

Bankruptcy Prediction in The Indonesia Sharia Stock Index Coal Mining: Altman Z-Score vs Zmijewski X-Score

Trisya Qurota A'yun¹, Clarashinta Canggi²

^{1,2}*Department of Islamic Economics, Universitas Negeri Surabaya, Surabaya, Indonesia*

**Corresponding author: Trisya Qurota A'yun*

Corresponding email: trisyaqurota.22081@mhs.unesa.ac.id

ARTICLE INFO

Article history:

Received 12 March 2026

Revised 08 June 2026

Accepted 17 June 2026

Available Online 20 June 2026

Keywords:

Altman Z-Score

Bankruptcy Prediction

Financial Distress

Indonesia Sharia Stock Index

Zmijewski X-Score

Cite as:

A'yun, T. Q., & Canggi, C. (2026). Bankruptcy Prediction in The Indonesia Sharia Stock Index Coal Mining: Altman Z-Score vs Zmijewski X-Score. *Economics, Business, Accounting & Society Review*, 5(2), 310-318. <https://doi.org/10.55980/eba-sr.v5i2.410>

ABSTRACT

Global economic uncertainty, coal price volatility, and energy transition pressures have increased the risk of financial distress among coal mining companies in Indonesia. This study aims to analyze and compare the Altman Z-Score and Zmijewski X-Score methods in predicting bankruptcy among coal mining companies listed on the Indonesia Sharia Stock Index (ISSI) during the 2015–2024 period. This research employs a quantitative approach with a comparative method. The data consist of annual financial statements from 10 companies over 10 years, resulting in 100 observations. The analysis was conducted by calculating bankruptcy scores using both models and evaluating their accuracy, Type I Error, Type II Error, and model consistency through K-Fold Cross Validation. The results show that the Altman Z-Score method achieved an accuracy rate of 94.74%, with a Type II Error of 4.49% and a Type I Error of 16.67%. The Zmijewski X-Score method demonstrated a slightly higher accuracy of 94.85%, with a Type II Error of 4.40% and a Type I Error of 16.67%. Although the accuracy difference is marginal, the Zmijewski X-Score appears more stable, while the Altman Z-Score is more sensitive to changes in companies' financial conditions. Overall, both methods are appropriate for predicting bankruptcy in coal mining companies listed on ISSI; however, their application should be complemented by additional financial analyses to minimize misclassification risk.

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1. Introduction

In recent years, the global economy has been confronted with increasing complexity and uncertainty. Following the recovery period from the global financial crisis, the world faced major disruptions from the COVID-19 pandemic, compounded by prolonged geopolitical conflicts such as the Russia-Ukraine war, global monetary tightening, and international supply chain tensions. In 2020, the global economy contracted sharply, reflecting widespread disruptions in production, trade, and investment (Lukman & Farique, 2024). Although recovery gradually materialized, ongoing energy price instability, global inflationary pressure, and high interest rate policies through 2023–2024 imposed new challenges on businesses, particularly in commodity-based sectors. These conditions increased liquidity risks and narrowed financing access for financially vulnerable companies (di Giovanni & Rogers, 2024), thereby elevating the potential for financial distress and bankruptcy (International Monetary Fund, 2022).

The ramifications of this global uncertainty were strongly felt by the Indonesian economy, a developing nation heavily reliant on commodity exports and foreign investment. The country's GDP contracted by approximately 2.1% in 2020 due to social restrictions and disruptions associated with the COVID-19 pandemic. During the 2022–2024 period, Indonesia showed signs of recovery, yet remained exposed to commodity price volatility, global energy transition pressures, and exchange rate fluctuations. These conditions were particularly important for Indonesia because its economy remains sensitive to movements in major commodity markets, while exchange rate and commodity price fluctuations can affect financial stability and corporate performance (Rizal S et al., 2024; Venessa & Yulfiswandi, 2022).

From a theoretical perspective, such macroeconomic shocks can trigger financial distress through established corporate failure mechanisms. The trade-off theory posits that while debt provides tax shield benefits, excessive leverage increases financial distress and bankruptcy costs, particularly when operating cash flows deteriorate (Marimuthu, 2021; Qin, 2024). When firms experience revenue shocks, the distress process may unfold through a deterioration in profitability and retained earnings. Empirical evidence also shows that high leverage can weaken financial performance, particularly when firms face elevated financial distress risk and adverse macroeconomic conditions (Kalash, 2023). Companies with thin profit margins, high debt dependency, and weak liquidity management become most vulnerable because they lack financial slack to absorb these shocks. These conditions align with findings from Andika and Zulkifli (2024), who demonstrated that bankruptcy risk sensitivity in Indonesia is heavily influenced by debt structure and industry characteristics.

The coal mining sector exemplifies these theoretical vulnerabilities (Rivaldo & Utaminingsih, 2026). The Ministry of Energy and Mineral Resources recorded that the mineral and coal sector's contribution to national GDP reached Rp2,198 trillion in 2023 (Kementerian Energi dan Sumber Daya Mineral, 2024). However, the sector's capital-intensive operations, high fixed costs, and revenue dependence on volatile global coal prices create structural exposure to the distress sequence described above. When coal prices decline, operating cash flows contract while debt servicing obligations remain fixed, depleting retained earnings and working capital, and subsequently depressing market value of equity. Research by Komaraputri and Aminah (2024) and Maninggarjati et al. (2021) empirically confirmed that coal mining companies exhibit high financial distress vulnerability during periods of commodity price weakness, consistent with trade-off theory predictions.

To detect these early symptoms of distress, various bankruptcy prediction methods have been developed in financial literature. Among the most widely applied are the Altman Z-Score and Zmijewski X-Score (Achmad & Hayet, 2024; Ashraf et al., 2019; Mehmood & De Luca, 2025; Nguyen et al., 2024). The theoretical foundation for these models lies in their ability to quantify the distress mechanisms outlined above. The Altman Z-Score, developed by Edward Altman in 1968, employs multiple discriminant analysis combining five key financial ratios that directly map to failure indicators: Working Capital to Total Assets (WCTA) captures liquidity deterioration, Retained Earnings to Total Assets (RETA) measures cumulative profitability decline, EBIT to Total Assets (EBITTA) reflects operating efficiency loss, and Market Value of Equity to Total Liabilities (MVETL) incorporates market-based assessment of leverage risk. The Zmijewski X-Score uses a probit regression approach, integrating Return on Assets (ROA) for profitability distress, Debt to Asset Ratio (DAR) for leverage vulnerability, and Current Ratio (CR) for short-term solvency (Kurniasih et al., 2022). Thus, these ratios are theoretically grounded predictors because they operationalize the sequential stages of corporate failure. Differing methodological approaches and variable sensitivities between these models potentially produce varied bankruptcy risk classifications, particularly in high-volatility industries such as coal mining where the speed of distress progression varies (Gülal et al., 2023).

Despite the widespread application of bankruptcy models, their validity in sharia-compliant capital markets remains theoretically and empirically underexplored. This study focuses specifically on companies constituting the Indonesia Sharia Stock Index (ISSI), a composite index encompassing shares that meet sharia compliance criteria listed on the Indonesia Stock Exchange (IDX). Launched on May 12, 2011, the ISSI is periodically evaluated through the Sharia Securities List (DES) issued by the Financial Services Authority (OJK). The unique characteristics of ISSI-listed companies create a distinct financial risk profile that challenges the generalizability of existing bankruptcy prediction models.

First, the DES screening imposes a maximum interest-based debt to total assets ratio of 45% and requires non-halal revenue below 10% of total revenue. These sharia constraints systematically alter capital structure decisions compared to conventional firms. According to trade-off theory, firms optimize debt to balance tax shields against bankruptcy costs, but ISSI firms face a regulatory ceiling on debt usage regardless of tax benefits. Consequently, the Market Value of Equity to Total Liabilities (MVETL) component in Altman's Z-Score and Debt to Asset Ratio (DAR) in Zmijewski's X-Score may exhibit different predictive power, because leverage levels are artificially suppressed and do not reflect managerial risk preferences.

Second, the DES mechanism evaluates only formal sharia compliance without integrating minimum financial health indicators. This creates a regulatory paradox where firms can satisfy sharia criteria while exhibiting severe financial distress, as evidenced by ARII in this study. Conventional bankruptcy models were calibrated on firms without such compliance filters; thus, their cutoff thresholds may misclassify ISSI firms that remain listed despite deteriorating fundamentals. The absence of interest-based financing also means ISSI firms rely more heavily on trade payables and equity financing, altering the behavior of Working Capital to Total Assets (WCTA) and Current Ratio (CR) during distress periods.

Existing empirical research applying Altman and Zmijewski models predominantly uses samples of conventional firms without sharia constraints, leaving the validity of these models in sharia-compliant contexts empirically untested. While Kumalasari & Falahuddin (2024) examined ISSI consumer goods firms, no study has specifically tested model performance in capital-intensive, commodity-dependent sectors like coal mining where sharia leverage restrictions interact with cyclical revenue volatility. This theoretical and contextual gap warrants dedicated investigation. This study therefore compares the Altman Z-Score and Zmijewski X-Score in predicting bankruptcy among coal mining companies listed on the ISSI from 2015 to 2024, to assess whether sharia compliance characteristics bankruptcy prediction accuracy.

2. Methods

This research employs a quantitative approach with a descriptive and comparative research design. A non-experimental, ex post facto design was applied, processing historical financial data from annual reports of 10 coal mining companies listed on the ISSI over the 2015–2024 period, resulting in 100 observations. The study population comprises all coal mining companies listed consistently on the ISSI during 2015–2024. Sample selection used purposive sampling, with the following criteria: (1) consistent ISSI listing throughout the study period, (2) complete annual financial reports for all 10 years, and (3) fully audited financial data sufficient to compute all required ratios. Ten companies met these criteria: ADRO (PT Adaro Energy Indonesia Tbk), ARII (PT Atlas Resources Tbk), BSSR (PT Baramulti Suksessarana Tbk), GEMS (PT Golden Energy Mines Tbk), HRUM (PT Harum Energy Tbk), ITMG (PT Indo Tambangraya Megah Tbk), KKG (PT Resource Alam Indonesia Tbk), MYOH (PT Samindo Resources Tbk), PTBA (PT Bukit Asam Tbk), and PTRO (PT Petrosea Tbk).

To evaluate prediction accuracy, this study establishes an objective benchmark for “actual financial distress” status. Consistent with prior Indonesian bankruptcy studies (Asih et al., 2025; Kembel et al., 2024) and IDX delisting regulations, a firm-year observation is classified as experiencing actual financial distress if it meets at least one of the following criteria during the observation year:

1. Negative net income for two consecutive years, indicating persistent operating losses that erode the equity base.
2. Negative shareholders' equity, reflecting technical insolvency where total liabilities exceed total assets.
3. Debt default or restructuring announcement, identified from notes to audited financial statements and IDX disclosures.
4. Stock trading suspension exceeding 12 months or delisting from IDX, indicating severe liquidity crisis.

This multi-criteria approach is necessary because ISSI firms' sharia compliance restricts interest-based debt, thus conventional default indicators may understate distress. Financial data for criteria 1–2 were extracted from audited annual reports, while criteria 3–4 were verified through IDX official announcements and company disclosures. Based on these criteria, 6 out of 100 firm-

year observations were classified as actual distress cases, all attributable to PT Atlas Resources Tbk (ARII) during 2015–2024. ARII consistently exhibited negative retained earnings, working capital deficits, and net losses, satisfying criteria 1 and 2. No other sample firms met any distress criteria. PTRO, although classified in the grey area by Altman's model in certain years, maintained positive equity and profitability and was therefore categorized as non-distress. The implications of this imbalanced class distribution for accuracy interpretation are addressed in the Discussion section.

The research variables consist of financial ratios used in both models: Working Capital to Total Assets (WCTA), Retained Earnings to Total Assets (RETA), Earnings Before Interest and Taxes to Total Assets (EBITTA), Market Value of Equity to Total Liabilities (MVETL) for the Altman Z"-Score; and Return on Assets (ROA), Debt to Asset Ratio (DAR), and Current Ratio (CR) for the Zmijewski X-Score. The Altman Z"-Score formula applied is: $Z'' = 6.56(WCTA) + 3.26(RETA) + 6.72(EBITTA) + 1.05(MVETL)$, with cutoffs: $Z'' < 1.1$ (distress), $1.1 \leq Z'' \leq 2.6$ (grey area), $Z'' > 2.6$ (safe). The Zmijewski X-Score formula is: $X = -4.336 - 4.513(ROA) + 5.679(DAR) - 0.004(CR)$, where $X > 0$ indicates distress and $X \leq 0$ indicates healthy.

Data analysis proceeded through six stages: (a) calculation of financial ratios as model components; (b) computation of Altman Z-Score and Zmijewski X-Score for each company-year observation; (c) accuracy testing by comparing model classifications against actual financial conditions; (d) error analysis encompassing Type I Error (misclassifying distress companies as healthy) and Type II Error (misclassifying healthy companies as distress); (e) K-Fold Cross Validation with $k=5$ to test model stability and consistency; and (f) comparative performance analysis between the two models based on accuracy, error types, and cross-validation results (Yanti & Dahruji, 2022).

3. Results

3.1 Descriptive Statistics of Bankruptcy Prediction Models

Descriptive analysis of the two bankruptcy prediction models across 100 observations reveals distinct characteristics. The Altman Z-Score demonstrated a wider value range (minimum -5.60, maximum 19.98, mean 7.1624) with high variability ($SD = 5.15625$), indicating strong discriminative ability and high sensitivity in differentiating financial conditions. The Zmijewski X-Score showed a narrower range (minimum -4.87, maximum 1.60, mean -2.6415, $SD = 1.49547$), reflecting a more conservative prediction approach. These differences arise from Altman's use of four financial ratios through multiple discriminant analysis, versus Zmijewski's three-ratio probit model.

3.2 Altman Z"-Score Results

The Altman Z"-Score classified 87 out of 100 observations as healthy, 3 as grey area, and 10 as financial distress. The following table presents selected results

Table 1. Selected Altman Z"-Score Calculation Results

Code	Year	WCTA	RETA	EBITTA	MVETL	Z-Score	Status
ADRO	2015	0.107	0.224	0.055	0.463	2.288	Grey Area
ADRO	2022	0.266	0.409	0.380	1.855	7.583	Safe
ARII	2015	-0.442	-0.181	-0.040	0.326	-3.416	Distress
ARII	2024	-0.196	-0.209	0.024	0.228	-3.010	Distress
ITMG	2022	0.297	0.627	0.385	2.012	8.845	Safe
PTBA	2022	0.295	0.530	0.316	2.108	9.120	Safe
PTRO	2023	0.120	0.389	0.048	0.519	2.256	Grey Area

Source: Secondary data, processed (2025)

Most sample companies including BSSR, GEMS, HRUM, ITMG, KKG, MYOH, and PTBA remained consistently in the safe zone throughout the study period, reflecting strong financial resilience. ADRO and PTRO experienced grey area classifications at certain points but recovered, demonstrating sensitivity to commodity cycles that remained manageable. The sole company consistently classified as financial distress across all 10 years of observation was ARII (PT Atlas Resources Tbk), recording persistently negative Z-Scores primarily driven by chronic working capital deficits, accumulated losses, and insufficient core operational surplus. Notably, ARII

remained listed on the ISSI because the DES inclusion mechanism evaluates only formal sharia compliance—specifically interest-based debt ratios and halal revenue composition without integrating minimum financial health indicators. This represents a regulatory gap with serious implications for Muslim investor protection.

3.3 Zmijewski X-Score Results

The Zmijewski X-Score classified 90 observations as healthy and 10 as financial distress, with all 10 distress observations belonging to ARII. This more conservative classification compared to Altman's 87 healthy, 3 grey area, and 10 distress is consistent with Andika and Zulkifli (2024), who found that Zmijewski consistently classifies more companies as healthy. The absence of a grey area zone is a significant limitation, directly restricting its utility as an early warning system.

Table 2. Selected Zmijewski X-Score Calculation Results

Code	Year	ROA	DAR	CR	X-Score	Status
ADRO	2015	0.052	0.36	1.52	-2.453	Healthy
ADRO	2022	0.237	0.347	2.021	-3.241	Healthy
ARII	2015	-0.072	0.77	0.196	0.243	Distress
ARII	2018	-0.08	0.971	0.235	1.6	Distress
ITMG	2022	0.454	0.261	3.259	-4.868	Healthy
PTRO	2021	0.066	0.593	1.401	-1.677	Healthy
PTRO	2024	0.032	0.662	1.01	-0.299	Healthy

Source: Secondary data, processed (2025)

ITMG recorded the lowest X-Score (-4.868 in 2022), reflecting ideal financial health: ROA of 0.454, DAR of only 0.261, and CR of 3.259. The most significant finding from the Zmijewski model is the consistent deterioration trend of PTRO, whose X-Score declined from -1.677 in 2021 to -0.299 in 2024. While still formally classified as healthy, the progressively narrowing safety margin represents a warning signal that the model's binary classification system fails to communicate explicitly to financial statement users. The convergence of both models in identifying ARII as the sole distress company provides strong cross-validation of this finding.

3.4 Accuracy and Error Analysis

The performance comparison between both models is summarized in Table 3:

Table 3. Comparative Performance of Altman Z-Score and Zmijewski X-Score

Company	Method	Accuracy (%)	Type I Error (%)	Type II Error (%)	CV Accuracy (%)	CV Type I Error (SD)
10 Coal Mining Companies (ISSI 2015–2024)	Altman Z-Score	94.74	16.67	4.49	93.68	0.4472
	Zmijewski X-Score	94.85	16.67	4.40	93.95	0.4472

Source: Secondary data, processed (2025)

4. Discussion

Both models achieved remarkably high overall accuracy (94.74% for Altman and 94.85% for Zmijewski). However, these figures require cautious interpretation because the dataset is severely imbalanced, with only approximately 6% of observations representing actual distress cases. Under such conditions, a naïve classifier that labels all firms as healthy could attain an accuracy of approximately 94%, illustrating why overall accuracy can be misleading when bankruptcy is a rare

event. Prior research emphasizes that bankruptcy prediction should therefore not rely on accuracy alone, but should also evaluate Type I and Type II errors, sensitivity, specificity, and the asymmetric costs of misclassification (Lahmiri & Bekiros, 2019; Lombardo et al., 2022; Yuan et al., 2025). In particular, failing to identify a truly distressed firm may impose substantially greater economic costs on investors, creditors, and other stakeholders than incorrectly classifying a healthy firm as distressed.

Both models recorded identical Type I Error rates of 16.67%, indicating that one in every six genuinely distressed firms was misclassified as healthy. This form of misclassification is particularly consequential in bankruptcy prediction because it may provide false reassurance to investors, creditors, and regulators regarding firms that are already experiencing financial difficulty. Prior studies emphasize that the cost of classifying a distressed firm as healthy is generally greater than the cost of classifying a healthy firm as distressed, and that model evaluation should therefore explicitly consider the trade-off between Type I and Type II Errors rather than relying on overall accuracy alone (Doupmpou & Zopounidis, 1999; Huang & Wang, 2026). The relatively high cross-validation standard deviation of the Type I Error rate (0.4472 for both models) further suggests substantial instability in distress detection across folds, indicating that the models' ability to identify distressed firms may be sensitive to sample composition and should be complemented with additional diagnostic or predictive approaches.

Type II Errors were very low for both models (4.49% for Altman, 4.40% for Zmijewski), indicating that both models rarely misclassify healthy companies as distressed. This is consistent with Andika and Zulkifli (2024), who found strong tendencies in both models against over-labeling financially sound companies as distressed. Prior research emphasizes that bankruptcy prediction models should be assessed using multiple performance criteria, including Type I and Type II Errors, sensitivity, specificity, and overall correct classification (Mousavi & Ouenniche, 2018). K-Fold Cross Validation with $k=5$ confirmed model consistency, yielding average accuracies of 93.68% (Altman) and 93.95% (Zmijewski). The most concerning finding was Fold 5, where both models recorded 100% Type I Error confirming that sensitivity limitations reflect fundamental constraints in detecting certain distress profiles rather than mere statistical randomness.

Quantitatively, the Zmijewski X-Score demonstrated marginally superior performance in nearly all aggregate metrics: higher accuracy, lower standard deviation, and lower Type II Error. This advantage stems from its exclusive reliance on historical financial statement data, making it less susceptible to capital market volatility that affects Altman's MVETL component. Braunsberger and Aschauer (2025) similarly found that historical financial ratio-based models tend to produce more stable and replicable predictions compared to market-integrated models, particularly during volatile market conditions.

However, the Altman Z"-Score retains a comparative advantage in terms of discriminative interpretation because its continuous score and three-zone classification framework provide a more graduated assessment of financial risk. In particular, the grey zone functions as an intermediate warning category between financial health and distress, allowing deterioration to be identified before a firm is classified as fully distressed. Prior studies confirm that the Altman model distinguishes firms into safe, grey, and distress zones and has been widely used as an early-warning tool for financial distress assessment (Ashraf et al., 2019; Bărbuță-Mișu & Madaleno, 2020). In the present study, PTRO's deterioration into the grey area illustrates this advantage, as the Altman model captured a transitional risk condition that was less evident under the binary interpretation of the Zmijewski model.

The persistent distress status of ARII throughout all 10 observation years while remaining ISSI-listed reveals a critical regulatory gap. ISSI inclusion criteria as reflected in OJK's DES screening—evaluate sharia compliance (interest-based debt ratio below 45% of total assets, non-halal revenue below 10% of total revenue) rather than minimum financial health. Since a significant portion of ARII's liabilities consists of trade payables and operational obligations rather than interest-bearing debt, it continues to satisfy DES criteria despite severely negative Z-Scores. This empirically demonstrates that companies can maintain extremely high financial risk profiles while meeting formal sharia compliance criteria a situation warranting regulatory reconsideration for the protection of Muslim investors under the principle of *hifzh al-mal* (preservation of wealth).

5. Conclusion

This study compared the Altman Z"-Score and Zmijewski X-Score methods in predicting bankruptcy among 10 coal mining companies listed on the ISSI during 2015–2024, yielding 100 observations. Both models demonstrated high and comparable overall accuracy (94.74% and 94.85%, respectively), with identical Type I Errors of 16.67% and very low Type II Errors (4.49% and 4.40%). K-Fold Cross Validation confirmed both models' consistency, though high Type I Error standard deviations (0.4472) indicate systemic sensitivity limitations. The Zmijewski X-Score showed marginally superior stability across aggregate performance metrics, while the Altman Z"-Score offered stronger discriminative power and graduated early warning capability through its grey area zone. ARII was the sole company consistently classified as distressed by both models throughout all 10 years validating through cross-model convergence yet remained ISSI-listed due to a regulatory gap between sharia compliance screening and financial health assessment. The integrated use of both models is recommended: Altman Z"-Score for comprehensive risk ranking and early warning detection, and Zmijewski X-Score for stability confirmation and cross-validation. For regulators, these findings support the integration of minimum financial health indicators into the DES screening mechanism to ensure that ISSI not only guarantees the halal nature of emittents' business activities but also their financial viability for Muslim investors.

6. References

- Achmad, A., & Hayet, H. (2024). Predicting Financial Distress in Companies Listed on The Indonesia Sharia Stock Index (ISSI): An Examination of The Zmejewski, Springate, and Altman Models. *Jurnal Ilmiah Ekonomi Islam*, 10(02), 1389–1397.
- Andika, R., & Zulkifli, Z. (2024). Analisis Kinerja Keuangan Dalam Memprediksi Kebangkrutan Pada Perusahaan Textile Dan Garment Dengan Metode Altman (Z-Score), Zmijewski (S-Score), Dan Springate (S-Score). *Jurnal Riset Akuntansi Dan Bisnis Indonesia*, 4(1). <https://doi.org/10.32477/jrabi.v4i1.956>
- Ashraf, S., G. S. Félix, E., & Serrasqueiro, Z. (2019). Do Traditional Financial Distress Prediction Models Predict the Early Warning Signs of Financial Distress? *Journal of Risk and Financial Management*, 12(2), 55. <https://doi.org/10.3390/jrfm12020055>
- Asih, S. P., Irawati, N., Nasution, F. N., Manajemen, M., & Sumatera, U. (2025). Analisis Komparatif Model Prediksi Kebangkrutan Pada Perusahaan Sektor Infrastruktur Yang Terdaftar Di Bursa Efek Indonesia Tahun 2018-2023. *Jurnal Darma Agung*, 33(1), 447–459.
- Bărbuță-Mișu, N., & Madaleno, M. (2020). Assessment of Bankruptcy Risk of Large Companies: European Countries Evolution Analysis. *Journal of Risk and Financial Management*, 13(3), 58. <https://doi.org/10.3390/jrfm13030058>
- Braunsberger, C., & Aschauer, E. (2025). Corporate Failure Prediction: A Literature Review of Altman Z-Score and Machine Learning Models Within a Technology Adoption Framework. *Journal of Risk and Financial Management*, 18(8), 1–32. <https://doi.org/10.3390/jrfm18080465>
- di Giovanni, J., & Rogers, J. (2024). The Impact of U.S. Monetary Policy on Foreign Firms. *IMF Economic Review*, 72(1), 58–115. <https://doi.org/10.1057/s41308-023-00218-7>
- Doumpos, M., & Zopounidis, C. (1999). A Multicriteria Discrimination Method for the Prediction of Financial Distress: The Case of Greece. *Multinational Finance Journal*, 3(2), 71–101. <https://doi.org/10.17578/3-2-1>
- Gülal, Ö. S., Seçme, G., & Köse, E. (2023). Predicting Financial Distress in the BIST Industrials Index: Evaluating Traditional Models and Clustering Techniques. *Ekonomi Politika ve Finans Arastirmalari Dergisi*, 8(4), 660–680. <https://doi.org/10.30784/epfad.1370893>
- Huang, W., & Wang, L. (2026). Combining Sampling Methods, Cost-Sensitive Learning, and Ensemble Techniques for Highly Class-Imbalanced Financial Distress Prediction. *Journal of Forecasting*, 45(6), 2861–2889. <https://doi.org/10.1002/for.70162>
- International Monetary Fund. (2022). *World Economic Outlook*. <https://www.imf.org/en/Publications/WEO>
- Kalash, I. (2023). The financial leverage–financial performance relationship in the emerging

market of Turkey: the role of financial distress risk and currency crisis. *EuroMed Journal of Business*, 18(1), 1–20. <https://doi.org/10.1108/EMJB-04-2021-0056>

- Kembi, L. D., Morasa, J., & Wokas, H. R. N. (2024). Comparative analysis of models (Altman, Grover, Zmijewski, Springate) in predicting company bankruptcy potential in the non-cyclical consumer sector. *The Contrarian : Finance, Accounting, and Business Research*, 3(2), 180–191. <https://doi.org/10.58784/cfabr.165>
- Kementerian Energi dan Sumber Daya Mineral. (2024). *Kontribusi Minerba pada PDB 2023 Capai Rp2.198 Triliun*. <https://www.esdm.go.id/en/media-center/news-archives/kontribusi-minerba-pada-pdb-2023-capai-rp2198-triliun>
- Komaraputri, D. F., & Aminah, I. (2024). Analisis Financial Distress Menggunakan Metode Altman Z-Score dan Springate Pada Perusahaan Pertambangan Batubara yang Terdaftar di Bursa Efek Indonesia (2019-2023). *Prosiding Seminar Nasional Akuntansi Dan Manajemen*, 5(2).
- Kumalasari, L., & Falahuddin, F. (2024). The Influence of Debt to Asset Ratio (DAR), Earning Per Share (EPS), Current Ratio (CR) on Sector Sharia Stock Prices Industry Goods Consumption (in Companies Listed on the Sharia Stock Index (ISSI). *Neraca Keuangan : Jurnal Ilmiah Akuntansi Dan Keuangan*, 19(2), 122–135. <https://doi.org/10.32832/neraca.v19i2.16803>
- Kurniasih, A., Heliantono, H., Sumarto, A. H., & Efni, Y. (2022). Impact of Financial Distress on Stock Price: the Case of Pulp & Paper Companies Registered in Indonesia Stock Exchange. *Business and Finance Journal*, 7(2), 141–154. <https://doi.org/10.33086/bfj.v7i2.2976>
- Lahmiri, S., & Bekiros, S. (2019). Can machine learning approaches predict corporate bankruptcy? Evidence from a qualitative experimental design. *Quantitative Finance*, 19(9), 1569–1577. <https://doi.org/10.1080/14697688.2019.1588468>
- Lombardo, G., Pellegrino, M., Adosoglou, G., Cagnoni, S., Pardalos, P. M., & Poggi, A. (2022). Machine Learning for Bankruptcy Prediction in the American Stock Market: Dataset and Benchmarks. *Future Internet*, 14(8), 1–23. <https://doi.org/10.3390/fi14080244>
- Lukman, M. L., & Farique, M. A. M. (2024). The Russia-Ukraine War and the Global Balance of Power. *International Journal of Interdisciplinary and Strategic Studies*, 5(8), 492–508. <https://doi.org/10.47548/ijistra.2024.82>
- Maninggarjati, E. R., Wulaningrum, R., Fitriana, R., & Putra, D. T. (2021). Financial Distress Analysis of Coal Mining Companies. *Proceedings of the International Conference on Applied Science and Technology on Social Science 2021 (ICAST-SS 2021)*. <https://www.atlantispress.com/proceedings/icast-ss-21/125971028>
- Marimuthu, F. (2021). Determinants of debt financing in South African state-owned entities. *Accounting and Financial Control*, 3(1), 40–52. [https://doi.org/10.21511/afc.03\(1\).2020.04](https://doi.org/10.21511/afc.03(1).2020.04)
- Mehmood, A., & De Luca, F. (2025). Financial distress prediction in private firms: developing a model for troubled debt restructuring. *Journal of Applied Accounting Research*, 26(6), 205–222. <https://doi.org/10.1108/JAAR-12-2022-0325>
- Mousavi, M. M., & Ouenniche, J. (2018). Multi-criteria ranking of corporate distress prediction models: empirical evaluation and methodological contributions. *Annals of Operations Research*, 271(2), 853–886. <https://doi.org/10.1007/s10479-018-2814-2>
- Nguyen, M., Nguyen, B., & Liêu, M. (2024). Corporate financial distress prediction in a transition economy. *Journal of Forecasting*, 43(8), 3128–3160. <https://doi.org/10.1002/for.3177>
- Qin, J. (2024). Application of Trade-off Theory in Real-Life Corporate Capital Structure Adjustments. *Advances in Economics, Management and Political Sciences*, 76(1), 88–93. <https://doi.org/10.54254/2754-1169/76/20241901>
- Rivaldo, M. U., & Utaminingsih, N. S. (2026). Do ESG and Earnings Management Influence Audit Opinions? Evidence from Indonesia Mining Sector. *Economics Business Accounting & Society Review*, 87. <https://doi.org/10.55980/ebasr.v5i1.349>
- Rizal S, M., Siraj, M. L., Syarifuddin, S., Tadampali, A. C. T., Zainal, H., & Mahmud, R. (2024). Understanding Financial Risk Dynamics: Systematic Literature Review inquiry into Credit, Market, and Operational Risks. *Atestasi : Jurnal Ilmiah Akuntansi*, 7(2), 1186–1213. <https://doi.org/10.57178/atestasi.v7i2.927>

- Venessa, V., & Yulfiswandi, Y. (2022). The Movement of Indonesia's Foreign Exchange Rates and Other Macroeconomic Variables to Its Stock Market Volatility in a Pandemic Setting. *Jurnal Administrasi Dan Manajemen*, 12(3), 215–231. <https://doi.org/10.52643/jam.v12i3.2331>
- Yanti, T. N., & Dahruji. (2022). Window Dressing Detection in the Energy Sector Industry Listed on the Indonesian Sharia Stock Index. *Jurnal Ekonomi Syariah Teori Dan Terapan*, 9(6), 800–814. <https://doi.org/10.20473/vol9iss20226pp800-814>
- Yuan, K., Abedin, M. Z., & Hajek, P. (2025). An Ensemble Model Minimising Misjudgment Cost: Empirical Evidence From Chinese Listed Companies. *International Journal of Finance & Economics*, 30(4), 3875–3900. <https://doi.org/10.1002/ijfe.3097>