Tbk. In terms of implications, this analysis can provide useful information for financial managers and regulators to assess the financial health of the banking industry in Indonesia. By knowing which banking industries consistently experience healthy predictions and bankruptcies, financial managers can evaluate and improve specific aspects to prevent bankruptcy. Additionally, regulators can be more proactive in monitoring banking industries that are predicted to go bankrupt consistently to maintain financial system stability. These research findings confirm the results of previous studies conducted by (Verlekar & Kamat, 2019; Sybirtsev, Mazhara & Moskalenko, 2020; and Ridwan, Pagalung, & Kara, 2022).

Results of the Zmijewski Z-Score Bankruptcy Prediction Analysis

The analysis in this study is the Z-Score discriminant model. This analysis is used to determine and analyze the bankruptcy prediction in the banking industry in Indonesia for the period of 2018-2022. The Z-Score formulation is as follows :

$$X = -4,3 - 4,5X_1 + 5,7X_2 - 0,004X_3 \quad (3)$$

Based on the calculation results using Microsoft Excel program, the following results were obtained :

Tabel 5. The Calculation Results of Z-Score

Issuer	Categories									
	1 th	2 th	3 th	4 th	5 th	6 th	7 th	8 th	9 th	10 th
PT. Bank Danamon, Tbk.	H	H	H	H	B	H	H	H	H	H
PT. Bank Rakyat Indonesia (Persero), Tbk.	H	H	H	H	B	H	H	H	H	H
PT. Bank Mandiri, (Persero) Tbk.	H	H	H	H	H	H	H	H	H	H
PT. Bank Negara Indonesia, (Persero) Tbk.	H	H	B	H	H	H	H	H	H	H
PT. Bank Syariah Indonesia, (Persero) Tbk.	B	B	B	B	B	B	B	B	H	H
PT. Bank Tabungan Pensiunan Nasional, Tbk.	H	H	H	B	H	B	H	H	H	H
PT. Bank OCBC NISP, Tbk.	H	H	B	H	H	H	H	B	H	H
PT. Bank Tabungan Negara (Persero), Tbk.	H	H	H	H	H	H	H	H	B	H
PT. Bank BTPN Syariah, Tbk.	H	H	H	H	H	H	B	H	H	H
PT. Bank Central Asia, Tbk.	H	H	H	H	H	H	H	H	H	H

B = **Bankrupt**, H = **Healthy**

In Table 5, it can be seen that several banking industries in Indonesia fall under the category of healthy predictions during the period of 2012-2022, including PT. Bank Danamon Tbk, PT. Bank Rakyat Indonesia (Persero) Tbk, PT. Bank Mandiri (Persero) Tbk, PT. Bank Negara Indonesia (Persero) Tbk, PT. Bank Tabungan Pensiunan Nasional Tbk, PT. Bank OCBC NISP Tbk, PT. Bank Tabungan Negara (Persero) Tbk, PT. Bank BTPN Syariah Tbk, and PT. Bank Central Asia Tbk. Meanwhile, the banks predicted to go bankrupt are PT. Bank Syariah Indonesia (Persero) Tbk and PT. Bank OCBC NISP Tbk. There are three banks that consistently fall under the category of healthy predictions during that period, namely PT. Bank Mandiri (Persero) Tbk and PT. Bank Central Asia Tbk. From the analysis of Z-Score (Zmijewski), it can be observed that

several banking industries in Indonesia consistently fall under the category of healthy predictions during that period. This indicates that the Zmijewski Z-Score model is more realistic in predicting the bankruptcy of the banking industry in Indonesia during that period and is in line with the current conditions. These findings also have important implications for the Indonesian banking industry, highlighting the importance of adopting more accurate credit analysis methods in accordance with changing market conditions. By using the right methods, the banking industry can minimize the risk of unpaid credit and ensure healthy financial performance. Philosophically, these findings emphasize the importance of adopting more advanced technology and methodologies in the business world. The rapid development of technology and methodologies can provide significant benefits to the business world, especially in decision-making. For example, in credit analysis, the use of more advanced methods can yield more accurate results and assist the banking industry in making better decisions. Therefore, these findings support research conducted by (Zelenkov, Fedorova & Chekrizov, 2017; Prusak, 2017; Manousaridis, 2017; Karas & Srbová, 2019; Laurila, 2020; Bărbuță-Mișu & Madaleno, 2020; Alibabae & Khanmohammadi, 2022).

Data Normality Testing

Normality test in this research is used to evaluate whether the data of a statistical model and analysis has a normal distribution or not. Normal distribution is important in statistical analysis because many statistical models are based on the assumption that data is taken from a normal distribution. In this research, Kolmogorov-Smirnov normality test is chosen to be used. The Kolmogorov-Smirnov test is one of the most common methods used to evaluate the normality of data. This test is based on the comparison between the empirical distribution of the observed data and the expected distribution of the data (normal distribution in this case). If the p-value of the normality test is greater than 0.05, it can be concluded that the data has a normal distribution, and if the p-value is less than or equal to 0.05, it can be concluded that the data does not have a normal distribution.

Tabel 6. Model Calculation Results

Univariate	Sig.	Probability	Description
<i>Altman X-Score</i>	0,179	0,05	Normal
<i>Springate S-Score</i>	0,206	0,05	Normal
<i>Zmijewski Z-Score</i>	0,216	0,05	Normal

Based on the normality test results with the Kolmogorov Smirnov Test above, it can be seen that the probability value > 0.05 . Therefore, it can be concluded that the data is normally distributed. This result indicates that the data taken from the sample meets the normal distribution assumption required to apply many statistical analysis techniques. Furthermore, this result emphasizes the importance of data validity in evaluating research hypotheses and provides confidence that the data taken from the sample can represent the population in general.

Homogeneity Testing with Levene Test

To determine whether the variable data in the model has homogenous distribution or not, a homogeneity test is conducted Yitnosumarto & O'Neill, (1986). In decision-making, a good data model is the one that has homogenous data distribution. To test for homogeneity, the probability value can be analyzed. If the probability value is > 0.05 , then it can be concluded that the regression model meets the homogeneity assumption. Conversely, if the probability value is ≤ 0.05 , then the regression model does not meet the homogeneity assumption. The homogeneity test is conducted using the Levene Test, and the results can be seen in the following table:

Tabel 7. Homogeneity Test Results with Levene

Univariate	Sig.	Probability	Description
<i>Altman – Springate – Zmijewski</i>	0,138	0,05	Homogeneous

The model data tested by Levene Test showed a probability value of 0.138, which is greater than the predetermined significance level of 0.05. Therefore, it can be concluded that the model data meets the assumption of homogeneity. This finding indicates that the data used in the study can be considered homogeneous, so that the statistical analysis performed can be relied upon and the results can be interpreted accurately. This is important to ensure that the conclusions drawn from the statistical analysis results are not distorted by unwanted differences in variance between groups.

One Way ANOVA Test

In this study, One Way ANOVA analysis was used to compare Altman, Springate, and Zmijewski models in predicting bankruptcy in the banking industry in Indonesia with a significance level (α) of $5\% = 0.05$. The results of One Way ANOVA Test showed that the probability value was 0.000, indicating a significant difference between the three models in predicting bankruptcy in the banking industry in Indonesia.

Tabel 8. *One Way ANOVA Test*

Model	F-test	Sig.	Level of Significant
<i>Altman – Springate – Zmijewski</i>	31,233	0,03	0,05

Based on the data analysis using One Way ANOVA, a probability value of 0.03 was obtained which is smaller than the significance level of 0.05. Therefore, it can be concluded that there is a significant difference between the three models, namely Altman, Springate, and Zmijewski, in predicting the bankruptcy of the banking industry in Indonesia. In addition, this technique can also reveal the differences between each model compared to the other models. These findings can provide an important contribution in decision-making for investors and other stakeholders in choosing the appropriate model to predict the bankruptcy of the banking industry in Indonesia.

Comparison of the Three Models

X-Score (Altman) is a model used to predict bankruptcy by measuring the financial health of a company or financial institution. This model uses five standardized financial ratios, and their weights are determined based on regression analysis. X-Score (Altman) generates a numerical score that can be used to classify companies into categories indicating bankruptcy risk. S-Score (Springate) is a model used to analyze the bankruptcy tendency of a company. This model uses financial ratios measured based on liquidity, profitability, operational efficiency, and sales growth. S-Score (Springate) produces a numerical score that can be used to evaluate the likelihood of a company's bankruptcy. Z-Score (Zmijewski) is a model used to predict the bankruptcy risk of a company. This model uses various financial ratios measured based on liquidity, profitability, operational efficiency, and sales growth. Z-Score (Zmijewski) generates a numerical score that can be used to identify companies with high bankruptcy risk. These three models have the same objective, which is to provide information and predictions regarding the likelihood of a company or financial institution going bankrupt. Although they use different approaches and variables, these models can be useful analytical tools in identifying bankruptcy risks and taking appropriate preventive measures.

Tabel 9. Comparison of the Three Models

Description	<i>Altman, Springate and Zmijewski</i>		
	X-Score	S-Score	Z-Score
Healthy	19,28%	26,45%	54,27%
Grey Area	89,60%	-	-
Bankrupt	-	14,47%	85,53%

Based on Table 8, it can be concluded that the *Springate* S-Score model can predict 14.47% of the banking industry in Indonesia in the bankrupt category and 26.45% in the healthy category, during the research period from 2012 to 2022. Furthermore, the *Zmijewski* Z-Score model can predict 85.53% of the banking industry in Indonesia in the bankrupt category and 54.27% in the healthy category, during the research period from 2012 to 2022. Additionally, the *Altman* X-Score model can predict that 89.60% of the banking industry in Indonesia falls into the grey area category, 19.28% in the healthy category, and none in the bankrupt category, during the research period from 2012 to 2022. Based on these results, it can be concluded that the *Zmijewski* Z-Score model is the most suitable for predicting the bankruptcy of the banking industry in Indonesia with an accuracy rate of 85.53%, followed by the *Springate* S-Score model with an accuracy rate of 14.47%. However, the *Altman* X-Score model is not suitable for predicting the bankruptcy of the banking industry in Indonesia. This is because the *Altman* X-Score model, designed by Edward Altman in 1968, is a model for predicting bankruptcy in the manufacturing sector. The model is based on financial ratio analysis that may not always be relevant to predicting the bankruptcy of the banking industry in Indonesia, as the banking industry has different business characteristics compared to manufacturing companies. Therefore, the *Altman* X-Score model is not suitable for predicting the bankruptcy of the banking industry in Indonesia.

Conclusion

Based on the analysis results, it can be concluded that the *Zmijewski Z-Score* model is the most accurate model for predicting the bankruptcy of the banking industry in Indonesia. This is also because the *Zmijewski Z-Score* model is considered the best model as it utilizes multidiscriminant approach analysis and key financial ratios that are deemed most important in predicting the bankruptcy of the banking industry in Indonesia. Factors such as credit risk, liquidity, and solvency significantly influence the risk of banking bankruptcy. However, it is important to be aware that this model still has limitations and needs to be complemented with external factors and careful assessment. Despite the high accuracy of the *Zmijewski Z-Score* model in predicting the bankruptcy of the banking industry in Indonesia based on historical financial data, it is important to remember that this model cannot fully account for non-financial factors that also impact bankruptcy risk. Factors such as regulatory changes, market shifts, risk management, and macroeconomic factors can affect banking bankruptcy but may not always be reflected in historical financial data. Therefore, it is important to conduct a comprehensive assessment by considering non-financial condition factors and the holistic and structured objectives of the banking industry before making an assessment of the banking industry risk in Indonesia.

Based on the above results, there are several suggestions or options that can be pursued in further research. First, the research can focus on developing bankruptcy prediction models based on machine learning or artificial intelligence. This method can involve algorithms such as *random forest*, *support vector machines*, or *neural networks* to obtain more accurate predictions and capture complex patterns in banking industry financial data. Second, the research can integrate multidimensional approaches such as factor analysis or cluster analysis to identify hidden financial patterns or groups of banks with similar bankruptcy risks. This approach can assist in developing more effective prediction models that focus on specific material aspects within the banking industry in Indonesia. Third, the research can explore the use of alternative data sources such as market sentiment, social media data, or geospatial data to enhance the accuracy of banking bankruptcy predictions. Lastly, expanding the sample to cross-country banks or the Islamic banking industry in other countries could help identify long-term trends and changes in global bankruptcy risk.

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