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Financial Distress Prediction Using MARS and Logistic Regression: Evidence from Indonesia

Cheng-Wen Lee[1] | **Moch Bisyri Effendi**[1]* | **Erwin Mangatur Siburian**[1]

[1]Chung Yuan Christian University, Taoyuan city, Taiwan, ROC.

Correspondence
*Moch Bisyri Effendi – Ph.D. Program in Business, Chung Yuan Christian University, Taoyuan city, Taiwan, ROC. Email: bisyrieffendi@gmal.com

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Abstract
The increasing uncertainty in the business environment has intensified the need for reliable financial distress prediction models, particularly within the manufacturing sector, which plays a strategic role in economic development. The study aims to compare the effectiveness of logistic regression and multivariate adaptive regression splines (hereinafter – MARS) in predicting financial distress among manufacturing companies listed on the Indonesian stock exchange. The study employs a quantitative research design with purposive sampling, using data from 70 manufacturing firms and 210 firm-year observations over the 2022–2025 period. Financial distress is examined using four key financial indicators, namely current ratio, total liabilities to total assets, return on assets, and sales to total assets. The findings reveal that both models are statistically valid; however, MARS outperforms logistic regression in terms of predictive accuracy, achieving an overall classification rate of 82.4% compared to 65.7%. Logistic regression revealed a statistically significant effect of return on assets only on financial distress ($p = 0.003$; $Exp(B) = 0.006$), whereas MARS showed that all financial indicators under consideration contributed to the predictive model. These findings highlight the importance of profitability as a primary determinant of financial distress and suggest that MARS provides a more robust framework for developing early warning systems and supporting financial decision-making. The practical significance of the study lies in the potential for businesses, investors, creditors, and regulatory authorities to use the results to identify financial risks early, which is important for the economy's stable development.

KEYWORDS
Finance, Corporate Finance, Financial Distress, Business Performance, Manufacturing Company, Economic Sustainability, Indonesia

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1 | INTRODUCTION

The manufacturing sector plays a crucial role in supporting economic growth, employment creation, and industrial development, particularly in emerging economies. In Indonesia, manufacturing activities contribute significantly to national economic performance and are among the primary drivers of sustainable development. However, rising global economic uncertainty, intensifying market competition, and commodity price fluctuations have intensified financial pressures on firms, thereby increasing the likelihood of financial distress. Financial distress is a condition in which a company has difficulty meeting its financial obligations and may eventually face bankruptcy if corrective actions are not taken (Altman, 1968; Sun et al., 2014). Consequently, the ability to predict financial distress has become increasingly important for managers, investors, creditors, and policymakers seeking to reduce risk and improve strategic decision-making.

Research on financial distress prediction has evolved substantially since the pioneering work of Altman (1968), who introduced the Z-Score model as an early warning system for corporate failure. Subsequent studies have demonstrated that financial ratios provide valuable information regarding a firm's financial condition and can effectively distinguish distressed firms from healthy firms (Beaver, 1966; Ohlson, 1980). Among the most frequently employed indicators are liquidity ratios, solvency ratios, profitability ratios, and activity ratios. Specifically, the Current Ratio (hereinafter – CR), Total Liabilities to Total Assets (hereinafter – TLTA), Return on Assets (hereinafter – ROA), and Sales to Total Assets (hereinafter – STA) are widely used to assess a firm's ability to meet short-term obligations, manage debt, generate profits, and utilize assets efficiently (Platt & Platt, 2002; Sun et al., 2014). These financial indicators have consistently been identified as important determinants of financial distress risk across various industrial and geographical contexts.

From a methodological perspective, Logistic Regression has become one of the most widely used techniques for financial distress prediction because it is relatively easy to interpret and well-suited to binary classification problems (Ohlson, 1980; Martin, 1977). Nevertheless, previous studies have highlighted several limitations of Logistic Regression, particularly its inability to capture nonlinear relationships and complex interactions among financial variables fully (Jones et al., 2017). To address these limitations, researchers have increasingly adopted machine-learning and nonparametric approaches capable of modeling more sophisticated data structures. One promising technique is multivariate adaptive regression splines, introduced by Friedman (1991), which is designed to identify nonlinear relationships and interaction effects without imposing strict statistical assumptions. Previous studies have shown that multivariate adaptive regression splines can provide competitive and, in some cases, superior predictive performance compared with conventional statistical approaches in bankruptcy and financial distress prediction (De Andrés et al., 2011; Barboza et al., 2017).

Despite the growing literature on financial distress prediction, empirical studies comparing logistic regression and multivariate adaptive regression splines remain relatively limited, particularly in emerging-market environments such as Indonesia.

Moreover, prior findings regarding the effects of liquidity, leverage, profitability, and activity ratios on financial distress have often been inconsistent, suggesting that the underlying relationships may be more complex than those captured by traditional linear models (Sun et al., 2014; Tian et al., 2015). Therefore, further investigation is required to evaluate whether more flexible analytical methods can improve prediction accuracy and provide deeper insights into the determinants of financial distress.

Accordingly, the study aims to compare the effectiveness of logistic regression and Multivariate Adaptive Regression Splines (hereinafter – MARS) in predicting financial distress among manufacturing companies listed on the Indonesian stock exchange. The study focuses on four financial ratios, CR, TLTA, ROA, and STA, and evaluates their ability to explain financial distress under both methodological approaches. By comparing model accuracy and identifying the most influential predictors, this research contributes to the financial distress literature and offers practical implications for developing more effective early warning systems and financial risk management strategies (Barboza et al., 2017; Jones et al., 2017). The results of the study are of practical importance for business, as they enable managers, investors, and creditors to promptly identify financially vulnerable companies and reduce corporate risks. In a broader economic context, the application of such models can help strengthen the financial sustainability of Indonesia's manufacturing sector and support its sustainable development.

2 | LITERATURE REVIEW

Signaling theory provides a fundamental explanation of how firms communicate information to external stakeholders in situations characterized by information asymmetry. Originally introduced by Michael Spence, the theory argues that managers possess superior information regarding a firm's financial condition, operational performance, and future prospects compared to investors and creditors. Consequently, stakeholders rely on observable signals to evaluate organizational quality and assess investment risk. In corporate finance, financial statements and financial ratios serve as important signaling mechanisms, providing objective information on profitability, liquidity, efficiency, and financial stability. Strong financial performance generally conveys positive signals concerning management effectiveness and future growth potential, whereas deteriorating financial indicators may signal increased uncertainty and financial vulnerability. Recent studies emphasize that accounting information remains one of the most influential sources of signals for investors when assessing firm value and financial sustainability (Connelly et al., 2011; Alareeni & Hamdan, 2020). Within the context of financial distress prediction, declining profitability, weakening liquidity, and increasing leverage serve as negative signals that may indicate future financial difficulties. Stakeholders interpret these signals to adjust investment and lending decisions accordingly. Therefore, Signaling Theory provides an appropriate theoretical foundation for explaining why financial ratios are frequently used as predictors of financial distress, as they convey valuable information about a firm's capacity to maintain

operational continuity and long-term financial stability.

Trade-off theory explains corporate financing decisions by emphasizing the balance between the benefits and costs of debt financing. Developed from modern capital structure theory, this framework posits that firms seek an optimal level of leverage that maximizes firm value by balancing the tax advantages of debt against the costs of financial distress and bankruptcy risk (Kraus & Litzenberger, 1973). Debt financing offers benefits because interest payments are tax-deductible, thereby reducing the effective cost of capital and increasing shareholder value. However, excessive reliance on debt increases fixed financial obligations and exposes firms to greater risks during periods of declining earnings or economic uncertainty. Manufacturing firms are particularly relevant to this theory because their operations typically require substantial investments in fixed assets, inventories, and production facilities, often financed through external debt. According to Trade-Off Theory, firms with stable profitability can sustain moderate leverage while maintaining financial flexibility, whereas excessive debt may increase vulnerability to financial distress (Frank & Goyal, 2009). Empirical evidence indicates that leverage remains one of the most important determinants of corporate financial stability, particularly when profitability and liquidity weaken simultaneously (Vo et al., 2022). Therefore, Trade-Off Theory provides a useful framework for understanding how financing decisions influence the probability of financial distress and why leverage-related indicators are frequently incorporated into bankruptcy prediction models.

Financial distress refers to a condition in which a firm experiences a deterioration in financial performance that impairs its ability to meet contractual obligations and sustain normal business operations. It is generally considered a transitional stage between financial stability and formal bankruptcy, during which firms encounter increasing financial pressure resulting from declining profitability, weakening liquidity, and excessive leverage. Early identification of financial distress is essential because timely intervention may prevent business failure and preserve organizational value. Contemporary literature recognizes financial distress as a multidimensional phenomenon influenced by both internal and external factors, including operational inefficiency, ineffective financial management, economic downturns, market competition, and unfavorable macroeconomic conditions (Sun et al., 2014). Advances in predictive analytics have significantly improved the ability to identify distress risk through accounting information and financial indicators. Recent studies demonstrate that profitability, liquidity, leverage, and activity ratios consistently provide valuable information for distinguishing financially healthy firms from distressed firms (Barboza et al., 2017; Hosaka, 2019; du Jardin, 2021). Furthermore, machine learning and data-driven approaches have enhanced predictive accuracy compared with traditional statistical techniques by capturing nonlinear relationships among financial variables. Consequently, financial distress remains a major topic in corporate finance research because of its significant implications for investors, creditors, managers, regulators, and policymakers seeking to reduce financial risk and improve organizational sustainability.

ROA is a profitability ratio that measures a firm's ability to generate net income relative to the total assets employed in its operations. The ratio reflects managerial effectiveness in utilizing available resources to create sustainable earnings and is widely regarded as one of the most important indicators of corporate financial performance. For manufacturing firms, ROA is particularly relevant because substantial investments in fixed assets, production facilities, and working capital require efficient use of resources to maintain profitability. A high ROA indicates effective asset management and strong operational performance, whereas a declining ROA suggests inefficiencies in asset utilization and weakening earning capacity. According to Signaling Theory, profitability serves as a positive signal regarding firm quality because profitable firms are generally perceived as more capable of sustaining operations and fulfilling financial obligations. Recent empirical studies consistently identify profitability as one of the strongest predictors of financial distress, with firms exhibiting higher ROA levels demonstrating significantly lower probabilities of bankruptcy and financial failure (Hosaka, 2019; Liang et al., 2015). Strong profitability enhances internal cash flow generation, reduces dependence on external financing, and increases financial flexibility during periods of economic uncertainty. Consequently, ROA is widely incorporated into financial distress prediction models because it captures both operational efficiency and a firm's ability to maintain long-term financial sustainability.

TLTA is a leverage ratio that measures the proportion of a firm's assets financed by debt. This ratio provides important information about capital structure decisions and financial risk exposure, as it reflects the extent to which a company depends on external financing to support its operations and investments. A higher TLTA ratio indicates greater reliance on debt financing, which may increase financial flexibility during periods of growth but simultaneously elevates the risk of financial distress when business performance deteriorates. According to Trade-Off Theory, firms attempt to balance the benefits of debt, such as tax advantages, against the potential costs associated with financial distress and bankruptcy. However, excessive leverage can significantly increase fixed financial obligations and reduce a firm's ability to withstand adverse economic conditions (Frank & Goyal, 2009). Manufacturing firms are particularly vulnerable to leverage-related risks because they generally require substantial investments in production facilities, machinery, and inventories, often financed through debt. Recent empirical studies consistently demonstrate that leverage is positively associated with the probability of financial distress and corporate failure (Barboza et al., 2017; Hosaka, 2019). Firms with high debt burdens frequently encounter difficulties in meeting interest and principal payments during periods of declining profitability or economic uncertainty. Consequently, TLTA is widely recognized as one of the most important indicators in financial distress prediction models because it captures the relationship between financing decisions, financial risk, and long-term corporate sustainability.

CR is one of the most widely used liquidity indicators for assessing a firm's ability to meet short-term financial obligations using current assets. Calculated as current

assets divided by current liabilities, the ratio reflects the adequacy of working capital to support daily operations and meet maturing liabilities. For manufacturing companies, liquidity management is particularly important because production activities require substantial investments in inventories, accounts receivable, and operational expenditures. A higher Current Ratio generally indicates stronger liquidity and greater capacity to absorb temporary financial shocks, thereby reducing the likelihood of financial distress. Conversely, insufficient liquidity may limit a firm's ability to fulfill short-term obligations and increase dependence on external financing, potentially leading to financial difficulties. Nevertheless, contemporary literature suggests that the relationship between liquidity and financial distress is more complex than traditionally assumed. While low liquidity is often associated with elevated distress risk, excessively high liquidity may indicate inefficient resource allocation and underutilization of productive assets (Alaka et al., 2018). Recent studies emphasize that liquidity should be evaluated alongside profitability and leverage indicators because financial distress is typically driven by multiple interconnected factors rather than a single financial metric (Mai et al., 2019; du Jardin, 2021). Therefore, CR remains an important variable in financial distress prediction models as it provides valuable information regarding short-term financial resilience and operational continuity.

STA, commonly referred to as total asset turnover, measures the efficiency with which a firm utilizes its assets to generate revenue. The ratio is calculated by dividing total sales by total assets, reflecting management's effectiveness in converting invested resources into productive business output. In manufacturing industries, where firms typically make large investments in fixed assets and production facilities, efficient asset utilization is critical to profitability and competitiveness. A higher STA ratio indicates that a company generates greater revenue from its asset base, suggesting effective operational management and productive resource allocation. Conversely, a lower STA ratio may indicate underutilized assets, operational inefficiencies, weak market demand, or declining competitiveness, all of which may contribute to financial difficulties over time. From the perspective of Signaling Theory, efficient asset utilization signals to investors and creditors that management can maximize organizational resources and sustain business performance. Empirical evidence suggests that activity ratios, including STA, contribute significantly to financial distress prediction because firms experiencing declining asset efficiency often exhibit deteriorating financial performance and increased financial vulnerability (Barboza et al., 2017; Hosaka, 2019). Furthermore, efficient asset utilization supports revenue growth, enhances cash flow generation, and strengthens profitability, thereby reducing the likelihood of financial distress (Liang et al., 2015). Therefore, STA is considered an important operational indicator in financial distress prediction models because it captures the relationship between resource efficiency, revenue generation, and long-term financial sustainability.

Logistic regression is widely used in financial distress prediction because it is well-suited to binary classification problems, in which firms are classified as either financially distressed or non-distressed. This method allows researchers to

estimate the probability of financial distress based on a set of explanatory variables and to interpret the influence of each predictor through regression coefficients and odds ratios. Its main advantage is interpretability, which makes it useful for explaining how liquidity, leverage, profitability, and activity ratios affect the likelihood of financial distress (Hosmer et al., 2013; Menard, 2002; Agresti, 2018). However, logistic regression has certain limitations because it mainly captures linear relationships between predictors and the log-odds of the outcome. As a result, it may not fully reflect nonlinear patterns and complex interactions among financial indicators (Peng et al., 2002).

Multivariate Adaptive Regression Splines (MARS) is considered a more flexible nonparametric approach for modeling complex relationships between dependent and independent variables. Introduced by Friedman (1991), MARS can identify nonlinear effects and interaction patterns without requiring a predefined functional form. This feature makes the method relevant to financial distress prediction, where the relationship between financial ratios and corporate financial vulnerability may vary with firm-specific conditions and market dynamics. Previous studies suggest that MARS can provide competitive or superior predictive performance compared with conventional statistical models, especially when the data contain nonlinear structures and interaction effects (Friedman, 1991; De Veaux & Ungar, 1994). Nevertheless, MARS may be more complex to interpret than logistic regression, particularly when many basis functions and interaction terms are included in the model (Lewis & Stevens, 1991). Overall, MARS is widely recognized as a strong alternative to, and complement of, logistic regression in binary classification, especially when flexibility and predictive accuracy are prioritized over strict parametric assumptions.

Building on signaling theory and prior empirical evidence, this study proposes an integrated conceptual framework linking liquidity, solvency, profitability, and activity ratios to the likelihood of financial distress among manufacturing firms. These financial ratios collectively signal a firm's financial condition, reflecting its ability to meet short-term obligations, manage its capital structure, generate profits, and utilize assets efficiently. Prior research confirms the relevance of financial ratios in explaining corporate distress. Beaver (1966) demonstrates that financial ratios have predictive power for identifying business failure, while Altman (1968) shows that combined financial indicators can effectively distinguish distressed from non-distressed firms. More recent evidence by Platt and Platt (2021) further supports the continued relevance of financial ratios as predictors of financial distress across different model specifications. Based on these theoretical and empirical foundations, this study posits that liquidity, solvency, profitability, and activity ratios jointly influence the probability of financial distress, forming the basis of the proposed conceptual framework and hypotheses.

Based on the theoretical discussion and previous empirical findings, this study proposes that liquidity, solvency, profitability, and activity ratios influence the probability of financial distress. The conceptual relationship among CR, TLTA, ROA, STA, and financial distress is presented in Figure 1.

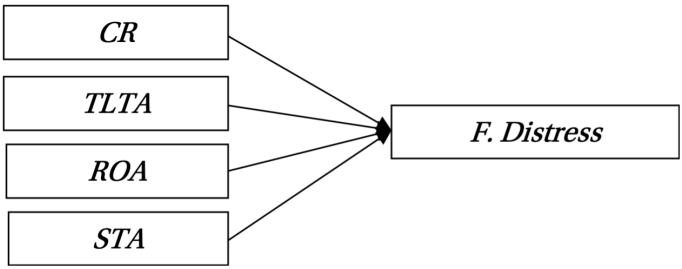


Figure 1. Conceptual framework of financial ratios and financial distress

CR, defined as current assets divided by current liabilities, is a widely used liquidity measure that reflects a firm's ability to meet its short-term obligations with readily available resources. From a theoretical perspective, higher liquidity reduces the likelihood of financial distress by strengthening a firm's capacity to absorb short-term cash flow shocks, maintain operational stability, and avoid default risk. Liquidity theory further suggests that firms with stronger short-term financial positions are better equipped to sustain operations during periods of economic uncertainty. Empirical evidence supports the relevance of financial ratios, including liquidity measures, in predicting financial distress and corporate failure. For instance, Moussa (2019) finds that liquidity ratios are significantly related to financial performance, which is closely linked to a firm's financial stability. Platt and Platt (2021) further emphasize that financial ratios, including liquidity indicators such as the current ratio, remain important predictors in corporate financial distress models, despite concerns related to sample bias in prediction studies. In addition, Beaver et al. (2005) demonstrate that financial ratios continue to possess strong explanatory power in predicting bankruptcy, highlighting the enduring relevance of liquidity measures in distress prediction models. However, the relationship between liquidity and financial distress may vary across industries and economic conditions and, in some cases, exhibit non-linear patterns due to differences in working capital management efficiency. Therefore, this study hypothesizes that CR has a significant effect on financial distress, with higher liquidity expected to reduce the probability of financial distress.

H1: CR has a significant influence on financial distress

TLTA ratio is a widely used proxy for leverage, reflecting the proportion of a firm's assets financed by debt, and serves as an important indicator of capital structure risk and long-term solvency. From a theoretical perspective, higher leverage increases the probability of financial distress by raising fixed financial obligations, reducing financial flexibility, and amplifying vulnerability to earnings volatility and macroeconomic shocks. In line with trade-off theory, although debt financing may provide tax advantages, excessive leverage increases expected financial distress costs, thereby elevating default risk. Recent empirical studies provide consistent evidence supporting the positive association between leverage and financial distress. For instance, Silalahi et al. (2024) find that leverage significantly affects financial distress in Indonesian listed firms, indicating that higher debt levels increase fi-

nancial vulnerability. Similarly, Ayatika et al. (2024) report that leverage has a significant effect on financial distress in state-owned enterprises, confirming its relevance as a predictor of financial instability. In addition, Sembiring et al. (2025) demonstrate that leverage is a key determinant of financial distress in consumer non-cyclical firms. However, the magnitude of its effect may vary across sectors and model specifications. However, some studies also indicate that leverage may not always be statistically significant when combined with other financial ratios, suggesting potential interaction effects with liquidity, profitability, and firm growth. Therefore, this study proposes that the TLTA ratio significantly influences financial distress, where higher leverage is expected to increase the probability of financial distress.

H2: TLTA ratio has a significant influence on financial distress

ROA, measured as net income relative to total assets, is widely recognized as a key indicator of a firm's profitability and operational efficiency. A higher ROA reflects management's ability to utilize organizational resources effectively to generate earnings, thereby strengthening the firm's financial position. From a theoretical perspective, profitable firms are generally less vulnerable to financial distress because they possess greater internal cash-generating capacity, stronger capital reserves, and enhanced access to external financing. Moreover, signaling theory suggests that sustained profitability conveys positive information about managerial effectiveness and the long-term viability of a firm's business model, reducing stakeholders' concerns regarding financial instability. Empirical evidence largely supports this view. For instance, Kebede et al. (2024) found that profitability significantly reduces the likelihood of financial distress, while Arya and Suhendah (2024) reported a similar negative relationship between profitability and financial distress among Indonesian firms. Nevertheless, prior studies have also documented inconsistent findings, indicating that the protective effect of profitability may vary across industries and economic conditions. Dahruji and Muslich (2022), for example, observed a negative but statistically insignificant relationship between profitability and financial distress in Islamic commercial banks. Such mixed results imply that the influence of profitability may be moderated by other financial characteristics, including leverage, liquidity, and firm-specific conditions. Given its strong theoretical foundation and extensive empirical support, ROA is expected to play a significant role in explaining variations in financial distress risk. Accordingly, this study hypothesizes that ROA has a significant effect on the probability of financial distress.

H3: ROA has a significant influence on financial distress

The STA ratio, also known as asset turnover, measures operational efficiency by quantifying revenue generated per unit of invested capital (Budhiarjo, 2024). Theoretically, higher asset turnover indicates effective resource utilization, which supports cash flow generation and reduces reliance on external financing, thereby mitigating distress risk. Signaling theory suggests that efficient asset deployment conveys managerial capability and competitive positioning, enhancing stakeholder confidence and reducing perceived operational risk. Empirical findings regard-

ing STA's predictive relevance exhibit notable heterogeneity: while some research documents significant relationships between asset turnover and financial distress in various industrial contexts, others report nonsignificant effects, potentially reflecting industry-specific dynamics, measurement differences, or unmodeled interaction effects (Ariefah & Hirdinis, 2025). Moreover, post-pandemic supply chain disruptions and demand volatility may have altered the relationship between asset efficiency and financial resilience, with firms maintaining flexible asset bases potentially outperforming those with rigid, high-turnover structures during periods of uncertainty. Studies employing multivariate approaches examining debt ratios, asset turnover, and profitability simultaneously demonstrate that total asset turnover significantly influences financial distress outcomes, suggesting that activity ratios warrant consideration in distress prediction models alongside leverage and profitability factors (Rafli & Nurismalatri, 2025).

H4: STA ratio has a significant influence on financial distress.

3 | RESEARCH METHODOLOGY

This study employs a quantitative research approach to examine the predictability of financial distress in manufacturing companies through financial ratios. The research design utilizes a structured sample of 70 manufacturing companies listed on the Indonesia Stock Exchange during the 2020–2023 period, generating a total of 210 observations to ensure robust statistical analysis. The sampling technique used is purposive sampling, with the selection criterion requiring that companies consistently publish complete financial statements in Indonesian rupiah throughout the research period. This stringent criterion ensures data reliability and continuity for longitudinal analysis. Secondary data were obtained from annual financial reports and the Indonesian Capital Market Directory, which provided standardized financial information for all sampled firms (Khotimah et al., 2026). Financial distress is operationalized as a sustained deterioration in a company's financial performance over time, characterized by low financial ratios and reduced capacity to meet financial obligations, with potential progression toward bankruptcy (Rech et al., 2025). The operational definition encompasses four key financial dimensions: liquidity, measured through the Current Ratio (CR) to assess short-term payment capability; solvency, proxied by Total Liabilities to Total Assets (TLTA) to evaluate long-term debt servicing capacity; profitability, represented by Return on Assets (ROA) to indicate asset efficiency in generating earnings; and activity, measured via Sales to Total Assets (STA) to capture asset utilization effectiveness in revenue generation (Putri & Irsan, 2025). This multidimensional operationalization aligns with established distress prediction frameworks and provides comprehensive coverage of financial health dimensions essential for accurate classification.

The analysis employs two complementary statistical techniques, logistic regression and MARS, to develop and compare financial distress prediction models. Logistic regression is the conventional statistical approach, with model validity assessed using the Hosmer and Lemeshow test (significance > 0.05), the Omnibus Test of Model Coefficients (significance < 0.05), and decreasing -2 log-likelihood

values converging to stable parameter estimates (Gajdosikova et al., 2025). The MARS model, a machine learning technique, is validated using F-statistics (Fcount > Ftable), thereby capturing nonlinear relationships between financial ratios and distress conditions (Kanapickienė et al., 2023). Classification accuracy for both models is measured as the proportion of correct predictions relative to the total number of observations, serving as a primary performance metric (Nair & Sachdeva, 2022). The influence of independent variables on financial distress is assessed using regression coefficient significance ($p < 0.05$), enabling the identification of key predictive factors. Comparative evaluation focuses on model validity, classification accuracy, and variable significance patterns to determine which approach more effectively identifies financial distress indicators among Indonesian manufacturing firms. This dual-method approach accommodates both linear and nonlinear patterns in financial data, enhancing predictive robustness. The comprehensive analysis framework provides stakeholders, including investors, creditors, and corporate managers, with reliable early-warning mechanisms to detect financial stress and support informed decision-making (Tang & Zhang, 2025).

4 | ANALYSIS AND RESULTS

The suitability test for the logistic regression model assesses whether the model is suitable for use and can be further analyzed. The suitability test of the logistic regression model consists of 3 tests: Hosmer and Lemeshow's Test, Omnibus Test, and -2 log-likelihood. The results of the model suitability test are significant; the model can explain the phenomenon of financial distress of manufacturing companies in the study period with a significance value of Hosmer and Lemeshow's Test of 0.298> 0.05, a significance value of the Omnibus Test of 0.000 <0.05, and a value of -2 log likelihood decreasing convergent from the initial value of 288.926 to 263.346. It can be concluded that the logistic regression model is feasible for use, meaning it can explain financial distress among manufacturing companies, with the factors involved being CR, TLTA, ROA, and STA. Hypothesis testing is conducted to assess the influence of independent variables on dependent variables, with a 5% tolerance level. The research hypothesis is accepted if the significance value of the independent variable is less than 0.05. The results of the hypothesis test using logistic regression are presented in Table 1 below.

Table 1. Logistic regression hypothesis testing

Variable	Sig.	Exp(B)
CR	0.396	1,093
TLTA	0.063	5,331
ROA	0.003	0.006
STA	0.587	0.894

Note: compiled by the authors based on SPSS 25 output

Table 1 presents the results of hypothesis testing using logistic regression to examine the effect of CR, TLTA, ROA, and STA on the dependent variable. The

significance level used in this study was 5% (α = 0.05). A variable is considered significant if its significance value (Sig.) is less than 0.05. Furthermore, the Exp(B) value, or odds ratio, measures the direction and magnitude of each variable's influence on the probability of the dependent variable occurring.

The test results show that the ROA variable has a significance value of 0.003, which is less than 0.05, thus having a significant effect on the dependent variable. The Exp(B) value of 0.006 indicates that an increase in ROA will reduce the probability of the dependent variable occurring by 99.4% [(1 - 0.006) × 100%], assuming other variables remain constant. Thus, higher profitability tends to reduce the likelihood of the condition measured by the dependent variable occurring. This finding indicates that a company's ability to generate profits is an important factor in determining the probability of the observed event.

The TLTA variable has a p-value of 0.063, which is slightly above the 5% significance threshold, making it statistically insignificant at the 95% confidence level. However, at the 10% significance level, this variable can be considered to have a marginal effect on the dependent variable. The Exp(B) value of 5.331 indicates that an increase in the total liabilities-to-total assets ratio increases the likelihood of the dependent variable by 5.331 times relative to the previous value. This indicates that companies with higher leverage are more likely to experience the condition measured by the dependent variable.

The CR variable has a significance value of 0.396, which is well above 0.05, so it does not have a significant effect on the dependent variable. The Exp(B) value of 1.093 indicates that an increase in the Current Ratio only increases the likelihood of the dependent variable occurring by 1.093 times. However, this effect is not statistically strong enough. Thus, the company's ability to meet short-term obligations was not proven to be a determining factor in this research model.

The STA variable also showed insignificant results with a significance value of 0.587. The Exp(B) value of 0.894 indicates that increasing the efficiency of asset utilization in generating sales tends to reduce the probability of the dependent variable occurring by 10.6%, but this effect is not statistically significant. Therefore, it can be concluded that the efficiency of company activities, as measured by STA, is not able to explain changes in the probability of the dependent variable convincingly.

The model accuracy classification shows the accuracy of the model in predicting the company's finances. The results of the model's classification accuracy are presented in Table 2 below.

Table 2. Model classification

Observed	Predicted NFD	Predicted FD	Percentage Correct
NFD	80	31	72.1
FD	41	58	58.6
Overall Percentage	–	–	65.7

Note: compiled by the authors based on SPSS 25 output

Table 2 indicates that the accuracy of the logistic regression model's classifi-

cation for manufacturing companies that do not experience financial distress is 80/(80+31) = 72.1%. The accuracy of the logistic regression model's classification for manufacturing companies experiencing financial distress is 58/(58+41) = 58.6%. The accuracy of the logistic regression model's classification for predicting financial distress among manufacturing companies is (80+58) / (80+31+41+58) = 65.7%. Thus, it can be concluded that the accuracy of the MARS model in predicting financial distress of manufacturing companies in the research period is 65.6%, namely, 137 out of 210 company observations.

The suitability test of the MARS model is to determine whether the model is feasible to use and can be analyzed further. The criteria for testing the significance test of the MARS model with error tolerance (α = 0.05) and obtained Ftable = F (0.05; 2; 107) = 3.039. The critical area / rejection of H0 for the MARS model significance test is, if Fcount> Ftable then the decision is to reject H0 and it can be concluded that the model is feasible to use which means the MARS model is able to explain the relationship between the independent variable and the dependent variable and vice versa. The results of the MARS model significance test on manufacturing companies listed on the IDX in the period 2022 - 2025, showed that the value of Fcount = 75.617> Ftable = 3.039, then reject H0, it can be concluded that the model is feasible to use which means the MARS model is able to explain the phenomenon of financial distress of manufacturing companies with the factors involved in it are CR, TLTA, ROA and STA.

Hypothesis testing in this study was conducted using the Multivariate Adaptive Regression Splines (MARS) method to identify the variables with the most significant influence on the dependent variable. Unlike conventional linear regression approaches, MARS can accommodate nonlinear relationships and interactions between variables frequently found in empirical data. In the testing process, the relative significance of each variable is evaluated through variable importance analysis, which indicates the contribution of each predictor to model performance. Variable importance is calculated based on the change in the Generalized Cross Validation (GCV) value when a variable is removed from the model. The greater the decline in model quality, as indicated by the -GCV value, the greater the variable's contribution in explaining the variation in the response variable. Therefore, this analysis allows researchers to determine the most dominant variables and objectively rank the influence of each predictor.

The results of the variable importance test in the MARS model are presented in Table 3.

Based on Table 3, the results of the MARS analysis show the variable importance of each variable in explaining the dependent variable studied. The MARS importance values are normalized, with the most influential variable assigned a value of 100%, and then the other variables are compared relative to that variable.

The ROA variable has an importance value of 100,000, indicating that ROA is the most dominant variable in shaping the prediction model. The -GCV value of 0.456 indicates that removing ROA from the model will result in the greatest decline in model performance compared to other variables. This finding indicates

that the company's ability to generate profits from its assets is the primary factor influencing the response variable. In other words, changes in the company's profitability level contribute the most to the variation in the observed dependent variable.

Table 3. Importance variable

Rank	Variable	Importance	−GCV
1	ROA	100.000	0.456
2	TLTA	84.678	0.234
3	CR	67.886	0.187
4	STA	28.987	0.145

Note: compiled by the authors based on SPSS 25 output

The TLTA variable ranks second with an importance value of 84.678 and α -GCV value of 0.234. These results indicate that the company's funding structure, reflected in the leverage level, has a fairly strong influence on the model, although its contribution is still below ROA. Furthermore, the CR (Current Ratio) variable has an importance value of 67.886 with a -GCV of 0.187, indicating that the company's ability to meet short-term obligations also contributes significantly to explaining the variation of the dependent variable. Meanwhile, the STA variable has the lowest value, namely 28.987, with a -GCV of 0.145, indicating that the efficiency of asset utilization in generating sales makes a relatively smaller contribution compared to other variables. Overall, the order of influence of variables, based on the MARS results, is ROA > TLTA > CR > STA, indicating that profitability is the main determinant in the model, followed by leverage, liquidity, and asset efficiency. These findings also indicate that the MARS model can identify the relative contribution of each variable more flexibly than conventional linear regression methods, as it accounts for nonlinear relationships and interactions among variables.

The classification accuracy shows the model's ability to predict the company's finances. The results of the model's classification accuracy are presented in Table 4 below.

Table 4. Model classification

Observed	Predicted NFD	Predicted FD	Percentage correct
NFD	95	16	85.6
FD	21	78	78.8
Overall percentage	–	–	82.4

Note: compiled by the authors based on SPSS 25 output

Table 4 indicates that the accuracy of the MARS model's classification for manufacturing companies that do not experience financial distress is 95/(95+16) = 85.6%. The accuracy of the MARS model's classification for manufacturing companies experiencing financial distress is 78/(78+21) = 78.8%. The accuracy of the MARS model classification in predicting financial distress in manufacturing companies is (95+78) / (95+16+21+78) = 82.4%. Thus, it can be concluded that the accuracy of the MARS model in predicting financial distress in manufacturing companies in the research period is 82.4%, namely, 173 out of 210 company observations.

The results from both methods (logistic regression and MARS) are consistent: ROA is the dominant factor. However, MARS shows that although CR and STA are not significant in the linear logistic model, both still contribute to prediction because MARS captures nonlinear relationships and interaction effects that logistic regression misses.

5 | DISCUSSION

CR reflects a company's ability to meet its short-term obligations using current assets, where a higher ratio theoretically indicates stronger liquidity and a lower likelihood of experiencing financial distress. However, the logistic regression results indicate that CR does not have a significant effect on financial distress (Sig. = 0.396), suggesting that manufacturing companies' liquidity levels during the study period were insufficient to directly explain the occurrence of financial distress. This finding indicates that a high current ratio does not necessarily represent strong financial health, as it may result from the accumulation of inventories or accounts receivable that cannot be readily converted into cash. Nevertheless, the MARS analysis shows that CR has an importance value of 67.886%, ranking third among the predictor variables. This result suggests that liquidity still contributes to predicting financial distress, although its influence is nonlinear and cannot be fully captured by the logistic regression model. The ability of MARS to identify complex relationships indicates that liquidity changes under certain conditions remain relevant for distinguishing distressed from non-distressed firms. These findings are consistent with Sari et al. (2025), who reported that stronger liquidity reduces the likelihood of financial distress by enhancing a firm's capacity to meet short-term obligations. However, the results differ from Febriyanti and Haryanto (2025), who found that the Current Ratio has a significant positive effect on financial distress, suggesting that excessive liquidity may indicate inefficient asset utilization rather than financial strength. Therefore, while liquidity is not the primary determinant of financial distress, it remains an important supporting factor in financial distress prediction models, particularly when nonlinear relationships are considered.

TLTA measures the proportion of a company's assets financed through liabilities and serves as an important indicator of leverage and financial risk. Theoretically, a lower TLTA ratio indicates a stronger asset base relative to liabilities, thereby reducing the likelihood of financial distress because the company has greater capacity to meet its financial obligations. The logistic regression results show that TLTA has a significance value of 0.063, indicating that although the variable is not statistically significant at the 5% level, it exhibits a marginal effect at the 10% level. Furthermore, the Exp(B) value of 5.331 suggests that an increase in leverage may increase the probability of financial distress by more than five times. This finding supports Trade-Off Theory, which argues that while debt financing can generate tax advantages, excessive reliance on debt increases financial costs and the risk of bankruptcy. In manufacturing companies, a high proportion of liabilities relative to assets may reduce financial flexibility, particularly during periods of economic uncertainty and fluctuating market demand. Although the logistic

regression model does not identify TLTA as a statistically significant predictor, the MARS analysis ranks it as the second most influential variable, with an importance value of 84.678%. This result suggests that the relationship between leverage and financial distress is likely nonlinear and therefore not fully captured by conventional logistic regression. The strong contribution of TLTA in the MARS model is consistent with previous studies showing that leverage remains one of the most important predictors of financial distress because highly leveraged firms face greater financial pressure and default risk (Liang et al., 2015; Kristanti & Pancawati, 2024). Therefore, despite its relatively weak linear effect, leverage remains a critical factor in predicting financial distress among manufacturing firms.

ROA measures a company's ability to generate net income from its total assets and serves as a key indicator of operational efficiency and financial performance. Theoretically, a higher ROA reflects a more effective utilization of corporate resources, thereby reducing the likelihood of financial distress. The logistic regression results demonstrate that ROA has a statistically significant negative effect on financial distress (Sig. = 0.003; Exp(B) = 0.006), indicating that an increase in profitability substantially decreases the probability of a firm experiencing financial distress. The odds ratio value below one suggests that profitable firms possess stronger capabilities to meet both operational and financial obligations, enhancing their resilience against financial difficulties. This finding is consistent with Signaling Theory, which posits that strong profitability serves as a positive signal of a firm's financial health, managerial effectiveness, and long-term sustainability to investors and creditors. The importance of profitability is further reinforced by the MARS analysis, which identifies ROA as the most influential predictor with an importance value of 100%, highlighting its dominant contribution to the model's predictive performance. This result indicates that variations in profitability generate more substantial changes in financial distress status than any other financial indicator included in the model. The findings are consistent with Waqas and Md-Rus (2018), who reported that profitability is among the most significant determinants of financial distress, and with Sari et al. (2025), who found that profitable firms are less likely to experience financial difficulties due to their stronger capacity to generate earnings and sustain operational activities. Therefore, within the context of Indonesian manufacturing companies during the 2022–2025 period, profitability emerges as the most critical factor distinguishing financially distressed firms from financially healthy firms.

STA represents the extent to which all assets are able to create sales, and according to theory, higher ratios indicate better asset efficiency and lower likelihood of financial distress. However, empirical evidence from Indonesian manufacturing companies during 2022–2025 reveals that STA has no significant effect on financial distress, with a logistic regression significance value of 0.587 and an Exp(B) of 0.894. This finding suggests that efficient asset utilization in generating sales is insufficient to explain financial distress likelihood in manufacturing companies. While Signaling Theory proposes that asset efficiency creates competitive advantage and improves company performance, research indicates that high asset turnover does

not necessarily translate into increased profitability, as companies must still cover substantial production, operational, and financing costs (Ariefah & Hirdinis, 2025). The low importance value of STA in MARS analysis (28.987%) further demonstrates that the information contained in STA is largely explained by other variables, particularly profitability and leverage ratios, meaning STA's additional contribution to the model's predictive ability is relatively small. This aligns with broader research showing that activity ratios have lower predictive power than profitability and leverage ratios in detecting financial distress (Sitompul et al., 2025). Therefore, both logistic regression and MARS results consistently demonstrate that asset efficiency is not the main determinant of financial distress in Indonesian manufacturing companies during the 2022–2025 period, although it still provides supplementary information in classifying the company's financial condition.

6 | CONCLUSION

This study was conducted to evaluate the effectiveness of logistic regression and MARS in predicting financial distress among manufacturing companies listed on the Indonesia Stock Exchange during the 2022–2025 period. The findings indicate that both models are capable of explaining financial distress; however, MARS demonstrates superior predictive performance with a classification accuracy of 82.4%, compared with 65.7% achieved by Logistic Regression. The results further reveal that ROA is the most influential predictor of financial distress across both analytical approaches. In contrast, CR, TLTA, and STA exhibit varying levels of contribution, particularly when nonlinear relationships are considered. These findings suggest that profitability remains the primary indicator of corporate financial health, while leverage, liquidity, and asset utilization provide additional explanatory value in identifying potential financial difficulties.

From a practical perspective, the results imply that managers should place greater emphasis on improving profitability and maintaining an optimal capital structure to reduce the likelihood of financial distress. Continuous monitoring of key financial indicators, particularly ROA and leverage-related measures, can support early detection of deteriorating financial conditions and facilitate timely corrective actions. In addition, investors, creditors, and other stakeholders may benefit from incorporating advanced predictive techniques such as MARS into their evaluation processes, as the method offers a more comprehensive understanding of complex financial patterns that are often overlooked by conventional linear models.

Despite its contributions, this study has several limitations. The analysis is restricted to manufacturing firms and relies primarily on accounting-based financial ratios, which may not fully capture broader determinants of financial distress such as macroeconomic conditions, corporate governance mechanisms, market performance, or cash flow dynamics. Furthermore, the observation period and sample size may limit the generalizability of the findings across different sectors and economic environments. Future studies are therefore encouraged to expand the scope of analysis by incorporating additional explanatory variables, extending

the observation horizon, and comparing MARS with other machine-learning techniques to enhance the robustness and predictive capability of financial distress models.

AUTHOR CONTRIBUTIONS

Writing – Original Draft: Cheng-Wen Lee, Moch Bisyri Effendi, Erwin Mangatur Siburian.
Conceptualization: Cheng-Wen Lee.
Formal Analysis and Investigation: Cheng-Wen Lee, Moch Bisyri Effendi, Erwin Mangatur Siburian.
Funding Acquisition and Research Administration: Moch Bisyri Effendi, Erwin Mangatur Siburian.
Development of Research Methodology: Cheng-Wen Lee, Moch Bisyri Effendi.
Resources: Cheng-Wen Lee, Moch Bisyri Effendi, Erwin Mangatur Siburian.
Software and Supervision: Cheng-Wen Lee, Moch Bisyri Effendi.
Data Collection, Analysis, and Interpretation: Cheng-Wen Lee, Erwin Mangatur Siburian.
Visualization: Cheng-Wen Lee, Moch Bisyri Effendi, Erwin Mangatur Siburian.
Writing – Review and Editing: Cheng-Wen Lee, Moch Bisyri Effendi.

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AUTHOR BIOGRAPHIES

Cheng-Wen Lee – Professor, Department of International Business, Chung Yuan Christian University, Taoyuan City, Taiwan, ROC. Email: chengwen@cycu.edu.tw, ORCID ID: https://orcid.org/0000-0002-4811-7000

Moch Bisyri Effendi – Ph.D. Program in Business, Chung Yuan Christian University, Taoyuan City, Taiwan, ROC. Email: bisyrieffendi@gmail.com.

Erwin Mangatur Siburian – Ph.D. Program in Business, Chung Yuan Christian University, Taoyuan City, Taiwan, ROC. Email: g11304621@cycu.edu.tw

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