Research Paper

Financial Modelling of Metal and Mineral Mining Companies in Indonesia using Altman Z-scores

Titin Agustin Nengsih

Faculty of Islamic Economics and Business, UIN Sulthan Thaha Saifuddin Jambi, Indonesia.
nengsih@uinjambi.ac.id

ARTICLE INFO	ABSTRACT
	Predictions about a company's financial condition related to bankruptcy are important information for interested parties, such as creditors, investors, government, auditors, and the company's internal management. This research models the financial condition of metal and mineral mining companies through the Altman Z-Score model and panel data regression analysis. This study focuses on a sample of nine companies involved in metal and mineral mining from 2017 to 2022. In this study, the Altman method was used to determine a company's health category using the Z-score standard. Panel Data Regression modelling showed that the fixed model was the best. The partial test results indicated that WCTA and RETA did not affect the Altman Z-score. However, when considering all the ratios simultaneously (WCTA, RETA, MVBV, and STA), they contribute to predicting a company's financial condition. These results highlight the importance of understanding the variables that influence a company's health and progress. Notably, the variables of WCTA, RETA, and STA play a crucial role in determining the Altman Z-score and contribute to our understanding of a company's financial condition.

Introduction

The mining sector, a key driver of the Indonesian economy, is evident in its increasing contribution to the state revenue each year. The 2009 Law of Mineral and Coal Mining signalled Indonesia's commitment to excel in mineral export competition, mandating downstream activities. However, by 2014, the government had acknowledged

the policy's suboptimal impact, as some mining companies failed to establish timely smelters for refining products. Consequently, the draft Law of Mineral and Coal Mining offers a three-year relaxation, making it obligatory to build smelters by 2022 (Kurniawati, 2016). Studying strict regulations, such as the 2009 Law of Mineral and Coal Mining, is crucial. It highlights the government's focus on resource nationalism and how it affects foreign investment and sectoral growth (Absori et al., 2022). The societal and economic dimensions of mining are pivotal research avenues, highlighting the sector's contribution to GDP, employment, and regional development, as well as exploring the displacement and socioeconomic disruptions experienced by indigenous and local communities (Ing et al., 2017).

A company's competitiveness is primarily influenced by its performance. Firms that cannot sustain competitive performance may face expulsion from their industries and eventually encounter bankruptcy. For a company to endure, its management must enhance both its performance and resilience (Bughin, 2023). An indicator of a company's progress can be seen in the analysis of its financial statements (Bunea et al., 2019). Financial statement analysis is needed to determine how a company's financial condition can help its management make better decisions (Robu & Istrate, 2015). Financial statement analysis has been studied extensively across various domains. Specifically, financial ratios can identify signs of bankruptcy or financial distress (Aviantara, 2022; Goh et al., 2022).

Altman formulated a Z-score model to assess firms' financial distress by utilizing multiple financial ratios derived from company statements (Altman, 1968). Ohlson (1980) developed a probabilistic model to predict bankruptcy by focusing on the role of financial ratios and market-driven variables. The Altman Z-score model is a multivariate analysis model that predicts company bankruptcy with a relatively reliable level of accuracy (Ch & Zulfiati, 2019). A discriminant analysis is carried out to predict a company's bankruptcy by analyzing the financial statements of a company for two to three years (Pangkey et al., 2018). If a company enters a period of financial distress and is not addressed quickly, business bankruptcy will occur (Aviantara, 2022). Implementing an effective bankruptcy prediction model allows firms to take corrective actions to prevent financial unsustainability and bankruptcy (Ghosh and Kapil, 2022).
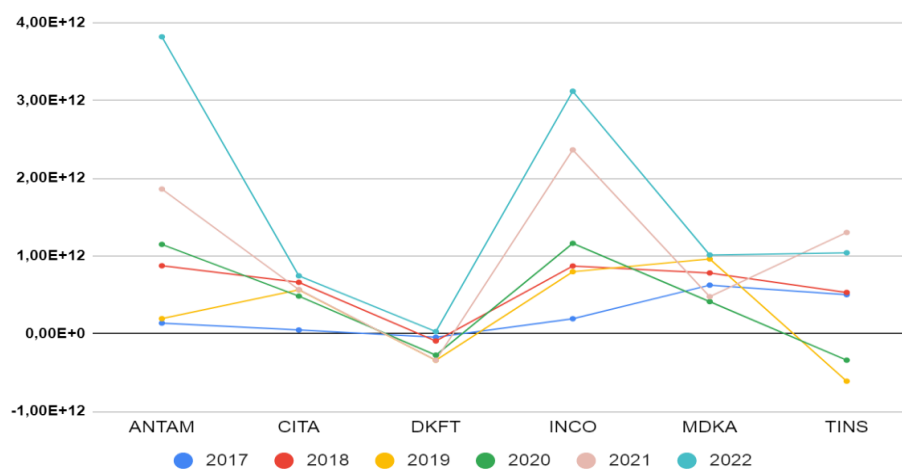

Figure 1. Net Profit/Loss Report for Mining Companies in Metal and Mineral Sub-sector from 2017 to 2022

Figure 1 depicts the financial components of profit and loss in the financial statements of mining companies in the metal and mineral subsectors. Figure 1 shows the development of metal and other mineral mining businesses in Indonesia for three consecutive years (2017-2022), with nine companies experiencing income fluctuations. Out of the nine companies, three—PT. Central Omega Resources, Tbk, PT. Timah Tbk, and PT. SMR Utama Tbk—reported significant losses. Additionally, PT. Aneka Tambang Tbk, Vale Indonesia Tbk, and PT. Cita Mineral Investindo Tbk saw a decline in revenue. Notably, although these companies experienced a substantial increase in revenue in 2018, it decreased again in 2019.

Several bankruptcy analysis studies using the Altman Z-score method have been conducted in Indonesia. Kurniawati (2016) conducted a bankruptcy analysis using the Altman Z-Score Model for the Multi-Industrial Sector on the IDX during 2013-2014. PT was identified PT. SAT Nusa Persada Tbk in the electronics sector, and PT. Kmi Wire Cable Tbk in the cable subsector as the highest-ranked companies with healthy Z-Score indices in 2013 and 2014, respectively. Conversely, PT. The Asia-Pacific Fiber Tbk in the textile and garment subsectors was identified as the most recent and lowest-ranking company facing bankruptcy in both years. Pangemanan et al. (2017) conducted a comparative analysis of financial performance using the Altman Z-Score method in the metal and mineral sub-sector mining industry listed on the IDX from 2012 to 2015. This study identified CKRA and PSAB as early indicators of bankruptcy. According to the Altman Z-score analysis, companies with a high potential for bankruptcy in the next two years were Aneka Tambang and Cita Mineral Investindo. Other companies, including DKFT, SMR, SMRU, TINS, and INCO, are in grey areas. Additionally, Pangkey et al. (2018) compared bankruptcy prediction analyses using the Altman and Zmijewski methods for companies that went public on the IDX. The study suggests that the Altman method is more accurate than the Zmijewski method for predicting bankruptcy.

Current research on the model of finance performance in many listed companies only depends on the Altman Z score and its similar financial ratios, such as the Zmijewski and Springate method, for a comparative analysis of robustness (Munawarah, 2020). Therefore, this study offers a comprehensive evaluation to analyze financial performance using WCTA, RETA, MVEB, and STA, which, in particular, influence the Z-score. The importance of this topic stems from the use of an estimation model of panel data regression, such as FEM, CEM, and REM, which were selected using the Chow and Housman test to eliminate Autocorrelation, Multicollinearity, and Heteroscedasticity. Another advantage of this research is the data obtained from 2017 to 2022 while Covid-19 is happened. Thus, this study aimed to model the financial performance of Metal and Mineral Mining companies in Indonesia using the Altman Z-score.

Hypothesis Development

Numerous studies have provided insights into the relevance of various financial ratios for predicting financial distress. Altman (1968) used the ratios of working capital to total assets and retained earnings to total assets as part of his Z-Score model to predict corporate bankruptcy. He found these ratios to be statistically significant indicators of financial distress. Additionally, studies have explored the relationship between market value equity, book value, and financial distress. For instance, Beaver (1966) highlights the

importance of market value ratios in assessing a firm's financial health, noting a significant correlation with instances of bankruptcy. Similarly, the ratio of sales to total assets is a pivotal component in predicting financial stability. For example, combining the five FRs from Altman's Z-score and 21 CGIs did not improve the prediction performance of the stacking ensembles and performed feature selection to identify representative features from a comprehensive list of 40 FRs and 21 CGIs (Liang et al., 2020). Based on these previous findings, it is hypothesized that these selected ratios significantly correlate with companies' financial distress, as measured by the Altman Z-score.

Several other scholarly works have delved deeper into financial ratios to explore their implications in financial distress. Dimitras et al. (1996) affirmed the relevance of capital to total assets and retained earnings to total assets in evaluating financial health, noting that firms with higher proportions of retained earnings and capital are typically more resilient to financial distress. Further, studies by Ohlson emphasized the significance of market value equity to book value, illustrating that a higher market valuation relative to book value often corresponds to a lower probability of financial distress (Ohlson, 1980). Additionally, the relevance of sales to total assets in determining the financial stability of companies has been underlined by studies like those conducted by Kieschnick (Michaely et al., 2014), which concluded that robust sales generation relative to assets often indicates sound financial health and lower susceptibility to distress (Dupret & Kielbasa, 2004). The cumulative insights from these studies provide substantial empirical grounding to hypothesize that the ratios of capital to total assets, retained earnings to total assets, market value equity to book value, and sales to total assets are pivotal indicators of financial distress, as measured by the Altman Z-Score.
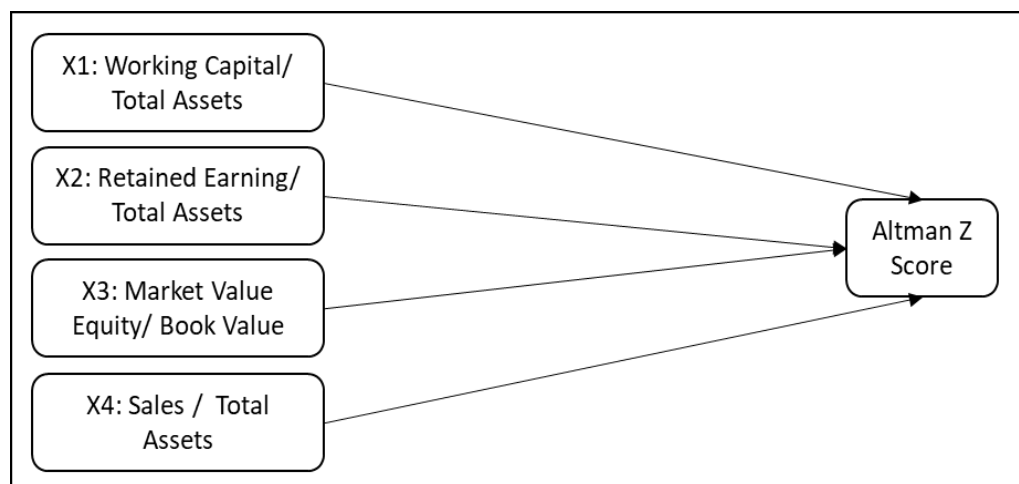

Figure 2. Research Model

A research model explaining the link between research variables was established based on previous studies. Figure 2 illustrates the relationship between the variables of working capital and total assets, retained earnings to total assets, market value equity to book value, and sales to total assets to financial distress of the selected companies defined using the Altman Z Score.

Altman (1968) developed a Z-Score formula, which is a score determined from standard calculations multiplied by financial ratios that show the level of probability of the company's bankruptcy. Z-score analysis can predict the level of bankruptcy or company

health. Anjum (2012) argues that this model can be applied to a modern economy that can predict bankruptcy in the next one to three years. To calculate a company's estimated bankruptcy, Altman uses five financial ratios: working capital to total assets, retained earnings to total assets, earnings before interest and tax to total assets, market value to book value of total debt, and total revenue to total assets. This research eliminates EBIT ratios and replaced by simulant financial ratios above (Pangemanan et al., 2017)

Working capital is defined as the difference between current assets and liabilities (Altman, 2000). The liquidity and size characteristics are explicitly considered. Ordinarily, a firm experiencing consistent operating losses will have shrinking current assets relative to total assets (Altman, 1977). In financial analysis, a greater level of safeguarding for short-term liabilities, as reflected by the Working Capital to Total Assets (WCTA) ratio, ensures prompt repayment of short-term debt.

Ha: *Working Capital to Total Assets influences Altman Z-Score (WCTA)*

The Retained Earnings to Total Assets (RETA) ratio is another crucial variable in the Altman Z-Score model, and it has been extensively studied in the context of predicting financial distress. Retained earnings is the financial record that discloses the cumulative sum of profits reinvested or losses incurred by a company throughout its existence (Altman, 2000). Altman mentioned that this measure is the cumulative company's profitability over time and implicitly considers the firm age; a young firm will probably show a low RETA ratio because it does not have time to build up its cumulative profits (Altman, 1977). Retained earnings represent the accumulation of a company's net income reinvested in the business, and a higher RETA ratio is typically associated with a stronger financial condition. The RETA ratio measures a firm's leverage. Usually, firms with high RE, relative to TA, have not utilized as much debt and financed their assets through the retention of profits. Altman (1968) included RETA in his model, positing that it has a significant positive impact on a company's Z-Score.

Ha: *Retained Earnings to Total Assets influences Altman Z-Score (RETA)*

The market Value of Equity to Book (MVBV) is another integral variable in the Altman Z-Score model, and its significance in predicting financial distress has been confirmed in numerous studies. Altman (1968) underscored the importance of MVBV in his original model, indicating that it significantly influences a company's Z-score. Equity is measured by the combined market value of all stocks' shares, preferred and common, while liabilities include both the current and long-term (Altman, 1968). This metric indicates the extent to which a company's assets, as measured by the combined market value of equity and debt, can decrease in value before their liabilities surpass assets, leading to insolvency (Altman, 2000).

Ha: *Market Value of Equity to Book influences Altman Z-Score (MVEB)*

The STA ratio is a critical component in the Altman Z-Score model and serves as a proxy for a firm's asset turnover and operational efficiency. Ratio is used to measure a company's ability to increase sales volume. According to Altman (1977), this final ratio is important because it is the least significant ratio on an individual basis and is ranked second in its contribution to the overall discriminating ability of the model.

Ha: *Sales to Total Assets influences Altman Z-Score (STA)*

Ha: *Working Capital to Total Assets, Retained Earnings to Total Assets, Market Value of Equity to Book, and Sales to Total Assets jointly influence the Altman Z-score.*

Method

The This study utilized secondary data sourced from the financial statements of mining companies in the metal and other mineral mining subsectors. The data covered the period from 2017 to 2020 and were extracted from the Indonesia Stock Exchange website. Information was collected through the recording and observation of financial statements. The sample comprised of all nine companies listed on the Indonesia Stock Exchange in the metal and mineral mining subsectors for the specified period, representing the entire population for the study. The Data were analyzed using Altman Z-score and panel data regression analyses. Altman Z-score analysis uses the following formula (Pangemanan et al., 2017).

$$Z = 6.54X_1 + 3.26X_2 + 6.72X_3 + 1.05X_4$$

where:

     X_1 = Working Capital to Total Assets
     X_2 = Retained Earning to Total Assets
     X_3 = Market Value of Equity to Book Value
     X_4 = Sales to Total Assets
     Z = Altman Z-Score

Companies were classified using the following formula: A company is considered not bankrupt if its Z-score value is greater than 2.90. Companies fall into the grey zone if their Z-scores are between 1.22 and 2.90. A company is deemed to have serious financial difficulties and is at risk of bankruptcy if its Z-score is less than 1.22 (Tampubolon, 2013).

Regression analysis was used to explain the effect of the dependent variable on independent variables. In general, various regression models are used in research studies. For instance, a Linear Regression model was utilized in a study conducted by Nengsih et al. (2021). Additionally, modified regression models such as the partial least squares regression (as presented by Nengsih, 2019) and the Panel Data Regression model (explored by Nengsih & Martaliah, 2021) are also frequently employed in research methodologies. The Panel Data Regression Model is formulated as follows:

$$Y_t = \alpha_t + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + e_t$$

Where:

     Y_t = Altman Z-Score
     α_t = Constant
     β_i = Variable Regression Coefficient, i = 1,2,3 and 4
     X_1 = Working Capital to Total Assets (WCTA)
     X_2 = Retained Earnings to Total Assets (RETA)
     X_3 = Market Value of Equity to Book (MVBV)
     X_4 = Sales to Total Assets (STA)
     e_t = Error Term

Three estimation models can be formed using panel data modelling (Khairunnisa et al., 2020). The first is the Common Effect Model (CEM). The model does not consider individual or time dimensions, and the behavior between individuals is the same in all time frames. The estimation technique of this model uses Ordinary Least Squares (OLS). The second model is the finite-element model (FEM). This model assumes that time units have different effects. Different effects are shown in the constant coefficient values, which have different values for each company. The third model is the random-effects model (REM). This model estimates panel data that are interconnected between time and individuals with different constants accommodated by the error terms of each company. The advantage of REM is that it eliminates the heteroscedasticity assumption. This model uses the generalized least squares (GLS) technique.

The three tests for selecting the best model in Panel Data Regression is Chow, Lagrange multiplier (LM), and Hausman tests (Gujarati & Porter, 2012). Chow test was used to determine whether the FEM model was better than the CEM (Widarjono, 2009). LM test was used to choose which of the CEM and REM models was betterels. Hausman test was used to determine which model was better than the FEM and REMels. After determining the best model, the assumption of normality test was performed. After the normality test is accepted, hypothesis testing, both F-test and t-test, can be carried out, which can then be continued to find the value of the coefficient of determination.

Results

Descriptive statistical analyses of each variable are presented in Table 1. Each variable was of a different size. Therefore, the descriptive statistics in Table 1 show the varied values and distance ranges.

Table 1. Descriptive Statistics for each Variable

	Altman Z-Score value	WCTA	RETA	MVBV	STA
Mean	5911154.	0.230222	0.61089	7.366889	-0.913111
Max	72326904	0.610000	1.180000	20.99000	0.160000
Min	-1.346200	0.000000	0.000000	-1.010000	-5.650000
Std. Deviation	17372821	0.117347	0.204437	6.756520	0.986327

A company's bankruptcy can be predicted using a formula invented by the Altman Z-score. The Altman Z-score can be used as an early warning system to detect the condition of a company, especially those related to the company's financial condition (Wu et al., 2022). In the event of financial difficulties, corrective actions can be taken immediately to achieve better future financial performance. In this study, the analysis of the company's condition was performed using the Altman Z-score method with the following formula:

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

Based on this formula, we can determine the conditions of metal and mineral mining companies for the 2017-2022 period. The results for the company conditions using the Altman Z-score method are presented in Table 2.

Table 2. Company Financial Health

No	Company	Period					
		2017	**2018**	**2019**	**2020**	**2021**	**2022**
1	PT. Aneka Tambang Tbk	healthy	healthy	healthy	healthy	healthy	healthy
2	PT. Cita Mineral Investindo Tbk	healthy	healthy	healthy	healthy	healthy	healthy
3	PT. Central Omega Resources Tbk	healthy	healthy	healthy	grey	grey	grey
4	PT. Vale Indonesia Tbk	healthy	healthy	healthy	healthy	healthy	healthy
5	PT. Merdeka Copper Gold Tbk	healthy	healthy	healthy	healthy	healthy	healthy
6	PT. Timah Tbk	healthy	healthy	healthy	healthy	healthy	healthy
7	PT. SMR Utama Tbk	healthy	healthy	healthy	grey	bankrup	bankrupt
8	PT. J Resources Asia Pasific Tbk	healthy	healthy	healthy	healthy	healthy	healthy
9	PT. Kapuas Prima Coal Tbk	healthy	healthy	healthy	healthy	healthy	healthy

As indicated in Table 2, 78% of metal and mineral mining companies from 2017 to 2022 are financially healthy. Notably, one company, PT. SMR Utama Tbk, initially exhibited good financial performance from early 2017 until 2019 but faced bankruptcy by the end of 2022. Additionally, there are companies, such as PT. Central Omega Resources Tbk, which fall into a grey area, indicate a potential financial challenge. It is crucial for these vulnerable companies to enhance sales, profits, and operational efficiency, while closely monitoring the market value of equity to mitigate financial risks (Buari et al., 2017).

Selecting the best model from the CEM, FEM, and REM is presented in Table 3. The p-value of the Chow test is 0.0062. This result indicates that the best model in the Chow test is FEM ($p < 0.05$). The next step is the Housman test for selecting between FEM and REM. The p-value for this test is 0.0284. This value indicates that the best model for this test was the FEM model ($p < 0.05$). Therefore, it can be said that the model used in this study is the Fixed Effect Model.

Table 3. Model Selection

Test	p-value	Testing	Best Model
Chow	0.0062	FEM VS CEM	FEM
Housman	0.0284	FEM VS REM	FEM
LM	-	CEM VS REM	-

After selecting the FEM (Finite Element Method) model as the best model, classical assumption tests were conducted. These tests include Normality, Autocorrelation, Multicollinearity, and Heteroscedasticity. The results of these tests suggest that the data exhibit normal distribution, and there are no issues detected with Autocorrelation, Multicollinearity, or Heteroscedasticity.

The FEM model shown in Table 4 is as follow:

$$Y_t = -1641.405 - 2252.553X_1 - 1288.945X_2 + 6.719036X_3 + 2687.732X_4 + e_t$$

Based on the FEM model, the results of the t-test show that the WCTA, RETA, and STA variables have a significant effect on the Alman Z-score value, whereas the MVBV variable has no effect on the Alman Z-score value (see Table 4). Table 4 shows that the WCTA variable had a significant effect on the Alman Z-score. RETA variable significantly positively affects the Alman Z-score; the higher the RETA value, the more prosperous the company is in managing its profitability. MVBV had no effect on the Alman Z-score or financial distress conditions. This shows that the market value of equity does not have a significant effect on bankruptcy predictions. Furthermore, the STA variable shows a significant negative effect on Financial Distress, which means that sales of total assets have a significant influence on predicting financial distress.

Table 4. T-test Results

Variable	Coefficient	Std. Error	t-value	p-value
Constant	-1641.405	485.1061	-3.383601	0.0016*
WCTA	-2252.553	1632.508	-1.379812	0.1751
RETA	1288.945	882.2542	1.460967	0.1516
MVBV	6.719036	0.005296	1268.710	0.0000*
STA	2687.732	852.2145	3.153820	0.0030*

* = significant effect (<5%)

The F-test in Table 5 was used to determine the joint effect of WCTA, RETA, MVBV, and STA variables on the Alman Z-score. Based on the results of the F-test in Table 5, the p-value is 0.000. It can be concluded that there is a joint effect of the four variables on bankruptcy prediction, as assessed by the Alman Z-score value (<0.05). The coefficient of determination ($R2$) is 0.570832. This explains why the model explains the effect of the WCTA, RETA, MVBV, and STA ratios on the prediction of bankruptcy in metal and mineral mining companies listed on the IDX, which is 99%, and the remaining 1% can be explained by other variables outside this research.

Table 5. F-test and R^2-test

p-value for F-test	0.000000
R^2	0.999992

Discussion

The Working Capital to Total Assets (WCTA) in financial analysis indicates that a higher level of protection for short-term liabilities ensures timely repayment of short-term debt. This reflects a company's effective management of obligations and reduces the risk of bankruptcy. The results of hypothesis testing indicate that the WCTA has no significant effect on the Alman Z-score value by predicting the company's financial condition. Research in financial distress prediction models, including the Altman Z-Score, predominantly focuses on the significance of the WCTA ratio. A previous study by Toly et al. (2019) indicated a negative relationship between the NWCTA ratio and financial distress. In contrast, Sari et al. (2020) and Ramadhan and Laksono (2021) show that the WCTA does not influence financial distress.

The retained Earnings to Total Assets (RETA) ratio does not significantly affect the Alman Z-Score value; the higher the RETA value, the more prosperous the company is in managing its profitability. While the RETA ratio is generally considered a significant variable in the Altman Z-score model for predicting financial distress, some studies have suggested that the impact of RETA may not always be significantly positive. Toly et al. (2019) suggest that The RETA ratio is negatively associated with financial distress, signifying that a larger RETA ratio reduces the likelihood of a business facing financial distress. This finding highlights the positive influence of the RETA ratio on mitigating financial distress. Sari et al. (2020) and Ramadhan and Laksono (2021) added that RETA has no influence on financial distress.

Equity market value serves as a proxy for a firm's asset value and is a more effective predictor of bankruptcy than a similar ratio. The Market Value of Equity to Book Value (MVBV) significantly and positively affects the Altman Z-Score value and financial distress conditions, suggesting that it may not have a significant impact on predicting bankruptcy, as noted by Sari et al. (2020) and Ramadhan and Laksono (2021).

On the other hand, the Sales to Total Assets (STA) variable demonstrates a significant positive influence on financial distress, indicating that total asset sales play a crucial role in predicting financial distress. By contrast, Sari et al. (2020) find no influence of Sales to Total Assets on financial distress, while Ramadhan and Laksono (2021) report no impact of the Market Value of Equity to Book Value of Debt on financial distress. Ramadhan and Marindah (2021) assert that WCTA, RETA, MVEBL, and STA collectively influence financial distress, but individually, they do not have a significant effect.

The results indicate that the financial distress analysis method can serve as a gauge for assessing a company's financial situation and may be considered when addressing financial challenges (Abidin et al., 2023). Predicting financial failure in companies is a crucial concern, garnering significant attention from researchers, organizations, and international bodies (Awwad & Razia, 2021). Based on these results and previous research, companies not only pay attention to changes in profits earned, but also must pay attention to changes in each component in the financial statements, such as an increase or decrease in current assets, sales, and others. Companies should pay attention to changes in every company's financial condition so that if the company is already in a grey area, it immediately takes preventive action. For example, in conditions of declining product sales, the company must instantly find consumer desires and effective promotions to increase sales.

Conclusion

This study models the financial status of nine metal and mineral mining companies from 2017 to 2022 using the Altman Z-Score ratio and Panel Data Regression analysis. Of the nine companies, seven were in healthy financial condition. One company showing signs of bankruptcy and falling into the grey category is advised to boost sales, increase profits, optimize operating costs, and monitor the market value of equity for improvement. The F-test indicates the collective influence of the WCTA, RETA, MVBV, and STA variables on bankruptcy prediction using the Altman Z-Score, with a high coefficient of determination (99.99%). This model effectively explains how these ratios affect the prediction of bankruptcy for metal and mineral mining companies on the IDX.

Specifically, the t-test revealed that MVBV and STA significantly affected the Altman Z-scores. This study contributes to the identification of key variables that determine a company's financial conditions.

While pivotal, this research has limitations, primarily rooted in the specificity of its focus on variables such as capital to total assets, retained earnings to total assets, market value equity to book value, and sales to total assets in the context of metal and mineral mining companies in Indonesia using the Altman Z Score. The study's specificity may limit its applicability to other industries and regions, and relying solely on selected financial ratios may overlook crucial indicators of financial distress. Future research should explore a more diverse range of financial and nonfinancial variables to predict financial distress. Future research can refine the models for more practical tools in various sectors and regions to assess and mitigate financial distress. These research avenues provide a holistic view of the intricate interplay between regulatory landscapes, environmental sustainability, economic vitality, and societal well-being in Indonesia's mining and mineral sectors..

Author's Declaration

ORCID

Titin Agustin Nengsih   https://orcid.org/0000-0002-6444-8782

References

Abidin, F. I. N., Hasanah, E., & Rizal, A. (2023, May). Financial distress prediction models: Altman Z-Score approach. In *International Conference on Intellectuals' Global Responsibility (ICIGR 2022)* (pp. 398-408). Atlantis Press. https://doi.org/10.2991/978-2-38476-052-7_44

Absori, A., Yulianingrum, A. V., Hasmiati, R. A., & Budiono, A. (2022). Government policies for the natural resource management of minerals and coal based on social welfare. *Pena Justisia: Media Komunikasi dan Kajian Hukum*, *20*(1), 23-37. http://dx.doi.org/10.31941/pj.v20i1.1715

Altman, E. I. (1968). Financial Ratios, discriminant analysis and the prediction of corporate bankruptcy. *Journal of Finance*, *23*(4), 589–609. https://doi.org/10.2307/2978933

Altman, E. I. (1977). A new model to identify bankruptcy risk of corporations. *Journal of Banking & Finance*, *1*(1). https://doi.org/10.1016/0378-4266(77)90017-6

Altman, E. (2000). Revisiting the Z-Score and ZETA®. *Predicting Financial Distress of Companies*, 2-16.

Aviantara, R. (2023). Scoring the financial distress and the financial statement fraud of Garuda Indonesia with «DDCC» as the financial solutions. *Journal of Modelling in Management*, *18*(1), 1-16. https://doi.org/10.1108/JM2-01-2020-0017

Awwad, B., & Razia, B. (2021). Adapting Altman's model to predict the performance of the Palestinian industrial sector. *Journal of Business and Socio-economic Development*, *1*(2), 149-164. https://doi.org/10.1108/JBSED-05-2021-0063

Beaver, W. (1966). Financial ratios as predictors of failure. *Journal of Accounting Research*, *4*, 71–111. https://doi.org/10.2307/2490171

Buari, D. I. R., Istiatin, & Djumali. (2017). Analisis tingkat kebangkrutan pada perusahaan manufaktur di Bursa Efek Indonesia. *Jurnal Bisnis Dan Ekonomi (JBE)*, *24*(1), 24–32. https://www.unisbank.ac.id/ojs/index.php/fe3/article/view/5560

Bughin, J. (2023). Resilience and performance: Capturing their synergy for ongoing success. *Journal of Business Strategy*, *45*(2), 124-132. https://doi.org/10.1108/JBS-07-2022-0114

Bunea, O. I., Corbos, R. A., & Popescu, R. I. (2019). Influence of some financial indicators on return on equity ratio in the Romanian energy sector-A competitive approach using a DuPont-based analysis. *Energy*, *189*, 116251. https://doi.org/10.1016/j.energy.2019.116251

Ch, F. N., & Zulfiati, L. (2019, February). Financial distress analysis with Altman Z Score method and value of SOEs Listed on BEI. In *5th Annual International Conference on Accounting Research (AICAR 2018)* (pp. 47-51). Atlantis Press.

Dimitras, A. I., Zanakis, S. H., & Zopounidis, C. (1996). A survey of business failures with an emphasis on prediction methods and industrial applications. *European Journal of Operational Research*, *90*(3), 487–513. https://doi.org/10.1016/0377-2217(95)00070-4

Dupret, Y., & Kielbasa, R. (2004). Modeling semiconductor manufacturing yield by test data and partial least squares. *Proceedings. The 16th International on Macroelectronics.* Tunis, Tunisia, pp. 404-407. https://ieeexplore.ieee.org/abstract/document/1434598/

Ghosh, A., & Kapil, S. (2022). Is Altman's Model efficient in predicting bankruptcy?–A comparison among the Altman Z-score, DEA, and ANN models. *Journal of Information and Optimization Sciences*, *43*(6), 1191-1207. https://doi.org/10.1080/02522667.2022.2117322

Goh, E., Mat Roni, S., & Bannigidadmath, D. (2022). Thomas Cook (ed): Using Altman's z-score analysis to examine predictors of financial bankruptcy in tourism and hospitality businesses. *Asia Pacific Journal of Marketing and Logistics*, *34*(3), 475-487. https://doi.org/10.1108/APJML-02-2021-0126

Gujarati, D. N., & Porter, D. C. (2012). *Dasar - Dasar Ekonometrika* (Edisi 5). Salemba Empat.

Ing, L. Y., Hanson, G. H., & Indrawati, S. M. (2017). The Indonesian economy: Trade and industrial policies. In *The Indonesian Economy: Trade and Industrial Policies*. https://doi.org/10.4324/9781315161976

Khairunnisa, J. M., Majidah, & Kurnia. (2020). Pengaruh financial distress, perencanaan pajak, ukuran perusahaan, komite audit dan kualitas audit terhadap manajemen laba. *Jurnal Ilmiah MEA (Manajemen, Ekonomi, & Akuntansi)*, *4*(3), 1114–1131. https://doi.org/10.31955/mea.vol4.iss3.pp1114-1131

Kurniawati, S. (2016). Analisis kebangkrutan dengan model Altman Z-Score pada perusahaan subsektor logam dan sejenisnya di BEI periode 2014. *Seminar Nasional Cendekiawan 2016*, Jakarta, Indonesia: Trisakti University.

Liang, D., Tsai, C. F., Lu, H. Y. (Richard), & Chang, L. S. (2020). Combining corporate governance indicators with stacking ensembles for financial distress prediction. *Journal of Business Research*, *120*, 137–146. https://doi.org/10.1016/j.jbusres.2020.07.052

Michaely, R., Rubin, A., & Vedrashko, A. (2014). Corporate governance and the timing of earnings announcements. *Review of Finance*, *18*(6), 2003–2044. https://doi.org/10.1093/rof/rft054

Munawarah, M. (2020). Zmijewski dan Springate : Analisis diskriminan dalam memprediksi financial distress. *Akuisisi: Jurnal Akuntansi*, *15*(1), 1–8. https://doi.org/10.24127/akuisisi.v15i1.279

Nengsih, T. A, Bertrand, F., Maumy-Bertrand, M., & Meyer, N. (2019). Determining the number of components in PLS regression on incomplete data set. *Statistical Applications in Genetics and Molecular Biology*, *18*(6), 20180059. https://arxiv.org/pdf/1810.08104

Nengsih, T. A, Arsa, A., & Putri, P. S. (2021). Determinan minat menabung masyarakat di Bank Syariah : Studi empiris di kota Jambi. *Journal of Business and Banking*, *11*(1), 93–111. https://doi.org/10.14414/jbb.v11i1.2599.

Nengsih, T. A, & Martaliah, N. (2021). *Regresi data panel dengan Software EViews dengan Software EViews*. Jambi.

Ohlson, J. (1980). Financial ratios and the probabilistic prediction of bankruptcy. *Journal of Accounting Research*, *18*, 109–131.

Pangemanan, F. H., Rate, P. Van, & Loindong, S. S. R. (2017). Analisis perbandingan kinerja keuangan menggunakan metode Z-Score pada industri pertambangan sub sektor logam dan mineral yang tercatat di Bei Periode 2012-2015. *Jurnal EMBA*, *5*(2), 1636–1643. https://doi.org/10.35794/emba.v5i2.16366

Pangkey, P. C., Saerang, I. S., Maramis, J. B., Ekonomi, F., Bisnis, D., Manajemen, J., … Manado, R. (2018). Analisis prediksi kebangkrutan dengan menggunakan metode Altman dan metode Zmijewski pada perusahaan bangkrut yang pernah go public di Bursa Efek Indonesia. *Jurnal EMBA: Jurnal Riset Ekonomi, Manajemen, Bisnis Dan Akuntansi*, *6*(4), 3178–3187. https://doi.org/10.35794/emba.v6i4.21292

Ramadhan, Y. & Laksono, Y. R. S. S. (2021). Bankruptcy analysis on coal mining companies. *Jurnal Riset Akuntansi dan Keuangan, 9*(2), 209-222. https://doi.org/10.17509/jrak.v9i2.29185

Ramadhan, Y., & Marindah, M. (2021). Financial distress analysis in an Indonesian textile company. *KnE Social Sciences*, 602-621. https://doi.org/10.18502/kss.v5i5.8846

Robu, I. B., & Istrate, C. (2015). The analysis of the principal components of the financial reporting in the case of Romanian listed companies. *Procedia Economics and Finance*, *20*, 553-561. https://doi.org/10.1016/S2212-5671(15)00108-2

Sari, N. R., Hasbiyadi, H., & Arif, M. F. (2020). Mendeteksi financial distress dengan model Z-Score Altman (Studi pada Perusahaan sektor utama yang terdaftar di Bursa Efek Indonesia). *Jurnal Ilmiah Akuntansi Dan Humanika*, *10*(1), 93-102. https://doi.org/10.23887/jiah.v10i1.23102

Tampubolon, M. (2013). *Manajemen Keuangan*. Jakarta: Mitra Wacana Medika.

Toly, A. A., Permatasari, R., & Wiranata, E. (2019). The effect of financial ratio (Altman Z-Score) on financial distress prediction in manufacturing sector in Indonesia 2016-2018. *Advances in Economics, Business and Management Research*, *144*, 47–53. https://www.atlantis-press.com/proceedings/afbe-19/125941217

Widarjono, A. (2009). *Ekonometrika Pengantar dan Aplikasinya* (Edisi 3). Yogyakarta: Ekonesia.

Wu, D., Ma, X., & Olson, D. L. (2022). Financial distress prediction using integrated Z-score and multilayer perceptron neural networks. *Decision Support Systems*, *159*, 113814. https://doi.org/10.1016/j.dss.2022.113814