Evaluating ESG Performance and Its Influence on Bond Default Risk

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Abstract

This study investigated the effectiveness of integrating ESG performance into a model for predicting corporate bond default by utilizing data from listed companies in the Stock Exchange of Thailand spanning 2017-2023. By building upon Altman's EM-score model, which is traditionally used with financial ratios, the study included an ESG indicator and calculates new coefficients and cutoff scores. The key finding indicates that the modified model exhibits superior accuracy for 95% overall in predicting bond default one year in advance compared to the original model. However, the analysis reveals that the inclusion of the ESG indicator and the book value of equity to total liabilities does not have a statistically significant effect on the bond default occurring in the Thai bond market.

Keywords: Altman's EM-Score model, Bond Default, ESG Indicator, Financial Ratios, Thai bond market

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Introduction

1.1 Statement of the Problems

As of July 5, 2023, the Thai Bond Market Association (ThaiBMA) reported a total of 37 billion baht in bond default by Thai companies, accounting for 0.48% of total outstanding corporate bonds. This amount has increased by 1.57 times compared to the pre-COVID-19 period, highlighting widespread negative impacts. However, the previous studies in Thailand primarily focus on financial data while overlooking sustainability factors. This narrow approach can lead to inaccurate creditworthiness assessments and expose investors to unforeseen risks. Integrating ESG criteria into these models could better align investments with sustainable practices.

The growing interest in Environmental, Social, and Governance (ESG) has significantly reshaped the investment landscape especially in stocks. Investors are now increasingly acknowledging the long-term risks and opportunities linked to a company's ESG practices. Numerous studies support the notion that strong ESG performance signifies effective risk management, enhances brand reputation, and contributes to a company's long-term financial well-being. Furthermore, regulatory bodies such as the Thai Securities and Exchange Commission (SEC) are actively promoting ESG integration in the Thai capital market to align with the global push towards sustainability and reflects Thailand's goal of achieving carbon neutrality by 2050 and net zero greenhouse gas emissions by 2065. This commitment manifests in initiatives such as their support for integrating ESG factors into equity analysis and the adoption of the Task Force on Climate-Related Financial Disclosures (TCFD) recommendations which encourages listed companies to disclose climate-related risks and opportunities, providing valuable insights for investors and demonstrate their dedication to fostering a more sustainable and transparent financial environment.

In summary, Thailand's bond market has faced a concerning increase in defaults in recent years. However, existing research has overlooked the role of ESG factors, highlighting a significant gap in the literature. This study aims to address this gap by exploring the relationship between ESG performance and bond default risk in the Thai market to enhance investment decisions and develop more robust risk assessment models.

1.2 Objectives

The primary objective of this study is to identify a statistically significant relationship between ESG performance and corporate bond default, with the aim of evaluating the efficacy of ESG performance in enhancing investment decision-making processes. Additionally, this research seeks to develop a modified Altman's EM-score model by integrating the ESG indicator with traditional financial ratios to predict bond default one year in advance for Thai listed companies. This involves computing new cutoff scores and weighted coefficients to enhance the model's predictive accuracy, thereby providing a more robust tool for assessing default risks in the context of the Thai bond market.

1.3 Significance of Research

By developing a model that integrated the ESG indicator alongside traditional financial ratios, this study aims to provide a more comprehensive and predictive tool for assessing bond default probabilities. This enhanced risk assessment would benefit various stakeholders within the market.

Investors and financial institutions, such as banks and asset managers, traditionally rely only on financial data for risk assessment and decision-making. This enhanced tool enables them to identify companies with a higher likelihood of bond default. By considering ESG performance, they can make more informed decisions, potentially avoiding risky investments and prioritizing companies committed to sustainable practices.

Moreover, policymakers and regulatory agencies, who play a vital role in overseeing the Thai capital market, can develop guidelines based on ESG considerations. The study also suggests incorporating ESG performance into credit rating procedures for bond issuers, leading to a more comprehensive approach to evaluating creditworthiness. This could potentially mitigate risk and promote responsible business practices.

Ultimately, this research aimed to provide valuable insights into decision-making and enhance the understanding of ESG practices' implications, thereby mitigating risks for stakeholders and promoting a more responsible and sustainable economy within the Thai financial landscape.

1.4 Scope of the Study

This study encompasses listed companies on the Stock Exchange of Thailand (SET) and the Market for Alternative Investment (mai) that have issued corporate bonds between 2017 and 2023 across various industries. The study excluded those in the financial sector (banking, finance & securities, and insurance), except for a few that had distress cases due to the limited number of distress occurrences. After organizing the data, resulting in a total sample of 1,363 companies over the seven-year period. ThaiBMA categorized these companies into two groups based on their financial health. The first group, the 'Distress Group,' includes companies that have defaulted on debt repayments, are at risk of default, or are undergoing debt restructuring. The second group, the 'Non-Distress Group,' comprises companies with good financial standing or those operating normally.

Financial data for the selected companies will be sourced from Refinitiv Eikon, and four key financial ratios will be calculated from this data. Additionally, listed companies included in the Thailand Sustainability Investment (THSI), which serves as an ESG indicator, will be obtained from the SET website. These financial and ESG data points will serve as the foundation for analysis. The primary techniques employed in this research are Linear Discriminant Analysis (LDA) and Altman's EM-Score model. This modified model will be compared against the traditional one to assess the impact of ESG performance on predicting bond default. Moreover, the analysis will be conducted using the Python programming language.

Literature Review

2.1 Concepts and Theories

There are several key concepts and theories that are crucial for this research. These include sustainable investment, bond event signs information, linear discriminant analysis, and Altman's EM-score model. A detailed exploration of each of these will provide a comprehensive understanding of the foundation of this study.

2.1.1 Sustainable Investment

Sustainable investing has emerged as a widely accepted strategy in the modern world among professional investors and individuals worldwide today. This approach goes beyond merely seeking companies with strong fundamentals poised for growth, but it also encompasses a comprehensive evaluation of a company's ESG performance. In today's business landscape, social and environmental factors significantly influence operations, making it imperative to consider risk management and opportunities in these areas. Consequently, sustainable investing is gaining popularity as it provides a holistic perspective, ensuring that investments grow sustainably over the long term while aligning with the values of diverse stakeholders.

Since 2015, SET has introduced the list of Thailand Sustainability Investment or THSI, which represents publicly traded companies that committed to sustainable practices across ESG dimensions. The list offers investors an alternative for engaging in sustainable investment practices by encouraging the integration of ESG factors alongside financial data in their decision-making processes.

The companies included in THSI voluntarily participate in a sustainability assessment questionnaire prepared by SET. This assessment covers various ESG dimensions, and is reviewed annually to align with international and national sustainability trends. To qualify as sustainable stocks in THSI, companies must attain a minimum score of 50% in each assessed area or be listed on the Dow Jones Sustainability Indices (DJSI). Additionally, they must meet specific criteria related to Corporate Governance Reporting (CGR) quality, net profit, and shareholder equity outcomes. They should also have satisfactory oversight on issues related to the qualifications of listed companies without causing ESG impacts and must not be securities marked with a "C" sign. A working group of experts in corporate governance and sustainable development, in collaboration with capital market agencies, oversees the selection process for sustainable stocks. This ensures transparency and accountability in the screening and selection process. In 2023, SET renamed "THSI" to "SET ESG Ratings" to better reflect its emphasis on ESG factors. However, the process for evaluating sustainable stocks and selecting them remains unchanged from the original THSI framework.

2.1.2 Bond Event Sign Information

The signs which referred to distress events related to debt securities are provided by ThaiBMA.

(1) Non-payment Signs (Not an Event of Default)

A. Failed to Pay (FP): Issuer missed principal or interest payment on due date; whether this is an Event of Default depends on bond terms and conditions.
B. Failed to Pay with Guarantee (FPG): Issuer of guaranteed bond missed principal or interest payment on due date; whether this is an Event of Default depends on guaranteed bond terms and conditions.

(2) Signs designated for the occurrence of event of default

A. Default Payment (DP): Issuer failed to pay as specified under the terms and conditions of the bond, experienced cross-default, faced automatic stay, or bankruptcy action accepted by court.
B. Default not related to payment (DNP): Issuer failed to comply with covenants or provisions stipulated in the terms and conditions of the bond other than the default according to the criteria for posting sign DP, FP or FPG

(3) Signs designated for debt restructuring

A. Restructure (RS): Issuer with debt restructuring or change in redemption date or maturity date approved by bondholders.
B. Rehabilitation (REH): Issuer under court-approved business rehabilitation plan.
C. Bankruptcy (BANKRUPT): Issuer adjudged bankrupt by bankruptcy court.

2.1.3 Linear Discriminant Analysis (LDA)

Linear Discriminant Analysis (LDA) is a supervised technique that aims to predict the class or category of a dependent variable using a linear combination of independent variables. It operates under the assumptions that the independent variables are normally distributed and that the classes have equal variance/covariance. LDA can be utilized for both classification and dimensionality reduction. When its assumptions hold, LDA constructs a linear decision boundary that effectively distinguishes between different classes, such as 0s and 1s in a dataset. The main goal of LDA is to find the best line that separates these classes. However, LDA often performs well even when these assumptions are not strictly met.

$$DS = \beta_0+\beta_1 X_1+\beta_2 X_2+...+\beta_k X_k \quad (1)$$

Where:

DS: Discriminant Score

β's: Discriminant Weights/ Coefficients

X's: Independent Variables

LDA estimates weights to maximize the separation between groups using discriminant functions. It constructs an equation aimed at minimizing the likelihood of misclassifying cases into their respective classes.

2.1.4 Altman's EM-score Model (1995)

The original Altman Z-score model, developed in 1968 by Dr. Edward I. Altman, serves as a numerical measure predicting the likelihood of a company facing bankruptcy or insolvency within the next two years. Initially designed for public manufacturing companies with assets exceeding $1 million, the model relies on five financial ratios encompassing profitability, leverage, liquidity, solvency, and activity. With an accuracy rate of over 80% in predicting business bankruptcies one year in advance, the Z-score model has become widely accepted and reliable in developed countries. However, its application in other nations, besides the United States, has encountered challenges with variable weights due to a lack of standard accounting systems, as well as management systems that may not fully reflect true credit risk.

To address these challenges, Altman developed a new model specifically tailored for emerging markets, known as Altman's Emerging Market Score Model (EM-score Model), in 1995. While retaining the core formula of Z-score, the EM-score excludes the "Total Sales/Total Assets" variable and adjusts the coefficients of the remaining ratios. The EM-score formula is as follows:

$$EM = 3.25+6.56X\_1+3.26X\_2+6.72X\_3+1.05X\_4 \qquad (2)$$

Where:

EM: Altman's EM-score

X1: Working Capital/Total Assets

X2: Retained Earnings/Total Assets

X3: Earnings Before Interest and Tax/Total Assets

X4: Book Value of Equity/Total Liabilities

A score below 1.1 indicates the distress zone, suggesting a high risk of bankruptcy within two years, while scores above 2.6 indicate a low risk, falling into the safe zone. Scores between 1.1 and 2.6 fall within a grey zone, signifying companies that require close monitoring as their bankruptcy risk is not yet clearly defined. The EM-score model comprises several key financial ratios, each providing valuable insights into a company's financial health:

(1) Working Capital/Total Assets: Working Capital represents the difference between a company's current assets and current liabilities, reflecting its capacity to meet short-term obligations with short-term assets. A higher ratio suggests superior liquidity and financial robustness, as it indicates a larger proportion of current assets relative to total assets.

(2) Retained Earnings/Total Assets: Retained Earnings denote the portion of a company's net income reinvested in the business rather than distributed as dividends. This ratio gauges how much retained earnings finance total assets. A higher ratio signifies that the company utilizes retained earnings to fund capital expenditures, indicating stability, profitability, and reduced reliance on borrowings.

(3) Earnings Before Interest and Tax/Total Assets: Earnings Before Interest and Tax (EBIT) measures a company's ability to generate profits solely from its operations before deducting interest and taxes. This ratio evaluates the company's capacity to generate operating profits relative to total assets. A higher ratio suggests sufficient revenue generation to sustain profitability, meet debt obligations, and fund ongoing operations, indicative of efficiency and profitability.

(4) Book Value of Equity/Total Liabilities: Book Value of Equity represents the net assets attributable to shareholders, calculated as total assets minus total liabilities. This ratio assesses the proportion of total liabilities covered by shareholders' equity. A higher ratio indicates greater coverage of liabilities by shareholders' equity, signaling financial stability and lower leverage.

2.2 Related Literatures

This section reviews the literature supporting this research, focusing on two key aspects: the relationship between ESG performance and default risk, and the potential of using Altman's EM-score model within the context of Thailand.

2.2.1 ESG and Default Risk

The relationship between ESG performance and corporate default risk has been explored in several studies across different regions and methodologies, with generally consistent findings regarding the role of ESG factors in mitigating default risk.

Both Li et al. (2020) and Aslan et al. (2021) found that stronger ESG performance is associated with lower corporate default risk, though their studies were conducted in different contexts and used different methodologies. Li et al. studied industrial bond issuers in China using a Logistic Regression model. Their results indicated that the bond default rate was positively correlated with energy consumption but negatively correlated with attention to social responsibilities, corporate governance, and financial performance. While social responsibility was less statistically significant, the overall conclusion was that incorporating ESG factors into decision-making can enhance corporate stability and credibility. Similarly, Aslan et al., in their analysis of US bonds using OLS regression, discovered that higher ESG performance significantly reduced the probability of corporate credit default. Their study emphasized the individual contributions of the ESG pillars, with the social pillar having the most significant impact. They also highlighted sectoral variations, noting that energy, financial, and IT sectors exhibited a stronger negative relationship between ESG performance and default probability.

Suganda et al. (2023) extended this line of inquiry to the Korean stock market, focusing on the relationship between corporate social responsibility (CSR), as measured by ESG scores, and default risk. Like the previous studies, they found that higher CSR practices are associated with lower financial risk and better creditworthiness. Using the Altman Z-score as a measure of default risk, they observed that firms with higher CSR scores had lower default risks, which in turn improved their access to funding. Their findings also suggested that CSR can mitigate financial distress, lower both idiosyncratic and systematic risks, and protect against legal risks.

In summary, these studies found that companies with strong ESG performance tend to exhibit lower corporate default risk, though the effects of individual ESG pillars and sectoral differences varied. Incorporating ESG practices into corporate strategies not only improves

financial stability but also enhances firm credibility and risk management. Therefore, it is advisable for both investors and companies to integrate ESG considerations into their assessments of financial risk and decision-making processes. However, there is currently no research on this topic within the Thai context as highlighted in the statement of the problem. Therefore, this study aims to fill this gap by exploring the potential of ESG factors in Thailand and assessing whether the results align with those observed in other countries.

2.2.2 Altman's EM-score Model in Thailand

Previous studies have assessed the effectiveness of models in predicting financial distress among Thai companies listed on the Stock Exchange of Thailand (SET), providing insights into the use of both Altman's Z-score and EM-score models. Leelahawas (2008) compared Altman's Z-score model (with 5 variables) and the EM-score model (with 4 variables) to forecast financial failures. The findings indicated that both models were highly accurate in predicting financial distress one year in advance, with no statistically significant difference between them. However, the 4-variable EM-score model was found to be more accurate in predicting companies that would not fail, making it better suited for Thailand. Leelahawas suggested that the EM-score model is preferable for Thailand due to differences in business scale and operating conditions compared to the US, particularly in variables such as market value of equity and the size of income and assets.

Similarly, Khemnguad (2011) refined Altman's EM-score model to predict financial distress among SET-listed companies. The study demonstrated significant accuracy, with a 95% precision rate for one-year forecasts and 83.33% for two-year forecasts. Khemnguad emphasized the appropriateness of the EM-score model for Thailand, given its classification as an emerging market, which inherently carries higher risks compared to developed capital markets. The model's adaptation to emerging market conditions allows for a comprehensive risk assessment aligned with Thailand's economic dynamics.

In summary, these studies suggest that Altman's EM-score model is more reliable for assessing bankruptcy risk among Thai companies, as it is better adapted to the unique conditions of emerging markets like Thailand. This is primarily due to its adaptation for emerging markets and its adjustments to better reflect the size and operational conditions of Thai businesses. Consequently, this study has selected the EM-score model as the most appropriate tool for predicting financial distress within the Thai context.

Methodology

3.1 Research Design

3.1.1 Data Collection

Building and evaluating the bond default prediction model requires compiling several key datasets. This section outlines the specific data collection steps involved in research.

Firstly, due to limitations in comprehensive ESG data for Thai companies, this research used an inclusion in the THSI as a proxy for strong ESG practices. The list of THSI companies was obtained from the SET website. Secondly, information regarding distressed companies was sourced from the ThaiBMA. This data is categorized into two groups. The first group includes companies undergoing debt restructuring, labeled as Restructure (RS) and Rehabilitation (REH), and are considered to be in the 'Grey' zone. The second group comprises companies facing default events, labeled as Default Payment (DP), and are classified in the 'Danger' zone. These three specific cases represent instances of distress in the Thai bond market. Additionally, a list of companies that have issued bonds was also sourced from the ThaiBMA. Next, financial data for the identified companies were collected from Refinitiv Eikon. This data includes a range of metrics that provide insights into a company's financial health, including Current Assets, Current Liabilities, Retained Earnings, EBIT, Total Assets, and Total Liabilities.

Companies in the financial industry (banking, finance & securities, and insurance) were excluded from the analysis, except for a few that had distress cases due to the limited number of distress occurrences. The final sample consists of totaling 1,363 samples spanning the period from 2017 to 2023. A summary of factors and corresponding indicators is listed in Table 1

Table 1: Independent variables

Independent Variable	Indicator Symbol	Formula
Working Capital to Total Assets	WCTA	(Current Assets - Current Liabilities) / Total Assets
Retained Earnings to Total Assets	RETA	Retained Earnings / Total Assets
EBIT to Total Assets	EBITTA	Earnings Before Interest and Tax / Total Assets
Book Value of Equity to Total Liabilities	BVETL	(Total Assets - Total Liabilities) / Total Liabilities
ESG Performance	THSI	THSI Listed = 1, Non-listed = 0

3.1.2 Model

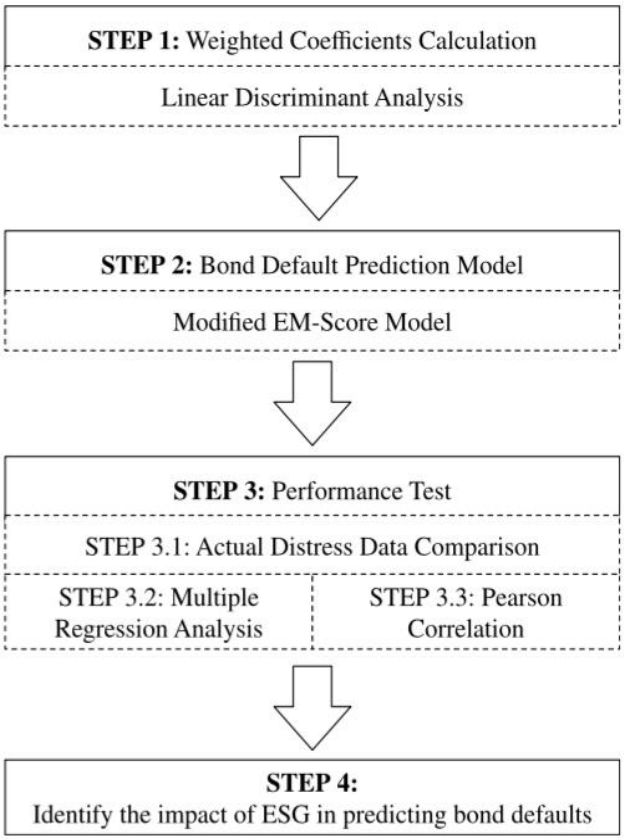

Figure 1: Conceptual framework

After collecting the data, the study utilized the OLS method to test the significance of the independent variables. Subsequently, various approaches were adopted to develop a more effective model for predicting bond default as a modified version of the original Altman's EM-score model. The modification was necessitated by the research's aim to integrate both financial ratios and THSI as predictive factors for companies' probability of default. This involved adjusting the weighted coefficients, independent variables, and cutoff scores.

The model construction began by leveraging historical data from 2017 to 2021, where a company's solvency or its ability to meet financial obligations, serves as the dependent variable. The independent variables are traditional financial ratios used in Altman's EM-score model and a newly introduced ESG indicator represented as a dummy variable signifies whether a company is included in the THSI. To calculate new coefficients for these independent variables, research employed LDA, which assigns greater weight to variables with a stronger influence on a company's financial health.

Once these coefficients are determined, they are applied to a modified EM-score model, which calculates scores for companies within a test set spanning the years 2022 and 2023.

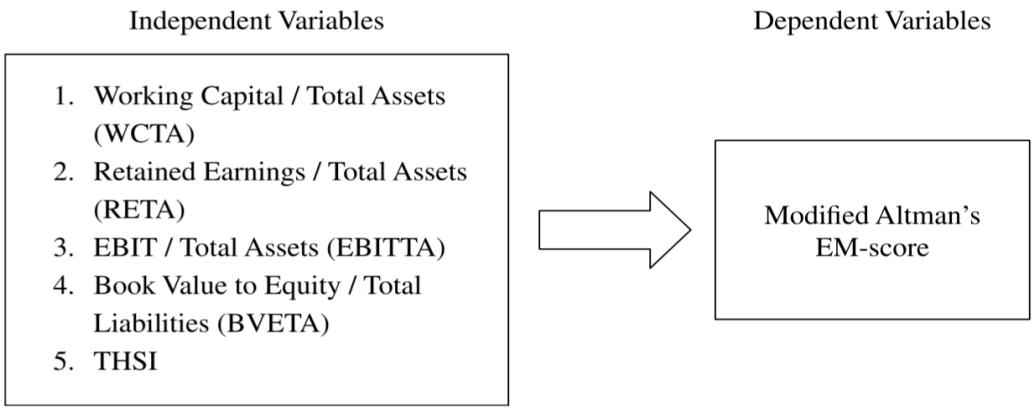

Figure 2: Variables in the modified EM-score model

The formula of the modified EM-score model:

$$EM = a + bX_1 + cX_2 + dX_3 + eX_4 + fX_5 \qquad (3)$$

Where:
EM: Modified Altman's EM-score

X1: Working Capital/Total Assets

X2: Retained Earnings/Total Assets

X3: Earnings Before Interest and Tax/Total Assets

X4: Book Value of Equity/Total Liabilities

X5: Dummy variable indicating whether a firm is listed in the THIS

Note that the constant term (a) in the model was derived from the median Z-score of distressed companies, allowing for standardized analysis.

The EM-scores of companies were then categorized into three zones: danger, grey, and safe. These zones reflect the predicted risk of default for each company. The cutoff scores defining the boundaries between the three zones are calculated using the following formula:

$$Cutoff\ Score = ln\frac{q1c1}{q2c2} \qquad (4)$$

Where:
q1, q2: Prior probability of distress and non-distress

c1, c2: Cost of type I and type II error

3.1.3 Performance Test

To evaluate the model's accuracy, the predicted zones were compared with the actual distress cases in the following year. This comparison allowed for an assessment of how effectively the model identifies companies at risk of defaulting on their bonds one year in advance. The model was further refined through an iterative process by recalculating cutoff scores, as well as the constant term in the model's equation. This iterative approach continues until the model achieves the highest possible level of accuracy in predicting bond default. Furthermore, research compared the accuracy performance of the modified model, with the original EM-score model.

Additionally, the results were analyzed using Multiple Regression Analysis and Pearson Correlation. Multiple Regression Analysis, conducted using the OLS method, played a crucial role in understanding the impact of each variable on the model's performance. Before performing OLS, it is essential to ensure that the data meet the assumptions of Multiple Linear Regression, which are as follows:

(1) Linearity: There should be a linear relationship between the dependent variable and each independent variable. This can be verified by visually inspecting scatterplots for linearity.

(2) Autocorrelation: The observations should be independent of one another. This can be tested using the Durbin-Watson statistic to ensure that the residuals are not autocorrelated.

(3) Multivariate Normality: The residuals should be normally distributed. This can be checked by examining the distribution of residual values.

(4) Homoscedasticity: The variance of the residuals should be constant. This can be tested by plotting the standardized residuals against the predicted values on a scatter plot to see if the points are evenly distributed across all values of the independent variables.

(5) Multicollinearity: The independent variables should not be highly correlated with each other. This can be tested using the Variance Inflation Factor (VIF) method.

3.2 Hypotheses

By addressing these hypotheses, research aims to provide a comprehensive understanding of the factors influencing bond default and the significance of integrating ESG considerations into financial models. Hypothesis 1 explores the relationship between financial ratios, ESG indicator, and their impact on predicting bond default. Hypothesis 2 focuses on comparing the accuracy of the different models in bond default prediction.

Hypothesis 1:
H0: The financial ratios from the original Altman's EM-score model and the ESG indicator are not significant predictors of bond default for Thai companies.

H1: The financial ratios from the original Altman's EM-score model and the ESG indicator are significant predictors of bond default for Thai companies.

Hypothesis 2:
H0: The modified EM-score model does not have higher predictive accuracy for bond default than the original EM-score model.

H2: The modified EM-score model has higher predictive accuracy for bond default than the original EM-score model.

Results & Discussion

4.1 Descriptive Statistics

Table 2: The classification of samples

Sample	Distress Group		Non-Distress Group		Total
	Number	% of Group	Number	% of Group	
Training Set (2017-2021)	18	1.86%	949	98.13%	967
Test Set (2022-2023)	24	6.06%	372	93.94%	396
Total	42	3.08%	1,321	96.92%	1,363

As illustrated in Table 2, the dataset was divided into training and test sets to avoid model overfitting. The training set included data from 2017 to 2021 is used to develop the model, while the test set consisted of data from 2022 and 2023 is later utilized to assess the model's accuracy. Specifically, the training set comprised 949 non-distressed bond issuers and 18 distressed bond issuers, representing 70.95% of the total samples. The test set included 372 non-distressed bond issuers and 24 distressed bond issuers, representing 29.05% of the total samples.

Despite the relatively limited number of observed bond distress cases in Thailand which has totaling only 42 samples from 2017 to 2023 out of a dataset comprising 1,363 samples, the increasing frequency of distress cases in recent years, particularly notable in 2022 and 2023, underscores the critical necessity of developing a model capable of effectively detecting distress signals. This highlights the significance and urgency of the research endeavor.

Table 3: The descriptive statistics of two groups

Indicators	Mean		SD	
	Distress Group	Non-Distress Group	Distress Group	Non-Distress Group
WCTA	-0.3764	0.1101	0.5921	0.2231
RETA	-0.4257	0.1265	0.4971	0.2704
EBITTA	-0.0437	0.0418	0.0808	0.0585
BVETL	0.1346	1.1244	0.3171	1.5260
THSI	0.0476	0.2594	0.2155	0.4384

The descriptive statistics reveal differences between distress and non-distress groups, as shown in Table 3. Distressed companies tend to have lower mean values for indicators compared to non-distressed companies. Additionally, the distress group shows greater variability in these indicators, as evidenced by their higher standard deviation values. Overall, these statistics underscore notable distinctions in metrics between distressed and non-distressed companies.

Table 4: The correlation between variables

	WCTA	RETA	EBITTA	BVETL	THSI
WCTA	1				
RETA	0.32	1			
EBITTA	0.20	0.41	1		
BVETL	0.28	0.14	0.02	1	
THSI	0.02	0.24	0.18	-0.04	1

The analysis in Table 4 found no correlations exceeding 0.7 or below -0.7 between independent variables. This indicates a low risk of multicollinearity, ensuring the stability and interpretability of regression coefficients. With no strong correlations, each variable contributes unique information to the model, reducing the likelihood of redundant overlap. Overall, this suggests that the regression analysis results are less susceptible to multicollinearity bias.

4.2 Empirical Results

The analysis involved performing Multiple Linear Regression using OLS methodology. This approach enabled the assessment of the statistical significance of independent variables when tested against historical solvency data.

Table 5: The estimation of coefficients and the result of T-test (Solvency)

Indicators	Coefficients
Constant	0.9251***
WCTA	0.1601***
RETA	0.1134***
EBITTA	0.3144***
BVETL	0.0022
THSI	0.0073

Note: * p < 0.1, ** p < 0.05, *** p < 0.01

According to hypothesis H1 that all financial ratios used in the original Altman's EM-score model and the ESG indicator are significant predictors of bond default for Thai companies. The results in Table 5 show that the financial ratios WCTA, RETA, and EBITTA are statistically significant indicators of companies' solvency at the 99% confidence level, underscoring their strong indicator of default risk. However, the analysis reveals that BVETL and THSI are not statistically significant, as their p-values exceed the threshold for all confidence levels. In simpler terms, BVETL and THSI do not significantly reflect solvency of the companies. Consequently, the null hypothesis cannot be rejected, indicating that not all variables are significant indicators of bond default for Thai companies.

There are two main explanations supporting the lack of significance that reflect the limitations of this study. First, the analysis included companies from a wide range of industries, some with inherently high leverage and others with lower leverage. This diversity might have masked the impact of BVETL on default risk. Additionally, the limited number of defaults within the Thai context prevented the researchers from creating industry-specific groups for a more focused analysis. Second, Thailand's adoption of ESG practices is in the early stage. Consequently, the relationship between bond default and a company's inclusion in the THSI may not yet be well-established.

Despite the lack of statistical significance in some variables, the researchers decided to include all variables in the final modified EM-Score model for several reasons. Firstly, prior research conducted in Thailand has demonstrated the effectiveness of the original EM-Score model in predicting financial distress one year in advance. Therefore, the researchers believe that the traditional financial ratios from this model remain relevant in the Thai context and contribute to the overall accuracy of the modified model. Secondly, although THSI was not

statistically significant on its own, its inclusion allows for an exploration of its potential influence when integrated with other variables. This comprehensive approach enables a thorough evaluation of THSI's possible indirect contribution to predicting default probabilities. Even if THSI does not directly impact the results, it may still offer valuable insights. Therefore, all variables will be retained in the modified EM-score model to explore their potential integration in predicting default probabilities.

After running the weighted coefficients using LDA for the key variables used in the modified EM-score model, the coefficients for x1, x2, x3, x4, and x5 were determined to be 8.70, 3.68, 19.35, 0.05, and 0.07 respectively. This resulted in the following formula:

$$EM = 5.93+8.70X\_1+3.68X\_2+19.35X\_3+0.05X\_4+0.07X\_5 \quad (5)$$

Where:

EM: Modified Altman's EM-score

X1: Working Capital/Total Assets

X2: Retained Earnings/Total Assets

X3: Earnings Before Interest and Tax/Total Assets

X4: Book Value of Equity/Total Liabilities

X5: Dummy variable indicating whether a firm is listed in the THSI

The model also incorporated a constant term of 5.93 and computed new optimal cutoff scores of -0.28 and 2.71 for classifying companies into risk zones.

According to hypothesis H2 that the modified EM-score model has a higher predictive accuracy for bond default than the original EM-score model, the following section presents an analysis comparing the performance of two models for predicting bond default one year in advance: the modified EM-score model and the original EM-score model. The modified EM-score model, which incorporates additional features and adjustments, demonstrates superior accuracy compared to the original model in both testing years. Specifically, in 2022, the modified EM-score model achieves an accuracy of 94.95%, while in 2023, it achieves an accuracy of 94.44%. In contrast, the original EM-score model achieves slightly lower accuracies of 93.43% and 91.41% for the same respective years.

When delving into the classification reports, the modified EM-score model exhibits more balanced performance across all classes compared to the original EM-score model. This balance is reflected in the model's high precision, recall, and F1-scores for the 'Safe' class, which is the majority class. As a result, the modified EM-score model achieves an overall weighted average F1-score of 0.95, indicating robust performance across all classes. Conversely, the original EM-score model demonstrates imbalanced performance, particularly

with lower precision and recall for the 'Grey' class. Consequently, the original EM-score model yields a slightly lower weighted average F1-score of 0.92.

The analysis demonstrates that the modified EM-score model outperforms the original EM-score model in terms of accuracy and classification metrics. Thus, the null hypothesis is rejected, confirming that the modified EM-score model exhibits higher predictive accuracy for bond default prediction compared to the original EM-score model in the Thai bond market. However, it's important to consider a limitation of the model which is the class imbalance problem since the dataset contained a significantly lower number of distressed companies compared to non-distressed ones. Thus, this class imbalance could potentially bias the accuracy results of the model which underscores the need for careful interpretation.

Furthermore, the results are examined using Multiple Regression Analysis and Pearson Correlation. Before conducting Multiple Regression Analysis, it is crucial to verify whether the data meet the assumptions of Multiple Linear Regression. The Durbin-Watson statistic yielded a result of 2.159, indicating the absence of autocorrelation. Additionally, VIF scores fell within the range of 1.2 to 1.5, suggesting no multicollinearity among the independent variables. Furthermore, scatter plots and residual distributions were observed to align with the assumptions.

Table 6: The estimation of coefficients and the result of T-test (EM-score)

Indicators	Coefficients
Constant	6.1053***
WCTA	7.7934***
RETA	4.8100***
EBITTA	9.0773***
BVETL	-0.0138
THSI	0.2519*

Note: * p < 0.1, ** p < 0.05, *** p < 0.01

The analysis of independent variables and the calculated EM-score was conducted using OLS as shown in Table 6. Despite the inclusion of BVETL and THSI in the modified EM-Score model, which were found to be not statistically significant when tested against actual solvency data. BVETL remained not statistically significant at all confidence levels which indicates that it does not serve as a reliable predictor of default. However, THSI showed statistical significance at the 0.1 confidence level. Additionally, traditional financial ratios such as WCTA, RETA, and EBITTA exhibited strong statistical significance and had a substantial positive influence on the EM-score.

When considering the magnitude of influence, EBITTA emerges as the most impactful factor on the EM-score, with a coefficient of 9.0773. WCTA follows with a coefficient of

7.7934, and RETA at 4.8100. Lastly, THSI exhibits a coefficient of 0.2519, highlighting its comparatively lesser influence on the EM-score.

Table 7: The estimation of coefficients and the result of Pearson Correlation

Indicators	Coefficients
WCTA	0.755***
RETA	0.725***
EBITTA	0.527***
BVETL	0.157***
THSI	0.206***

Note: * p < 0.1, ** p < 0.05, *** p < 0.01

In the analysis of Pearson correlation as the results in Table 7, the correlation coefficients between the EM-score and each independent variable are statistically significant across all confidence levels. This indicates a strong and consistent relationship between the EM-score and each of the independent variables. These coefficients indicate the magnitude and direction of the impact of each independent variable on the EM-score. Overall, both the Pearson correlation analysis confirms the significant relationships between the independent variables and the EM-score, providing valuable insights into the factors influencing bond default prediction.

Conclusion

5.1 Summary of the Research Findings

Regarding Hypothesis H1, the null hypothesis cannot be rejected, as not all financial ratios from the original Altman's EM-score model and the ESG indicator are significant predictors of bond default for Thai companies. Specifically, the analysis revealed that BVETL and THSI were not statistically significant, suggesting that these variables do not currently reflect bond default risk in the Thai context. However, other financial ratios demonstrated statistical significance and can serve as reliable indicators of default occurrences.

Furthermore, the research successfully developed a modified EM-score model that outperforms the original model in predicting bond default one year in advance within the Thai market. The modified model achieved significantly higher accuracy rates, reaching 94.95% in 2022 and 94.44% in 2023. Consequently, the null hypothesis for Hypothesis H2 can be rejected, confirming that the modified EM-score model has higher predictive accuracy for bond default than the original EM-score model.

In conclusion, the research identified WCTA, RETA, and EBITTA as crucial variables for signaling bond default in the Thai market. The findings also highlight the enhanced effectiveness of the modified EM-score model, which integrates THSI into bond default predictions while recalibrating weighted coefficients, constants, and cutoff scores. This underscores the importance of these adjustments in refining financial models for improved predictive performance.

Importantly, this study addresses a significant research gap, as there are currently no existing studies in Thailand that incorporate ESG indicators in the context of bond default risk. The findings indicate that the ESG indicator does not effectively capture company solvency or bond default risk in Thailand at present, even though it holds significance in other countries.

5.2 Limitation

The study encountered limitations related to data availability in two key areas. First, researcher conducted the study within the context of the Thai bond market, which experiences a relatively low number of bond default cases. This scarcity is further compounded by the fact that readily available data extends only back to 2017. The limited dataset size and timeframe for analysis may restrict the model's predictive ability. Furthermore, due to the scarcity of default cases, the research necessitated the analysis of samples from various industries together. However, these different industries possess distinct characteristics and operational methods, potentially impacting the model differently across sectors.

Second, obtaining comprehensive ESG data for Thai companies remains a significant challenge. Ideally, the research would have directly incorporated specific ESG scores to more comprehensively assess a company's sustainability practices. However, the limited availability of such data for a significant number of companies necessitated the use of an alternative approach.

5.3 Recommendation for Further Studies

The research successfully established a foundation for future studies aimed at refining bond default prediction models, particularly those that incorporate ESG considerations. However, it also acknowledges several limitations that present opportunities for further exploration. The following recommendations can enhance future research:

(1) Broaden the Data Scope: Incorporating data over a wider timeframe and including samples from non-listed companies could provide a more comprehensive foundation for model training. A broader dataset would enable the model to handle diverse scenarios more effectively and ultimately enhance its overall predictive power.

(2) Address Class Imbalance: Ensuring a more balanced representation of distressed and non-distressed groups is essential for mitigating bias in the model's performance. This adjustment would enhance the reliability of the predictions.

(3) Develop Industry-Specific Models: Creating models tailored to specific industries by computing coefficients or using financial ratios relevant to each industry can improve the model's accuracy. This approach would better capture the unique characteristics and dynamics of different industries.

(4) Advance ESG Integration: As ESG reporting standards evolve and larger datasets become available, there is a significant opportunity to integrate ESG factors more directly into future models. This could lead to more robust and informative predictions of bond default risk in the Thai market.

(5) Explore Alternative Financial Ratios: Given that the variable BVETL was not statistically significant in the current model, future research should consider other financial ratios. Investigating metrics that better reflect a company's liquidity and ability to meet short-term obligations, such as those from the cash flow statement, could enhance predictive accuracy.

By implementing these recommendations, future studies can build upon this research foundation to develop even more precise and informative models for predicting bond default in the Thai market, particularly as ESG considerations become increasingly integral to financial analysis.

5.4 Policy Recommendations

While Thailand has demonstrated potential for growth in ESG practices, there is still significant room for further development. Government agencies should play a proactive role in implementing supportive policies and foster a conducive environment for ESG integration. For example, imposing penalties for non-compliance with ESG standards. offering targeted tax breaks for companies demonstrating strong ESG commitment, establishing a regulatory framework for standardized ESG reporting practices, and increasing public awareness about the importance of ESG considerations. Moreover, the Stock Exchange of Thailand should be considering implement more rigorous methods for selecting companies to be included in the THSI, rather than relying solely on self-reported questionnaires from the companies.

In Thailand, ESG practices remain in the early stages compared to more developed regions like the Nordic countries, which may explain why their influence on predicting financial distress among Thai companies has not yet achieved statistical significance. Nevertheless, by implementing supportive policies and fostering an environment that encourages ESG integration, Thailand has the potential to develop a robust ESG ecosystem that will ultimately benefit all market stakeholders in the future.

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A Comparative Analysis of Deep Learning-Based Models with Hyperparameters tuning: A Case Study of the SET and S&P 500 Indices

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Abstract

The stock market, a complex and dynamic environment, significantly impacts global economies through the interplay of various factors influencing stock prices. Accurate price predictions are vital for investors and financial analysts, particularly for major indices like the S&P 500 in the United States and the Stock Exchange of Thailand (SET). This study offers a detailed comparative analysis of different prediction methodologies for stock closing prices, concentrating on both the SET Index and the S&P 500 Index. Using daily data from January 1, 1997, to May 14, 2024, and covering multiple financial crises, the research examines a variety of deep learning models and hybrid models, including Stacked-LSTM, CNN, CNN-LSTM, ConvLSTM, and CN-BI-LSTM. A critical aspect of this study is hyperparameter tuning to enhance model accuracy. The study concludes that while models perform admirably for the SET Index, demonstrating high predictive accuracy, there is a discernible decline in performance metrics when applied to the S&P 500. However, the Stacked-LSTM model consistently emerges as robust across both indices, underscoring its potential for effective trend prediction in diverse market conditions. This research contributes valuable insights into the nuanced dynamics of predictive modeling in fluctuating and stable markets.

Keywords: Deep Learning, Long Short-Term Memory, Convolutional Neural Network, Hyperparameter Tuning, Stock Price, Prediction

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Analyzing How ESG-Integrated Smart Beta Strategies Perform in the ASEAN Stock Market

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Abstract

This study investigates the performance of Environmental, Social, and Governance (ESG)-integrated smart beta strategies in the ASEAN stock market from 2015 to 2023. Amidst growing global interest in sustainable investment practices, this research aims to bridge the gap in knowledge concerning the efficacy of combining ESG criteria with smart beta strategies within the unique economic and regulatory landscapes of the ASEAN region. Utilizing data sourced from Bloomberg, the study employs a quantitative approach, comparing the risk-adjusted returns of ESG-integrated smart beta portfolios against traditional market capitalization-weighted indices. The findings indicate that ESG-integrated smart beta strategies generally enhance portfolio performance in terms of Sharpe ratios and reduce portfolio risk, as measured by standard deviation across several ASEAN markets. However, the effectiveness varies significantly across different markets and factors, highlighting the importance of tailored investment strategies that consider local market dynamics. This research contributes to the academic literature by offering new insights into the applicability of ESG and smart beta strategies in emerging markets, providing valuable implications for both institutional and retail investors aiming to optimize portfolio performance while adhering to sustainability standards.

Keywords: ASEAN stock markets, ESG Integration, Smart Beta Strategies, Sustainable Investing

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The Relationship between Return of Sustainable Funds with Total Expense Ratio, Evidence in Thailand

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Abstract

This article examines the relationship between the returns of sustainable funds and the total expense ratio in the context of sustainable mutual funds in Thailand by employing regression and multiple regression models to construct models. The aim is to test whether the total expense ratio of funds is related to the performance of sustainable funds registered in Thailand. The goal is to support investors, stakeholders, and decision-makers in making sustainable investment decisions in Thailand. It delves into the details of the total expense ratio and returns of recognized and sustainability-rated funds, which will contribute to fostering a more sustainable and socially responsible investment environment in the Thai context. The outcomes of this research will enhance the knowledge about sustainable mutual funds in Thailand by exploring the complexities of the interaction between fund expenses and performance by studying various types of funds recognized as sustainable. The research focuses on elucidating the factors influencing investment decisions, with the main variable being the expenses of mutual funds and other variables in the multiple regression models, such as the Sharpe ratio, Standard deviation, and Sustainability Rating by Morningstar. The results from the regression model and the multiple regression model with additional control variables are consistent, indicating that the Total Expense Ratio can partially explain the returns of sustainable mutual funds in the Thai market over 3 years with a significant level.

Keywords: Morningstar Sustainability Ratings, Regression Analysis, Sustainable Mutual Funds, Sharpe Ratio, Standard Deviation, Total Expense Ratio.

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