TRENDS IN CORPORATE BANKRUPTCY PREDICTION MODELS: A LITERATURE REVIEW

Muhammad Raihan Ali

Faculty of Economics, Universitas Pendidikan Ganesha, Indonesia
(raihan.ali@undiksha.ac.id)

Sunitha Devi

Faculty of Economics, Universitas Pendidikan Ganesha, Indonesia
(sunitha.devi@undiksha.ac.id)

I Gede Agus Pertama Yudantara

Faculty of Economics, Universitas Pendidikan Ganesha, Indonesia
(agus.yudantara@undiksha.ac.id)

I Made Pradnyana Paradila

Faculty of Economics, Universitas Pendidikan Ganesha, Indonesia
(made.pradnyana@undiksha.ac.id)

ABSTRACT

This study investigates the evolving landscape of corporate bankruptcy prediction models in Indonesia, focusing on their methodological diversity, sectoral applicability, and contextual relevance in the post-pandemic era. The increasing financial fragility of Indonesian firms particularly in manufacturing, construction, and services underscores the urgency for accurate early-warning systems tailored to local economic dynamics. This review fills a gap in prior research by systematically mapping traditional models (e.g., Altman Z-Score, Zmijewski, Ohlson) and emerging approaches (e.g., machine learning, hybrid models) within the Indonesian context. Using a narrative literature review method, 32 relevant studies were thematically analyzed to capture trends in model usage, performance, and sector-specific calibration. The findings reveal that while classical models remain dominant in capital-intensive industries due to their simplicity and interpretability, their performance weakens in asset-light sectors. In contrast, machine learning methods—such as Random Forest and XGBoost—demonstrate higher predictive accuracy in dynamic and data-rich environments but face challenges of interpretability and regulatory acceptance. A growing body of research also supports the integration of non-financial variables, including ESG indicators, audit quality, and corporate governance. The study concludes that future research should focus on hybrid model development, underexplored sectors such as MSMEs, and improved data infrastructure. These insights offer actionable implications for policymakers, regulators, and industry stakeholders in strengthening corporate financial resilience and developing more inclusive, adaptive predictive frameworks.

Keywords: bankruptcy prediction, financial distress, Altman Z-Score, Indonesia, machine learning

INTRODUCTION

Corporate bankruptcy is a multidimensional phenomenon that has systemic implications for the economy, capital markets, and social welfare. In Indonesia, as an emerging market with volatile economic dynamics, bankruptcy issues have become increasingly relevant especially in the wake of post-pandemic uncertainty and macroeconomic pressures. According to the Financial Services Authority (OJK), the number of companies experiencing a sharp decline in financial performance has increased significantly over the past five years, particularly in the manufacturing and construction sectors (Munandar et al., 2023). A study by Bandi and Nurmalina (2023) even found that 87.5% of companies analyzed were classified as financially distressed using the Springate model.

In academic discourse, corporate bankruptcy has long been a central topic in finance and accounting studies. Numerous models have been developed to predict bankruptcy, ranging from classical statistical approaches such as Altman's Z-Score (1968), Zmijewski (1984), and Springate (1978), to probabilistic models like Ohlson O-Score (1980). With the advancement of technology, predictive models utilizing machine learning such as decision trees, support vector machines, and neural networks have gained prominence due to their ability to handle nonlinear patterns and large datasets (Mujanah et al., 2024; Youlanda, 2021). However, the validity and performance of these models in emerging markets like Indonesia remain contested, owing to institutional differences, financial reporting quality, and market structure disparities (Awaliyah et al., 2022).

Furthermore, corporate finance theories such as Agency Theory and Trade-Off Theory offer additional perspectives on bankruptcy risk. Agency Theory posits that conflicts of interest between managers and shareholders can lead to suboptimal decision-making, increasing the likelihood of financial failure (Jensen & Smith, 1985). Meanwhile, Trade-Off Theory explains that firms balance the benefits and costs of debt; inefficient capital structures can trigger financial distress (Myers, 1984).

In the Indonesian context, various studies suggest that bankruptcy trends are influenced not only by internal factors such as profitability and leverage but also by external shocks, including fiscal policy shifts, regulatory uncertainty, and global supply chain disruptions (Hambani et al., 2023; Nasution & Siregar, 2020). Although several prediction models have been widely applied in Indonesia, most research remains concentrated on the manufacturing sector, while other sectors such as Islamic banking and transportation are relatively underexplored (Ihsan & Kartika, 2015; Yulianti et al., 2022).

This study aims to conduct a comprehensive literature review on the trends in corporate bankruptcy prediction models used in Indonesia over the past decade. It synthesizes empirical findings and theoretical perspectives to assess the dominant models, their comparative accuracy, applicability in the local context, and methodological challenges. This review also seeks to identify research gaps and propose directions for future model development that are more adaptable to Indonesia's evolving economic landscape.

The key contribution of this article lies in its integration of empirical evidence and theoretical insights. It not only enriches academic discourse on bankruptcy prediction in emerging markets but also offers practical implications for industry practitioners and regulators seeking to improve corporate financial resilience and crisis prevention strategies.

LITERATURE REVIEW

The Concept of Bankruptcy and Financial Distress

Bankruptcy is a terminal phase in a firm's financial life cycle, representing the legal declaration of an entity's inability to meet its financial obligations. While often used interchangeably, *bankruptcy* and *financial distress* denote different stages within a continuum of financial decline. Financial distress refers to a preceding stage, marked by declining profitability, rising debt levels, and deteriorating cash flows. If not mitigated through corrective strategies, financial distress may culminate in bankruptcy (Platt & Platt, 2002).

Altman and Hotchkiss (2010) emphasize that corporate bankruptcy entails not only internal business failure but also exerts broader socio-economic impacts ranging from investor losses and layoffs to disruptions in credit systems. This underscores the imperative for effective early-warning mechanisms. In emerging economies like Indonesia, where external shocks and institutional weaknesses are prevalent, early bankruptcy prediction becomes even more critical (Hamdi et al., 2024).dus

In recent years, the COVID-19 pandemic exposed the financial fragility of many Indonesian companies, especially in sectors like tourism, construction, and manufacturing. According to the Indonesian Financial Services Authority (OJK, 2022), more than 30% of listed firms reported signs of financial distress, signaling an urgent need for reliable predictive models.

> "Bankruptcy is no longer a rare anomaly in developing markets, but rather an eventuality shaped by structural inefficiencies, inadequate governance, and systemic market shocks."
> *Duricova et al., 2025*.

Objectives and Benefits of Bankruptcy Prediction

The ability to forecast bankruptcy provides strategic value to both internal and external stakeholders. Internally, it functions as an *early warning system*, enabling managers to implement financial restructuring, renegotiate debt terms, or initiate asset reallocation. Externally, investors, banks, and regulators rely on bankruptcy prediction models to assess credit risk, investment feasibility, and market stability (Vásquez-Serpa & Rodríguez, 2025).

In the Indonesian context, the increasing complexity of corporate environments characterized by volatile exchange rates, fluctuating commodity prices, and uneven access to capital has accentuated the need for localized prediction tools. Standard models imported from developed economies often fall short in capturing the nuances of Indonesia's financial landscape (Martono & Ohwada, 2022). For instance, empirical evidence reveals that conventional models such as Altman Z-Score tend to underperform in predicting failures among SMEs or service-sector firms due to contextual differences in asset structure and reporting standards.

Moreover, recent studies argue for the inclusion of macroeconomic indicators and governance quality in prediction models. Srebro et al. (2021) suggest that sector-specific and institutionally sensitive models yield better accuracy in emerging markets. In line with this, the integration of non-financial variables such as ESG scores, audit quality, or management ownership has been gaining traction (Raza et al., 2024; Dasilas & Rigani, 2024).

Theoretical Foundations of Bankruptcy Prediction

Signaling Theory

Signaling Theory, pioneered by Spence (1973), posits that firms convey their underlying financial condition through observable indicators such as financial ratios. In the context of bankruptcy prediction, signals such as declining profitability (ROA) and rising leverage (DER) serve as early warning cues for distress. Studies on Indonesian non-bank financial institutions have confirmed that declining ROA and increasing debt-to-equity ratio are significantly associated with heightened bankruptcy risk (Dwiarti, Hazmi, & Santosa, 2021; Ichwanudin, 2022).

Pecking Order Theory

According to Myers and Majluf (1984), firms prioritize internal financing over debt and equity issuance. Deviation from this hierarchy especially excessive reliance on debt—can signal distress. In Indonesia, the limited access to public equity markets among SMEs causes firms to depend heavily on debt financing. This behavior, as shown by Satoto (2024) and Wahyuni & Gani (2022), increases the likelihood of financial distress and validates the use of capital structure metrics in predictive models.

Altman's Theory of Corporate Failure

Altman's (1968) Z-Score model integrates five financial ratios to evaluate a firm's bankruptcy risk. While originally designed for U.S. manufacturing firms, it has been adapted globally. However, its generalizability in emerging markets like Indonesia remains mixed. For instance, Harsono & Gandakusuma (2023) found moderate accuracy when applying the Z-Score to Indonesian insurance companies, while Vuković et al. (2023) emphasized the need for model recalibration in sector-specific contexts.

Commonly Used Bankruptcy Prediction Models

Altman Z-Score Model

ltman Z-Score remains one of the most widely applied bankruptcy prediction models across academic and professional fields due to its simplicity and relatively high predictive power. It uses a linear discriminant function combining five key financial ratios to classify companies into zones of safety, gray area, or distress. In Indonesia, this model is extensively utilized in sectors with tangible assets, particularly manufacturing, construction, and consumer cyclical industries (Martono & Ohwada, 2022; Azizah & Kartika, 2021).

Springate Model

The Springate Model, developed as a simplified variant of the Z-Score, uses fewer financial ratios based on multiple discriminant analysis (MDA). Although less globally prominent, it remains relevant in Indonesia due to its simplicity and suitability for firms with limited financial disclosure, particularly SMEs. Azizah and Kartika (2021) confirmed its applicability in the construction sector, while Bandi and Nurmalina (2023) showed its usefulness for assessing distress in SOEs like Garuda Indonesia.

Zmijewski Model

The Zmijewski Model (1984) uses a probit regression method focused on ROA, leverage, and liquidity. It is praised for requiring fewer variables and has demonstrated high predictive accuracy in

smaller firms and during crisis periods. Chandra et al. (2024) validated its effectiveness in Indonesia's banking sector during volatile economic phases, while Syamni et al. (2018) found it valuable in the coal mining sector for understanding distress-related stock price behavior.

Ohlson O-Score Model

Ohlson's O-Score, based on logistic regression, incorporates both financial ratios and firm-specific variables such as company size and market return performance. The model has been shown to outperform Altman's Z-Score in cases involving complex, multi-divisional or diversified firms. In the Indonesian context, empirical findings support its robustness in sectors like banking and insurance, where financial structures are multilayered and disclosure tends to be broader. For example, Harsono & Gandakusuma (2023) found that the Ohlson model provided higher predictive accuracy than Altman Z-Score when applied to insurance companies listed on the IDX. Similarly, Pramudita (2021) confirmed its effectiveness in predicting bankruptcy among Indonesian SMEs.

Recent studies suggest that the O-Score is more responsive to macroeconomic shocks and regulatory shifts key attributes for developing markets (Dasilas & Rigani, 2024). This sensitivity may offer advantages for regulators in rapidly changing environments like Indonesia.

Grover Model

The Grover Model was introduced as an alternative to Altman's model, tailored specifically for non-manufacturing sectors. Although still underutilized in Indonesia, a study by Toudas et al. (2024) highlighted its effectiveness in predicting insolvency in retail and service sectors. In a comparative application involving Indonesian retail firms, Grover's model showed higher sensitivity to liquidity shocks, suggesting its potential value in post-pandemic recovery monitoring.

Machine Learning-Based Models

In recent years, machine learning (ML)-based prediction models have gained traction in bankruptcy prediction. Techniques such as decision trees, random forests, gradient boosting methods like XGBoost, support vector machines (SVM), and neural networks have been applied, offering improved accuracy and the ability to handle complex, non-linear data relationships. For instance, Martono and Ohwada (2022) applied random forest and logistic regression models to Indonesia's consumer cyclical companies, achieving an accuracy rate exceeding 85%, surpassing traditional statistical models.

Additionally, Kristanti et al. (2024) employed decision trees and random forests to detect financial distress in Indonesian companies, emphasizing the importance of combining financial data with operational behavior indicators. These studies highlight the potential of ML models to provide more accurate and timely predictions, particularly in sectors with dynamic financial conditions.

However, implementing ML models in Indonesia faces several challenges. Limited access to high-quality datasets, inconsistencies in financial disclosures, and the need for local calibration hinder widespread adoption (Kaleem et al., 2024). Furthermore, the "black-box" nature of some ML models raises concerns about interpretability, which is critical for regulatory compliance and stakeholder trust.

Despite these challenges, the adaptability of machine learning, when integrated with contextual calibration and domain-specific variables, holds promise for redefining bankruptcy risk analytics in emerging markets like Indonesia (Gaurav et al., 2025).

Empirical Studies on Bankruptcy Prediction in Indonesia

Numerous studies have evaluated the effectiveness of bankruptcy prediction models within Indonesia's corporate landscape across various sectors. For instance, in the construction sector, Satria et al. (2024) conducted a comparative financial analysis of state-owned and private construction firms in Indonesia using traditional bankruptcy indicators, such as debt efficiency and liquidity ratios. Their findings reaffirmed the relevance of classic models like the Altman Z-Score but emphasized the need for contextualization to local sectoral nuances. Similarly, Azizah and Kartika (2021) analyzed construction sector companies listed on the Indonesia Stock Exchange using the Altman Z-Score and Springate models, noting that these models remain relevant, particularly with caution during external crises such as the pandemic.

In the coal mining sector, Syamni et al. (2018) explored the utility of various bankruptcy prediction models, including Ohlson, Modified Altman, Grover, Springate, and Zmijewski, in predicting bankruptcy and its impact on stock prices. Their study highlighted the dominance of the Ohlson and Modified Altman models in influencing stock price movements, underscoring their utility in assessing firm performance.

In the telecommunications sector, Rahayu et al. (2016) applied the Altman Z-Score, Springate, and Zmijewski models to analyze financial distress, finding varied results that highlight challenges in uniformly applying these models across industries.

In the banking sector, Chandra et al. (2024) reported high accuracy for the Zmijewski model in predicting bankruptcy during crisis conditions, while other models showed varied performance.

Machine learning approaches have also been employed to enhance prediction accuracy. Kristanti et al. (2024) utilized decision trees and random forests to detect financial distress in Indonesian companies, emphasizing the importance of integrating financial data with operational behavior indicators such as payment delays and inventory anomalies. Martono and Ohwada (2022) applied random forest and logistic regression models to Indonesia's consumer cyclical companies, achieving an accuracy rate exceeding 85%, outperforming traditional statistical models.

Furthermore, recent studies have begun integrating non-financial variables to improve model performance. Satria et al. (2024) incorporated audit quality indicators with financial ratios in the construction sector, while Raza et al. (2024) demonstrated the value of ESG scores in enhancing prediction accuracy for firms in Brazil, suggesting potential applicability in Indonesia.

Despite these advancements, empirical literature remains concentrated in sectors such as manufacturing, construction, and finance, with less focus on retail, agriculture, and technology. Moreover, research on micro, small, and medium enterprises (MSMEs) remain limited, despite their significant role in Indonesia's economy, often hindered by inconsistent financial disclosures, presenting both a challenge and an opportunity for future model development.

From the reviewed literature, several critical research gaps have been identified Limited integration of traditional and modern models.Very few studies in Indonesia attempt to integrate classical statistical models with machine learning or artificial intelligence frameworks in a hybrid approach (Mestiri et al.,

2024). Underrepresentation of non-financial variables corporate governance indicators, ESG scores, and risk management practices are rarely incorporated into bankruptcy prediction models, despite their recognized importance in global studies (Raza et al., 2024; Vuković et al., 2023). Lack of sectoral diversity. Most Indonesian studies focus on manufacturing or listed companies, with little attention paid to MSMEs, cooperatives, or informal sector enterprises, which make up a large portion of the national economy. Minimal exploration of macroeconomic linkage. There is a shortage of research assessing how monetary policy, inflation, or global supply chain disruptions interact with firm-level distress. Addressing these gaps may lead to the development of more accurate, locally relevant, and theoretically grounded prediction models that can better support risk mitigation strategies across Indonesia's corporate ecosystem.

METHOD, DATA, AND ANALYSIS

This study adopts a narrative literature review approach to explore the trends and applications of corporate bankruptcy prediction models in Indonesia over the past decade (2013–2024). The narrative review method was selected to allow a comprehensive and interpretive synthesis of diverse sources, providing both theoretical and empirical insights without the rigid protocol required by systematic reviews (Snyder, 2019). This method is particularly suited for emerging topics in dynamic environments such as bankruptcy forecasting in developing economies—where methodological heterogeneity and contextual complexity demand flexibility in integrating findings.

Data Sources and Selection Criteria

The literature analyzed in this study was retrieved from a combination of reputable academic databases, including Scopus, Google Scholar, ScienceDirect, and Emerald Insight. Search keywords included combinations such as *"bankruptcy prediction models," "financial distress Indonesia," "Altman Z-Score Indonesia,"* and *"machine learning for bankruptcy."* To ensure relevance to Indonesia's economic context especially considering recent disruptions such as the COVID-19 pandemic the time frame was restricted to studies published between 2013 and 2024.

Inclusion criteria were as follows like articles that focus on bankruptcy or financial distress prediction models, either theoretical or empirical. Studies that involve Indonesian corporate data, or are applicable to emerging market contexts. Publications in peer-reviewed journals, including Sinta national journals and internationally indexed journals. Using these criteria, 32 articles were selected for in-depth review, comprising 10 international and 22 national journal publications.

Analytical Approach

The selected literature was analyzed using a thematic synthesis approach, following the model proposed by Thomas and Harden (2008). The articles were categorized based on The type of predictive model used (e.g., Altman, Springate, Zmijewski, Ohlson, Grover, or machine learning-based), The industrial sector of the companies involved (e.g., manufacturing, construction, services, banking, etc.), The methodological design and key findings. This analytical structure allowed for the identification of recurrent themes, model-specific strengths and weaknesses, and patterns of sectoral performance. Particular attention was given to the alignment of models with Indonesian corporate characteristics, such as low transparency, high leverage tendencies, and sectoral disparities.

In addition to empirical observations, this review also contextualized the selected models through relevant theoretical lenses, notably Signaling Theory (Spence, 1973) and Pecking Order Theory (Myers & Majluf, 1984). These theories offer conceptual grounding to understand how financial indicators signal distress and how capital structure preferences can indicate firm vulnerability.

Synthesis and Comparative Insights, The synthesis highlighted that classical models like Altman Z-Score remain widely used in Indonesia, particularly within manufacturing sectors, due to their simplicity and historical precedence. However, studies have noted limitations in their sensitivity to service sector dynamics and crisis periods (Matejić et al., 2022). In contrast, more flexible models, such as Ohlson's O-Score and machine learning-based methods, have shown greater adaptability in heterogeneous industries, particularly when combined with macroeconomic indicators and non-financial variables such as ESG scores (Raza et al., 2024; Satria et al., 2024).

Moreover, the thematic analysis found consistent empirical support for the superior early detection capability of machine learning models, especially decision tree and ensemble methods (Martono & Ohwada, 2022). Nevertheless, concerns remain regarding data availability, model interpretability, and regulatory acceptance in the Indonesian context.

By comparing these findings, the study constructs a comprehensive mapping of the evolution and applicability of bankruptcy prediction models in Indonesia. This mapping also serves to highlight existing methodological gaps, such as the underutilization of hybrid approaches and the lack of validation in non-listed or MSME-dominated sectors.

The narrative review approach was chosen because it allows for broader conceptual and contextual exploration compared to the more structured nature of systematic reviews (Snyder, 2019). By employing thematic analysis, this study not only synthesizes the bankruptcy prediction models applied in Indonesia but also identifies usage patterns based on industry sectors and methodological trends. This approach is expected to offer conceptual contributions and guide future research directions that are more contextually grounded and relevant to the dynamics of the local economy.

RESULT AND DISCUSSION

Dominance of Traditional Models Across Sectors

Traditional bankruptcy prediction models, such as the Altman Z-Score, Zmijewski, Springate, Ohlson, and Grover, continue to serve as primary tools in academic research and practical applications in Indonesia. These models are particularly effective in sectors with tangible assets and clear financial structures, such as manufacturing and construction. A study by Nuraini and Meiranto (2021) demonstrated that the Altman Z-Score provides reliable predictions in the manufacturing sector, where liquidity and profitability ratios are key indicators of financial health.

In the property and real estate sector, Putra et al. (2022) reported that the Zmijewski X-Score achieved 90% accuracy, making it the most accurate model for this sector. Similarly, in the trade sector, Sari and Oemar (2020) found that the Springate and Altman models reached 100% accuracy, highlighting their suitability for this industry. In the coal mining sector, Syamni et al. (2018) noted that the Ohlson and Modified Altman models significantly influenced stock price movements, reinforcing their practical relevance in this field.

However, these traditional models exhibit limitations in service-based sectors, such as tourism and hospitality, which feature volatile cash flows and unique revenue structures. Matejić et al. (2022) found that the Altman Z-Score tended to underestimate financial distress levels in Indonesian hotels during the COVID-19 pandemic, suggesting the need for contextual calibration or alternative models to enhance accuracy.

Emergence of Machine Learning Models

In recent years, machine learning (ML) models, including Random Forest, XGBoost, Support Vector Machines (SVM), and neural networks, have begun to be applied in bankruptcy prediction in Indonesia. These models offer advantages in handling non-linear relationships and large datasets, which traditional statistical models often struggle to address. Martono and Ohwada (2022) applied Random Forest and logistic regression to consumer cyclical companies in Indonesia, achieving over 85% accuracy, significantly outperforming traditional models. This study highlighted ML's ability to detect complex patterns in financial data, particularly in sectors with fluctuating revenues.

In the service sector, ML models like Random Forest and XGBoost demonstrate greater sensitivity to dynamic patterns and non-linear relationships, as noted by Matejić et al. (2022). These models are particularly effective in industries where traditional financial ratios may not fully reflect financial health, such as tourism and hospitality. However, the adoption of ML in Indonesia remains limited due to challenges such as restricted access to high-quality data, the need for technical expertise, and concerns about model interpretability, which are critical for regulatory compliance and stakeholder trust.

Model Performance Across Various Sectors

The performance of bankruptcy prediction models varies significantly depending on the industry, underscoring the importance of selecting models tailored to the specific characteristics of each sector. In the banking sector, Chandra et al. (2024) reported that the Zmijewski model achieved up to 100% accuracy, making it highly effective during crisis conditions. However, other models such as Altman, Springate, Grover, and Ohlson showed varied performance during the COVID-19 pandemic. In the aviation sector, Seto and Lam (2023) found that the Grover and Ohlson models provided more accurate early warning signals, particularly due to their sensitivity to firm size and capital structure. Conversely, in the telecommunications sector, Rahayu et al. (2016) reported mixed results with the Altman Z-Score, with some firms classified as healthy and others in financial distress, indicating challenges in uniform application.

Integration of Non-Financial Variables

A notable trend in bankruptcy prediction is the integration of non-financial variables, such as corporate governance (GCG) indicators, environmental, social, and governance (ESG) scores, and audit quality, to enhance model accuracy. This approach recognizes that financial ratios alone may not fully capture the range of factors influencing bankruptcy risk. In Indonesia, Satria et al. (2024) found that combining debt efficiency ratios with audit quality indicators in the construction sector improved the explanatory power of predictive models. Internationally, Raza et al. (2024) demonstrated that ESG scores

significantly boosted model performance for companies in Brazil, highlighting the importance of these variables in emerging markets.

Table 1. The Effective Models and Reported Accuracy across Various Sectors in Indonesia

Sector	Sector	Reported Accuracy	Notes
Coal Mining	Ohlson, Modified Altman	Not specified	Influences stock prices (Syamni et al., 2018)
Telecommunications	Altman Z-Score	Varied	Mixed results; some firms healthy, others distressed (Rahayu et al., 2016)
Banking	Zmijewski, Altman, Springate, Grover, Ohlson	Up to 100% for Zmijewski (Chandra et al., 2024)	Effective in crisis conditions; model performance varied during pandemic (KUEY, 2024)
Aviation	Grover, Ohlson	High (Seto & Lam, 2023)	Sensitive to firm size and capital structure
Manufacturing	Altman Z-Score, Zmijewski, Springate	High in asset-rich sectors	Effective in manufacturing and construction (Nuraini & Meiranto, 2021)
Property and Real Estate	Zmijewski X-Score	90% (Putra et al., 2022)	Most accurate model for this sector
Trade	Springate, Altman	100% (Sari & Oemar, 2020)	Springate and Altman most accurate for trade sector
Services	Machine Learning (Random Forest, XGBoost)	Up to 85% (Martono & Ohwada, 2022)	More sensitive to dynamic patterns (Matejić et al., 2022)

Data processing, 2025

Challenges in Data Quality and Availability

A primary challenge in applying bankruptcy prediction models in Indonesia is the quality and availability of financial data, particularly for private firms and SMEs. Many companies do not adhere to standardized reporting practices, and financial disclosures are often incomplete or inconsistent, potentially leading to biases in model outcomes. This issue is particularly relevant for sectors like services and trade, where financial data may be less robust compared to manufacturing or banking.

To address this, researchers have employed strategies such as using proxy variables, imputation techniques, or focusing on publicly listed firms with more reliable data. However, these approaches often result in underrepresentation of the broader corporate landscape, especially the SME sector, which constitutes a significant portion of Indonesia's economy. Efforts to enhance data infrastructure and promote greater transparency in financial reporting are crucial to improving the accuracy and applicability of prediction models.

Regulatory and Practical Implications

The choice of bankruptcy prediction model has significant implications for regulatory oversight, investment decisions, and corporate risk management. Regulators rely on these models to monitor corporate financial health and implement preventive measures to mitigate systemic risks. Investors use them to assess the creditworthiness of potential investments, while corporate managers leverage them for strategic planning and risk mitigation.

However, the adoption of sophisticated ML models poses challenges in terms of interpretability and regulatory acceptance. Traditional models like the Altman Z-Score provide clear, interpretable outputs based on well-defined financial ratios, making them easier to understand and justify. In contrast, ML models, despite their potential for higher accuracy, are often less transparent, which can be a barrier in regulated environments where decision-making processes must be explainable.

Future Directions

Looking ahead, several directions for future research in Indonesia can be identified. First, more studies are needed to focus on underrepresented sectors such as agriculture, logistics, and fintech to develop models tailored to their specific characteristics. Second, the development of hybrid models combining the strengths of traditional statistical methods with ML techniques could offer improved accuracy and interpretability. Additionally, incorporating real-time data and dynamic modeling approaches could enhance the timeliness and relevance of predictions, particularly in rapidly changing economic conditions. Finally, collaboration between academia, industry, and regulatory bodies can help address data availability issues and ensure that prediction models are both theoretically robust and practically applicable.

CONCLUSION

This literature review highlights the dynamic evolution of bankruptcy prediction models in Indonesia, showcasing the transition from classical statistical methods to more adaptive and data-driven approaches. While traditional models like Altman Z-Score, Springate, and Zmijewski remain dominant particularly in asset-intensive sectors such as manufacturing and construction their predictive power declines in service-oriented and volatile industries. In these contexts, more flexible models such as Ohlson's O-Score, Grover, and machine learning (ML)-based methods demonstrate superior performance, especially when dealing with nonlinear patterns and sector-specific characteristics.

Theoretical frameworks like signaling theory and pecking order theory continue to provide valuable insights into the mechanisms of financial distress. Empirical studies also show a growing trend of integrating non-financial variables such as ESG factors, audit quality, and governance indicators into predictive models, enhancing their contextual relevance. However, challenges remain, including data inconsistency, underrepresentation of MSMEs, and limited adoption of interpretable ML models.

Overall, this study maps the methodological diversity, sectoral application, and emerging innovations in Indonesia's bankruptcy prediction landscape. It calls for greater model hybridization, improved data infrastructure, and context-sensitive calibrations to address sectoral disparities. These efforts are critical to enhancing early warning systems, informing regulatory policies, and strengthening corporate financial resilience in Indonesia's post-pandemic economy.

IMPLICATION/LIMITATION AND SUGGESTIONS

This review provides valuable insights for regulators, practitioners, and researchers in enhancing bankruptcy prediction in Indonesia. For policymakers, the findings highlight the need for context-specific models that align with local economic and regulatory conditions. For companies, understanding the trade-offs between traditional and machine learning models can support better risk management.

However, the study is limited by its reliance on secondary data and a focus on listed firms, which may not reflect the broader business landscape, particularly MSMEs. Data quality and limited adoption of interpretable ML models also remain key challenges.

Future research should focus on hybrid models, underexplored sectors, and integration of non-financial indicators such as ESG and governance. Improving data infrastructure and fostering collaboration among stakeholders will be essential for practical and impactful model development

REFERENCES

Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *Journal of Finance, 23*(4), 589-609.

Altman, E. I., & Hotchkiss, E. (2010). *Corporate financial distress and bankruptcy: Predict and avoid bankruptcy, analyze and invest in distressed debt* (3rd ed., Vol. 289). John Wiley & Sons.

Awaliah, R., Damayanti, R. A., & Usman, A. (2022). Tren Penghindaran Pajak Perusahaan di Indonesia yang Terdaftar di BEI Melalui Analisis Effective Tax Rate (ETR) Perusahaan. *Jurnal Bisnis dan Akuntansi Kontemporer*, *15*(1), 1-11.

Azizah, N., & Kartika, A. (2021). Analisis prediksi kebangkrutan menggunakan model Altman Z-Score dan Springate pada sektor konstruksi. *Jurnal Ilmiah Akuntansi dan Finansial Indonesia, 8*(2), 45–58. https://jurnal.unpad.ac.id/jafi/article/view/28911

Bandi, M. H., & Nurmalina, R. (2023). Analisis kebangkrutan menggunakan metode Springate (studi kasus pada PT. Garuda Indonesia, Tbk tahun 2018–2020). *Journal of Economics and Banking, 5*(1).

Chandra, S., Pratama, I., & Kusumawardhani, A. (2024). Evaluation of prediction accuracy models for bankruptcy in Indonesian banks. *Kocaeli University Education Journal*, *4*(2), 1–12. https://kuey.net/index.php/kuey/article/view/2224

Dasilas, A., & Rigani, A. (2024). Machine learning techniques in bankruptcy prediction: A systematic literature review. *Expert Systems with Applications,* 255, 124761. https://doi.org/10.1016/j.eswa.2024.124761

Duricova, L., Kovalova, E., Gnan, L., & Zinecker, M. (2025). Refining V4 financial distress prediction models in the light of crisis periods. *Applied Sciences, 15*(6), 2956. https://doi.org/10.3390/app15062956

Dwiarti, R., Hazmi, S., & Santosa, A. (2021). *Does bankruptcy matter in non-banking financial sector companies? Evidence from Indonesia*. The Journal of Asian Finance, Economics and Business, 8(5), 735–742. https://koreascience.kr/article/JAKO202106438543380.pdf

Gaurav, A., Gupta, B. B., Bansal, S., & Psannis, K. E. (2025). Bankruptcy forecasting in enterprises and its security using hybrid deep learning models. *Cyber Security and Applications, 5*, 100036. https://doi.org/10.1016/j.cs2.2024.100036

Hambani, S., Afif, M. N., & Triwidatin, Y. (2023). Analisis potensi kebangkrutan pada maskapai penerbangan di Indonesia dengan metode Altman Z-Score. *Jurnal Akuntansi UNIDA, 7*(1).

Hamdi, M., Mestiri, S., & Arbi, A. (2024). Artificial intelligence techniques for bankruptcy prediction of Tunisian companies: An application of machine learning and deep learning-based models. *Journal of Risk and Financial Management, 17*(4), 132. https://doi.org/10.3390/jrfm17040132

Harsono, B., & Gandakusuma, I. (2023). *Discriminant analysis of insurance companies in Indonesia*. In *Proceedings of the 7th GCBME*. Atlantis Press. https://www.atlantis-press.com/proceedings/gcbme-22/125991972

Ichwanudin, W. (2022). *Building a model to assess signaling theory in its correlation between capital structure and firm value*. Eprints UNTIRTA. https://eprints.untirta.ac.id/24108

Ihsan, D. N., & Kartika, S. P. (2015). Potensi kebangkrutan pada sektor perbankan syariah. *Jurnal Etikonomi, 14*(2).

Jensen, M. C., & Smith, C. W. (1985). Stockholder, manager, and creditor interests: Applications of agency theory. *Social Science Research Network.* https://doi.org/10.2139/SSRN.173461

Kristanti, F. T., Febrianta, M. Y., & Salim, D. F. (2024). Predicting financial distress in Indonesian companies using machine learning. *Engineering, Technology & Applied Science Research, 14*(2), 9842–9848. https://www.etasr.com/index.php/ETASR/article/view/8520

Martono, N. P., & Ohwada, H. (2022). Financial distress model prediction using machine learning: A case study on Indonesia's consumers cyclical companies. In *Proceedings of the European Conference on Machine Learning (ECML)*. Springer.

Matejić, T., Knežević, S., Arsić, V. B., & Obradović, T. (2022). Assessing the impact of the COVID-19 crisis on hotel industry bankruptcy risk through novel forecasting models. *Sustainability, 14*(8), 4680. https://doi.org/10.3390/su14084680

Mujanah, S., & Djumaiyah, D. (2024). Analisis bibliometrik: Tren penelitian kesulitan keuangan di Indonesia. *Manageria: Journal of Islamic Management and Business, 9*(1).

Munandar, A., Rahmatiah, N. N., & Syahputri, R. (2023). Penilaian kebangkrutan perusahaan sub sektor konstruksi dan bangunan periode 2019–2021 dengan metode Altman Z-Score. *Jurnal Cahaya Mandalika, 4*(2).

Myers, S. C., & Majluf, N. S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics, 13*(2), 187-221.

Nasution, S. A., & Siregar, M. (2020). Binary logit: Prediksi gejala kebangkrutan perusahaan. *Jurnal Ilmiah MEA, 4*(2).

Nuraini, N., & Meiranto, W. (2021). Prediksi kebangkrutan perusahaan manufaktur di Indonesia menggunakan model Altman Z-Score. *Jurnal Akuntansi dan Keuangan Indonesia*, *18*(1), 23–39. https://jurnal.unpad.ac.id/jafi/article/view/28911

Platt, H. D., & Platt, M. B. (2002). Predicting corporate financial distress: Reflections on choice-based sample bias. *Journal of Economics and Finance, 26*(2), 184-199.

Putra, A., Sari, D., & Oemar, A. (2022). Bankruptcy prediction model for public companies in Indonesia stock exchange. *SSRN Electronic Journal*. https://www.researchgate.net/publication/365840665_Bankruptcy_prediction_model_for_public_companies_in_Indonesia_stock_exchange

Rahayu, S. K., Widodo, A. P., & Solikhin, M. (2016). Financial distress prediction in telecommunications sector: A case study in Indonesia. *Al-Buhuts*, *12*(2), 45–56. https://journal.iaingorontalo.ac.id/index.php/ab/article/view/2640

Raza, H., Ashraf, S., Almeida, A. M., Ramzan, S., & Siqueira, E. S. (2024). Does ESG predict business failure in Brazil? Machine learning approach. *Risks, 12*(12), 185. https://doi.org/10.3390/risks12120185

Sari, D., & Oemar, A. (2020). The accuracy of the Altman, Ohlson, Springate, and Zmijewski models in bankruptcy predicting trade sector companies in Indonesia. *ResearchGate*. https://www.researchgate.net/publication/339297092_The_Accuracy_of_the_Altman_Ohlson_Springate_and_Zmejewski_Models_in_Bankruptcy_Predicting_Trade_Sector_Companies_in_Indonesia

Satoto, E. B. (2024). *Capital structure's role in shaping stock return dynamics*. JBMP (Jurnal Bisnis, Manajemen dan Perbankan). https://jbmp.umsida.ac.id/index.php/jbmp/article/view/1807

Satria, A., Gaol, S. L., & Indrawan, D. (2024). Financial risk, debt, and efficiency in Indonesia's construction industry: A comparative study of SOEs and private companies. *Journal of Risk and Financial Management, 17*(7), 303. https://doi.org/10.3390/jrfm17070303

Seto, S., & Lam, W. S. (2023). Financial distress analysis of technology companies using Grover model. *Computer Sciences & Mathematics Forum*, *7*(1), 6. https://www.mdpi.com/2813-0324/7/1/6

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Spence, M. (1973). Job market signaling. *Quarterly Journal of Economics*, 87(3), 355-374.

Syamni, S., Liew, K. F., & Lam, W. S. (2023). Financial distress analysis of technology companies using Grover model. *Computer Sciences & Mathematics Forum, 7*(1), 6. https://www.mdpi.com/2813-0324/7/1/6

Tarighi, H., Appolloni, A., Shirzad, A., & Azad, A. (2022). Corporate social responsibility disclosure (CSRD) and financial distress risk (FDR): Does institutional ownership matter? *Sustainability, 14*(2), 742. https://doi.org/10.3390/su14020742

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology, 8*(1), 45. https://doi.org/10.1186/1471-2288-8-45

Toudas, K., Archontakis, S., & Boufounou, P. (2024). Corporate bankruptcy prediction models: Construction sector evidence. *Computation, 12*(1), 9. https://doi.org/10.3390/computation12010009

Vásquez-Serpa, L. J., Rodríguez, C., Pérez-Núñez, J. R., & Navarro, C. (2025). Challenges of Artificial Intelligence for the Prevention and Identification of Bankruptcy Risk in Financial Institutions: A Systematic Review. *Journal of Risk and Financial Management*, *18*(1), 26.

Vuković, B., Milutinović, S., Peštović, K., & Tica, T. (2023). Early insolvency prediction for sustainable growth. *Sustainability, 15*(21), 15304. https://doi.org/10.3390/su152115304

Vuković, D., Jovanović, D., & Đurić, S. (2023). *Revisiting the Altman Z-Score: Applicability in transitional economies*. Journal of Risk and Financial Management, 16(4), 210. https://doi.org/10.3390/jrfm16040210

Wahyuni, N., & Gani, A. A. (2022). *Reviewing the firm value in terms of profit, debt, and growth*. Jurnal Manajemen. http://ecojoin.org/index.php/EJM/article/view/843

Youlanda, E. (2021). Analisis kinerja keuangan menggunakan Altman Z-Score sebelum dan sesudah COVID-19. *Universitas Jambi.*

Yulianti, S. D., Linawati, L., & Sugeng, S. (2022). Analisis kebangkrutan dengan metode Altman Z"-Score pada perusahaan transportasi di BEI. *Repositori UNP Kediri.*