

Evaluating the Effectiveness of Financial Distress Prediction Models in the Property and Real Estate Sector

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ABSTRACT

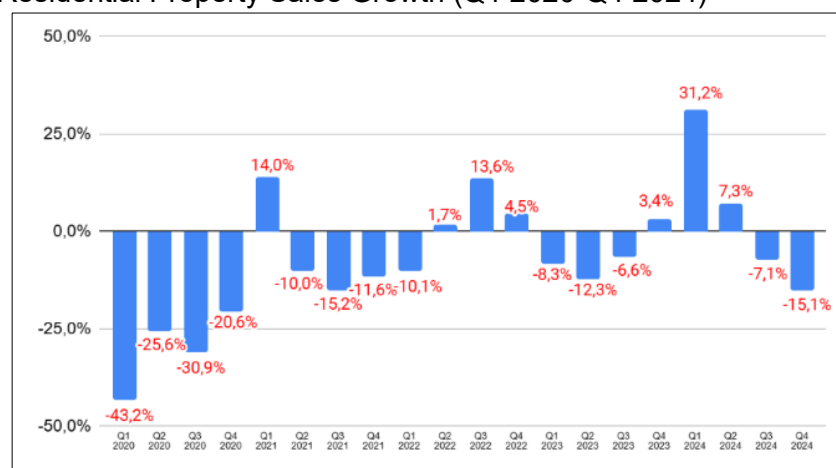
Financial distress poses a serious threat to Indonesia's property and real estate sector, requiring reliable prediction models to prevent bankruptcy and maintain economic stability. This study compares the predictive accuracy of four classical financial distress prediction models (Altman Z-Score, Zmijewski X-Score, Springate S-Score, and Grover G-Score) using data from 30 IDX-listed firms (150 observations) from 2020 to 2024. A quantitative approach was applied through descriptive statistics, Kolmogorov-Smirnov normality tests, Kruskal-Wallis, and Mann-Whitney U tests, with cash flow patterns as the benchmark of financial distress. The results show significant differences among the models ($p < 0.001$), confirming H1, with the Zmijewski X-Score achieving the highest accuracy (79%), followed by Altman (76%), Grover (72%), and Springate (29%). The Zmijewski model's logistic regression approach and emphasis on leverage make it the most effective predictor for firms in volatile market conditions, supporting H2. These findings highlight that model performance depends on economic context, emphasizing the need for continuous validation in emerging markets. The Zmijewski X-Score offers practical value for investors, managers, and policymakers in strengthening financial resilience and early distress detection.

Keywords: Altman Z-Score; Bankruptcy Models; Financial Distress Prediction; Property and Real Estate Sector; Zmijewski X-Score

INTRODUCTION

The property and real estate sector significantly boosts Indonesia's economic growth by generating jobs. However, this sector has faced various challenges over time, including economic fluctuations, legislative reforms, and the widespread impacts of the COVID-19 pandemic (Awwaliyah et al., 2024; Oktafirningsih & Suryaningsum, 2024; Saraswati et al., 2024).

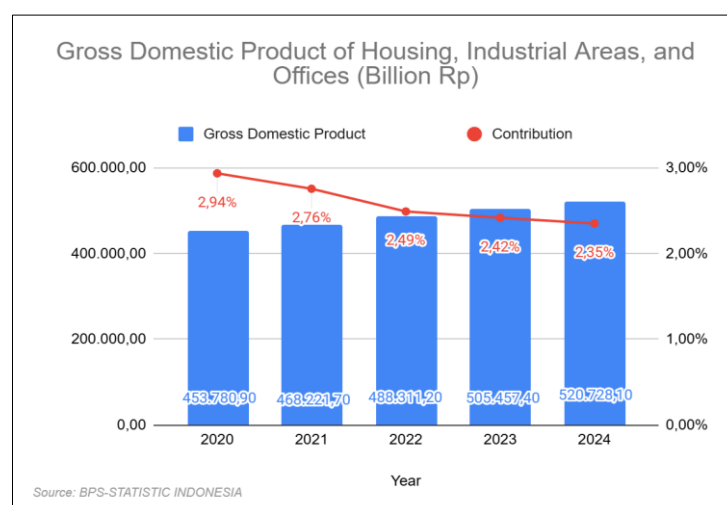
Figure 1. Residential Property Sales Growth (Q1 2020-Q4 2024)



Source: Bank Indonesia (2025)

The residential property sector in Indonesia saw major fluctuations from 2020 to 2024. As shown in Figure 1, sales growth dropped sharply during the pandemic in 2020, then gradually recovered with occasional improvements. However, by the third and fourth quarters of 2024, the sector experienced declines of 7.1% and 15.1%, respectively. Bank Indonesia (2025) explained that this decrease was mainly due to slow economic activity, changing consumer preferences, and weak demand in middle- and lower-income housing markets. Despite Bank Indonesia's efforts to boost the market by lowering its benchmark interest rate from 6.25% to 6.00% in Q3 2024, the effect was limited because of ongoing economic uncertainty and cautious household spending (Pinhome, 2024). Additionally, since mortgage loans make up about 75.8% of residential property purchases, the sector was highly sensitive to changes in interest rates and lending policies. Consumers increasingly chose long-term fixed-interest financing, showing a rising need for financial stability amid economic uncertainty (Global Property Guide, 2025). Although infrastructure improvements in regions like Bandung and Greater Jakarta provided some localized support, these efforts were not enough to counteract the nationwide sales decline (Pinhome, 2024).

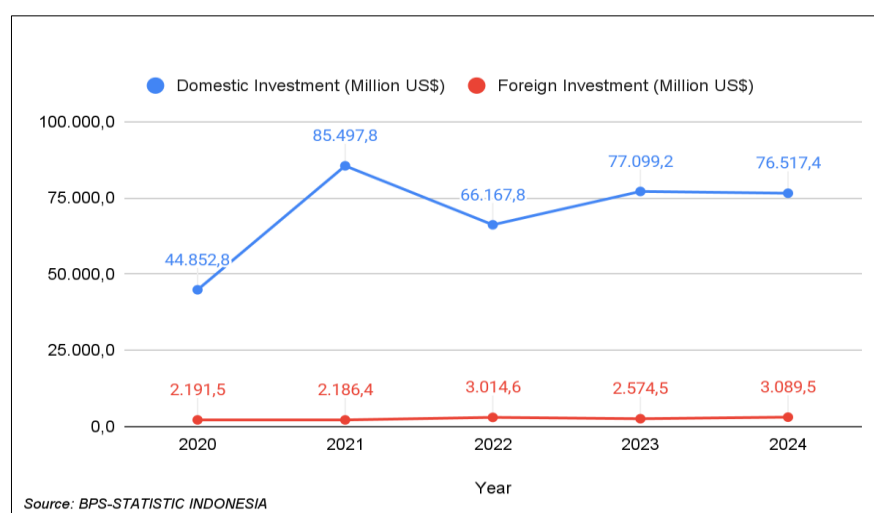
Figure 2. Gross Domestic Product of Housing, Industrial Areas, and Offices (2020-2024)



Source: [Central Agency of Statistics of Indonesia \(BPS Indonesia, 2025\)](#)

Moreover, the economic contribution from the offices, housing, and industrial sectors has grown significantly, in monetary terms, from IDR 453,780.90 billion in 2020 to IDR 520,723.10 billion in 2024. However, their share of national GDP has continued to decline, in this case, from 2.94% in 2020 to 2.35% in 2024. This indicates that the sector's value has increased, but in comparison with the entire economy, its importance has diminished, which highlights the importance of planning efforts to retain the sector's value and its relevance as a prominent economic driver (see [Figure 2](#)).

Figure 3. In Total Domestic Investment and Foreign Investment of Housing, Industrial Estate, and Office Building (2020 – 2024)



Source: [BPS Indonesia \(2025\)](#)

The real estate market is significantly influenced by investment patterns as well. From USD 44,852.8 million in 2020 to USD 85,497.8 million in 2021, domestic investment in Indonesia's real estate market increased dramatically before leveling off at USD 76,517.4 million in 2024. Despite its modest size, foreign investment grew steadily, rising from USD 2,191.5 million in 2020 to USD 3,089.5 million in 2024. These investment trends

demonstrate the industry's tenacity and capacity to draw in money in spite of economic uncertainty (see [Figure 3](#)).

Based on data from the Indonesia Stock Exchange (IDX), out of 94 property and real estate companies listed between 2020 and 2024, 30 firms (approximately 32%) experienced financial losses. This high proportion of loss-making firms underscores the sector's vulnerability to post-pandemic economic shocks, rising interest rates, and high leverage structures. Such conditions highlight the urgent need for reliable financial distress prediction models that can provide early warning signals for stakeholders and help mitigate bankruptcy risks in Indonesia's property market.

Financial distress, characterized by declining profitability, liquidity, and leverage, poses a significant risk to firms, potentially leading to bankruptcy ([Awwaliyah et al., 2024](#); [Saraswati et al., 2024](#)). Many models have been developed to predict a firm's financial distress. Recent studies highlight the effectiveness of these approaches across various industries. [Ulfah and Moin \(2022\)](#), for instance, noted that the Springate model was the best in predicting bankruptcy in the tobacco industry. [Manda et al. \(2024\)](#) found that in tourism sub-sector firms, the Grover G-Score and Zmijewski X-Score models had a perfect score of 100%, while the Modified Altman Z-Model scored 83% and the Springate S-Score 33%. [Fauzi et al. \(2021\)](#) found that the Altman, Springate, and Grover models produced reliable results in the analysis of bankruptcy. Regardless, Altman modeling proved to be the most effective in the telecommunication sub-sector because it is a robust, consistently reliable, and validated model, both descriptively and statistically. The Grover model, according to [Putri et al. \(2023\)](#), is most applicable in predicting retail firms listed on the IDX facing financial distress in the period 2019-2022.

Despite extensive research on financial distress prediction models, few studies have specifically examined Indonesia's property and real estate subsector. This study addresses that gap by evaluating the effectiveness of the Altman, Zmijewski, Springate, and Grover models in predicting financial distress among IDX-listed companies from 2020 to 2024. By analyzing multiple models over a five-year period, the study provides comprehensive insights into the financial health of this crucial industry.

Accurate financial distress prediction is essential for maintaining the sector's contribution to economic growth and employment. By identifying early warning signals, these models enable proactive risk management, strengthen financial resilience, and reduce potential losses for investors, management, and policymakers. Overall, this research enhances understanding of financial stability within Indonesia's property market and offers practical guidance for sustaining sectoral performance.

LITERATURE REVIEW

Financial Distress

Financial distress happens when a company has difficulty meeting its financial obligations, raising the risk of bankruptcy or liquidation ([Mselmi et al., 2017](#)). Major signs include declining profitability, liquidity problems, and high leverage ([Kamaluddin et al., 2019](#)). [Kristanti \(2019\)](#) describes three traits of failing companies: investment failure (returns below risk-adjusted standards), insolvency (inability to fulfill obligations), and default (violation of creditor agreements). Both internal factors (like poor product strategy) and external factors (such as economic downturns) lead to distress, highlighting the need for effective prediction models ([Kristanti, 2019](#)). Management must immediately adopt new provisions to overcome financial distress, as this condition increases audit risk, especially in control and detection risk ([Sumajow et al., 2022](#)).

Bankruptcy Prediction Model

Bankruptcy prediction models act as early warning systems by analyzing financial ratios to evaluate a firm's health (Kovacova et al., 2019). These models, developed in various economic contexts, differ in their applicability to specific industries (Balcaen & Ooghe, 2006). After the 2008 financial crisis, the need for accurate prediction models increased, focusing on profitability, debt management, and operational efficiency as key indicators (Fauzi et al., 2021). This study assesses four models for their effectiveness in Indonesia's property sector.

Altman Z-Score

The Altman (1968) Z-Score, based on Multiple Discriminant Analysis (MDA), is a cornerstone of prediction literature, but its application in the property and real estate sector, especially in emerging markets, is often problematic. The model heavily relies on the market value of equity (X4 ratio), a measure highly sensitive to stock market sentiment and volatility. In emerging markets, where stock markets can be less efficient, this reliance often leads to Type I errors (false positives), where financially sound but temporarily undervalued firms are incorrectly classified as distressed (Fadia & Simon, 2024). Consequently, while some studies still find its accuracy high (Hesi & Zelmiyanti, 2024), many recent comparative analyses report that the Altman often underperforms models that utilize more stable book-value metrics (Oktafiraningsih & Suryaningsum, 2024). This divergence highlights the need to test whether the structural weakness of its market-based ratio outweighs its historical predictive strength in the context of capital-intensive real estate firms.

Zmijewski X-Score

The Zmijewski (1984) X-Score marks a methodological improvement by using Logistic Regression (Logit), which is statistically more reliable because it does not require the strict assumption of multivariate normality that is necessary for MDA. The model emphasizes essential book-value financial metrics: profitability (ROA), leverage, and liquidity (Current Ratio). Importantly, Zmijewski's focus on stable accounting ratios rather than market value makes it especially suitable for the property sector in emerging markets, where market volatility can hide underlying financial health (Kamila et al., 2024). Studies in this sector often find Zmijewski's predictive accuracy to be strong and competitive, frequently ranking it as the most dependable predictor compared to the original MDA models, due to its ability to handle data that violate classical MDA assumptions (Yendrawati & Adiwafi, 2020).

Springate S-Score

Developed in the 1970s, the Springate S-Score is an MDA-based model that aimed to improve upon Altman by reducing the number of predictive ratios and, importantly, removing the market-value component. This exclusion of the highly volatile equity market ratio gives the Springate model an advantage in markets characterized by inefficiency or high debt, such as the real estate sector (Elviani et al., 2020). Its emphasis on the Earnings Before Taxes/Current Liabilities (C) ratio is highly relevant for evaluating a property company's ability to cover its short-term debt with pre-tax operating performance. Although the model remains limited by the constraints of the MDA technique, its use of book-value stability often results in higher predictive power than the Altman Z-Score in recent studies comparing their performance on property firms in emerging economies (Hesi & Zelmiyanti, 2024).

Grover G-Score

The Grover G-Score is a more modern MDA model designed to improve prediction accuracy through optimized ratio selection (Hesi & Zelmiyanti, 2024). Its main contribution is the inclusion of Net Income/Total Assets (X3). For the property and real

estate sector, this choice is crucial. Since these firms carry very high interest burdens and are highly sensitive to financing costs, the Net Income metric (profit after interest and tax) provides a more accurate measure of a company's true financial health than the EBIT measure used by both Altman and Springate (Jariah et al., 2024; Kamila et al., 2024). This theoretical alignment has been strongly supported by empirical studies: Jariah et al. (2024) and Kamila et al. (2024) consistently found that the Grover G-Score provides the best predictive accuracy for real estate companies. The superiority of Grover's model, especially due to the inclusion of Net Income/Total Assets, confirms that it is well-suited to the debt-heavy nature of the industry and its high exposure to financing risk (Wulandari & Fauzi, 2022).

Hypotheses Development

Differences Among Financial Distress Prediction Models

Financial distress prediction models help identify early warning signals of a firm's potential failure by analyzing key financial ratios (Kovacova et al., 2019). Each classical model differs in focus and methodology, leading to different predictive results across sectors (Balcaen & Ooghe, 2006). The Altman Z-Score combines profitability, liquidity, and leverage ratios using MDA but may give biased results in volatile markets (Fadia & Simon, 2024; Oktafiraningsih & Suryaningsum, 2024). The Zmijewski X-Score, created with logistic regression and book-value variables, is more reliable during financial instability (Kamila et al., 2024; Yendrawati & Adiwafi, 2020). The Springate S-Score simplifies Altman by focusing on efficiency ratios and excluding market-based values (Elviani et al., 2020), while the Grover G-Score includes net income to total assets, effectively measuring solvency and profitability in highly leveraged firms (Jariah et al., 2024; Wulandari & Fauzi, 2022).

Given these methodological differences, there is likely significant variation in predictive accuracy among the four models, especially within Indonesia's property and real estate sector, which faced post-pandemic financial turbulence from 2020 to 2024 (Amelia & Setiawan, 2022; Hesi & Zelmiyanti, 2024). Empirical evidence further demonstrates that model performance depends on sector characteristics and economic conditions. Altman performs better in stable markets, Zmijewski under crisis conditions, Springate when operational efficiency dominates, and Grover in highly leveraged environments (Duricova et al., 2025; Kamila et al., 2024; Oktafiraningsih & Suryaningsum, 2024; Toudas et al., 2024).

H1: There are significant differences among the Altman, Zmijewski, Springate, and Grover models in predicting financial distress for property and real estate companies listed on the IDX during 2020–2024.

The Most Accurate Financial Distress Prediction Model

The second hypothesis focuses on determining which model provides the best predictive accuracy for property and real estate firms listed on the IDX during 2020–2024. Since each model captures different aspects of financial health, identifying the most accurate one is crucial for decision-making by investors, creditors, and regulators.

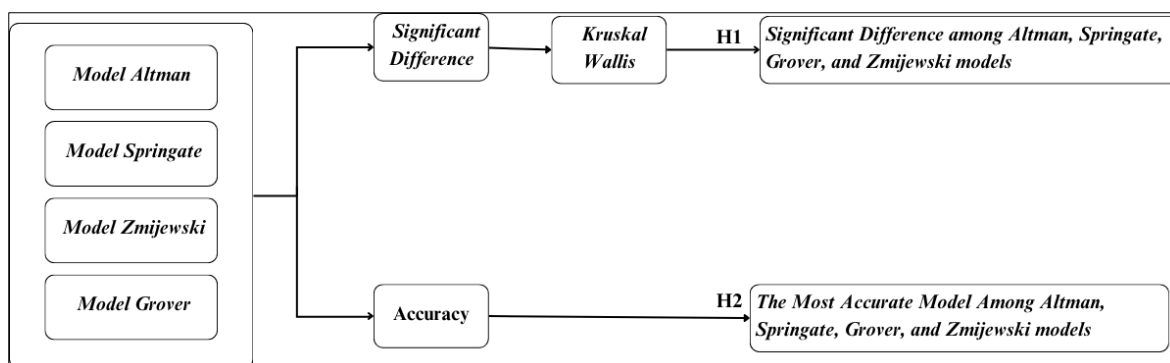
Empirical comparisons reveal that the Zmijewski X-Score model demonstrates superior accuracy due to its robustness in handling non-normally distributed data and its emphasis on solvency and profitability. These factors make it especially effective during periods of financial instability. In contrast, models like Springate and Grover, which rely more heavily on profitability and efficiency ratios, perform inconsistently in sectors characterized by high leverage and cyclical revenue, such as property and real estate.

H2: There is one financial distress predicting methodology with the best accuracy performance for IDX-listed property and the real estate sector during 2020-2024.

Conceptual Framework

The study framework model is depicted in Figure 4.

Figure 4. Research Framework



RESEARCH METHOD

Research Design

This study employs a quantitative approach using secondary data to evaluate the predictive accuracy of financial distress models. The data consists of the annual financial statements of property and real estate companies listed on the IDX over a five-year period, from 2020 to 2024. Data were sourced directly from the official IDX database and company annual reports, ensuring the consistency and reliability of the financial figures used (Saptutyningsih & Setyaningrum, 2020). The analysis utilizes four classical models, which serve as the primary predictive tools in the study.

Population and Sampling Plan

The research population includes all companies categorized under the property and real estate sector listed on the IDX during the 2020–2024 period, totaling approximately 94 firms. To ensure the relevance of the analysis to financial distress conditions, a purposive sampling technique was employed. The selection process required that companies remain continuously listed on the IDX from 2020 to 2024, submit annual reports for each year within this period, present financial statements in Indonesian Rupiah (IDR), and record losses during the study period.

Applying these criteria resulted in a final sample of 30 companies, producing 150 firm-year observations. This number meets and exceeds the minimum standard of 30 observations generally recommended for correlational and comparative statistical research (Saptutyningsih & Setyaningrum, 2020). Concentrating on firms that experienced losses allows for a more rigorous examination of financial distress phenomena, ensuring the model comparisons are based on genuinely at-risk cases.

The chosen sample size was considered adequate to capture sectoral trends while maintaining the accuracy and completeness of available data. The financial statements of these 30 companies were then utilized to compute the relevant financial ratios required for applying the four selected multivariate bankruptcy prediction models.

Data Analysis Design

Calculation of Financial Distress Prediction

Altman Z-Score

$$Z'' = 6.56 X_1 + 3.26 X_2 + 6.72 X_3 + 1.05 X_4$$

Information:

Z = Overall index

X₁ = Working capital/Total assets

X₂ = Retained earnings/Total assets

X₃ = Earnings before interest and taxes/Total assets

X₄ = Book value of equity/Book value of liabilities

Financial condition classification:

a. $Z < 1.1$ indicates the company is in distress

b. $1.1 \leq Z \leq 2.6$ indicates the company is in the gray area

c. $Z > 2.6$ indicates the company is healthy or non-distressed

Springate S-Score

$$S = 1.03A + 3.07B + 0.66C + 0.4D$$

Information:

S = Overall index

A = Working capital/Total assets

B = Earnings before interest and taxes/Total assets

C = Earnings before taxes/Current liabilities

D = Sales/Total assets

Financial condition classification:

a. $S < 0.862$ indicates the company is in distress

b. $S > 0.862$ indicates the company is healthy or non-distressed

Zmijewski Z-Score

$$X = -4.33 - 4.5X_1 + 5.7X_2 - 0.004X_3$$

Information:

X = Overall index

X₁ = Return on Assets (ROA)

X₂ = Leverage (Debt Ratio)

X₃ = Liquidity (Current Ratio)

Financial condition classification:

a. $X > 0$ indicates the company is in financial distress

b. $X < 0$ indicates whether the company is healthy or in financial distress

Grover G-Score

$$G = 1.650X_1 + 3.404X_2 - 0.016X_3 + 0.057$$

G-Score Model Information:

G = Overall index

X₁ = Working capital/Total assets

X₂ = Earnings before interest and taxes/Total assets

X₃ = Net income/Total assets

Financial condition classification:

- a. $G < -0.02$ indicates the company is in distress
- b. $-0.02 < G < 0.01$ indicates the company is in the gray area
- c. $G > 0.01$ indicates the company is healthy or non-distressed

To predict financial distress in the property and real estate sector listed on the IDX from 2020 to 2024, four established prediction models were employed: the Altman (1968) Z-Score, Zmijewski (1984) X-Score, Springate (1978) S-Score, and Grover (2001) G-Score. These models were chosen for their simplicity, empirical reliability across global contexts, and collective ability to capture the volatility characteristic of the property sector. The Altman model effectively assesses liquidity and profitability with an accuracy rate of 82–88%, while the Zmijewski model emphasizes leverage, achieving 84–90% accuracy. The Springate model focuses on asset efficiency (72–85%), and the Grover model integrates solvency and profitability with an accuracy range of 81–100%. Together, these models offer a robust framework for comparison, particularly when contrasted with more complex models such as the Ohlson O-Score, which require advanced statistical assumptions (Husein & Pambekti, 2015; Martini et al., 2023).

In this study, financial distress is operationalized as a pre-bankruptcy condition, identified through the model scores derived from financial ratios related to liquidity, leverage, and solvency. These indicators, drawn from company annual reports, reflect symptoms of financial instability, such as declining profitability or the inability to meet debt obligations, which were especially relevant to the property sector during the pandemic (Hantono, 2019).

Comparative testing of these models is crucial given their differing performances across economic conditions. The Altman model is prone to Type II errors (up to 40%) and tends to lose 20–30% of its accuracy during crisis periods like 2020–2022. In contrast, the Zmijewski model performs more reliably in turbulent periods due to its sensitivity to leverage (84–90%). The Springate model demonstrates high accuracy in stable environments (pre-2019) but performs less effectively in emerging markets (around 72%), while the Grover model, despite its tendency to over-predict distress (Type II error up to 60%), shows strong predictive power in high-risk industries (Fadia & Simon, 2024; Toudas et al., 2024). Recent studies suggest that Zmijewski and Grover are more adaptable during crises, while Altman and Springate perform better in stable periods, though they may require coefficient recalibration during economic shocks (Duricova et al., 2025). Therefore, this comparative testing is essential to identify the most appropriate and context-sensitive model for assessing financial distress in Indonesia's property and real estate sector amid ongoing economic turbulence.

Descriptive Statistics

Muchson (2017) states that descriptive statistics is a branch of analysis that deals with methods of collecting, summarizing, and presenting data in a way that makes interpretation easier. Descriptive statistics is defined as an examination of data where the data is presented in its original form without attempting to draw broad conclusions. Descriptive statistics can be used when the research goal is to explain the sample and not to generalize the findings to the population from which the sample is taken (Saptutyingsih & Setyaningrum, 2020).

Descriptive statistics utilizes data tables and graphs, including pie graphs and scatter graphs. They also use polynomials, histograms, averages, medians, modes, percentile ranks, quartiles, deciles, measures of variation like standard deviations, averages, and even percentage calculations (Saptutyingsih & Setyaningrum, 2020).

Normality Test

The method used in this study is to evaluate whether the regression residuals return to a normal distribution (Saptutyningasih & Setyaningrum, 2020). This test categorizes the results into two groups: normally distributed or not normally distributed. The normality of the distribution was tested using Statistical Package for the Social Sciences (SPSS) with the Kolmogorov-Smirnov test. The data are considered normally distributed if the Kolmogorov-Smirnov statistic is greater than 0.05. Conversely, if the statistic is less than 0.05, the data are deemed not to be normally distributed.

Hypothesis Testing

The Kruskal-Wallis test was used to compare the predictive accuracy of the four models, testing the null hypothesis (H0) that there are no significant differences among the models versus the alternative (H1) that differences exist (Tapia & Cevallos, 2022). A post-hoc Mann-Whitney U test was conducted to identify specific model pairs with significant differences (Mann & Whitney, 1947).

The decision rule for the test is as follows: if the significance value (p-value) is less than 0.05, the null hypothesis (H0) is rejected, indicating that at least one model performs differently from the others in predicting financial distress.

Accuracy Test

Table 1. Cashflow Pattern as Cut-Off Point for Stable & Distressed Company Indication

Financial Condition	Financial Position			
	Earning	Cashflow Activities		
		Operating	Investing	Financing
Stable	+	There is no cash flow pattern indicated in Group 1.		
	-	+	-	-
	-	-	-	+
	-	-	+	+
	-	-	+	-
Distress	-	+	+	-
	-	+	-	+
	-	-	-	-

Source: Amelia & Setiawan (2022)

Model accuracy was assessed by comparing predictions to actual financial conditions, using cash flow patterns as cutoff points (Table 1). The percentage of correct predictions determined the accuracy rate.

$$\text{Accuracy rate} \equiv \frac{\text{The number of correct prediction}}{\text{Total number of sample}} \times 100\%$$

RESULTS

The study analyzed 150 observations from 30 IDX-listed property and real estate companies (2020–2024) using four financial distress prediction models.

Table 2. Descriptive Statistics Result (2020-2024)

Model	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Z-Score	150	-16.8	54.1	6.2423	10.12663	102.549

X-Score	150	-4.28	5.2	-2.0394	1.64398	2.703
S-Score	150	-2.05	2.78	0.1523	0.67496	0.456
G-Score	150	-2.91	1.99	0.2591	0.71837	0.516
Valid N	150					

Table 2 presents the descriptive statistics, highlighting significant variability in scores, especially for the Altman Z-Score (range: -16.8 to 54.1, mean: 6.242) and Grover G-Score (range: -2.91 to 1.99, mean: 0.259). The Zmijewski X-Score (mean: -2.039) indicates that most companies were stable, while the Springgate S-Score exhibited the least variation (SD: 0.675).

Table 3. Normality Test Result

Model	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	sig	Statistic	df	sig
G-Score	0.157	150	<0.001	0.891	150	<0.001
S-Score	0.098	150	0.001	0.954	150	<0.001
X-Score	0.115	150	<0.001	0.904	150	<0.001
Z-Score	0.210	150	<0.001	0.723	150	<0.001

The results of the Kolmogorov-Smirnov (Table 3) test indicate that certain data, specifically the G-Score, S-Score, X-Score, and Z-score, are not normally distributed ($p < 0.001$). Consequently, the comparison test in this research cannot be performed using the paired t-test sample with a parametric method, since it fails to meet the requirement that data intended for parametric testing should follow a normal distribution. As a result, the Kruskal-Wallis test and the Post Hoc test (which employs the Mann-Whitney test) will serve as the non-parametric approaches for the different analyses conducted in this research.

Table 4. Kruskal-Wallis Test Statistics

Item Name	Model
Kruskal-Wallis H	340.853
df	3
Asymp. Sig.	<0.001

Based on the Kruskal–Wallis test results (Table 4), which yielded an Asymp. Sig. Value of less than 0.001, it is confirmed that there are statistically significant differences among the Altman, Zmijewski, Springgate, and Grover models in predicting financial distress for property and real estate companies listed on the IDX during 2020–2024. Therefore, H1 is accepted.

Table 5. Mann-Whitney U-Test Result

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig. ^a
X-Score-S-Score	177.643	20.017	8.875	<0.001	0.000
X-Score-G-Score	197.513	20.017	9.868	<0.001	0.000
X-Score-Z-Score	-368.99	20.017	-18.434	<0.001	0.000
S-Score-G-Score	19.87	20.017	0.993	0.321	1.000
S-Score-Z-Score	-191.347	20.017	-9.559	<0.001	0.000
G-Score-Z-Score	-171.477	20.017	-8.567	<0.001	0.000

The follow-up Mann–Whitney U test (Table 5) further verified that most model pairs differ significantly, except the Springgate–Grover pair (Adj. Sig. = 1.000), which showed no significant difference in predictive ability.

Table 6. Accuracy Test

Model	Total Sample	Number of Correct Prediction	Accuracy Rate
Z-Score Method	150	114	76%
X-Score Method	150	118	79%
S-Score Method	150	43	29%
G-Score Method	150	108	72%

In support of H2, the accuracy test results (Table 6) demonstrate that the Zmijewski X-Score model achieved the highest predictive accuracy at 79%, outperforming Altman (76%), Grover (72%), and Springate (29%). This indicates that the Zmijewski model provides the most reliable prediction of financial distress within the Indonesian property and real estate sector during the observed period. Hence, H2 is accepted as well.

DISCUSSION

Differences Among Financial Distress Prediction Models (H1)

This study evaluated the predictive accuracy of four financial distress models across 30 Indonesian property and real estate firms listed on the IDX during the volatile period of 2020 to 2024. The economic instability caused by the COVID-19 pandemic and subsequent recovery efforts underscores the importance of effective early warning tools in this highly sensitive and debt-intensive sector.

The Kruskal–Wallis H test yielded highly significant results (Asymp. Sig. < 0.001), confirming that the four models show statistically significant differences in their predictive outcomes (H1 accepted). This finding aligns with several comparative studies in Indonesia, which indicate that the effectiveness of financial distress models largely depends on the industrial sector and the period of analysis (Amelia & Setiawan, 2022; Intansari et al., 2023). Therefore, selecting the most appropriate predictive model is crucial.

Empirical evidence further demonstrates that model performance depends on sector characteristics and economic conditions. Altman performs better in stable markets, Zmijewski under crisis conditions, Springate when operational efficiency dominates, and Grover in highly leveraged environments (Duricova et al., 2025; Kamila et al., 2024; Oktafiraningsih & Suryaningsum, 2024; Toudas et al., 2024). The Mann–Whitney U test further confirmed significant differences among most model pairs, indicating statistically meaningful variations in predictive accuracy. An exception was found in the Springate–Grover pair (Adj. Sig. = 1.000), which showed no significant difference in predictive ability. This is consistent with Kanapickienė et al. (2023) and Setiawan & Rafiani (2021), who observed that models using similar profitability and leverage ratios often yield comparable results.

The Most Accurate Financial Distress Prediction Model (H2)

The accuracy test results support the second hypothesis (H2), showing that the Zmijewski X-Score is the most accurate predictor (79%) for the property and real estate sector. The performance ranking lists Zmijewski (79%), followed by Altman (76%) and Grover (72%), while the Springate model performed significantly lower (29%). These findings align with Toudas et al. (2024), who studied the construction industry in Greece, a sector similar to real estate because it is capital-intensive, high-risk, and highly sensitive to macroeconomic changes. They found that the Zmijewski model was the most accurate and stable predictor compared to Altman and Ohlson. Manda (2024) also reported that Altman's financial ratios, such as liquidity, profitability, and solvency, have causal links with financial distress in South African REITs. However, logistic-based

models like Zmijewski are more effective at capturing financial instability in volatile emerging markets.

The superior performance of the Zmijewski model also supports the findings of [Oktafiraningsih and Suryaningsum \(2024\)](#), who identified Zmijewski as the most accurate predictor for property and real estate companies listed on the IDX, and [Setiawan and Rafiani \(2021\)](#), who reached a similar conclusion for Indonesia's textile sector. This consistent accuracy across industries reinforces the model's robustness in emerging market contexts. In contrast, [Hariyani and Sujianto \(2018\)](#) found that the Springate model performed best in Indonesia's Islamic banking sector, while [Amelia and Setiawan \(2022\)](#) discovered that the Data Envelopment Analysis (DEA) model achieved the highest accuracy (79%) in the tourism, restaurant, and hotel sectors, followed by Zmijewski (74%), Grover (69%), Altman (43%), and Springate (33%). These variations highlight that bankruptcy prediction models perform differently depending on sector-specific characteristics.

The superior performance of the Zmijewski X-Score (79%) has significant theoretical implications. Its logistic regression method is inherently more robust than models based on MDA, such as Altman, especially when handling non-normally distributed financial data, which is common in emerging markets. This aligns with [Duricova et al. \(2025\)](#), who found that the predictive accuracy of traditional models like Altman, Ohlson, and Zmijewski decreased considerably during the COVID-19 crisis due to financial volatility but improved after recalibrating model coefficients. Therefore, the dominance of Zmijewski in this study highlights the resilience of logistic-based methods during unstable economic conditions.

[Giriūniene et al. \(2019\)](#) emphasized that models integrating macroeconomic and sector-specific variables tend to outperform purely financial models. Although this study relies solely on financial ratios, the strong performance of the Zmijewski model, which focuses on solvency and profitability based on book values, suggests that these fundamental ratios are sufficient to capture distress signals in Indonesia's property sector, which is strongly influenced by macroeconomic cycles.

The very low performance of the Springate S-Score (29%) underscores its theoretical limitations. The model's heavy reliance on the Sales/Total Assets ratio makes it unsuitable for industries with uneven revenue recognition and volatile sales patterns, such as the property sector. This finding aligns with [Anisah et al. \(2025\)](#) and [Toudas et al. \(2024\)](#), who noted that a model's effectiveness depends heavily on the industry type and the research period.

Meanwhile, the Grover G-Score (72%) showed relatively strong performance among MDA-based models. This supports the findings of [Giriūniene et al. \(2019\)](#) and [Kanapickienė et al. \(2023\)](#), who concluded that optimizing traditional financial ratios can improve predictive accuracy. Grover's use of the Net Income/Total Assets ratio offers a more realistic measure of financial distress in the property sector, as it reflects the significant interest burden carried by highly leveraged developers, a structural vulnerability observed both domestically and globally ([Jariah et al., 2024](#); [Kamila et al., 2024](#)).

Theoretically, these results support [Manda's \(2024\)](#) argument that stable, book-value-based financial ratios are the most effective indicators of distress in emerging markets. Practically, they back [Duricova et al.'s \(2025\)](#) suggestion that classical models should be locally validated and recalibrated to stay reliable after crises. Therefore, the Zmijewski

X-Score can be seen as the most dependable early warning system for Indonesia's property and real estate sector.

Theoretical and Practical Implications

By emphasizing the importance of local model validation and demonstrating the superiority of book-value-focused logistic models, this study contributes to the global academic discourse by highlighting that the effectiveness of bankruptcy prediction models is highly sensitive to macroeconomic conditions, industry structures, and the high-leverage characteristics that define emerging markets (Ambarwati et al., 2025).

CONCLUSION

Corporate financial distress prediction has long been a subject of considerable interest, as numerous analysts have sought to develop models capable of anticipating corporate failure across different countries and industries over the past decades. Despite these efforts, there remains no universal consensus regarding the most effective variables or methods of analysis. This study contributes to this continuing debate by assessing and comparing the predictive performance of four classical financial distress models, Altman Z-Score, Zmijewski X-Score, Springate S-Score, and Grover G-Score, within Indonesia's property and real estate sector during the economically turbulent years from 2020 to 2024.

The empirical results provide strong evidence supporting both hypotheses. The Kruskal-Wallis test confirmed significant differences among the four models (supporting H1), indicating that their predictive performances vary substantially depending on the analytical approach and underlying financial ratios. Furthermore, the accuracy test results (supporting H2) revealed that the Zmijewski X-Score model achieved the highest overall accuracy at 79%, followed by Altman at 76% and Grover at 72%, while Springate performed considerably lower at 29%. These findings indicate that logistic regression-based approaches like Zmijewski's outperform MDA-based models when analyzing data that deviates from normal distribution, a condition common in emerging markets. Additionally, the results suggest that solvency and profitability ratios based on book values are more effective predictors of distress than market-based indicators, especially during periods of financial instability.

This research reinforces the argument that the suitability of bankruptcy prediction models is highly contingent on sectoral characteristics and macroeconomic conditions. The study contributes to existing literature by confirming that traditional models, though foundational, require contextual revalidation when applied in emerging economies. By evidencing the superior performance of the Zmijewski X-Score in Indonesia's property and real estate firms, this research advances the understanding of how statistical modeling techniques should adapt to the realities of volatile markets, where capital structure, leverage, and liquidity play dominant roles.

The findings also have several practical implications. Adopting the Zmijewski model as an early warning system for investors and creditors can improve credit risk evaluation and enhance investment decision-making. For corporate managers, the model offers a reliable diagnostic tool for monitoring financial stability and guiding strategic restructuring before insolvency occurs. Regulators and policymakers may also use the results to refine financial surveillance systems, enabling them to anticipate systemic risks and strengthen corporate governance frameworks within the capital market.

Because the property and real estate sector plays a key role in Indonesia's economic growth and job creation, accurately identifying financial distress is crucial for maintaining

market confidence and preventing systemic disruptions. This study underscores the importance of continuously testing and recalibrating predictive models, particularly during periods of economic uncertainty, rising interest rates, and shifting consumer demand.

In summary, this study concludes that the Zmijewski X-Score model is the most accurate and theoretically consistent method for predicting financial distress in Indonesia's property and real estate sector from 2020 to 2024. Its dominance across volatile market conditions validates that traditional financial ratio analysis remains a relevant and valuable tool when applied within the appropriate economic and sectoral context.

LIMITATION

This study has several limitations. First, the models were originally developed for different economic environments and sectors, which could limit their applicability to Indonesia's property industry. Second, their assumptions, based on data from the 1960s to 2000s, may not fully reflect the dynamics of the 2020–2024 period, especially the effects of COVID-19. Third, the findings are specific to the 30 sampled companies and might not be generalizable to other industries or markets. Future research could address these issues by testing models in various sectors, updating assumptions for current conditions, and increasing sample sizes.

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DECLARATION OF CONFLICTING INTERESTS

The authors confirm that they have no connections with or roles in any organization or entity with a financial or non-financial interest in the subject matter or materials discussed in this paper.

REFERENCES

- Altman, E. I. (1968). Financial ratios, discriminant analysis, and the prediction of corporate bankruptcy. *The Journal of Finance*, 23(4), 589–609. <https://doi.org/10.2307/2978933>
- Ambarwati, S. D. A., Haryono, S. T., Fatmayuni, I. A., Nusanto, G., & Sukarno, A. (2025). Survival analysis: The impact of key factors on financial distress and longevity of real estate firms listed on the Indonesia Stock Exchange, with inflation as a moderating variable (2014–2023). *The Indonesian Accounting Review*, 15(1), 47–58. <https://doi.org/10.14414/tiar.v15i1.4917>
- Amelia, P., & Setiawan, C. (2022). Predicting financial distress using DEA and multivariate discriminant for tourism, restaurant, and hotel sector in Indonesia. *Journal of International Conference Proceedings*, 5(4), 172–184. <https://doi.org/10.32535/jicp.v5i4.1936>
- Anisah, D. A., Delilah, L. N., & Maiyaliza. (2025). Financial distress analysis and comparison of Altman Z-score, Springate, and Grover models at PT Sritex for the period 2019-2023. *Journal of Management Small and Medium Enterprises (SMEs)*, 18(2), 1225–1235. <https://doi.org/10.35508/jom.v18i2.21263>
- Awwaliyah, I. N., Widodo, R., Singgih, M., Susanto, A. B., & Prajitiasari, E. D. (2024). Financial metrics for distress prediction in Indonesia's property and real estate sector. *Advances in Economics, Business and Management Research*, 189–202. https://doi.org/10.2991/978-94-6463-585-0_14
- Balcaen, S., & Ooghe, H. (2006). 35 years of studies on business failure: An overview of

- the classic statistical methodologies and their related problems. *The British Accounting Review*, 38(1), 63–93. <https://doi.org/10.1016/j.bar.2005.09.001>
- Bank Indonesia. (2025). *Survei Harga properti Residensial di Pasar Primer Triwulan IV 2024*. Bank Indonesia. https://www.bi.go.id/id/publikasi/laporan/Pages/SHPR_Tw_IV_2024.aspx
- Central Agency of Statistics of Indonesia (BPS Indonesia). (2025). *Badan Pusat Statistik Indonesia*. BPS Indonesia. <https://www.bps.go.id/id>
- Duricova, L., Kovalova, E., Gazdíková, J., & Hamranova, M. (2025). Refining the best-performing V4 financial distress prediction models: Coefficient re-estimation for crisis periods. *Applied Sciences*, 15(6), 2956. <https://doi.org/10.3390/app15062956>
- Elviani, S., Simbolon, R., Riana, Z., Khairani, F., Dewi, S. P., & Fauzi, F. (2020). The Accuracy of the Altman, Ohlson, Springate and Zmijewski models in bankruptcy predicting trade sector companies in Indonesia. *Budapest International Research and Critics Institute (BIRCI-Journal: Humanities and Social Sciences*, 3(1), 334–347. <https://doi.org/10.33258/birci.v3i1.777>
- Fadia, N. A., & Simon, Z. Z. (2024). Evaluating precision: Comparing Altman, Springate, Zmijewski, and Grover models in financial distress prediction. *Taxation and Public Finance*, 2(1), 1–12. <https://doi.org/10.58777/tpf.v2i1.284>
- Fauzi, S. E., Sudjono, S., & Saluy, A. B. (2021). Comparative analysis of financial sustainability using the Altman Z-Score, Springate, Zmijewski, and Grover models for companies listed at the Indonesia Stock Exchange Sub-Sector Telecommunication period 2014 – 2019. *Journal of Economics and Business*, 4(1). <https://doi.org/10.31014/aior.1992.04.01.321>
- Giriūniene, G., Giriūnas, L., Morkunas, M., & Brucaite, L. (2019). A comparison on leading methodologies for bankruptcy prediction: The case of the construction sector in Lithuania. *Economies*, 7(3), 82. <https://doi.org/10.3390/economies7030082>
- Global Property Guide. (2025). Indonesia: Bali Booms, Jakarta Stable. *Global Property Guide*. <https://www.globalpropertyguide.com/Asia/Indonesia/Price-History>
- Grover, J. (2001). *Financial ratios, discriminant analysis, and the prediction of corporate bankruptcy: A service industry extension of Altman's Z-Score model of bankruptcy prediction* [Doctoral dissertation, Nova Southeastern University]. Nova Southeastern University.
- Hantono, H. (2019). Predicting financial distress using Altman score, Grover score, Springate score, and Zmijewski score (case study on consumer goods company). *Accountability*, 8(1), 1. <https://doi.org/10.32400/ja.23354.8.1.2019.1-16>
- Hariyani, D. S., & Sujianto, A. (2018). Analisis perbandingan model Altman, model Springate, dan model Zmijewski dalam memprediksi kebangkrutan bank Syariah di Indonesia. *Inventory: Jurnal Akuntansi*, 1(1), 13. <https://doi.org/10.25273/inventory.v1i1.2289>
- Hesi, T., & Zelmiyanti, R. (2024). Analisis perbandingan model Springate dan Altman Z-Score terhadap potensi financial distress sektor properti & real estate di Indonesia tahun 2018-2022. *Journal of Applied Managerial Accounting*, 8(2), 277–289. <https://doi.org/10.30871/jama.v8i2.7908>
- Husein, M. F., & Pambekti, G. T. (2015). Precision of the models of Altman, Springate, Zmijewski, and Grover for predicting the financial distress. *Journal of Economics, Business & Accountancy Ventura*, 17(3), 405. <https://doi.org/10.14414/jebav.v17i3.362>
- Intansari, N. P. D., Sudrajat, N., & Azhar, R. (2023). Comparison of the Grover, Zmijewski, and Springate methods in predicting financial distress (case study of pharmaceutical companies listed on the IDX 2019-2021). *Asian Journal of Economics and Business Management*, 2(1), 335–341. <https://doi.org/10.53402/ajebm.v2i1.264>

- Jariah, A., Irdiana, S., & Lukiana, N. (2024). Accuracy of bankruptcy predictions of real estate companies in Indonesia based on the Altman, Springate, Zmijewski, and Grover models. *Assets: Jurnal Ilmiah Ilmu Akuntansi, Keuangan Dan Pajak*, 8(2), 92–101. <https://doi.org/10.30741/assets.v8i2.1317>
- Kamaluddin, A., Ishak, N., & Mohammed, N. F. (2019). Financial distress prediction through cash flow ratios analysis. *International Journal of Financial Research*, 10(3), 63. <https://doi.org/10.5430/ijfr.v10n3p63>
- Kamila, N., Ferli, O., Putri Destania, K., Permata Sari, L., & Aisy Salma, P. (2024). Measuring financial distress in the property and real estate sector listed on the Indonesian stock exchange. *OIKOS: Jurnal Kajian Pendidikan Ekonomi Dan Ilmu Ekonomi*, 9(1).
- Kanapickienė, R., Kanapickas, T., & Nečiūnas, A. (2023). Bankruptcy prediction for micro and small enterprises using financial, non-financial, business sector and macroeconomic variables: The case of the Lithuanian construction sector. *Risks*, 11(5), 97–97. <https://doi.org/10.3390/risks11050097>
- Kovacova, M., Klietk, T., Valaskova, K., Durana, P., & Juhaszova, Z. (2019). Systematic review of variables applied in bankruptcy prediction models of Visegrad group countries. *Oeconomia Copernicana*, 10(4), 743–772. <https://doi.org/10.24136/oc.2019.034>
- Kristanti, F. T. (2019). *Financial Distress Teori dan Perkembangannya Dalam Konteks Indonesia*. Inteligencia Media.
- Manda, G. S., Muhammad, R. F., Putra, A. S., Megawati, L., & Anggraeni, G. P. (2024). Comparative analysis of financial distress by using the bankruptcy prediction model. *Advances in Economics, Business and Management Research*, 193–199. https://doi.org/10.2991/978-94-6463-443-3_28
- Manda, T. A. (2024). Bankruptcy Prediction in REITs. *International Real Estate Review*, 27(1), 139–167.
- Mann, H. B., & Whitney, D. R. (1947). On a test of whether one of two random variables is stochastically larger than the other. *The Annals of Mathematical Statistics*, 18(1), 50–60. <https://doi.org/10.1214/aoms/1177730491>
- Martini, R., Aksara, R. R., Sari, K. R., Zulkifli, Z., & Hartati, S. (2023). Comparison of financial distress predictions with Altman, Springate, Zmijewski, and Grover models. *Golden Ratio of Finance Management*, 3(1), 11–21. <https://doi.org/10.52970/grfm.v3i1.216>
- Mselmi, N., Lahiani, A., & Hamza, T. (2017). Financial distress prediction: The case of French small and medium-sized firms. *International Review of Financial Analysis*, 50(50), 67–80. <https://doi.org/10.1016/j.irfa.2017.02.004>
- Muchson, M. (2017). *Statistik Deskriptif*. Spasi Media.
- Oktafiraningsih, O., & Suryaningsum, S. (2024). Financial distress prediction analysis using Altman Z-Score, Grover and Zmijewski models in property and real estate sector companies listed on the Indonesia Stock Exchange for the 2020-2023 period. *Count: Journal of Accounting, Business and Management*, 2(3), 204–211. <https://doi.org/10.61677/count.v2i3.313>
- Pinhome. (2024). *Indonesia Residential Market Report 2024 & Outlook 2025*. Pinhome. <https://www.pinhome.id/research/market-report/en/indonesia-residential-market-report-2024-and-outlook-2025>
- Putri, I. T., Hadiwibowo, I., & Azis, M. T. (2023). Springate, Ohlson, Altman Z-Score, Zmijewski, Grover, CA Score model of financial distress analysis in retail companies. *AFEBI Economic and Finance Review*, 8(2), 89-102.
- Saptutyningsih, E., & Setyaningrum, E. (2020). *Penelitian Kuantitatif Metode dan Alat Analisis*. Gosyen Publishing.
- Saraswati, R. A., Ratnawati, A., & Irawan, T. (2024). Determinants of financial distress in property and real estate companies listed on the Indonesian Stock Exchange: *Jurnal Ekonomi dan Kebijakan Pembangunan*, 13(2), 80–92.

- <https://doi.org/10.29244/jekp.13.2.2024.80-92>
- Setiawan, C., & Rafiani, T. T. (2021). *Financial distress prediction models: Case study of textile industry in Indonesia*. President University Repository. <http://repository.president.ac.id/xmlui/handle/123456789/10668>
- Springate, G. L. (1978). Predicting the possibility of failure in a Canadian firm. *Unpublished MBA Research Project, Simon Fraser University*, 1.
- Sumajow, K. C., Kalangi, L., & Weku, P. (2022). The effect of financial distress, audit committee, auditor switching, and industry types on audit delay in the COVID-19 pandemic of companies listed on the Indonesian Stock Exchange's KOMPAS100 Index. *International Journal of Accounting and Finance in Asia Pasific*, 5(1). <https://doi.org/10.32535/ijafap.v5i1.1406>
- Tapia, C. E. F., & Cevallos, K. L. F. (2022). Kruskal-Wallis, Friedman and Mood nonparametric tests applied to business decision making. *Espirales Revista Multidisciplinaria De Investigación*, 6(43). <https://doi.org/10.31876/er.v6i43.827>
- Toudas, K., Archontakis, S., & Boufounou, P. (2024). Corporate bankruptcy prediction models: A comparative study for the construction sector in Greece. *Computation*, 12(1), 9–9. <https://doi.org/10.3390/computation12010009>
- Ulfah, H. K., & Moin, A. (2022). Predicting financial distress using Altman Z-Score, Springate S-Score and Zmijewski X-Score on tobacco companies in the Indonesia Stock Exchange. *Selekta Manajemen: Jurnal Mahasiswa Bisnis & Manajemen*, 1(2), 159-169.
- Wulandari, E., & Fauzi, I. (2022). Analisis perbandingan potensi kebangkrutan dengan Model Grover, Altman Z-Score, Springate dan Zmijewski pada perusahaan real estate dan property di Bursa Efek Indonesia. *Ekonomi, Keuangan, Investasi Dan Syariah (EKUITAS)*, 4(1), 109–117. <https://doi.org/10.47065/ekuitas.v4i1.1743>
- Yendrawati, R., & Adiwafi, N. (2020). Comparative analysis of Z-Score, Springate, and Zmijewski models in predicting financial distress conditions. *Journal of Contemporary Accounting*, 2(2), 72–80. <https://doi.org/10.20885/jca.vol2.iss2.art2>
- Zmijewski, M. E. (1984). Methodological issues related to the estimation of financial distress prediction models. *Journal of Accounting Research*, 22(22), 59–82. <https://doi.org/10.2307/2490859>

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