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Comparative Analysis of Zmijewski and Grover Methods in Predicting Financial Distress of Islamic Banks in Indonesia

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Abstract

This study is motivated by Indonesia's economic instability, which has led to a rise in problematic financing within Islamic banking. Given the fluctuating nature of real-based financing, an early prediction model is needed to minimize the negative impact of financial distress. This research aims to analyze and compare the accuracy of the Zmijewski and Grover models in predicting financial distress among Islamic Commercial Banks registered with the Financial Services Authority (OJK) during the 2014-2023 period. A descriptive quantitative approach was employed using secondary data from annual financial reports of five purposively selected banks. Data analysis involved descriptive statistics, normality tests, Wilcoxon Signed Ranks test, accuracy rate, and type error measurement. The findings reveal a significant difference between the two models. The Zmijewski model achieved 76% accuracy with a 24% type error, while the Grover model reached perfect accuracy of 100% with no error. These results indicate that the Grover model provides a more accurate tool for predicting financial distress and offers practical implications for risk management in Islamic banking.

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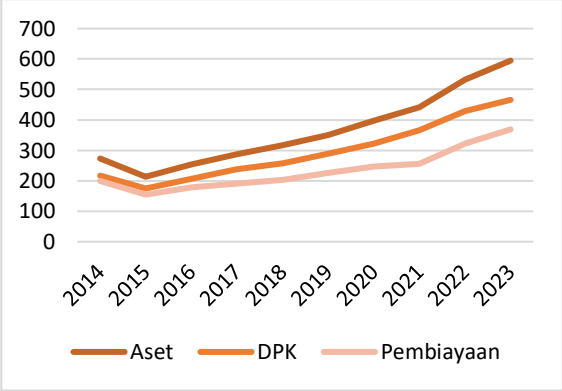
INTRODUCTION

The rapid development of financial institutions in Indonesia has intensified competition, not only among conventional banks but also among Islamic financial institutions. This increasing rivalry underscores the need for every financial institution, particularly Islamic banks, to offer consistent and high-quality services to retain customer loyalty and ensure sustainable growth (Hana et al., 2022). Islamic banking in Indonesia is perceived as resilient during economic crises, as evidenced by its relatively strong performance during the 1998 Asian financial crisis and the 2008 global financial crisis (Ambo Masse et al., 2024). Despite its potential, the Islamic banking sector still faces significant operational risks, one of which is the rise in non-performing financing (NPF), which reflects the proportion of troubled financing.

Chart 1. Sharia Banking Growth 2014-2023

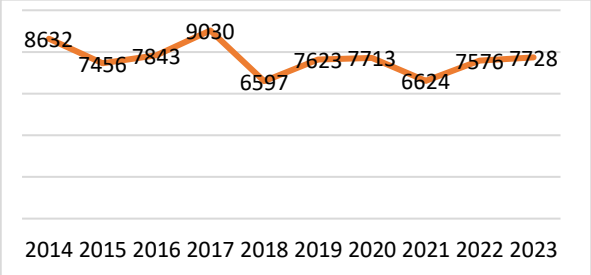


Source: OJK, data processed 2025.

The growth of assets, third-party funds (*DPK*), and financing reflects positive progress in the development of Sharia Commercial Banks. However, this is contrasted by the rise in Non-Performing Financing (*NPF*), which indicates an increase in problematic financing within the sector. Elevated levels of *NPF* can significantly impact the productivity of Islamic banks. Although Islamic banks are often regarded as resilient during economic crises, their financial health is ultimately determined by the effectiveness of their internal management. If these institutions fail to manage and reduce their NPF levels, they may be exposed to a range of operational risks that could lead to financial distress.

Fluctuations in the number of Islamic Commercial Banks (BUS) from 2014 to 2023, as recorded by the Financial Services Authority (OJK), also highlight structural and performance-related challenges. While the sector experienced growth until 2021, a major consolidation through the merger of several Islamic banks into PT Bank Syariah Indonesia, Tbk reduced the number of Islamic Commercial Banks by 2023.

Chart 2. Non-Performing Financing (NPF) Level of Islamic Commercial Banks 2014-2023 (Billion Rp)



Source: OJK, data processed 2025

Persistent fluctuations in Non-Performing Financing (NPF) levels sharia banks raise concerns about financial stability and indicate inefficiencies in risk management, which can undermine a bank's productivity and profitability. These risks are further exacerbated by Indonesia's broader economic instability, particularly affecting Islamic commercial banks. A higher NPF ratio reflects greater financing risk and is often associated with a decline in profitability, as measured by Return on Assets (ROA) (Yuniar et al., 2022).

Due to the real-sector-based nature of Islamic banking, financing performance tends to follow macroeconomic fluctuations, making early detection of financial distress essential for maintaining overall banking stability. This study is grounded in *signal theory*, which posits that financial ratios serve as early indicators of corporate health and financial distress (Spence, 1973). Financial distress refers to a situation where a firm is unable to meet its financial obligations, which may lead to bankruptcy if not addressed (Putri & Mulyani, 2019). In the context of financial institutions, especially banks, such conditions can disrupt intermediation functions and negatively impact economic activity. Therefore, early identification of financial distress is crucial to anticipate losses, performance degradation, and potential insolvency.

Islamic Commercial Banks in Indonesia, such as PT BCA Syariah, PT Bank Muamalat Indonesia, PT Bank Mega Syariah, PT BTPN Syariah, and PT Bank Aceh Syariah, exhibit varying levels of profitability, leverage, and liquidity. This variation underscores the importance of applying appropriate analytical tools to assess financial vulnerability.

To address this need, several financial distress prediction models have been developed. Among the most recognized are the Zmijewski and Grover models, both of which utilize different sets of financial ratios, such as profitability, leverage, and liquidity metrics to assess a firm's risk of financial distress. The Zmijewski model uses Return on Assets (ROA), Debt Ratio, and Current Ratio, while the Grover model includes Earnings Before Interest and Taxes to Total Assets (EBITTA), ROA, and Working Capital to Total Assets (WCTA). The Zmijewski Model (1984) is a bankruptcy prediction model developed using the probit technique in its calculation indicators. The Grover Model (2001), on the other hand, was developed through a design and revision process based on the Altman Z-Score model. While these models have been widely applied in the

context of conventional companies, their application to Islamic commercial banks in Indonesia remains limited.

Among various bankruptcy prediction models, the Zmijewski and Grover models were selected due to their distinct methodological foundations and relevance to banking institutions. The Zmijewski model emphasizes financial distress through profitability, leverage, and liquidity using a probit approach, while the Grover model is a refined extension of the Altman Z-Score, incorporating measures of long-term solvency and operational efficiency.

While other models are widely used in bankruptcy studies, they were originally developed for manufacturing and service companies in Western economies. Their application in the context of Islamic commercial banks in Indonesia may not fully capture the characteristics of Sharia-compliant financial operations. Therefore, this study focuses on comparing Zmijewski and Grover as representative models with contrasting analytical emphasis.

Previous studies, such as those by Prasetianingtias & Kusumowati (2019), Helastica & Paramita (2020), Fathiyati et al (2021), and Octavera & Syafel (2022), applied Zmijewski and Grover models in non-financial firms. However, limited empirical evidence is available regarding their implementation in Islamic commercial banks in Indonesia. This gap presents an opportunity to assess the models' relevance and accuracy in a *sharia*-compliant context.

This study aims to fill that gap by applying and comparing the accuracy of the Zmijewski and Grover models in predicting financial distress among Islamic Commercial Banks in Indonesia registered with the Financial Services Authority (OJK) during the 2014-2023 period. By analyzing relevant financial indicators, the research seeks to determine which model offers greater predictive power and provides effective early warning signals to support the sustainability of Islamic banks in Indonesia.

Although various financial distress prediction models have been widely studied, there is limited comparative research applying both Zmijewski and Grover models specifically to Islamic Commercial Banks in Indonesia. Previous studies tend to focus on either one model or on conventional banks, thus lacking insight into their effectiveness in Sharia-based financial institutions. This research seeks to fill that gap by providing a direct comparison using real data from Islamic banks, aiming to evaluate which model aligns best with their operational and risk characteristics.

The Zmijewski model (1984) is a bankruptcy prediction tool using probit analysis, which assesses a firm's financial distress risk based on profitability (ROA), leverage (Debt Ratio), and liquidity (Current Ratio). Firms with X-Score > 0 are considered financially distressed. The model has been validated through prior studies and is known for its conservative risk assessment (Ningsih & Permatasari, 2019). The Zmijewski model equation (X-Score) is as follows:

$$\text{X-Score} = -4.3 - 4.5X1 + 5.7X2 + 0.004X3$$

Where:

- X_1 = Return on Assets (ROA) = Net Income / Total Assets

- X_2 = Leverage (Debt Ratio) = Total Debt / Total Assets
- X_3 = Liquidity (Current Ratio) = Current Assets / Current Liabilities

The Grover model (2001) was adapted from the Altman Z-Score and emphasizes long-term solvency using working capital, EBIT to total assets, and ROA. A G-Score ≤ -0.02 signals distress, while ≥ 0.01 indicates financial health. It is considered more tolerant toward short-term financial fluctuations (Ningsih & Permatasari, 2019). The Grover model equation (G-Score) is as follows:

$$G\text{-}Score=1.650X1+3.404X2+0.016ROA+0.057$$

Where:

- X_1 = Working Capital / Total Assets
- X_2 = Earnings Before Interest and Tax (EBIT) / Total Assets
- ROA (X_3) = Return on Assets = Net Income / Total Assets

Based on the background described above, the research questions formulated in this study are as follows: How do the Zmijewski and Grover models perform in predicting financial distress among Islamic Commercial Banks in Indonesia that are registered with the Financial Services Authority (OJK) during the 2014-2023 period?, Is there a significant difference between the Zmijewski and Grover models in predicting financial distress among Islamic Commercial Banks in Indonesia that are registered with the Financial Services Authority (OJK) during the 2014-2023 period?, Which predictive model is the most accurate in forecasting financial distress among Islamic Commercial Banks in Indonesia that are registered with the Financial Services Authority (OJK) during the 2014-2023 period?.

Based on the background and research questions presented above, the hypotheses in this study are formulated as follows: H_1: There is a significant difference in the financial distress prediction scores between the Zmijewski and Grover models applied to Islamic Commercial Banks in Indonesia registered with the Financial Services Authority (OJK) during the 2014-2023 period. H_2: The Grover model demonstrates a higher level of accuracy compared to the Zmijewski model in predicting financial distress among Islamic Commercial Banks in Indonesia registered with the Financial Services Authority (OJK) during the 2014-2023 period.

METHOD

This study applies a quantitative descriptive approach (Sugiyono, 2018) to examine the financial distress prediction of Islamic commercial banks in Indonesia using the Zmijewski and Grover models. The research aims to assess the predictive accuracy of both models by analyzing financial ratio data over a ten-year period. The population in this study is the Islamic Commercial Banks in Indonesia registered with the Financial Services Authority (OJK) during the period of 2014-2023, amounts 13 banks. The sampling technique in this study used purposive sampling. The criteria for sample selection are Islamic commercial banks registered with Bank Indonesia

and the Financial Services Authority (OJK), and Islamic commercial banks that publish complete financial statements on their official websites during the 2014-2023 period.

The study employs quantitative secondary data obtained from the published annual financial statements of Islamic commercial banks registered with the Financial Services Authority (OJK) for the period 2014-2023, which were accessed through official bank websites and OJK publications. The data collection method in this study was obtained from the documentation. The data was obtained through various internet sources provided on the official websites of each bank. The collected data consists of the financial statements of Islamic commercial banks registered with the Financial Services Authority (OJK) for the period 2014-2023.

The variables analyzed in this study include financial distress as the dependent variable, and financial ratios derived from the Zmijewski and Grover models as the independent variables. Data analysis was performed using SPSS version 26, which facilitated the descriptive statistical analysis, a normality test, and a hypothesis test using the Wilcoxon Signed-Rank Test and an accuracy level test.

RESULT AND DISCUSSION

Description of Research Sample

The secondary research data consists of annual financial statements from 2014 to 2023 of 13 banks registered with the Financial Services Authority (OJK). The samples were obtained using a purposive sampling method based on predetermined criteria. The sample selection process is explained in more detail in the table below:

Table 1. Sample Criteria

No.	Criteria	Total
1	Islamic commercial banks officially registered with Bank Indonesia and the Financial Services Authority (OJK).	13
2	Islamic commercial banks that did not publish complete financial statements during the 2014-2023 period on their official websites.	(8)
Total research samples used		5

Based on Table 1 above, it can be seen that the research population consisted of 13 banks, which was then narrowed down to 5 banks that were designated as the research sample. The list of banks included as the research sample is presented in the table below:

Table 2. List of Banks that Become Sample

No.	Name of Islamic Commercial Bank
1	PT. BCA Syariah
2	PT. Bank Muamalat Indonesia
3	PT. Bank Mega Syariah
4	PT. BTPN Syariah
5	PT. Bank Aceh Syariah

Description of Research Data

The following presents the results of bankruptcy prediction analysis based on each measurement model, as outlined below.

a. Measurement Results of the Zmijewski Model

The equation of the Zmijewski Model (X-Score) is as follows:

$$\text{X-Score} = -4.3 - 4.5X1 + 5.7X2 - 0.004X3 \quad (1)$$

Notes:

X_1 = Return on Assets (ROA) = Net Income / Total Assets

X_2 = Leverage (Debt Ratio) = Total Debt / Total Assets

X_3 = Liquidity (Current Ratio) = Current Assets / Current Liabilities

The results of calculations using the Zmijewski Model (X-Score) as shown in the following table.

Table 3. Zmijewski Model Calculation Results (X-Score) 2014-2023

No	Code	Category									
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1	BCAS	S	S	S	S	S	S	S	S	S	S
2	BMI	S	S	S	S	S	S	S	S	S	S
3	BMS	FD	FD	S	S	FD	FD	FD	FD	FD	FD
4	BTPNS	S	S	S	S	FD	FD	S	S	S	S
5	BAS	FD	FD	S	S	S	S	S	S	S	S

Source: Processed data, 2025.

The content of the table above shows that there are three Islamic commercial banks in Indonesia registered with the Financial Services Authority (OJK) that have scores above the cut-off value (Z-Score), which is greater than 0 (> 0). These include PT Bank Mega Syariah Tbk (BMS) in the years 2014-2015 and 2018-2023, PT Bank Tabungan Pensiunan Nasional Syariah Tbk (BTPNS) in 2018 and 2019, and PT Bank Aceh Syariah Tbk (BAS) in 2014 and 2015. This indicates that the three banks are predicted to be in a condition heading toward bankruptcy, which may be due to low profitability, high leverage, or low liquidity.

b. Measurement Results of the Grover Model

The equation of the Grover Model (G-Score) is as follows:

$$\text{G-Score} = 1.650X_1 + 3.404X_2 + 0.016\text{ROA} + 0.057 \quad (2)$$

Notes:

X_1 = Working Capital / Total Assets

X_2 = Earnings Before Interest and Taxes / Total Assets

ROA = Return on Assets = Net Income / Total Assets

The results of calculations using the Grover Model (G-Score) as shown in the following table.

Table 4. Grover Model Calculation Results (X-Score) 2014-2023

No	Code	Category									
		2014	2015	2016	2017	2018	2019	2020	2021	2022	2023

1	BCAS	S	S	S	S	S	S	S	S	S	S
2	BMI	S	S	S	S	S	S	S	S	S	S
3	BMS	S	S	S	S	S	S	S	S	S	S
4	BTPNS	S	S	S	S	S	S	S	S	S	S
5	BAS	S	S	S	S	S	S	S	S	S	S

Source: Processed data, 2025.

The content of the table above shows that none of the Islamic commercial banks in Indonesia registered with the Financial Services Authority (OJK) have scores below the cut-off value (G-Score), which is less than or equal to -0.02 (≤ -0.02). This indicates that all five banks have average scores equal to or above the cut-off value (G-Score), namely greater than or equal to 0.01 (≥ 0.01), meaning their financial condition is considered healthy based on indicators of long-term business continuity and capital strength. This suggests that all five banks are predicted to be financially healthy and are not expected to experience bankruptcy.

Descriptive Statistics

The descriptive statistics in this study describe the mean, maximum, minimum, and standard deviation values of each variable. The descriptive statistical results for the Zmijewski Model and Grover Model variables are shown in the table below:

Table 5. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ZMIJEWSKI	50	-3.5372	14.0127	-.860708	3.6021981
GROVER	50	.5953	4.6484	1.612990	1.2022946
Valid N (listwise)	50				

Source: IBM SPSS Output Version 26, 2025.

The descriptive statistical results shown in Table 5 above can be explained as follows:

a. The Zmijewski Model consists of a total of 50 data, with a minimum value of 0.595, a maximum value of 14.012, a mean value of -0.861, and a standard deviation of 3.602.
b. The Grover Model also consists of a total of 50 data, with a minimum value of -3.537, a maximum value of 4.648, a mean value of 1.161, and a standard deviation of 1.202.

Normality Test

The normality test used to determine whether the data follow a normal distribution. The results of the normality test with Kolmogorov-Smirnov can be seen in the table below:

Table 6. One Sample Kolmogorov-Smirnov Test Result

		ZMIJEWSKI	GROVER
N		50	50
Normal Parameters[a,b]	Mean	-.860708	1.612990
	Std. Deviation	3.6021981	1.2022946
Most Extreme Differences	Absolute	.265	.317
	Positive	.265	.317

	Negative	-.229	-.199
Test Statistic		.265	.317
Asymp. Sig. (2-tailed)		.000[c]	.000[c]
a. Test distribution is Normal.			
b. Calculated from data.			
c. Lilliefors Significance Correction.			

Source: IBM SPSS Output Version 26, 2025.

The normality test results shown in Table 6 indicate that all variable data have significance values less than 0.05. Therefore, it can be concluded that the data distribution is not normal. Consequently, hypothesis testing can be conducted using the non-parametric Wilcoxon Signed Ranks Test (Ghozali, 2018).

Hypothesis Test

Hypothesis test was conducted using the non-parametric Wilcoxon Signed Ranks Test. The decision-making for the Wilcoxon Signed Ranks Test is based on the following criteria: If the asymp. sig. (2-tailed) > α (0.05), there is no significant difference between the two models; however, if the asymp. sig. (2-tailed) < α (0.05), there is a significant difference between the two models. The following results of hypothesis testing with the Wilcoxon Signed Ranks Test can be seen as follows:

Table 7. Wilcoxon Signed Ranks Test Result

Test Statistics[a]	
	GROVER - ZMIJEWSKI
Z	-4.214[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Source: IBM SPSS Output Version 26, 2025.

The Wilcoxon Signed Ranks Test resulted shown in Table 7 indicate that Asymp. Sig. (2-tailed) value of 0.000, which is less than α = 0.05. This result indicates a significant difference between the financial distress scores generated by the Zmijewski and Grover models.

Accuracy Level and Type Error Tests

The calculation of accuracy level and types of errors was conducted after obtaining the results from each method, which include the Zmijewski and Grover models.

a. Accuracy and Type Error Test Results of the Zmijewski Model

Table 8. Calculation of Accuracy Level and Type Error Zmijewski Model

Description	Prediction		Total
	Distress	*Non-Distress*	
Zmijewski Model Calculation	12	38	50
Actual Condition: Non-Distress			50

Accuracy Rate	76%
Type Error	24%

Source: Processed data, 2025.

Calculation:

Accuracy Rate = $\frac{38}{50}$ *x* 100% = 76%

Type Error = $\frac{12}{50}$ *x* 100% = 24%

Based on the analysis conducted on five banks (Table 8), the Zmijewski Model shows an accuracy rate of 76% in predicting financial distress among five Islamic commercial banks registered with the Financial Services Authority (OJK) over a 10-year period (50 data points). All actual data indicated that no banks experienced financial distress. The model correctly classified 38 data points as healthy, while 12 were misclassified, resulting in a 24% type error rate.

b. Accuracy and Type Error Test Results of the Grover Model

Table 9. Calculation of Accuracy Level and Type Error Grover Model

Description	Prediction		Total
	Distress	*Non-Distress*	
Zmijewski Model Calculation	0	50	50
Actual Condition: Non-Distress			50
Accuracy Rate	100%		
Type Error	0%		

Source: Processed data, 2025.

Calculation:

Accuracy Rate = $\frac{50}{50}$ *x* 100% = 100%

Type Error = $\frac{0}{50}$ *x* 100% = 0%

Based on the analysis conducted on five banks (Table 9), the Grover Model shows an accuracy rate of 100% in predicting financial distress among five Islamic commercial banks registered with the Financial Services Authority (OJK) over a 10-year period (50 data points). All data indicated healthy financial conditions, with no misclassifications, resulting in a 0% type error rate.

DISCUSSION

Calculation Results of the Zmijewski and Grover Models in Predicting Financial Distress

The results of financial distress prediction models applied to Islamic commercial banks in Indonesia registered with the Financial Services Authority (OJK) for the 2014-2023 period show varying outcomes. The Zmijewski Model indicated that two banks were financially healthy, while three banks: PT Bank Mega Syariah Tbk, PT Bank Tabungan Pensiunan Nasional Syariah Tbk, and PT Bank Aceh Syariah Tbk recorded Z-Scores above the cut-off (> 0), suggesting potential financial distress. This model highlights a firm's ability to manage liabilities, and distress predictions were

associated with high current liabilities exceeding current assets, implying liquidity risk. Meanwhile, the Grover Model consistently classified all five sampled banks as financially sound throughout the period. All banks recorded G-Scores equal to or above 0.01 (≥ 0.01), indicating no signs of financial distress.

Comparison Results of the Zmijewski and Grover Models in Predicting Financial Distress

The analysis reveals a statistically significant difference between the Zmijewski and Grover models in predicting financial distress, as evidenced by the Wilcoxon Signed Ranks Test (Asymp. Sig. = 0.000 < 0.05). This discrepancy stems from differences in the financial ratios and cut-off values employed by each model. The Zmijewski model, which emphasizes return on assets, debt ratio, and current ratio, tends to be more conservative in identifying distress conditions. Conversely, the Grover model, which utilizes working capital to total assets and EBIT to total assets alongside return on assets, reflects a greater tolerance for financial fluctuations and focuses on long-term solvency.

Despite both models incorporating the same number of ratios and sharing return on assets as a common indicator, the prediction outcomes differ significantly. The Zmijewski model classifies more banks as financially distressed compared to the Grover model. This indicates that the two models have distinct levels of sensitivity and analytical focus, resulting in divergent interpretations of the same financial data.

The Wilcoxon Signed Ranks Test between the Zmijewski and Grover models yielded an Asymp. Sig. value of 0.000 (< 0.05), indicating a significant difference in financial distress prediction scores between the two models for Islamic commercial banks in Indonesia registered with the Financial Services Authority (OJK) during the 2014–2023 period. Therefore, the alternative hypothesis (H_1), which states that there is a significant difference in prediction scores between the Zmijewski and Grover models, is accepted.

These findings carry important practical implications. For bank regulators and policymakers, the selection of a predictive model should consider the type of financial risk being prioritized. The Grover model, which focuses on profitability and long-term solvency, may be more suitable for identifying efficiency and sustainability concerns in Islamic banks. In contrast, the Zmijewski model is more sensitive to short-term liquidity and leverage issues, making it useful in early detection of potential crises stemming from operational inefficiencies or sudden financial shocks.

Furthermore, for investors and internal risk management teams, the differences in model sensitivity underscore the importance of using multiple perspectives when assessing the financial health of banks. Relying solely on one model may lead to over- or underestimation of actual risk exposure. These insights can guide the design of more robust early warning systems and inform strategic decisions in capital allocation, risk mitigation, and compliance planning. On a theoretical level, the results support the notion that bankruptcy prediction models are not one-size-fits-all;

their effectiveness is context-dependent and influenced by institutional characteristics and financial structures, especially in dual-banking systems like Indonesia.

The Highest Accuracy Results of Financial Distress Prediction Models

The accuracy results reflect each model's ability to predict financial distress based on the actual conditions of Islamic Commercial Banks in Indonesia. A higher accuracy rate indicates a model's stronger alignment with real financial conditions, while a lower accuracy rate suggests limitations in its predictive capability. The Grover Model demonstrated the highest accuracy at 100%, with no prediction errors (0% type error), indicating strong reliability in assessing the financial health of the sampled banks. In contrast, the Zmijewski Model achieved a lower accuracy rate of 76%, with a 24% type error rate, the highest among the two models.

Furthermore, the Grover Model proved to be an effective bankruptcy prediction tool, as it consistently generated positive average scores across all observations, suggesting that all sampled banks were in a healthy financial condition and did not experience bankruptcy during the study period. These findings align with the actual conditions in the Indonesian Islamic banking sector. Therefore, the alternative hypothesis (H_2), which states that the Grover model demonstrates a higher level of accuracy than the Zmijewski model in predicting financial distress in Islamic Commercial Banks in Indonesia registered with the Financial Services Authority (OJK) for the 2014–2023 period, is accepted.

CONCLUSION

This study examined the comparative accuracy of the Zmijewski and Grover models in predicting financial distress among Islamic commercial banks in Indonesia registered with the Financial Services Authority (OJK) during the 2014–2023 period. The findings indicate that the Zmijewski Model identified three banks, PT Bank Mega Syariah Tbk, PT BTPN Syariah Tbk, and PT Bank Aceh Syariah Tbk as potentially distressed due to low profitability, high leverage, and poor liquidity, while the other two banks were considered financially healthy. In contrast, the Grover Model consistently classified all five banks as financially sound throughout the period, suggesting better long-term solvency and capital resilience.

Statistical testing using the Wilcoxon Signed Ranks Test confirmed a significant difference between the two models (Asymp. Sig. = 0.000 < 0.05), indicating that the models provide distinct outcomes due to their different analytical focuses. Furthermore, the Grover Model demonstrated superior predictive accuracy, achieving 100% with no misclassification errors, while the Zmijewski Model showed 76% accuracy, implying that the Grover Model is more reliable in assessing financial health in this context.

Theoretically, this research contributes to the understanding of bankruptcy prediction models in Islamic banking and highlights the importance of selecting appropriate indicators for different financial environments. Practically, the findings offer valuable insights for regulators, investors, and bank management in using early warning tools to monitor financial risks. However,

the study is limited by its sample size and focus on a single banking segment in Indonesia. Future research is encouraged to expand the sample size, incorporate qualitative factors, or apply the models in different financial contexts to enhance generalizability.

Despite its contributions, this study acknowledges several limitations. The sample was limited to five Islamic banks due to data availability, which may restrict the generalizability of the findings. In addition, the study focused solely on two prediction models, Zmijewski and Grove, excluding other potentially relevant models, which may limit the breadth of comparison and overlook models that might better fit the characteristics of Islamic banking. Furthermore, the accuracy validation relied on publicly available financial statements, which may not fully capture the internal financial health or managerial decisions of each bank, potentially affecting the reliability of distress assessments. Future research is encouraged to broaden the model comparison and incorporate alternative data sources to enhance predictive validity.

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