The Impact of Carbon Emission Disclosure on Financial Performance: A Study of Thai Listed Companies

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This Independent Study Has Been Approved as a Partial Fulfillment of the Requirements for the Degree of Master of Business Administration

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ABSTRACT

As climate change concerns reshape corporate strategies and investor preferences, carbon emission disclosure has gained attention as a potential factor influencing financial performance. This study examined the relationship between voluntary carbon emission disclosure and stock returns of Thai listed companies across multiple industries. Given that carbon disclosure remains optional in Thailand, this research focused on firms that voluntarily report their emissions to assess whether transparency in environmental practices is associated with differences in market performance.

This study employed a quantitative research design using secondary data and adopts a portfolio performance comparison approach to evaluate the impact of carbon emission disclosure on financial performance. By analyzing a market-capitalization-weighted portfolio of 160 Thai companies that disclosed carbon emissions in 2024, the study founed that the portfolio achieved a total return of +3.68%, significantly outperforming the SET Index benchmark by approximately 6.00 percentage points, as the SET Index recorded a return of -2.31% over the same period. This clear numerical outperformance, supported by a statistically significant one-tailed t-test ($p=0.0466$), highlights a positive association between carbon emission disclosure and stock performance at the portfolio level. Furthermore, sectoral analysis showed significant variations, with the technology sector achieving a high return of 54.09%, while sectors like industrials (-37.04%) and property and construction (-22.18%) significantly underperformed, indicating the influence of industry-specific dynamics.

These findings contribute to the growing discourse on environmental transparency and financial performance, offering insights for investors, corporate leaders, and

policymakers. While carbon emission disclosure alone does not guarantee superior stock returns, its potential role in enhancing investor confidence and differentiating companies in sustainability-conscious markets cannot be overlooked. The study underscores the need for industry-specific approaches to carbon emission disclosure and further research into the long-term financial implications of environmental transparency.

Keywords: carbon emission disclosure, financial performance, ESG reporting, Thailand, greenhouse gas emissions, disclosure of nonfinancial information

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(Navid Abdolaji Nejadniari)
Feb 22, 2025

DECLARATION

I, Navid Abdolahi Nejadniari , hereby declare that this Independent Study entitled "The Impact of Carbon Emission Disclosure on Financial Performance: A Study of Thai Listed Companies" is an original work and has never been submitted to any academic institution for a degree.

(Navid Abdolaji Nejadniari)
Feb 22, 2025

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Chapter 1 Introduction

1.1 Research Background

The global spotlight on climate change has elevated corporate responsibility and sustainability into key pillars of modern business strategies. Companies worldwide are under increasing pressure to minimize their environmental impact, particularly by reducing carbon emissions in line with international commitments such as the Paris Agreement and the United Nations Sustainable Development Goals (SDGs). As governments introduce stricter environmental regulations and investors prioritize sustainability-linked portfolios, corporate transparency in environmental practices has become a key determinant of long-term business success. In this context, carbon emission disclosures have emerged as a crucial mechanism for businesses to communicate their environmental performance to key stakeholders, including investors, customers, regulatory authorities, and non-governmental organizations. These disclosures play a vital role in shaping corporate reputation, influencing investment decisions, and driving operational improvements in sustainability. Beyond regulatory compliance, companies that voluntarily disclose their carbon emissions often seek to gain a competitive advantage by demonstrating environmental leadership, thereby enhancing investor confidence and customer trust.

A growing body of research suggests that environmental transparency is closely linked to financial performance. Transparency in carbon emissions reporting can affect market valuation, cost of capital, and investor sentiment, making it a critical area of study. In Thailand, where economic expansion remains a priority, balancing growth with sustainability poses a unique challenge. The country has committed to achieving carbon neutrality by 2050 and net-zero greenhouse gas emissions by 2065, reflecting its dedication to long-term environmental responsibility. However, many businesses struggle to align their operations with these targets while maintaining profitability in an increasingly competitive market. Understanding the relationship between carbon emission disclosure and financial performance is thus vital for Thai companies navigating these complex dynamics.

Several studies have examined the relationship between carbon emission disclosures and corporate financial performance, offering valuable insights into the potential risks and benefits of environmental transparency. Research conducted by

Ahmad et al. (2021) provided evidence that profitability and company size positively influence carbon emission disclosure, while sales growth exhibits a negative relationship—suggesting that rapidly growing firms may deprioritize sustainability reporting due to resource constraints or strategic focus elsewhere. Additionally, leverage was found to have no significant impact, indicating that capital structure alone may not drive environmental disclosure behavior. Their study also revealed that carbon emission disclosures correlate positively with market variables such as bid-ask spreads, trading volume, and stock price volatility. These findings imply that transparency in environmental reporting can increase investor awareness and engagement, potentially leading to greater market responsiveness. This aligns with broader research indicating that firms with comprehensive Environmental, Social, and Governance (ESG) disclosures often experience enhanced stock liquidity and valuation premiums, as investors perceive them as lower-risk, forward-thinking enterprises. Further supporting this perspective, a study by Suttipun & Treepongkaruna (2024) found that ESG reporting has a positive impact on corporate performance, reinforcing the idea that environmental transparency can drive both financial and reputational benefits. As ESG reporting becomes increasingly standardized and integrated into corporate strategies, companies that fail to adapt may risk investor divestment, regulatory penalties, and reputational damage.

The Thai business landscape presents a unique case for studying the effects of carbon emission disclosures, as the country balances industrialization with sustainability commitments. Thailand's key industries, including energy, manufacturing, and agriculture, are significant contributors to national carbon emissions. However, growing pressure from both domestic policies and international trade partners is forcing businesses to adopt more transparent and proactive sustainability practices. As sustainability considerations increasingly shape business competitiveness, understanding the financial implications of carbon emission disclosures is critical. By analyzing how carbon reporting influences stock performance and financial outcomes in a diverse range of Thai companies, this research contributes to the growing discourse on corporate sustainability, market behavior, and financial risk management. It also provides insights for Thai businesses seeking to align with global ESG standards while maintaining profitability, ensuring they remain competitive in a rapidly evolving economic and regulatory landscape.

1.2 Research Problems

Despite the increasing emphasis on sustainability and the growing adoption of Environmental, Social, and Governance (ESG) principles, the relationship between carbon emission disclosure and financial performance remains ambiguous and potentially varies across industries and and regions. While some studies suggest a positive correlation, indicating that companies with greater environmental transparency are rewarded by investors through higher stock valuations, lower capital costs, and improved financial performance, others present contrasting findings. Some research indicates that the relationship between carbon disclosure and financial outcomes can be neutral or even negative, particularly in markets where sustainability disclosures are not yet fully integrated into corporate valuation frameworks or where investors remain skeptical about the financial materiality of such disclosures. Additionally, compliance costs, reporting burdens, and potential exposure to regulatory risks could deter companies from adopting extensive disclosure practices, further complicating the financial implications of transparency.

In the Thai context, empirical research on the financial effects of carbon emission disclosures remains limited. As Thailand continues its transition toward a low-carbon economy and aligns with global sustainability commitments, including its carbon neutrality goal by 2050, businesses are under increasing pressure to enhance environmental reporting and integrate sustainability into corporate strategy. However, it remains unclear whether such efforts yield tangible financial benefits for companies operating within its diverse economic landscape. Understanding how carbon disclosure affects stock performance, market valuation, and overall financial health is essential for companies striving to balance sustainability and profitability in an evolving economic landscape.

This research seeks to bridge this gap by analyzing the financial outcomes associated with carbon disclosure practices among a sample of Thai listed companies. This study aims to provide insights into whether carbon transparency serves as a value-enhancing strategy or merely a compliance-driven obligation in Thailand's capital markets. The findings will contribute to the ongoing discourse on corporate sustainability and financial performance, offering practical implications for business leaders, investors, and policymakers navigating the transition toward a more sustainable economy.

1.3 Research Objectives

The primary objective of this study is to explore the relationship between carbon emission disclosures and the financial performance of Thai listed companies. Specifically, the study will:

- Investigate whether a market capitalization-weighted portfolio of carbon-disclosing companies in Thailand outperforms the SET Index over the 2024 period.
- Examine the influence of firm size, profitability (P/E and P/BV ratios), and sector on the monthly financial performance of individual stocks of carbon-disclosing companies.

By focusing on these objectives, the study aims to provide a clearer understanding of the financial implications of sustainability practices, particularly in the context of a developing economy like Thailand.

1.4 Research Scope

This study examined the relationship between carbon emission disclosure and financial performance of 160 Thai listed companies that voluntarily disclosed carbon emission data for the year 2024. In Thailand, carbon emission disclosure remains voluntary, meaning that firms choose whether or not to publicly report their emissions. This research focused exclusively on firms that have demonstrated this environmental transparency by disclosing their carbon emissions, allowing for an in-depth examination of how investors react to corporate environmental transparency within this group.

By utilizing voluntarily disclosed carbon emission data, this research explored whether firms that were more transparent about their environmental impact experienced differences in stock market performance, reflecting investor perceptions, risk assessment, and market valuation. The study analyzed overall portfolio performance against the SET Index and also examined the performance of individual stocks within the portfolio, identifying trends and patterns across various industries. This included a descriptive overview of how different industries within the portfolio performed relative

to the index, without formal hypothesis testing or regression specifically comparing the impact of disclosure across these industries.

The study provides insights into whether carbon emission disclosure serves as a value-enhancing strategy, a risk-mitigation tool, or simply a regulatory compliance mechanism with limited financial impact. The findings are relevant for business leaders, investors, policymakers, and sustainability advocates, helping them understand the financial significance of carbon disclosure in Thailand's evolving corporate landscape.

1.5 Research Significance

This research is significant both academically and practically, as it contributes to the growing understanding of environmental transparency and corporate financial performance in developing economies, with a particular focus on Thailand. As sustainability and corporate responsibility gain prominence on the global stage, the role of carbon emission disclosure in shaping financial outcomes remains a crucial area of study, especially in markets where such disclosures are still voluntary. This study aims to fill that gap by examining how voluntary carbon disclosure influences stock performance across its diverse sample, providing insights into the financial consequences of environmental transparency in an emerging economy.

From an academic standpoint, this research extends the body of knowledge on the relationship between environmental disclosures and financial performance, particularly in emerging markets where regulatory environments, investor awareness, and corporate sustainability practices are still evolving. Much of the existing literature focuses on developed economies, where ESG (Environmental, Social, and Governance) frameworks are more mature and widely adopted. However, the impact of carbon disclosure in developing markets remains relatively underexplored. By focusing on Thailand, this study provides a regional perspective that can help academics, researchers, and policymakers better understand how environmental transparency interacts with financial performance in an economy where sustainability practices are still evolving.

Furthermore, this study contributes to the understanding of how traditional firm characteristics and general sector effects influence stock performance within a cohort of carbon-disclosing companies. By analyzing performance, the study will help bridge the knowledge gap in ESG dynamics, providing valuable insights into how carbon

disclosure might affect investor confidence, stock price stability, and overall financial outcomes, after controlling for these factors. This research also enhances discussions on corporate governance, risk management, and market valuation by shedding light on whether carbon transparency serves as a financial advantage or a mere compliance tool.

Beyond academia, this research holds significant practical value for business leaders, investors, and policymakers who are navigating the evolving landscape of corporate sustainability. Understanding how investors react to voluntary carbon disclosure can help corporate decision-makers determine whether sustainability reporting is merely a compliance measure or a strategic tool for financial growth. If a strong positive relationship between carbon disclosure and stock performance is found, it could encourage more firms to adopt proactive environmental reporting as a means of enhancing investor trust, reducing financial risks, and improving market positioning.

For investors, this study provides insights into how carbon transparency can serve as a financial indicator, helping them identify companies with strong environmental commitments that align with long-term investment strategies. As ESG-driven investing gains momentum, the findings of this research could aid in refining investment criteria and risk assessment models by demonstrating whether carbon disclosure correlates with financial resilience and stock stability. By offering a data-driven perspective on environmental transparency, this research can support investors in making informed, sustainability-conscious investment decisions.

For policymakers and regulatory bodies, the study's findings can inform discussions on corporate sustainability policies and disclosure regulations. As Thailand continues to balance economic growth with environmental responsibility, policymakers need to understand how businesses and investors respond to voluntary disclosure practices. If carbon transparency is shown to have financial benefits, regulatory authorities may consider incentivizing or mandating disclosures. The insights gained from this study could serve as a foundation for future sustainability policies, reinforcing the importance of corporate environmental responsibility in shaping Thailand's economic and financial future.

1.6 Definition of Key Terms

Carbon Emission: The release of carbon compounds, primarily Carbon Dioxide (CO2), into the atmosphere. While often used broadly, in the context of climate change and corporate reporting, it commonly refers to the total volume of greenhouse gases released as a result of a company's activities or operations.

Carbon Emission Disclosure: A form of corporate transparency and responsibility involving the public release of information regarding a company's CO2 or other greenhouse gas (GHG) emissions, its strategies, targets, and projects for reducing these emissions, and its exposure to climate-related risks.

Financial Performance: A measure of a company's overall success in generating profits and value. It is commonly measured using two categories of metrics: Accounting-Based Performance (e.g., Return on Assets, Net Income), which reflects historical results; and Market-Based Performance (e.g., stock price, stock returns, or Tobin's Q), which reflects investor expectations and forward-looking value.

ESG Reporting: The disclosure of a company's data and performance across three interconnected pillars: Environmental, Social, and Governance. It provides a comprehensive, nonfinancial view of a company's sustainability and ethical conduct.

Disclosure of Nonfinancial Information: The public communication of data that is not based on conventional financial figures. This information typically encompasses a company's environmental, social, and governance (ESG) impacts and performance, offering stakeholders a better understanding of the essential areas of value creation and corporate responsibility that go beyond standard financial statements.

Profitability: A company’s ability to generate earnings (profit) from its activities compared to its expenses and other costs over a certain period of time.

Firm Size: Overall scale or magnitude of a company’s operations. It can be assessed using total assets, annual revenue, number of employees, or market capitalization. Larger firms often benefit from economies of scale, higher market power, and greater access to resources.

Sector: A sector is a broad category of the economy that groups companies with similar business activities. Examples include energy, financial services, healthcare, and technology. Each sector has unique characteristics, growth patterns, and risk factors that affect company performance. Classifying firms by sector allows comparisons across industries and provides context for financial and strategic analysis.

Chapter 2 Literature Review

Research on carbon emission disclosure and financial performance reveals diverse findings across industries and regions, reflecting both direct and indirect impacts on firm outcomes. As corporate transparency gains significance, particularly in the environmental, social, and governance (ESG) framework, companies face increasing pressure to disclose carbon emissions. This literature review examines various independent variables affecting financial performance in relation to carbon emission disclosure, organizing each factor with supporting research evidence.

2.1 Prior Studies on Company's Financial Performance and Independent Variables

2.1.1 Carbon Emission Disclosure

Carbon emission disclosure serves as a critical measure of a company's environmental accountability. Some studies suggest that carbon disclosure may not always yield immediate financial benefits and can even negatively affect short-term profitability due to associated costs. Siddique et al. (2021) found that carbon disclosure negatively impacts accounting-based financial performance, such as return on assets (ROA), though it does not significantly affect stock performance. Similarly, Ghosh et al. (2024) reported a non-linear relationship in India, where initial increases in carbon performance negatively influence financial metrics before yielding long-term benefits. Conversely, research in non-carbon-intensive industries suggests a positive correlation. In the U.S., Lu et al. (2021) demonstrated that transparency in carbon disclosures enhances investor trust and financial performance. Velte et al. (2020) emphasized that governance mechanisms can enhance both carbon and financial performance. Furthermore, Downar et al. (2021) investigated the impact of mandatory carbon disclosure in the UK. They found that such mandates led to a significant 8% reduction in treated firms' greenhouse gas (GHG) emissions. Crucially, despite these measurable environmental improvements and associated production costs, their study concluded that the mandate did not significantly affect the financial operating performance of the firms. This suggests that while disclosure can drive real environmental change, its financial repercussions may be limited.

2.1.2 Profitability

Profitability is a fundamental indicator of a company's financial health and operational efficiency, representing its ability to generate earnings in relation to its expenses, assets, and overall business activities. A highly profitable firm not only signals strong management performance but also demonstrates resilience in competitive markets. Research has identified profitability as a key driver of voluntary carbon disclosure, as financially stable companies are more inclined to adopt transparent reporting practices that reflect their commitment to sustainability. This relationship is particularly significant in capital markets, where profitability influences stock market factors such as bid-ask spreads, trading volume, and investor perception. Companies with strong profitability tend to have greater financial flexibility, enabling them to allocate resources toward environmentally sustainable initiatives without experiencing significant financial strain. Such firms are more likely to invest in green technologies, carbon reduction strategies, and ESG reporting frameworks, strengthening their reputation among socially responsible investors. Moreover, higher profitability can lead to improved access to capital, as investors and financial institutions often favor companies with a solid earnings track record and responsible business practices. By integrating sustainability into their corporate strategy, profitable companies can enhance long-term value creation, reduce regulatory risks, and maintain a competitive advantage in an evolving global economy (Ahmad et al., 2021).

2.1.3 Firm Size

Firm size, commonly assessed through total assets, market capitalization, or revenue, plays a crucial role in shaping a company's financial performance and strategic capabilities. Larger firms tend to benefit from economies of scale, allowing them to reduce costs through efficient production processes, bulk purchasing, and widespread market presence. Additionally, these companies often have better access to financial resources, enabling them to invest in new technologies, research and development, and sustainability initiatives without facing significant financial constraints (Ahmad et al., 2021).

A company's size also influences its ability to navigate regulatory challenges and meet evolving investor expectations regarding Environmental, Social, and Governance

(ESG) factors. Larger firms, with their established brand reputation and extensive stakeholder networks, are more likely to be scrutinized by investors, regulators, and the public, prompting them to adopt transparent and proactive sustainability practices. This is particularly evident in developing markets, where investor demand for ESG-related disclosures is increasing as part of global trends toward responsible investment. Firms with substantial market power are more likely to integrate carbon disclosure into their reporting frameworks, recognizing that transparency in environmental impact can enhance investor confidence and long-term business resilience (Emmanuel at el., 2023).

Moreover, the financial stability of larger firms allows them to absorb the costs associated with ESG compliance, such as implementing carbon reduction strategies, obtaining sustainability certifications, or integrating green technologies into their operations. This ability to allocate resources toward sustainability not only strengthens their corporate image but also contributes to improved financial outcomes, including better stock performance and lower capital costs. As ESG considerations become more central to investment decisions, larger firms that proactively disclose their carbon emissions and sustainability strategies may enjoy a competitive advantage in attracting institutional investors and maintaining market leadership. Ultimately, firm size serves as a significant determinant of both carbon disclosure and financial success, especially in regions where regulatory frameworks and investor expectations surrounding sustainability are rapidly evolving (Emmanuel et al., 2023).

2.1.4 Sector

Industry sector is a crucial variable in analyzing financial performance due to varying market dynamics, competitive landscapes, and regulatory pressures across different industries. Companies operating in distinct sectors may face unique challenges and opportunities that influence their financial outcomes, regardless of other firm-specific characteristics. While firm-level factors are generally found to be more significant determinants of firm performance, accounting for a substantial portion of variation in measures like return on asset (ROA) and Tobin's Q, the industry sector remains a relevant consideration. For instance, a study examining firm performance in a developing economy found that while firm-level factors were relatively more important, the industry sector of the firm was identified as the most relevant industry-level determinant of firm market performance (Adetunji & Owolabi, 2016). This

highlights that even when not the primary driver, the industry context still plays a role in how a firm's stock is valued by the market. Consequently, acknowledging these inherent industry-specific differences is essential for a more accurate assessment of how other factors, such as carbon emission disclosure, truly impact financial outcomes.

2.1.5 Summary of Review

The relationship between carbon emission disclosure and financial performance is complex and varies depending on industry characteristics, corporate structures, and market conditions. While the initial costs of disclosure, such as data collection, reporting, and compliance, may impose financial burdens that reduce short-term profitability, the long-term advantages often outweigh these expenses. Firms that integrate carbon disclosure into their broader sustainability strategies tend to enhance their reputation, strengthen stakeholder trust, and mitigate regulatory risks, positioning themselves favorably in the market.

Companies with greater firm size and high profitability are better equipped to absorb the costs of carbon disclosure and leverage its benefits. Furthermore, sector-specific dynamics can significantly influence financial outcomes, making it important to account for these differences in any comprehensive analysis.

By aligning ESG transparency with sound operational and financial strategies, firms can gain a competitive edge in attracting capital from institutional investors, particularly those focused on sustainable and responsible investing. Additionally, businesses that proactively disclose their carbon emissions are more likely to secure favorable financing terms, improve risk management, and enhance long-term financial resilience. In an era where environmental concerns increasingly influence consumer behavior and investment decisions, firms that integrate sustainability into their core business models can achieve sustained growth while maintaining a strong financial position.

2.2 Conceptual Framework

The increasing emphasis on sustainability and corporate responsibility has led many companies to voluntarily disclose their carbon emissions to enhance their market position. This study examines the effect of carbon emission disclosure on the financial

performance of Thai listed companies, exploring how transparency in environmental practices influences investor perceptions and stock performance.

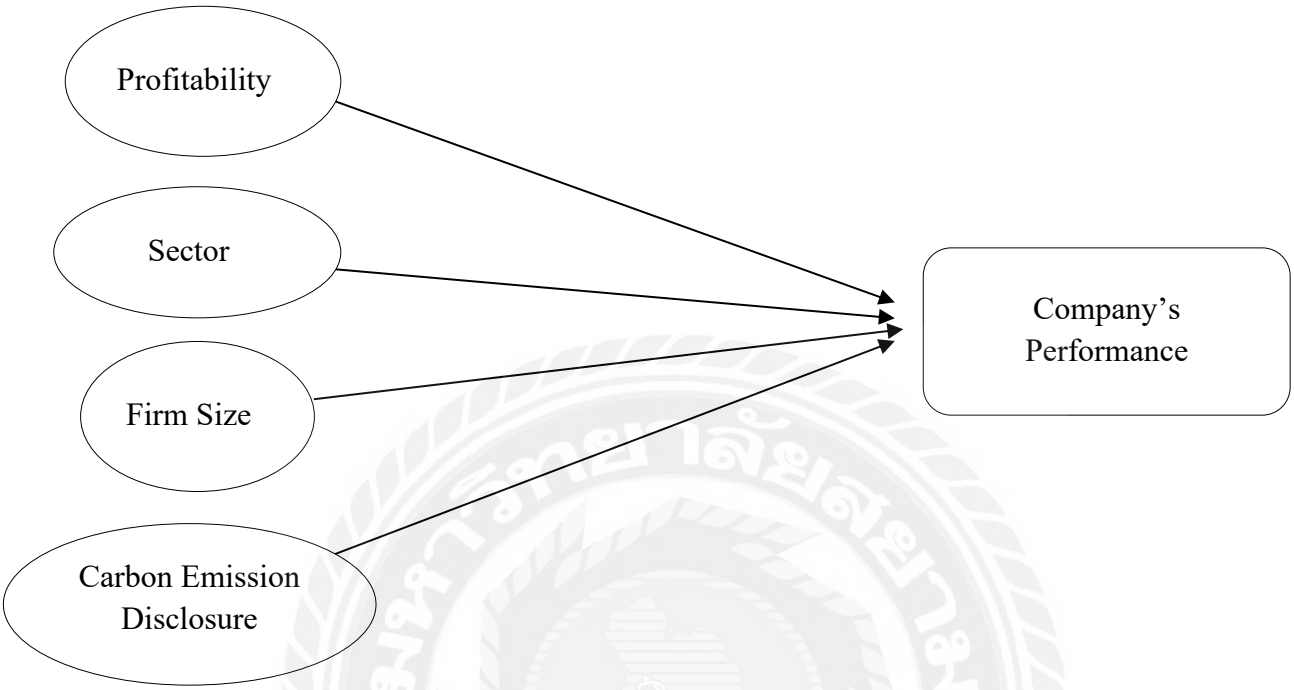

Figure 1: Conceptual Framework

Carbon emission disclosure serves as the primary independent variable, with the following additional factors influencing financial performance:

- Sector: Different industries may exhibit varying financial performance due to distinct market dynamics and regulatory pressures (Adetunji & Owolabi, 2016).
- Profitability: Financially stable firms invest more effectively in sustainability (Ahmad et al., 2021).
- Firm Size: Larger firms benefit from economies of scale in sustainability initiatives (Emmanuel et al., 2023).

Each of these factors contributes to understanding how carbon disclosure interacts with financial performance in Thai-listed firms. The study investigates whether transparency in carbon emissions, combined with strong financial and governance structures, leads to measurable financial advantages.

2.3 Theoretical Framework

This study is grounded in several key theories that provide a basis for understanding the relationship between carbon emission disclosure and financial performance. These include Signaling Theory, Stakeholder Theory, Legitimacy Theory, Voluntary Disclosure Theory, and Agency Theory.

1. Signaling Theory (Spence, 1973) posits that companies disclose information to signal their quality to stakeholders. In the context of carbon emissions, firms may disclose their environmental efforts to attract environmentally conscious investors, potentially enhancing their stock performance.

2. Stakeholder Theory (Freeman, 1984) suggests that organizations must consider the interests of all stakeholders, not just shareholders. This theory emphasizes the importance of transparency in environmental practices, as stakeholders increasingly value sustainability, which can positively influence a firm's stock performance.

3. Legitimacy Theory (Suchman, 1995) posits that organizations that seek to ensure their operations are perceived as legitimate by society. Companies that disclose their carbon emissions may be viewed more favorably, leading to enhanced stock performance through increased investor confidence.

4. Voluntary Disclosure Theory (Healy & Palepu, 2001) focuses on the motivations behind companies' voluntary disclosures. Firms that voluntarily disclose carbon emission data may aim to differentiate themselves from competitors, thereby positively impacting their market value and stock performance.

5. Agency Theory (Jensen & Meckling, 1976) highlights the relationship between managers and shareholders. Effective disclosure of carbon emissions can align managerial actions with shareholder interests, ultimately contributing to better stock performance.

Chapter 3 Research Methodology

3.1 Research Design

This study employed a documentary research method using publicly available financial and sustainability data. It aimed to analyze the financial performance of Thai-listed companies that voluntarily disclose carbon emissions. The primary objective was to determine if a market capitalization-weighted portfolio of these companies can outperform the SET Index, which was assessed through a two-sample t-test. Furthermore, the study utilized multivariate regression analysis to control for firm size, profitability, and sector when examining individual stock performance within the sample. This comprehensive approach provided robust insights by evaluating relative financial performance over a fixed one-year period and isolating the potential impact of carbon emission disclosure from other known drivers of stock returns.

3.2 Sample Selection

The sample for this research consisted of 160 companies listed on the Stock Exchange of Thailand (SET) that disclosed carbon emission data for 2024. The criteria for selection include:

- Carbon Emission Disclosure: Companies included in the portfolio must have published carbon emission data in 2024, as reported by the Stock Exchange of Thailand.
- Availability of Comprehensive Financial Data: Companies must have available daily stock price data, market capitalization, and profitability ratios accessible via the SETSmart API for the entire study period. This ensures that all variables required for performance calculation and multivariate regression can be collected.

The selected sample represented a diverse range of industries, ensuring that findings reflected the broad impact of carbon disclosure across the Thai stock market.

3.3 Data Collection

The data for this study were sourced from publicly available and reliable repositories, focusing on the performance period from January 1, 2024, to December 31, 2024, to encompass a full calendar year of market activity.

- Carbon Emission Disclosure Data: Information regarding companies' carbon emissions and related sustainability disclosures for 2024 was obtained from the Stock Exchange of Thailand (SET)'s official publications.
- SET Index Data: Monthly and yearly performance data for the SET Index, which serves as the overall market benchmark, was obtained from the official SET website.

This financial data (prices, market capitalization, P/E, P/BV) was systematically retrieved from the SETSmart API (specifically, the eod-price-by-symbol endpoint for prices and other relevant endpoints for fundamental data), ensuring consistency and reliability.

- Daily Close Prices: These are used for calculating monthly stock returns and are critical as they account for corporate actions like stock splits, dividends, and rights issues, providing an accurate reflection of investment performance.
- Market Capitalization: Employed for portfolio weighting and as a control variable for firm size in the regression analysis.
- Price-to-Earnings (P/E) Ratio: Included as a control variable to account for profitability and valuation.
- Price-to-Book Value (P/BV) Ratio: Also used as a control variable for valuation.

The complete Python script used for data collection, processing, and subsequent analysis is provided in Appendix B for full transparency.

3.4 Data Analysis

This study employed a dual approach to analyze the financial performance of Thai listed companies with carbon emission disclosure. First, it evaluated the aggregated

performance of the carbon-disclosing portfolio against the broader market index using a t-test. Second, it utilized multivariate regression analysis to assess the influence of specific firm-level and industry-level factors on the individual stock performance of these disclosing companies.

3.4.1 Portfolio Performance Analysis

To assess the overall financial impact of carbon emission disclosure, this study constructed a market capitalization-weighted portfolio comprising all 160 Thai listed companies that voluntarily disclosed their carbon emissions for the year 2024. The monthly returns of this portfolio were calculated for the period of analysis.

The performance of this carbon-disclosing portfolio was then compared against the performance of the Stock Exchange of Thailand (SET) Index, which serves as a proxy for the broader market performance. A paired-samples t-test was conducted to statistically determine whether there was a significant difference between the average monthly returns of the carbon-disclosing portfolio and the average monthly returns of the SET Index. This test allowed the study to ascertain if the portfolio of carbon-disclosing companies demonstrably outperformed, underperformed, or performed similarly to the overall market.

3.4.2 Multivariate Regression

To investigate the factors influencing the performance of individual stocks within the carbon-disclosing portfolio, a multivariate regression model was employed. This regression allowed for the examination of how firm-specific characteristics (size and profitability) and industry affiliation affected monthly stock returns for companies that disclose carbon emissions.

The general form of the multivariate regression equation is as follows:

$$\text{M. P} = \beta_0 + \beta_1(\log market\ cap) + \beta_2\left({}^{P}/_{E}\ ratio\right) + \beta_3\left({}^{P}/_{BV}\ ratio\right) + \beta_4(C_{sector})$$

Where:

- Monthly Performance (M.P): Represents the monthly stock return for each individual company within the 160-stock carbon-disclosing portfolio.
-
- β0: Is the intercept.
- Log Market Cap: Represents the natural logarithm of the firm's market capitalization, serving as a proxy for Firm Size. Larger firms are often hypothesized to have different performance characteristics due to economies of scale, access to capital, and regulatory scrutiny.
- PE Ratio (Price-to-Earnings Ratio): Measures the company's profitability and market valuation relative to its earnings. It serves as an indicator of Profitability.
- PBV Ratio (Price-to-Book Value Ratio): Compares a company's market price to its book value, also reflecting Profitability and market valuation, often indicating growth opportunities or asset intensity.
- C(Sector): Represents the Industry Sector of the firm, included as a categorical control variable. This accounts for inherent differences in performance that may be attributed to industry-specific dynamics, competitive landscapes, or regulatory environments.
- ϵ: Is the error term, representing unexplained variation in monthly performance.

This regression model helped to disentangle the effects of these control variables on individual stock performance within the context of carbon-disclosing companies, providing insights into their relative importance. The analysis identified which factors significantly influenced monthly returns, thereby contributing to a comprehensive understanding of the financial implications of carbon emission disclosure.

Chapter 4 Findings and Discussion

This study is grounded in several key theories that provide a basis for understanding the relationship between carbon emission disclosure and financial performance. These include Signaling Theory, Stakeholder Theory, Legitimacy Theory, Voluntary Disclosure Theory, and Agency Theory.

4.1 Calculation Methodology

To evaluate the financial performance of Thai listed companies that disclosed carbon emission data, this study utilized stock return data sourced from the Stock Exchange of Thailand (SET). The return of each company was based on total return, which included both capital gains and dividends, providing a comprehensive measure of investor gains during the study period, which spanned from January 1, 2024, to December 31, 2024.

The total portfolio return was calculated as a weighted average of individual stock returns, using market capitalization weights to reflect each company's relative size within the portfolio. This approach ensured that larger firms had a proportionally greater influence on the overall performance.

Formula:

$$R_P = \sum_{i=1}^{n} w_i . R_i$$

Where:

- $\boldsymbol{R_P}$ = Portfolio return
- $\boldsymbol{R_i}$= Total return of stock i (including dividends)
- $\boldsymbol{w_i}$ = Weight of stock i based on market capitalization
- n = Total number of companies in the portfolio

4.2 Portfolio Performance and Comparative Discussion of Existing Literature

The market-capitalization-weighted portfolio, comprising 160 Thai listed companies that disclosed carbon emission data, achieved a total return of +3.68% during the performance period (January 1, 2024, to December 31, 2024). In comparison, the SET Index, representing the broader market, recorded a return of -2.31% over the same period.

This indicates that, during a year when the broader market experienced a downturn, the portfolio of companies with carbon emission disclosures significantly outperformed the market by approximately 6.00 percentage points. This result suggests a positive association between carbon emission disclosure and stock performance, indicating that transparency in environmental practices may enhance investor confidence and yield superior financial performance.

This finding aligns with studies such as Lu et al. (2021), and Velte et al. (2020), who observed that transparency in carbon disclosures enhances investor trust and improves financial performance, particularly in capital markets where ESG awareness is rising. The observed outperformance in the Thai context during this period suggests that investors may indeed reward firms that proactively disclose carbon emissions.

This result contrasts with observations such as Siddique et al. (2021), who found that carbon disclosure had a negative effect on accounting-based measures, and Ghosh et al.(2024), who identified a non-linear relationship where initial stages of improved carbon performance were associated with weaker financial outcomes due to short-term costs. In the present study, the clear outperformance supports the notion that carbon transparency can serve as a signal of long-term resilience and commitment to responsible practices, which are valued by investors in emerging markets.

4.3 Statistical Analysis (T-Test and Regression)

To provide a robust statistical foundation for the observed findings, further analyses were conducted, including a paired-samples t-test and Ordinary Least Squares (OLS) regression. These statistical methods aimed to determine the significance of the relationship between carbon emission disclosure and financial performance, as well as to identify factors influencing stock returns.

a) Variables

Portfolio Performance: Variable 1 represents the portfolio of companies that voluntarily disclosed their carbon emissions. This portfolio was constructed using monthly return data of disclosing firms listed on the Stock Exchange of Thailand (SET). The objective of including this variable was to measure whether these companies, as a group, demonstrated stronger financial performance compared to the broader market benchmark.

Portfolio performance was calculated as the average monthly return of all carbon-emission-disclosing companies during the study period. The resulting mean value was 0.358127, indicating a positive average monthly return. This value reflects the overall profitability trend of the disclosing firms and serves as a key indicator of how environmental transparency may relate to financial outcomes.

By comparing this portfolio's performance to variable 2 (SET Index), this study determined whether the companies engaging in carbon emission disclosure generated superior returns relative to the general market. The variable thus captures the combined financial effect of disclosure practices within a single aggregated measure.

Financial Performance: Financial performance was measured using monthly stock price returns or performance percentage. This variable reflects how well each company performed in the market over time. In the paired t-test, company returns were compared to the SET Index benchmark to determine whether firms that disclosed carbon emissions performed better than the overall market.

Carbon Emission Disclosure: This variable represents whether a company voluntarily disclosed its carbon emission information. It reflects the firm's environmental transparency and commitment to sustainability, which may influence investor confidence and financial results.

Profitability: this study used profitability indicators such as return on assets (ROA), and return on equity (ROE) to capture a firm's financial strength and efficiency in generating profit.

Firm Size: Firm size was measured by the natural logarithm of market capitalization. Larger companies generally have more stable financial performance due to greater resources and stronger market positions.

Sector: Companies were categorised into sector groups based on the Stock Exchange of Thailand classification:

- Technology (TECH)
- Consumer Products (CONSUMP)
- Financials (FINCIAL)
- Industrials (INDUS)
- Property & Construction (PROPCON)
- Resources (RESOURC)
- Services (SERVICE)

These dummy variables were used to compare performance across different industries and control for sector-specific effects.

Benchmark (SET Index): The SET Index was included as a benchmark variable to represent the overall market performance. This was used to compare individual firm performance against market trends and assess whether carbon disclosure has any association with outperforming the market.

b) T-Test Results

A paired two-sample t-test for means was conducted, likely comparing the average monthly performance of the portfolio against a benchmark (SET Index). With 12 observations (monthly data), the test yielded the following results:

- Mean of Variable 1 (Portfolio/Disclosing Companies): 0.358127
- Mean of Variable 2 (Benchmark): -0.15143
- t-Statistic: 1.837702
- Degrees of Freedom (df): 11
- One-tailed P-value (P(T<=t) one-tail): 0.046622
- Two-tailed P-value (P(T<=t) two-tail): 0.093244

The positive mean difference (0.358127 vs. -0.15143) numerically indicates outperformance. When testing for a one-sided hypothesis (e.g., if the portfolio's mean performance is greater than the benchmark's), the p-value of 0.0466 is less than the conventional significance level of 0.05, suggesting statistical significance for a directional difference. However, for a two-sided hypothesis (testing for any difference, positive or negative), the p-value of 0.0932 is greater than 0.05, meaning the difference is not statistically significant at the 5% level, but it is approaching significance. This provides some, albeit borderline, statistical support for the portfolio's numerical outperformance on an average basis over the period.

c) OLS Regression Results

An OLS regression model was fitted with performance as the dependent variable. The model included various sector dummy variables along with log market cap, p/e, and pbv as independent variables. The results are as follows:

- R-squared: 0.008
- Adjusted R-squared: 0.002
- F-statistic: 1.350
- Prob (F-statistic): 0.198 This indicates that the overall model is not statistically significant at the conventional 5% level, suggesting that the independent variables, as a group, do not significantly explain the variation in performance.
- Number of Observations: 1756

While the overall model is not statistically significant, examination of individual coefficients provides further insight:

- The coefficient for the TECH sector dummy (C(sector)[T.TECH]) was positive at 2.0619, with a p-value of 0.055. This suggests that being in the TECH sector might be associated with higher performance, approaching statistical significance at the 5% level.
- All other sector dummy variables (CONSUMP, FINCIAL, INDUS, PROPCON, RESOURC, SERVICE) were not statistically significant at the 5% level, with p-values much higher than 0.05.
- Control variables such as log market Cap (p=0.356), p/e (p=0.981), and p/bv (p=0.828) were also not statistically significant.

The statistical analyses present a nuanced picture. While the t-test (under a one-tailed assumption) offers some support for the statistical significance of the portfolio's outperformance, the OLS regression model indicates that the chosen independent variables, including sector classifications and traditional financial ratios, do not collectively or individually (with the marginal exception of the TECH sector) statistically explain the variation in individual company performance within the large sample. The low R-squared and non-significant F-statistic for the overall model suggest that either the selected variables are not strong predictors of individual stock performance, or there are other unmodeled factors, or issues like multicollinearity are obscuring the relationships. This implies that while the aggregate portfolio numerically outperformed the market, the specific factors included in this regression model do not strongly account for individual stock performance differences.

4.4 Sector-Wise Analysis

The performance of individual sectors within the portfolio varied significantly, highlighting diverse responses to market conditions and potentially differing investor perceptions of carbon disclosure impact across industries. The table 1 summarizes the sector-specific returns and their performance relative to the SET Index:

Sector	Return (%)	Performance Relative to SET Index (%)
TECH	54.09	56.4
FINCIAL	5.13	7.45
CONSUMP	1.99	4.3
AGRO	-4.73	-2.41
SERVICE	-13.27	-10.96
PROPCON	-22.18	-19.87
RESOURC	-24.45	-22.14
INDUS	-37.04	-34.72

Table 1 Performance of Sector-Specific Portfolios (Market Cap Weighted)

a) Top-Performing Sector: Technology (TECH)

- The Technology sector recorded the highest return at 54.09%, significantly outperforming the SET Index by 56.40 percentage points. This robust performance suggests strong investor confidence and growth within the tech companies in the portfolio, possibly driven by innovation and adaptability.
- This strong performance can be attributed to companies with large market capitalizations, such as DELTA Electronics (Thailand) Public Company Limited and True Corporation Public Company Limited, which demonstrated outstanding returns during the study period.

b) Moderate Performers: Consumer Products (CONSUMP) and Financials (FINCIAL)

- The Financials sector generated a positive return of 5.13%, outperforming the SET Index by 7.45 percentage points. The Consumer Products sector also showed a positive return of 1.99%, surpassing the SET Index by 4.30 percentage points. These sectors demonstrated relatively stable performance amidst the broader market downturn.

c) Low Performers: Agriculture (AGRO)

- The Agriculture sector experienced a negative return of -4.73%, underperforming the SET Index by 2.41 percentage points. This indicates challenges within the agricultural sector during the study period.

d) Negative Performers: Services (SERVICE), Property and Construction (PROPCON), Resources (RESOURC), and Industrial (INDUS)

- The Service sector posted -13.27%, lagging the SET Index by 10.96 percentage points.
- Property and Construction (PROPCON) faced substantial challenges, delivering -22.18%, which was 19.87 percentage points below the SET Index.
- The Resources (RESOURC) sector also saw a considerable decline at -24.45%, underperforming by 22.14 percentage points.
- The Industrials (INDUS) sector was the weakest performer, recording a return of -37.04%, significantly underperforming the SET Index by 34.72 percentage points. These sectors likely faced greater headwinds or higher costs associated with their operations and environmental footprints during the period.

4.5 Implications of Findings

The findings highlight that the overall portfolio of carbon-disclosing companies significantly outperformed the SET Index during a period of market downturn, demonstrating the potential financial benefits of transparency in environmental practices. While this overall outperformance is notable, the performance varied widely across sectors. Technology and Financials demonstrated exceptional strength and

resilience, potentially reflecting strong investor confidence in their business models and proactive sustainability efforts.

In contrast, traditional sectors including Property and Construction, Resources, and Industrials appeared to face significant challenges. This could be attributed to a combination of factors, including higher operational costs, stricter environmental regulations, or reduced investor interest in industries with larger environmental footprints or slower adaptation to sustainability trends.

Overall, the portfolio's outperformance relative to the SET Index underscores the potential financial benefits of sustainability practices and suggests that selecting a portfolio of companies based on carbon emission disclosure can serve as a viable investment strategy to beat the market, even in challenging economic environments. This dual perspective reinforces the relevance of carbon transparency as both an ethical and a practical financial consideration for investment decisions.

Chapter 5 Conclusion and Recommendation

5.1 Conclusion

This study aimed to explore the relationship between carbon emission disclosure and financial performance of Thai listed companies. By examining the returns of a market-capitalization-weighted portfolio of 160 companies that disclosed carbon emission data for the period between January 1, 2024, and December 31, 2024, the study compared its performance to the SET Index.

The findings indicate that the portfolio achieved a total return of +3.68%, significantly outperforming the broader market benchmark, the SET Index, which recorded a return of -2.31% over the same period. This represents an outperformance of approximately 6.00 percentage points. This clear numerical outperformance, coupled with a one-tailed t-test demonstrating statistical significance ($p=0.0466$) for the difference in means, highlights a positive association between carbon emission disclosure and stock performance at the portfolio level. These results support the growing argument that transparency in environmental practices can enhance investor confidence, making carbon disclosure an important consideration for both companies and investors.

However, the Ordinary Least Squares (OLS) regression analysis, which aimed to explain individual stock performance based on sector classifications, firm size (log_marketCap), and profitability/valuation ratios (pe, pbv), yielded a more nuanced picture. The overall regression model was not statistically significant (Prob(F-statistic) = 0.198) and had a very low R-squared (0.008). This suggests that while the aggregate portfolio numerically outperformed the market, the traditional firm-specific factors included in this particular regression model do not strongly account for individual stock performance differences within the sample of carbon-disclosing companies. This implies that other, unmodeled factors, potentially related to the broader implications of carbon disclosure or ESG commitments, might be more influential for these firms.

Sectoral analysis further revealed significant variations in performance. The Technology sector emerged as the top-performing sector, achieving a return of 54.09%, substantially outperforming both the portfolio and the market index. In contrast, Industrials (returning -37.04%) and Property and Construction (returning -22.18%) showed significant negative returns, underperforming the overall portfolio and the

market index. This sectoral disparity suggests that while carbon disclosure is associated with stronger financial performance in some industries, structural challenges or higher environmental impact in other sectors may limit its positive financial impact or necessitate more significant operational transformations.

In summary, this study emphasizes the dual importance of carbon emission disclosure: as a method to improve sustainability practices and as a factor in creating investment portfolios that can potentially outperform the market. The results align with the global trend of integrating environmental, social, and governance (ESG) factors into investment decisions, providing a practical framework for investors and companies alike, albeit with the understanding that the mechanisms are complex and not fully explained by traditional firm characteristics alone.

5.2 Recommendations

Recommendations for Companies

The findings underscore the need for companies to enhance their carbon disclosure practices to meet growing investor and regulatory expectations. Firms should adopt more detailed and standardized reporting frameworks, aligning with international standards such as the Global Reporting Initiative (GRI) or Task Force on Climate-related Financial Disclosures (TCFD). This includes clearly outlining carbon reduction strategies, governance structures overseeing sustainability efforts, and progress toward environmental targets.

Improved transparency not only strengthens corporate reputation but also enhances investor confidence, particularly among sustainability-focused investors who prioritize ESG performance. Additionally, Property and Construction and industrials sectors, which underperformed in this study, should invest in innovative solutions to address environmental and operational challenges. Implementing energy-efficient technologies, shifting to renewable energy sources, and integrating circular economy principles can help these sectors mitigate risks, comply with emerging regulations, and potentially enhance financial performance.

a) Competitive Strategy of Carbon Emission Disclosure

Carbon emission disclosure serves as a critical strategic tool for managing stakeholder relations and significantly enhancing corporate reputation. This study's

findings directly support the notion that such transparency translates into a competitive advantage and improved financial performance, as suggested by existing literature (Lu et al., 2021; Siddique et al., 2021). Specifically, the market-capitalization-weighted portfolio of carbon-disclosing companies in Thailand significantly outperformed the SET Index by 6.00 percentage points, with a statistically significant one-tailed t-test (p=0.0466). This empirical evidence from the Thai market reinforces that strong carbon disclosure is not just a regulatory compliance matter but a value-creating strategy.

Companies can utilize these results in several ways to improve:

- Strategic Integration: Integrate carbon disclosure deeply into overall business strategy, identifying opportunities for carbon efficiency and innovation that align with financial goals.
- Enhanced Investor Attraction: Leverage robust disclosure in investor communications to attract sustainability-focused capital, demonstrating long-term value creation and risk management.
- Operational Improvements: Use the process of disclosure to identify areas for operational efficiencies in energy consumption and resource use, leading to cost savings and reduced environmental impact.
- Reputation and Legitimacy: Proactively disclose carbon performance to strengthen corporate legitimacy and build trust with customers, employees, and regulators, thereby reducing potential agency costs.
- Market Leadership: Position the company as a leader in environmental transparency, setting benchmarks for peers and attracting talent committed to sustainable practices

b) Sector-Specific Strategies for Performance Improvement

While the OLS regression did not find most sectors to significantly explain individual stock performance, the stark sectoral disparities observed in the portfolio's aggregate performance warrant sector-specific attention. As industry factors can be crucial drivers of firm performance (Adetunji & Owolabi, 2016), Property and Construction and industrials sectors, which significantly underperformed in this study, should prioritize investing in innovative solutions to address their unique environmental and operational challenges. Implementing energy-efficient technologies, shifting to

renewable energy sources, and integrating circular economy principles can help these sectors mitigate risks, comply with emerging regulations, and potentially enhance financial performance. However, given that this study's primary focus was not on deep-diving into specific industry dynamics, a more focused and comprehensive study is needed to fully ascertain the drivers of these sectoral performance disparities.

c) Firm Size and Performance: A Limited Impact

Existing literature often suggests that firm size influences financial performance, with larger firms often having greater resources for disclosure and potentially a strategic advantage (Ahmad et al., 2021). However, this study's regression model did not find a statistically significant relationship between firm size (log market Cap) and individual stock performance within the sample of 160 carbon-disclosing companies. This suggests that while firm size might influence disclosure practices, its direct explanatory power for stock performance was not evident in our specific context. Further comprehensive studies, particularly on a broader market, are needed to fully understand the nuanced impact of firm size on stock performance in relation to carbon disclosure.

d) Profitability Metrics and Performance: A Limited Observance

Similarly, while general expectations and some literature suggest that profitable firms show superior financial performance and are more likely to invest in and disclose sustainability initiatives (Ahmad et al., 2021), this study's regression model found that traditional profitability and valuation ratios (pe, pbv) were not statistically significant in explaining individual stock performance in our sample. Therefore, the direct explanatory power of these traditional profitability factors for stock performance should be re-evaluated within the context of carbon-disclosing firms. A more comprehensive market-wide analysis for these variables is required to ascertain their full impact on stock performance.

Recommendations for Investors

Investors should consider carbon emission disclosure as a key factor in portfolio selection, as this study demonstrates its potential link to financial performance. Companies that actively disclose and manage their carbon emissions may indicate stronger governance structures and long-term sustainability, making them attractive investment opportunities.

However, investors must recognize that the financial benefits of carbon disclosure can vary across industries. For instance, highly regulated sectors or those with high carbon footprints may face different challenges and opportunities compared to service-oriented industries. A sector-specific approach, rather than a one-size-fits-all strategy, is advisable when integrating carbon disclosure into investment decisions.

Additionally, diversification remains essential—balancing investments across high-performing sectors and those showing improvement in sustainability practices can optimize returns while managing risks. Investors should also engage with companies by encouraging better transparency and holding them accountable for meeting environmental targets.

Recommendations for Policymakers and Regulators

Policymakers and regulatory bodies play a critical role in fostering the adoption of carbon disclosure practices by setting clear standards and providing incentives. Regulatory organizations, such as the Stock Exchange of Thailand (SET), should establish mandatory and standardized reporting frameworks to ensure consistency and comparability across companies. Aligning with international disclosure standards would further enhance investor confidence and make Thai companies more competitive on the global stage.

Regulators and policymakers also play a crucial role in encouraging transparency and reducing agency costs. Better carbon disclosure can reduce agency problems, especially when firms align their environmental actions with stakeholder expectations. The power of policy in shaping corporate behavior has been demonstrated where government-mandated disclosure led to significant reductions in greenhouse gas emissions (Siddique et al., 2021; Downar et al., 2021).

Beyond regulation, introducing financial incentives—such as tax benefits, subsidies, or grants for companies that meet or exceed carbon disclosure benchmarks—

can accelerate corporate adoption of sustainability initiatives. Additionally, public-private partnerships could support companies, particularly SMEs, in developing the capacity to track, report, and reduce their carbon footprint effectively.

Furthermore, policymakers should consider sector-specific policies that address the unique challenges faced by different industries. For example, stricter emissions regulations and incentives for green building technologies may be more relevant to the property and construction sector, while the industrial sector could benefit from energy efficiency grants and low-carbon manufacturing incentives.

By creating a comprehensive regulatory framework that balances enforcement with incentives, policymakers can drive greater corporate accountability, investor confidence, and long-term sustainability in the Thai market.

5.3 Study Limitations

This study provides valuable insights into the relationship between carbon emission disclosure and financial performance in the Thai market, particularly at the portfolio level. However, like all empirical research, it is subject to certain limitations that warrant acknowledgment.

Firstly, the study focused on a specific period from January 1, 2024, to December 31, 2024, and utilized a sample of 160 carbon-disclosing companies listed on the Stock Exchange of Thailand. This limited timeframe and specific sample size may affect the generalizability of the findings to different market conditions or a broader range of companies.

Secondly, it is important to note that the data collection for carbon disclosure was reliant on API availability. As such, the sample includes only companies for which accurate and complete carbon disclosure data could be retrieved through the API. We acknowledge that a small number of carbon-disclosing companies (approximately 5-6) may not have been included due to data unavailability or inconsistencies from the API, which could potentially affect the comprehensiveness of our sample of carbon-disclosing firms.

Thirdly, while the portfolio analysis demonstrated significant outperformance for carbon-disclosing firms, the Ordinary Least Squares (OLS) regression model, which aimed to explain individual stock performance, exhibited a low R-squared (0.008) and did not find statistically significant relationships for traditional firm characteristics such

as firm size (log_marketCap) and profitability/valuation ratios (pe, pbv). This indicates that these conventional variables did not strongly explain individual stock performance within the sampled carbon-disclosing companies, suggesting that other unmodeled factors or more complex dynamics might be at play. The model's limited explanatory power for individual stock performance highlights the need for more nuanced and possibly alternative modeling approaches in future research.

Finally, the study primarily focused on carbon emission disclosure as a single aspect of environmental, social, and governance (ESG) performance. While carbon is a critical component, a more holistic understanding of sustainability's impact on financial performance would require examining other ESG dimensions, which were beyond the scope of this research.

These limitations underscore the need for further, more comprehensive research to build upon these findings and explore the intricate relationships between sustainability practices and financial outcomes more deeply.

5.4 Further Study

Future research could expand the scope and depth of this study to provide more comprehensive insights into the relationship between carbon emission disclosure and financial performance. A longitudinal analysis over multiple years would allow for an evaluation of the consistency and sustainability of the observed benefits. Such an approach could also help in identifying trends related to the impact of carbon disclosure over time, potentially utilizing panel data regressions for more rigorous causal assessments.

Building on this study's findings, future investigations should explicitly include a direct variable representing carbon disclosure as an independent variable in regression models to directly test its impact on stock performance across a broader sample, including non-disclosing firms. Given the limited explanatory power of traditional firm characteristics in our current OLS model, exploring other unmodeled factors or alternative model specifications could better explain individual stock performance within carbon-disclosing portfolios.

Sector-specific studies are also recommended, particularly for industries that underperformed in this study, such as industrial and property and construction. These studies could explore the unique challenges faced by these sectors and identify

strategies to better integrate environmental practices into their operations, contributing to a deeper understanding of the drivers of these sectoral performance disparities.

Additionally, while this study focused solely on carbon emission disclosure, future research could examine other dimensions of ESG factors. Analyzing the combined impact of environmental, social, and governance practices could provide a more holistic view of how sustainability influences financial performance.

Lastly, a comparative analysis between Thailand and other countries could provide valuable insights into how regional and cultural differences affect the relationship between carbon disclosure and financial performance. Such studies could offer a global perspective, helping policymakers and investors to adapt their strategies to different market contexts.

5.5 Managerial Implication

The results of this study offer several important implications for corporate managers and executives in Thailand. The positive relationship observed at the portfolio level between carbon emission disclosure and stock performance suggests that environmental transparency can be a value-creating strategy. Managers should therefore prioritize carbon disclosure not merely for compliance or reputational purposes but as a deliberate financial strategy aimed at enhancing investor trust and long-term firm value.

The outperformance of the carbon disclosure portfolio relative to the SET Index by approximately 6.00 percentage points underscores the growing importance of ESG metrics in capital markets. Firms, especially in emerging markets, are increasingly rewarded for their environmental accountability. Managers should implement standardized reporting frameworks such as GRI or TCFD to improve the quality and comparability of their disclosures.

Moreover, the sector-specific findings provide guidance on strategic focus. Technology and consumer goods companies that led in returns likely benefited from investor perception of sustainability alignment. In contrast, underperforming sectors like Industrials and Property and Construction may need to innovate their operations by integrating energy-efficient technologies and transitioning toward low-carbon models. These sectors should not view carbon disclosure as a risk but rather as an opportunity to rebuild stakeholder confidence.

Lastly, managers should recognize that while environmental investments may involve upfront costs, they have the potential to yield long-term financial returns, especially as regulatory and investor pressure continues to rise. The implications are clear: firms that lead in transparency and sustainability are more likely to maintain a competitive edge in the evolving Thai capital market.

5.6 Academic Contribution

This study contributes to academic literature by providing empirical evidence on the relationship between carbon emission disclosure and financial performance in the context of an emerging market, Thailand. Unlike most prior research that relies on accounting-based indicators such as ROA or ROE, this study evaluates stock performance using total return, offering a market-based perspective that aligns closely with investor behavior.

The findings, particularly the aggregate portfolio's outperformance of the market and the statistical significance shown by the one-tailed t-test, support Signaling Theory, Stakeholder Theory, and Legitimacy Theory, showing that transparent environmental practices can enhance investor confidence and firm valuation. While the OLS regression revealed that traditional firm characteristics (sector, size, profitability) did not statistically explain individual stock performance within the carbon-disclosing sample, this also contributes by highlighting the complexity of performance drivers in this specific context. By highlighting sector-specific differences (with Technology and Consumer Products outperforming, and Industrials and Property and Construction sectors lagging) this study also modifies the understanding of how ESG impacts can vary across industries.

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Appendix 1: List of Thai Companies Disclosed Their Carbon Emissions in 2024 (Published by SET)

* Total greenhouse gas emissions target (Metric tonnes of carbon dioxide equivalent) = TGGET
** Total greenhouse gas emissions (Metric tonnes of carbon dioxide equivalent) = TGGE

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
BTG	BETAGRO PUBLIC COMPANY LIMITED	AGRO	-	436,398	420,244
CBG	CARABAO GROUP PUBLIC COMPANY LIMITED	AGRO	A	N/A	416,058
CFRESH	SEAFRESH INDUSTRY PUBLIC COMPANY LIMITED	AGRO	A	9,112	9,016
CPF	CHAROEN POKPHAND FOODS PUBLIC COMPANY LIMITED	AGRO	AAA	N/A	12,931,539
GFPT	GFPT PUBLIC COMPANY LIMITED	AGRO	BBB	N/A	49,764
HTC	HAAD THIP PUBLIC COMPANY LIMITED	AGRO	AA	N/A	18,381
ICHI	ICHITAN GROUP PUBLIC COMPANY LIMITED	AGRO	A	161,500	154,556
NER	NORTH EAST RUBBER PUBLIC COMPANY LIMITED	AGRO	A	N/A	29,622
NRF	NR INSTANT PRODUCE PUBLIC COMPANY LIMITED	AGRO	A	N/A	9,614
OSP	OSOTSPA PUBLIC COMPANY LIMITED	AGRO	AA	275,000	566,406
PM	PREMIER MARKETING PUBLIC COMPANY LIMITED	AGRO	A	980	1,004
RBF	R&B FOOD SUPPLY PUBLIC COMPANY LIMITED	AGRO	BBB	N/A	21,395
SAPPE	SAPPE PUBLIC COMPANY LIMITED	AGRO	BBB	N/A	17,986

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
SNP	S & P SYNDICATE PUBLIC COMPANY LIMITED	AGRO	A	N/A	14,737
STA	SRI TRANG AGRO-INDUSTRY PUBLIC COMPANY LIMITED	AGRO	AAA	N/A	150,522
TFMAMA	THAI PRESIDENT FOODS PUBLIC COMPANY LIMITED	AGRO	AAA	N/A	131,552
TVO	THAI VEGETABLE OIL PUBLIC COMPANY LIMITED	AGRO	AA	N/A	739,501
TWPC	THAI WAH PUBLIC COMPANY LIMITED	AGRO	A	157,675	166,311
BLC	Bangkok Lab and Cosmetic Public Company Limited	CONSUMP	-	4,809	5,445
S&J	S & J INTERNATIONAL ENTERPRISES PUBLIC COMPANY LIMITED	CONSUMP	AA	25,600	25,600
SABINA	SABINA PUBLIC COMPANY LIMITED	CONSUMP	AAA	3,341	13,409
STGT	SRI TRANG GLOVES (THAILAND) PUBLIC COMPANY LIMITED	CONSUMP	AAA	N/A	1,328,600
TOG	THAI OPTICAL GROUP PUBLIC COMPANY LIMITED	CONSUMP	A	N/A	33,218
WACOAL	THAI WACOAL PUBLIC COMPANY LIMITED	CONSUMP	A	N/A	15,358
AYUD	ALLIANZ AYUDHYA CAPITAL PUBLIC COMPANY LIMITED	FINCIAL	-	968	881
BAM	BANGKOK COMMERCIAL ASSET MANAGEMENT PUBLIC COMPANY LIMITED	FINCIAL	AA	1,547	1,637
BAY	BANK OF AYUDHYA PUBLIC COMPANY LIMITED	FINCIAL	AAA	43,973	81,753

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
BBL	BANGKOK BANK PUBLIC COMPANY LIMITED	FINCIAL	AA	69,590	80,124
BLA	BANGKOK LIFE ASSURANCE PUBLIC COMPANY LIMITED	FINCIAL	AA	2,710	2,439
HENG	HENG LEASING AND CAPITAL PUBLIC COMPANY LIMITED	FINCIAL	A	N/A	2,832,209
KBANK	KASIKORNBANK PUBLIC COMPANY LIMITED	FINCIAL	AAA	76,766	76,643
KKP	KIATNAKIN PHATRA BANK PUBLIC COMPANY LIMITED	FINCIAL	BBB	N/A	11,366
KTB	KRUNG THAI BANK PUBLIC COMPANY LIMITED	FINCIAL	AAA	N/A	82,738
KTC	KRUNGTHAI CARD PUBLIC COMPANY LIMITED	FINCIAL	AAA	N/A	2,010
LHFG	LH FINANCIAL GROUP PUBLIC COMPANY LIMITED	FINCIAL	BBB	2,787	2,564
MTC	MUANGTHAI CAPITAL PUBLIC COMPANY LIMITED	FINCIAL	A	32,441	35,567
SAK	SAKSIAM LEASING PUBLIC COMPANY LIMITED	FINCIAL	A	N/A	6,196
SAWAD	SRISAWAD CORPORATION PUBLIC COMPANY LIMITED	FINCIAL	BBB	8,000	4,004
SCB	SCB X PUBLIC COMPANY LIMITED	FINCIAL	AA	66,650	65,384
TCAP	THANACHART CAPITAL PUBLIC COMPANY LIMITED	FINCIAL	A	N/A	561
THANI	RATCHTHANI LEASING PUBLIC COMPANY LIMITED	FINCIAL	AA	285	317

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
THREL	THAIRE LIFE ASSURANCE PUBLIC COMPANY LIMITED	FINCIAL	A	N/A	54
TISCO	TISCO FINANCIAL GROUP PUBLIC COMPANY LIMITED	FINCIAL	AAA	3,810	3,260
TTB	TMBTHANACHART BANK PUBLIC COMPANY LIMITED	FINCIAL	AA	7,412	32,658
AH	AAPICO HITECH PUBLIC COMPANY LIMITED	INDUS	A	5,682	29,761
AJ	A.J. PLAST PUBLIC COMPANY LIMITED	INDUS	AAA	485,844	599,999
ALLA	ALLA PUBLIC COMPANY LIMITED	INDUS	-	1,659	1,723
BGC	BG CONTAINER GLASS PUBLIC COMPANY LIMITED	INDUS	AA	534,024	865,361
CSC	CROWN SEAL PUBLIC COMPANY LIMITED	INDUS	BBB	N/A	82,028
IRC	INOUE RUBBER (THAILAND) PUBLIC COMPANY LIMITED	INDUS	A	N/A	31,159
IVL	INDORAMA VENTURES PUBLIC COMPANY LIMITED	INDUS	AA	0	9,578,678
PAP	PACIFIC PIPE PUBLIC COMPANY LIMITED	INDUS	A	N/A	N/A
PCC	Precise Corporation Public Company Limited	INDUS	-	3,944	3,958
PCSGH	P.C.S. MACHINE GROUP HOLDING PUBLIC COMPANY LIMITED	INDUS	BBB	27,331	26,362
PJW	PANJAWATTANA PLASTIC PUBLIC COMPANY LIMITED	INDUS	A	34,466	30,234
PTTGC	PTT GLOBAL CHEMICAL PUBLIC COMPANY LIMITED	INDUS	AAA	9	48
QTC	QTC ENERGY PUBLIC COMPANY LIMITED	INDUS	A	631,219	604,110

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
SAT	SOMBOON ADVANCE TECHNOLOGY PUBLIC COMPANY LIMITED	INDUS	AA	106,922	99,197
SCGP	SCG PACKAGING PUBLIC COMPANY LIMITED	INDUS	AAA	4,616,072	6,075,529
SITHAI	SRITHAI SUPERWARE PUBLIC COMPANY LIMITED	INDUS	A	N/A	21,037
SMPC	SAHAMITR PRESSURE CONTAINER PUBLIC COMPANY LIMITED	INDUS	AA	23,999	23,420
SSSC	SIAM STEEL SERVICE CENTER PUBLIC COMPANY LIMITED	INDUS	BBB	N/A	883
SUTHA	GOLDEN LIME PUBLIC COMPANY LIMITED	INDUS	A	0	350,590
THIP	THANTAWAN INDUSTRY PUBLIC COMPANY LIMITED	INDUS	A	N/A	76,986
TMT	TMT STEEL PUBLIC COMPANY LIMITED	INDUS	AA	N/A	1,210,594
TPBI	TPBI PUBLIC COMPANY LIMITED	INDUS	AA	18,614	150,887
TSC	THAI STEEL CABLE PUBLIC COMPANY LIMITED	INDUS	A	124	2,369
TSTH	TATA STEEL (THAILAND) PUBLIC COMPANY LIMITED	INDUS	A	678,817	692,906
AMATA	AMATA CORPORATION PUBLIC COMPANY LIMITED	PROPCON	AAA	N/A	63,220
AMATAV	AMATA VN PUBLIC COMPANY LIMITED	PROPCON	AA	N/A	3,569
AP	AP (THAILAND) PUBLIC COMPANY LIMITED	PROPCON	AA	N/A	1,579
ASW	ASSETWISE PUBLIC COMPANY LIMITED	PROPCON	A	N/A	1,408

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
AWC	ASSET WORLD CORP PUBLIC COMPANY LIMITED	PROPCON	A	120,653	165,445
BRI	BRITANIA PUBLIC COMPANY LIMITED	PROPCON	AA	N/A	4,466
CK	CH. KARNCHANG PUBLIC COMPANY LIMITED	PROPCON	A	N/A	235,757
CPN	CENTRAL PATTANA PUBLIC COMPANY LIMITED	PROPCON	AA	772,194	688,197
CPNREIT	CPN RETAIL GROWTH LEASEHOLD REIT	PROPCON	-	103,365	83,718
DRT	DIAMOND BUILDING PRODUCTS PUBLIC COMPANY LIMITED	PROPCON	AA	45,050	49,867
EPG	EASTERN POLYMER GROUP PUBLIC COMPANY LIMITED	PROPCON	AA	N/A	98,536
FPT	FRASERS PROPERTY (THAILAND) PUBLIC COMPANY LIMITED	PROPCON	AA	100,237	98,960
GLAND	GRAND CANAL LAND PUBLIC COMPANY LIMITED	PROPCON	-	18,925	23,918
LH	LAND AND HOUSES PUBLIC COMPANY LIMITED	PROPCON	A	N/A	4,572
NOBLE	NOBLE DEVELOPMENT PUBLIC COMPANY LIMITED	PROPCON	AA	N/A	482
NVD	NIRVANA DEVELOPMENT PUBLIC COMPANY LIMITED	PROPCON	AA	109	128
ORI	ORIGIN PROPERTY PUBLIC COMPANY LIMITED	PROPCON	AA	N/A	6,235
PPP	PREMIER PRODUCTS PUBLIC COMPANY LIMITED	PROPCON	A	5,427	4,489

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
PSH	PRUKSA HOLDING PUBLIC COMPANY LIMITED	PROPCON	BBB	N/A	33,243
S	SINGHA ESTATE PUBLIC COMPANY LIMITED	PROPCON	A	42,480	38,716
SC	SC ASSET CORPORATION PUBLIC COMPANY LIMITED	PROPCON	AA	9,540	9,510
SCC	THE SIAM CEMENT PUBLIC COMPANY LIMITED	PROPCON	AAA	N/A	37,690,118
SCCC	SIAM CITY CEMENT PUBLIC COMPANY LIMITED	PROPCON	AA	9,261,984	10,218,017
SIRI	SANSIRI PUBLIC COMPANY LIMITED	PROPCON	AA	2,795,700	1,929,603
SPALI	SUPALAI PUBLIC COMPANY LIMITED	PROPCON	AA	40	143,980
STEC	SINO-THAI ENGINEERING AND CONSTRUCTION PUBLIC CO.,LTD.	PROPCON	A	N/A	1,065
TASCO	TIPCO ASPHALT PUBLIC COMPANY LIMITED	PROPCON	-	16,414	12,996
TOA	TOA PAINT (THAILAND) PUBLIC COMPANY LIMITED	PROPCON	A	15,603	N/A
TPIPL	TPI POLENE PUBLIC COMPANY LIMITED	PROPCON	AA	N/A	8,638,405
TTCL	TTCL PUBLIC COMPANY LIMITED	PROPCON	A	N/A	667
WHA	WHA CORPORATION PUBLIC COMPANY LIMITED	PROPCON	AAA	17,667	18,610
BANPU	BANPU PUBLIC COMPANY LIMITED	RESOURC	AAA	10,263,293	56,618,372
BBGI	BBGI PUBLIC COMPANY LIMITED	RESOURC	AA	N/A	403,589
BCP	BANGCHAK CORPORATION	RESOURC	AAA	N/A	2,867,843

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
	PUBLIC COMPANY LIMITED				
BCPG	BCPG PUBLIC COMPANY LIMITED	RESOURC	AA	N/A	1,770
BGRIM	B.GRIMM POWER PUBLIC COMPANY LIMITED	RESOURC	AAA	0	6,420,053
BPP	BANPU POWER PUBLIC COMPANY LIMITED	RESOURC	AAA	8,938,715	6,133,999
CKP	CK POWER PUBLIC COMPANY LIMITED	RESOURC	AAA	723,674	721,781
EASTW	EASTERN WATER RESOURCES DEVELOPMENT AND MANAGEMENT PCL.	RESOURC	AA	N/A	86,008
EGCO	ELECTRICITY GENERATING PUBLIC COMPANY LIMITED	RESOURC	AA	N/A	17,060,803
GPSC	GLOBAL POWER SYNERGY PUBLIC COMPANY LIMITED	RESOURC	AA	N/A	6,720,415
GULF	GULF ENERGY DEVELOPMENT PUBLIC COMPANY LIMITED	RESOURC	AA	N/A	14,624,745
GUNKUL	GUNKUL ENGINEERING PUBLIC COMPANY LIMITED	RESOURC	AA	5,173	13,634
IRPC	IRPC PUBLIC COMPANY LIMITED	RESOURC	AA	4,450,000	3,600,000
OR	PTT OIL AND RETAIL BUSINESS PUBLIC COMPANY LIMITED	RESOURC	AAA	28,900	66,384,108
PTT	PTT PUBLIC COMPANY LIMITED	RESOURC	AAA	11,500,000	83,791,527
PTTEP	PTT EXPLORATION AND PRODUCTION PUBLIC COMPANY LIMITED	RESOURC	AAA	5,457,809	6,813,154
RATCH	RATCH GROUP PUBLIC COMPANY LIMITED	RESOURC	AA	N/A	6,561,776

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
SCG	RATCH PATHANA ENERGY PUBLIC COMPANY LIMITED	RESOURC	A	640,052	839,557
SGP	SIAMGAS AND PETROCHEMICALS PUBLIC COMPANY LIMITED	RESOURC	AA	30,653	31,564
SUSCO	SUSCO PUBLIC COMPANY LIMITED	RESOURC	-	1,800	1,520
TOP	THAI OIL PUBLIC COMPANY LIMITED	RESOURC	AAA	3,460,000	3,384,406
TPIPP	TPI POLENE POWER PUBLIC COMPANY LIMITED	RESOURC	AA	3,000,000	1,858,850
TTW	TTW PUBLIC COMPANY LIMITED	RESOURC	AA	83,039	92,785
UBE	UBON BIO ETHANOL PUBLIC COMPANY LIMITED	RESOURC	A	N/A	110,717,199
WHAUP	WHA UTILITIES AND POWER PUBLIC COMPANY LIMITED	RESOURC	AAA	N/A	13,359
BA	BANGKOK AIRWAYS PUBLIC COMPANY LIMITED	SERVICE	BBB	N/A	293,222
BCH	BANGKOK CHAIN HOSPITAL PUBLIC COMPANY LIMITED	SERVICE	AA	N/A	29,672
BDMS	BANGKOK DUSIT MEDICAL SERVICES PUBLIC COMPANY LIMITED	SERVICE	AA	230,400	184,210
BEM	BANGKOK EXPRESSWAY AND METRO PUBLIC COMPANY LIMITED	SERVICE	AA	96,386	143,834
BTS	BTS GROUP HOLDINGS PUBLIC COMPANY LIMITED	SERVICE	AA	175,935	153,249
CENTEL	CENTRAL PLAZA HOTEL PUBLIC COMPANY LIMITED	SERVICE	A	N/A	161,598

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
CHG	CHULARAT HOSPITAL PUBLIC COMPANY LIMITED	SERVICE	-	600,000	6,733,490
COM7	COM7 PUBLIC COMPANY LIMITED	SERVICE	A	N/A	N/A
CPALL	CP ALL PUBLIC COMPANY LIMITED	SERVICE	AAA	17,360,000	17,194,457
CPAXT	CP AXTRA PUBLIC COMPANY LIMITED	SERVICE	AAA	N/A	8,561,881
CRC	CENTRAL RETAIL CORPORATION PUBLIC COMPANY LIMITED	SERVICE	AAA	N/A	893,754
DMT	DON MUANG TOLLWAY PUBLIC COMPANY LIMITED	SERVICE	A	N/A	3,668
ERW	THE ERAWAN GROUP PUBLIC COMPANY LIMITED	SERVICE	A	0	50,291
GLOBAL	SIAM GLOBAL HOUSE PUBLIC COMPANY LIMITED	SERVICE	AA	10	57,454
HMPRO	HOME PRODUCT CENTER PUBLIC COMPANY LIMITED	SERVICE	AA	101,920	92,369
III	TRIPLE I LOGISTICS PUBLIC COMPANY LIMITED	SERVICE	BBB	N/A	2,556
ILM	INDEX LIVING MALL PUBLIC COMPANY LIMITED	SERVICE	BBB	N/A	20,076
MAJOR	MAJOR CINEPLEX GROUP PUBLIC COMPANY LIMITED	SERVICE	AA	19,282	19,282
MC	MC GROUP PUBLIC COMPANY LIMITED	SERVICE	AA	N/A	1,631
M-CHAI	MAHACHAI HOSPITAL PUBLIC COMPANY LIMITED	SERVICE	AAA	2,181	2,482
MEGA	MEGA LIFESCIENCES PUBLIC COMPANY LIMITED	SERVICE	A	N/A	9,001

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
MINT	MINOR INTERNATIONAL PUBLIC COMPANY LIMITED	SERVICE	AA	N/A	1,780,267
NYT	NAMYONG TERMINAL PUBLIC COMPANY LIMITED	SERVICE	A	508	778
PLANB	PLAN B MEDIA PUBLIC COMPANY LIMITED	SERVICE	AA	N/A	37,000
PR9	PRARAM 9 HOSPITAL PUBLIC COMPANY LIMITED	SERVICE	AAA	11,461	11,537
PSL	PRECIOUS SHIPPING PUBLIC COMPANY LIMITED	SERVICE	A	N/A	537,684
RCL	REGIONAL CONTAINER LINES PUBLIC COMPANY LIMITED	SERVICE	-	1,036,066	972,699
RS	RS PUBLIC COMPANY LIMITED	SERVICE	AA	N/A	3,414,894
SHR	S HOTELS AND RESORTS PUBLIC COMPANY LIMITED	SERVICE	A	N/A	26,326
SJWD	SCGJWD LOGISTICS PUBLIC COMPANY LIMITED	SERVICE	AA	N/A	44,235
SPI	SAHA PATHANA INTER-HOLDING PUBLIC COMPANY LIMITED	SERVICE	A	N/A	287,271
TKS	T.K.S. TECHNOLOGIES PUBLIC COMPANY LIMITED	SERVICE	A	20,925	20,515
TTA	THORESEN THAI AGENCIES PUBLIC COMPANY LIMITED	SERVICE	AA	33,206	35,822
VGI	VGI PUBLIC COMPANY LIMITED	SERVICE	AA	N/A	5,369
WICE	WICE LOGISTICS PUBLIC COMPANY LIMITED	SERVICE	AA	2,190	2,315

Symbol	Company Name	Industry	SET ESG Ratings	TGGET*	TGGE**
ADVANC	ADVANCED INFO SERVICE PUBLIC COMPANY LIMITED	TECH	AAA	701,642	704,264
DELTA	DELTA ELECTRONICS (THAILAND) PUBLIC COMPANY LIMITED	TECH	-	232,067	226,774
HANA	HANA MICROELECTRONICS PUBLIC COMPANY LIMITED	TECH	AA	24,000	22,522
INTUCH	INTOUCH HOLDINGS PUBLIC COMPANY LIMITED	TECH	AA	N/A	27
JTS	JASMINE TECHNOLOGY SOLUTION PUBLIC COMPANY LIMITED	TECH	BBB	0	3,791
MFEC	MFEC PUBLIC COMPANY LIMITED	TECH	AA	462	465
MSC	METRO SYSTEMS CORPORATION PUBLIC COMPANY LIMITED	TECH	A	1,805	1,814
SYNEX	SYNNEX (THAILAND) PUBLIC COMPANY LIMITED	TECH	A	641,189	641,189
THCOM	THAICOM PUBLIC COMPANY LIMITED	TECH	AAA	N/A	3,176
TRUE	TRUE CORPORATION PUBLIC COMPANY LIMITED	TECH	-	1,164,790	1,062,163

Appendix 2: Python Code

```
import requests
import pandas as pd
from datetime import datetime, timedelta
import numpy as np # For log transformation and NaN handling
import statsmodels.formula.api as smf # For regression

# --- Configuration ---
# Your API key from SET Smart
API_KEY = "9f3c748c-ec0e-4266-8d4a-43e7f6a0c293"

# Base URL for the SET Smart API
# This is the base part before the specific endpoint
SET_SMART_BASE_URL = "https://www.setsmart.com/api"

# Specific endpoint for EOD stock price by symbol
EOD_PRICE_ENDPOINT = "/listed-company-api/eod-price-by-symbol"

# Dictionary to map symbols to their full names and industries
(provided by user)
INDUSTRY_MAPPING = {
    "BTG": "AGRO", "CBG": "AGRO", "CFRESH": "AGRO", "CPF":
"AGRO", "GFPT": "AGRO",
    "HTC": "AGRO", "ICHI": "AGRO", "NER": "AGRO", "NRF": "AGRO",
"OSP": "AGRO",
    "PM": "AGRO", "RBF": "AGRO", "SAPPE": "AGRO", "SNP": "AGRO",
"STA": "AGRO",
    "TFMAMA": "AGRO", "TVO": "AGRO", "TWPC": "AGRO",

    "BLC": "CONSUMP", "S&J": "CONSUMP", "SABINA": "CONSUMP",
"STGT": "CONSUMP",
    "TOG": "CONSUMP", "WACOAL": "CONSUMP",

    "AYUD": "FINCIAL", "BAM": "FINCIAL", "BAY": "FINCIAL", "BBL":
"FINCIAL",
    "BLA": "FINCIAL", "HENG": "FINCIAL", "KBANK": "FINCIAL",
"KKP": "FINCIAL",
    "KTB": "FINCIAL", "KTC": "FINCIAL", "LHFG": "FINCIAL", "MTC":
"FINCIAL",
    "SAK": "FINCIAL", "SAWAD": "FINCIAL", "SCB": "FINCIAL",
"TCAP": "FINCIAL",
    "THANI": "FINCIAL", "THREL": "FINCIAL", "TISCO": "FINCIAL",
"TTB": "FINCIAL",

    "AH": "INDUS", "AJ": "INDUS", "ALLA": "INDUS", "BGC":
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    "IRC": "INDUS", "PAP": "INDUS", "PCC": "INDUS", "PCSGH":
"INDUS",
    "PJW": "INDUS", "PTTGC": "INDUS", "QTC": "INDUS", "SAT":
"INDUS", "SCGP": "INDUS",
    "SITHAI": "INDUS", "SMPC": "INDUS", "SSSC": "INDUS", "SUTHA":
"INDUS", "THIP": "INDUS",
```

```
    "TMT": "INDUS", "TPBI": "INDUS", "TSC": "INDUS", "TSTH":
"INDUS",

    "AMATA": "PROPCON", "AMATAV": "PROPCON", "AP": "PROPCON",
"ASW": "PROPCON",
    "AWC": "PROPCON", "BRI": "PROPCON", "CK": "PROPCON", "CPN":
"PROPCON",
    "CPNREIT": "PROPCON", "DRT": "PROPCON", "EPG": "PROPCON",
"FPT": "PROPCON",
    "GLAND": "PROPCON", "LH": "PROPCON", "NOBLE": "PROPCON",
"NVD": "PROPCON",
    "ORI": "PROPCON", "PPP": "PROPCON", "PSH": "PROPCON", "S":
"PROPCON",
    "SC": "PROPCON", "SCCC": "PROPCON", "SIRI": "PROPCON",
    "SPALI": "PROPCON", "SCC": "PROPCON",
    "TASCO": "PROPCON", "TOA": "PROPCON", "TPIPL": "PROPCON",
"TTCL": "PROPCON", "WHA": "PROPCON",

    "BANPU": "RESOURC", "BBGI": "RESOURC", "BCP": "RESOURC",
"BCPG": "RESOURC",
    "BGRIM": "RESOURC", "BPP": "RESOURC", "BCK": "RESOURC",
"EASTW": "RESOURC",
    "EGCO": "RESOURC", "GULF": "RESOURC", "GUNKUL": "RESOURC",
    "IRPC": "RESOURC", "OR": "RESOURC",
    "RATCH": "RESOURC", "SCG": "RESOURC", "SGP": "RESOURC",
"SUSCO": "RESOURC",
    "TOP": "RESOURC", "TPIPP": "RESOURC", "TTW": "RESOURC",
"UBE": "RESOURC",
    "WHAUP": "RESOURC",

    "BA": "SERVICE", "BCH": "SERVICE", "BDMS": "SERVICE", "BEM":
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    "CENTEL": "SERVICE", "CHG": "SERVICE", "COM7": "SERVICE",
    "CRC": "SERVICE", "DMT": "SERVICE",
    "ERW": "SERVICE", "GLOBAL": "SERVICE", "HMPRO": "SERVICE",
"III": "SERVICE",
    "ILM": "SERVICE", "MAJOR": "SERVICE", "MC": "SERVICE", "M-
CHAI": "SERVICE",
    "MEGA": "SERVICE", "MINT": "SERVICE", "NYT": "SERVICE",
"PLANB": "SERVICE",
    "PR9": "SERVICE", "PSL": "SERVICE", "RCL": "SERVICE", "RS":
"SERVICE",
    "SHR": "SERVICE", "SJWD": "SERVICE", "SPI": "SERVICE", "TKS":
"SERVICE",
    "TTA": "SERVICE", "VGI": "SERVICE", "WICE": "SERVICE",

    "ADVANC": "TECH", "DELTA": "TECH", "HANA": "TECH", "INTUCH":
"TECH",
    "MFEC": "TECH", "MSC": "TECH", "SYNEX": "TECH",
    "THCOM": "TECH", "TRUE": "TECH"
}

# SYMBOLS list now contains all keys from INDUSTRY_MAPPING
SYMBOLS = list(INDUSTRY_MAPPING.keys())

YEAR_TO_ANALYZE = 2024
```

```
# --- API Interaction Function ---
def fetch_historical_data(symbol, start_date_str, end_date_str):
    """
    Fetches historical close prices, market cap, P/E, and P/BV
for a given symbol
    and date range from the SET Smart API.
    """
    url = f"{SET_SMART_BASE_URL}{EOD_PRICE_ENDPOINT}"

    params = {
        "symbol": symbol,
        "startDate": start_date_str,
        "endDate": end_date_str,
        "adjustedPriceFlag": "N" # 'N' for unadjusted price
information
    }

    headers = {
        "api-key": API_KEY
    }

    print(f"Fetching data for {symbol} from {start_date_str} to
{end_date_str}...")
    try:
        response = requests.get(url, params=params,
headers=headers)
        response.raise_for_status() # Raise an exception for HTTP
errors (4xx or 5xx)

        data = response.json()

        if isinstance(data, dict):
            data = [data]
        elif not isinstance(data, list):
            print(f"Unexpected API response format for {symbol}:
{data}")
            return None

        print(f"Successfully fetched data for {symbol}. Records:
{len(data)}")
        return data
    except requests.exceptions.HTTPError as http_err:
        print(f"HTTP error occurred for {symbol}: {http_err} -
Response: {response.text}")
    except requests.exceptions.ConnectionError as conn_err:
        print(f"Connection error occurred for {symbol}:
{conn_err}")
    except requests.exceptions.Timeout as timeout_err:
        print(f"Timeout error occurred for {symbol}:
{timeout_err}")
    except requests.exceptions.RequestException as req_err:
        print(f"An unexpected request error occurred for
{symbol}: {req_err}")
    except ValueError:
        print(f"Error decoding JSON response for {symbol}.
Response: {response.text}")
    return None
```

```
# --- Data Processing Functions ---
def calculate_monthly_performance(df, symbol, year_to_analyze):
    """
    Calculates monthly price performance for a given year, and
also
    extracts monthly market cap, P/E, and P/BV.
    For Jan-Nov: Uses first price of current month and first
price of next month (within the same year).
    For Dec: Uses first price of December and last price of
December.
    NOTE: df is expected to have 'date' as its index.
    """
    if df.empty:
        print(f"No data to calculate monthly performance for
{symbol}.")
        return pd.DataFrame()

    # Resample to get the first trading day of each month and
extract relevant columns
    monthly_data_points = df.resample('MS').first()

    # Get the last price of the entire year for this symbol, for
December calculation
    last_price_of_year = df['close'].iloc[-1] if not df.empty
else None

    monthly_result_list = []

    # Create a series for end-of-month calculation based on next
month's start price
    # This aligns the 'end_price_for_calculation' with the
'first_price_of_month' from the *next* month
    monthly_calc_end_values =
monthly_data_points['close'].shift(-1)

    # Explicitly set December's end value to the last price of
the year for this symbol
    december_period_start = pd.Timestamp(f"{year_to_analyze}-12-
01") # Use Timestamp for direct comparison
    # Find the actual first trading day in December for this
stock
    actual_dec_start_date_in_data =
monthly_data_points.index[monthly_data_points.index.month ==
12].min()

    if actual_dec_start_date_in_data in monthly_data_points.index
and last_price_of_year is not None:
        # Find the Period for this actual December start date
        december_period =
pd.Period(actual_dec_start_date_in_data, freq='M')

monthly_calc_end_values.loc[actual_dec_start_date_in_data] =
last_price_of_year


    for month_start_date, row_data in
monthly_data_points.iterrows():
        month_period = pd.Period(month_start_date, freq='M')
```

```
        first_price_current_month = row_data['close']
        market_cap_current_month = row_data['marketCap']
        pe_current_month = row_data['pe']
        pbv_current_month = row_data['pbv']

        # Handle -100000 for P/E and P/BV
        if pe_current_month == -100000.0:
            pe_current_month = np.nan
        if pbv_current_month == -100000.0:
            pbv_current_month = np.nan

        end_price_for_calculation =
monthly_calc_end_values.get(month_start_date)

        if pd.isna(first_price_current_month) or
pd.isna(end_price_for_calculation) or first_price_current_month
== 0:
            # We need valid start and end prices for performance
calculation
            continue

        performance = ((end_price_for_calculation -
first_price_current_month) / first_price_current_month) * 100

        monthly_result_list.append({
            'Month_Start_Date': month_start_date, # Keep as
datetime for easier merging
            'Month': str(month_period),
            'symbol': symbol,
            'sector': INDUSTRY_MAPPING.get(symbol, 'UNKNOWN'), #
Get sector here
            'performance_percent': performance,
            'marketCap': market_cap_current_month,
            'pe': pe_current_month,
            'pbv': pbv_current_month
        })

    return pd.DataFrame(monthly_result_list) # Do not set index
here yet for easier concat/merge later


def calculate_yearly_performance(df, symbol, year):
    """
    Calculates yearly price performance using the first trading
price
    of the year and the last trading price of the year.
    NOTE: df is expected to have 'date' as its index.
    """
    if df.empty:
        print(f"No data to calculate yearly performance for
{symbol}.")
        return None

    try:
        start_year_first_price = df.iloc[0]['close']
    except IndexError:
```

```
        print(f"No start price found for {symbol} in {year} for
yearly performance.")
        return None

    try:
        end_year_last_price = df.iloc[-1]['close']
    except IndexError:
        print(f"No end price found for {symbol} in {year} for
yearly performance.")
        return None

    yearly_performance_percent = ((end_year_last_price -
start_year_first_price) / start_year_first_price) * 100

    return {
        'symbol': symbol,
        'year': year,
        'first_price_year': start_year_first_price,
        'last_price_year': end_year_last_price,
        'performance_percent_year': yearly_performance_percent
    }


def get_initial_market_caps(individual_dfs, year_to_analyze):
    """
    Extracts the market capitalization for each symbol on the
first trading day
    of the year from their respective DataFrames.
    """
    market_caps = {}
    for symbol, df in individual_dfs.items():
        if df.empty:
            print(f"Warning: No data for {symbol} to get initial
market cap.")
            continue
        try:
            market_cap = df.iloc[0]['marketCap']
            if market_cap == 0:
                print(f"Warning: Initial market cap for {symbol}
is zero. This stock will have zero weight.")
            market_caps[symbol] = market_cap
        except KeyError:
            print(f"Error: 'marketCap' column not found for
{symbol}. Cannot calculate portfolio weights.")
            return {}
        except IndexError:
            print(f"Warning: No data available for the beginning
of {year_to_analyze} for {symbol} to get market cap.")
            continue
        except Exception as e:
            print(f"An error occurred getting market cap for
{symbol}: {e}")
            continue
    return market_caps

def calculate_portfolio_weights(initial_market_caps):
    """
```

```
    Calculates market-cap-based weights for each symbol in the
portfolio.
    """
    if not initial_market_caps:
        print("No market cap data provided to calculate portfolio
weights.")
        return {}

    total_market_cap = sum(initial_market_caps.values())
    if total_market_cap == 0:
        print("Total market cap is zero, cannot calculate
weights.")
        return {}

    weights = {symbol: mc / total_market_cap for symbol, mc in
initial_market_caps.items()}
    return weights

def
calculate_portfolio_performance_buy_and_hold(individual_stock_dfs
, initial_portfolio_weights, year_to_analyze):
    """
    Calculates the performance of a market-cap-weighted portfolio
using a "buy and hold" strategy.
    The portfolio value is calculated monthly based on the
initial shares and monthly prices.

    individual_stock_dfs: Dictionary of DataFrames for each
stock, date as index, 'close' column.
    initial_portfolio_weights: Dictionary of initial weights
(from year start).
    """
    if not individual_stock_dfs or not initial_portfolio_weights:
        print("No individual stock data or portfolio weights to
calculate portfolio performance (buy and hold).")
        return None, pd.DataFrame()

    portfolio_monthly_data_list = []

    initial_portfolio_value = 100.0 # Conceptual initial
investment
    shares_held = {}

    # 1. Determine Initial Shares for each stock based on initial
weights and their first price of the year
    # Also collect all monthly first prices to form a combined
view
    all_monthly_first_prices = pd.DataFrame()
    all_yearly_end_prices = {}

    for symbol, weight in initial_portfolio_weights.items():
        df = individual_stock_dfs.get(symbol)
        if df is None or df.empty:
            print(f"Warning: No valid data for {symbol}. Cannot
include in portfolio.")
            continue

        # Get first price of the year for shares calculation
```

```
        first_price_of_year = df['close'].iloc[0] if not df.empty
else 0
        if first_price_of_year == 0:
            print(f"Warning: Initial price for {symbol} is zero
or not available. Cannot allocate to this stock. Excluding from
buy-and-hold portfolio.")
            continue

        dollar_allocation = weight * initial_portfolio_value
        shares_held[symbol] = dollar_allocation /
first_price_of_year

        # Get monthly first prices for this stock
        monthly_firsts =
df['close'].resample('MS').first().rename(symbol)
        if all_monthly_first_prices.empty:
            all_monthly_first_prices = monthly_firsts.to_frame()
        else:
            all_monthly_first_prices =
pd.merge(all_monthly_first_prices, monthly_firsts.to_frame(),
                                                 left_index=True,
right_index=True, how='outer')

        # Get last price of the year for this stock
        all_yearly_end_prices[symbol] = df['close'].iloc[-1] if
not df.empty else None

    if not shares_held:
        print("No stocks with valid initial prices after
allocation. Cannot calculate buy-and-hold portfolio.")
        return None, pd.DataFrame()

    # Fill any missing monthly first prices by ffill/bfill for
consistency
    all_monthly_first_prices =
all_monthly_first_prices.ffill().bfill()
    all_monthly_first_prices =
all_monthly_first_prices.dropna(axis=0, how='all') # Drop months
with no data for any stock

    if all_monthly_first_prices.empty:
        print("No valid monthly first prices for any stock after
cleaning. Cannot calculate portfolio monthly performance.")
        return None, pd.DataFrame()

    # 2. Calculate Monthly Portfolio Values and Performance
    portfolio_monthly_values_start = pd.Series(dtype=float)
    portfolio_monthly_values_end = pd.Series(dtype=float)

    for month_period_start_date in
all_monthly_first_prices.index:
        month_period = pd.Period(month_period_start_date,
freq='M')

        current_month_portfolio_value = 0.0
        for symbol, num_shares in shares_held.items():
            monthly_price =
all_monthly_first_prices.loc[month_period_start_date, symbol]
```

```
            if pd.isna(monthly_price) or monthly_price == 0:
                # If a stock's price is missing for this month,
its contribution is 0 for this month's start value
                continue
            current_month_portfolio_value += num_shares *
monthly_price

        if current_month_portfolio_value > 0:
            portfolio_monthly_values_start.loc[month_period] =
current_month_portfolio_value
        else:
            print(f"Warning: Portfolio start value for
{month_period} is zero. Skipping this month's performance.")
            continue # Skip this month if start value is 0

        # Determine end value for calculation (next month's start
or year-end for Dec)
        end_value_for_calculation = 0.0
        is_december = (month_period.month == 12)

        if is_december:
            # For December, use the last price of the year for
each stock
            for symbol, num_shares in shares_held.items():
                end_price_stock =
all_yearly_end_prices.get(symbol)
                if end_price_stock is None or
pd.isna(end_price_stock) or end_price_stock == 0:
                    continue
                end_value_for_calculation += num_shares *
end_price_stock
        else:
            # For other months, use the first price of the next
month
            next_month_period = month_period + 1
            if next_month_period.start_time in
all_monthly_first_prices.index:
                for symbol, num_shares in shares_held.items():
                    next_month_price =
all_monthly_first_prices.loc[next_month_period.start_time,
symbol]
                    if pd.isna(next_month_price) or
pd.isna(next_month_price) or next_month_price == 0:
                        continue
                    end_value_for_calculation += num_shares *
next_month_price

        if end_value_for_calculation > 0:
            portfolio_monthly_values_end.loc[month_period] =
end_value_for_calculation
        else:
            print(f"Warning: Portfolio end value for
{month_period} is zero. Skipping this month's performance.")
            continue # Skip this month if end value is 0

        # Calculate monthly performance
        if portfolio_monthly_values_start.loc[month_period] > 0:
            monthly_performance_percent = (
```

```
                (portfolio_monthly_values_end.loc[month_period] -
portfolio_monthly_values_start.loc[month_period]) /
                portfolio_monthly_values_start.loc[month_period]
            ) * 100
        else:
            monthly_performance_percent = 0.0 # Or pd.NA,
depending on desired handling of zero start value

        portfolio_monthly_data_list.append({
            'Month': str(month_period),
            'symbol': 'PORTFOLIO (Buy and Hold)',
            'first_price_of_month':
portfolio_monthly_values_start.loc[month_period],
            'end_price_for_calculation':
portfolio_monthly_values_end.loc[month_period],
            'performance_percent': monthly_performance_percent
        })

    # Ensure overall portfolio summary is also based on monthly
first/last values
    overall_start_value = portfolio_monthly_values_start.iloc[0]
if not portfolio_monthly_values_start.empty else 0
    overall_end_value = portfolio_monthly_values_end.iloc[-1] if
not portfolio_monthly_values_end.empty else 0

    if overall_start_value > 0:
        overall_performance = ((overall_end_value -
overall_start_value) / overall_start_value) * 100
    else:
        overall_performance = 0.0

    portfolio_summary = {
        'symbol': 'PORTFOLIO (Buy and Hold - Initial Market Cap
Weighted)',
        'year': year_to_analyze,
        'first_price_year': overall_start_value,
        'last_price_year': overall_end_value,
        'performance_percent_year': overall_performance
    }

    if not portfolio_monthly_data_list:
        print("No monthly portfolio data could be generated.")
        return portfolio_summary, pd.DataFrame()

    portfolio_monthly_df =
pd.DataFrame(portfolio_monthly_data_list).set_index('Month')

    return portfolio_summary, portfolio_monthly_df

# --- Main Execution Logic ---
if __name__ == "__main__":
    all_monthly_performances = pd.DataFrame()
    all_yearly_performances = []

    individual_stock_dfs = {}

    # New DataFrame to store all data needed for regression
    regression_data_list = []
```

```
    start_date_api = f"{YEAR_TO_ANALYZE}-01-01"
    end_date_api = f"{YEAR_TO_ANALYZE}-12-31"

    print(f"Starting analysis for year {YEAR_TO_ANALYZE}...")

    # --- Phase 1: Fetch and Preprocess Individual Stock Data ---
    for symbol in SYMBOLS:
        raw_data = fetch_historical_data(symbol, start_date_api,
end_date_api)

        if raw_data:
            try:
                df = pd.DataFrame(raw_data)

                # Ensure all required columns exist and convert
to numeric, coercing errors to NaN
                for col in ['close', 'marketCap', 'pe', 'pbv']:
                    if col not in df.columns:
                        print(f"Warning: '{col}' column not found
in data for {symbol}. Skipping this data point for {col}.")
                        df[col] = np.nan # Add column as NaN if
missing
                    else:
                        df[col] = pd.to_numeric(df[col],
errors='coerce')

                if df.empty:
                    continue

                # Drop rows where essential columns ('close',
'marketCap') are missing immediately after numeric conversion
                df = df.dropna(subset=['close', 'marketCap'])

                if df.empty:
                    print(f"No valid price or market cap data
found for {symbol} after initial cleanup. Cannot perform
analysis.")
                    continue

                df['date'] = pd.to_datetime(df['date'])
                df = df.set_index('date').sort_index()

                # Handle zero close prices by filling
                df['close'] = df['close'].replace(0,
pd.NA).ffill().bfill()

                if df['close'].isnull().all():
                    print(f"Warning: All prices for {symbol}
became NaN after attempting to fill zero values. Skipping
{symbol}.")
                    df = pd.DataFrame()
                    continue

                # Store the processed DataFrame
                individual_stock_dfs[symbol] = df
```

```
                # Calculate monthly performance and extract
monthly metrics for regression
                monthly_perf_and_metrics_df =
calculate_monthly_performance(df, symbol, YEAR_TO_ANALYZE)
                if not monthly_perf_and_metrics_df.empty:

regression_data_list.append(monthly_perf_and_metrics_df)
                    # Add to all_monthly_performances (which is
just performance, not all metrics)
                    all_monthly_performances =
pd.concat([all_monthly_performances,

monthly_perf_and_metrics_df[['Month', 'symbol',
'performance_percent']].set_index('Month')])

            except KeyError as e:
                print(f"Error creating DataFrame for {symbol}:
Missing key {e}. Please check API response structure.")
                continue
            except Exception as e:
                print(f"An unexpected error occurred while
processing data for {symbol}: {e}")
                continue
        else:
            print(f"Skipping {symbol} due to failed data fetch.")

    # Consolidate all regression data
    if regression_data_list:
        regression_df = pd.concat(regression_data_list,
ignore_index=True)
        # Drop rows where performance, marketCap, P/E, or P/BV
are still NaN after combining
        # This is crucial for regression
        regression_df =
regression_df.dropna(subset=['performance_percent', 'marketCap',
'pe', 'pbv'])

        if not regression_df.empty:
            # Handle problematic P/E and P/BV values (e.g., -
100000)
            regression_df['pe'] = regression_df['pe'].replace(-
100000.0, np.nan)
            regression_df['pbv'] = regression_df['pbv'].replace(-
100000.0, np.nan)

            # For regression, we typically use the natural
logarithm of market cap
            # Add a small constant to avoid log(0) if marketCap
can be zero after NaN drop
            regression_df['log_marketCap'] =
np.log(regression_df['marketCap'] + 1e-6)

            # --- Handle NaNs for regression variables ---
            # You might want a more sophisticated strategy, but
for simplicity:
            # Option A: Drop rows with any NaN in the regression
variables
```

```
            regression_df_cleaned =
regression_df.dropna(subset=['performance_percent',
'log_marketCap', 'pe', 'pbv', 'sector'])

            # Option B (less recommended for P/E, P/BV as NaN can
mean unprofitability): Impute with mean/median
            # regression_df['pe'] =
regression_df['pe'].fillna(regression_df['pe'].mean())
            # regression_df['pbv'] =
regression_df['pbv'].fillna(regression_df['pbv'].mean())
            # regression_df_cleaned =
regression_df.dropna(subset=['performance_percent',
'log_marketCap', 'sector']) # Only drop if other critical NaNs
exist

            if not regression_df_cleaned.empty:
                print("\n--- Performing Multivariate Regression -
--")

                # Define the regression formula
                # C(sector) tells statsmodels to treat 'sector'
as a categorical variable and create dummies.
                # It automatically handles the dummy variable
trap by dropping one category (usually the first alphabetically).
                formula = "performance_percent ~ log_marketCap +
pe + pbv + C(sector)"

                try:
                    model = smf.ols(formula=formula,
data=regression_df_cleaned)
                    results = model.fit()
                    print(results.summary())

                    # Save regression results to a text file
                    with
open(f"regression_results_{YEAR_TO_ANALYZE}.txt", "w") as f:
                        f.write(results.summary().as_text())
                    print(f"\nRegression results saved to
regression_results_{YEAR_TO_ANALYZE}.txt")

                except Exception as e:
                    print(f"Error during regression: {e}")
                    print("Ensure sufficient non-NaN data points
for all variables after cleaning.")
            else:
                print("\nNot enough clean data points to perform
regression after dropping NaNs. Skipping regression.")
        else:
            print("\nNo consolidated data available for
regression after initial processing. Skipping regression.")
    else:
        print("\nNo stock data collected for regression. Skipping
regression.")


    # --- Phase 2: Portfolio Calculation (Now Buy and Hold) ---
    portfolio_weights = {}
    portfolio_monthly_df = pd.DataFrame()
```

```
    portfolio_summary = None

    if not individual_stock_dfs:
        print("\nNo valid stock data fetched to perform any
analysis.")
    else:
        # This fillna/dropna is kept for
combined_df_for_portfolio if it's used elsewhere, though not for
portfolio calc
        # combined_df_for_portfolio =
combined_df_for_portfolio.ffill().bfill()
        # combined_df_for_portfolio =
combined_df_for_portfolio.dropna(axis=1, how='all')

        if not individual_stock_dfs: # Re-check after potential
empty individual_stock_dfs
            print("\nIndividual stock data became empty after
preprocessing. Skipping portfolio analysis.")
        else:
            initial_market_caps =
get_initial_market_caps(individual_stock_dfs, YEAR_TO_ANALYZE)
            initial_market_caps_df =
pd.DataFrame(list(initial_market_caps.items()),
columns=['symbol', 'market_cap'])

            portfolio_weights =
calculate_portfolio_weights(initial_market_caps)

            if portfolio_weights:
                print("\n--- Portfolio Weights (Market Cap at
Year Start) ---")
                for symbol, weight in portfolio_weights.items():
                    if symbol in initial_market_caps:
                        print(f"{symbol}: {weight:.4f}
({initial_market_caps[symbol]:,.0f} Market Cap)")
                    else:
                        print(f"{symbol}: {weight:.4f} (Market
Cap N/A)")

                # CALL THE NEW BUY-AND-HOLD PORTFOLIO CALCULATION
(passing individual_stock_dfs)
                portfolio_summary, portfolio_monthly_df =
calculate_portfolio_performance_buy_and_hold(
                    individual_stock_dfs, portfolio_weights,
YEAR_TO_ANALYZE
                )

                if portfolio_summary:

all_yearly_performances.append(portfolio_summary)

            else:
                print("\nCould not calculate portfolio weights.
Skipping portfolio performance.")

    # --- Phase 2.5: Calculate SET Index Performance ---
    set_index_symbol = 'SET Index'
    set_index_data = {
```

```
        "2024-01-02": 1433.38,
        "2024-02-01": 1367.96,
        "2024-03-01": 1367.42,
        "2024-04-01": 1379.48,
        "2024-05-02": 1363.25,
        "2024-06-04": 1337.32,
        "2024-07-01": 1299.35,
        "2024-08-01": 1322.75,
        "2024-09-02": 1353.64,
        "2024-10-02": 1451.40,
        "2024-11-01": 1464.17,
        "2024-12-02": 1437.11,
        "2024-12-30": 1400.21 # Year-end close price for SET
Index
    }
    set_df = pd.DataFrame.from_dict(set_index_data,
orient='index', columns=['close'])
    set_df.index = pd.to_datetime(set_df.index)
    set_df = set_df.sort_index()

    set_monthly_data = []
    set_month_start_dates = {
        1: pd.Timestamp("2024-01-02"), 2: pd.Timestamp("2024-02-
01"),
        3: pd.Timestamp("2024-03-01"), 4: pd.Timestamp("2024-04-
01"),
        5: pd.Timestamp("2024-05-02"), 6: pd.Timestamp("2024-06-
04"),
        7: pd.Timestamp("2024-07-01"), 8: pd.Timestamp("2024-08-
01"),
        9: pd.Timestamp("2024-09-02"), 10: pd.Timestamp("2024-10-
02"),
        11: pd.Timestamp("2024-11-01"), 12: pd.Timestamp("2024-
12-02"),
    }
    set_year_end_date = pd.Timestamp("2024-12-30") # Explicit
year-end date

    for month_num in range(1, 13):
        current_month_period = pd.Period(f"{YEAR_TO_ANALYZE}-
{month_num:02d}", freq='M')

        start_date_current_month =
set_month_start_dates.get(month_num)

        if start_date_current_month is None or
start_date_current_month not in set_df.index:
            continue

        first_price_current_month =
set_df.loc[start_date_current_month, 'close']

        end_price_for_calculation = None
        if month_num == 12:
            if set_year_end_date in set_df.index:
                end_price_for_calculation =
set_df.loc[set_year_end_date, 'close']
            else:
```

```
                # Fallback: if explicit year-end date not in
index, use last available price in December
                last_price_in_december_index =
set_df.loc[set_df.index.to_period('M') == current_month_period,
'close'].last_valid_index()
                if last_price_in_december_index is not None:
                    end_price_for_calculation =
set_df.loc[last_price_in_december_index, 'close']

        else:
            start_date_next_month =
set_month_start_dates.get(month_num + 1)
            if start_date_next_month and start_date_next_month in
set_df.index:
                end_price_for_calculation =
set_df.loc[start_date_next_month, 'close']

        if first_price_current_month is not None and
end_price_for_calculation is not None and
first_price_current_month != 0:
            performance = ((end_price_for_calculation -
first_price_current_month) / first_price_current_month) * 100
            set_monthly_data.append({
                'Month': str(current_month_period),
                'symbol': set_index_symbol,
                'first_price_of_month':
first_price_current_month,
                'end_price_for_calculation':
end_price_for_calculation,
                'performance_percent': performance
            })
    set_monthly_df =
pd.DataFrame(set_monthly_data).set_index('Month')

    set_year_start_price =
set_df.loc[set_month_start_dates.get(1), 'close']
    set_year_end_price = set_df.loc[set_year_end_date, 'close']
    set_yearly_performance_percent = ((set_year_end_price -
set_year_start_price) / set_year_start_price) * 100

    set_yearly_data = {
        'symbol': set_index_symbol,
        'year': YEAR_TO_ANALYZE,
        'first_price_year': set_year_start_price,
        'last_price_year': set_year_end_price,
        'performance_percent_year':
set_yearly_performance_percent
    }

    all_yearly_performances.append(set_yearly_data)

    # --- Section for Sector-Specific Portfolio Analysis ---
    print("\n--- 4. Performance Analysis of Sector-Specific
Portfolios ---")

    unique_sectors = sorted(list(set(INDUSTRY_MAPPING.values())))
    sector_performance_data = []
```

```
    # Get SET Index performance for comparison
    print(f"\nComparing sector portfolio performance against SET
Index return for the period:
{set_yearly_performance_percent:.2f}%")

    for sector in unique_sectors:
        # Get symbols for the current sector that actually have
price data
        # Corrected: Using individual_stock_dfs keys to filter
for symbols with fetched data
        sector_symbols = [symbol for symbol, ind in
INDUSTRY_MAPPING.items() if ind == sector and symbol in
individual_stock_dfs]

        if not sector_symbols:
            print(f"Skipping sector {sector}: No companies with
price data found for the period in this sector.")
            continue

        # Filter initial market caps for the current sector's
symbols
        # Note: initial_market_caps_df is created *after*
individual_stock_dfs is populated
        sector_initial_market_caps = {
            s: initial_market_caps[s] for s in sector_symbols if
s in initial_market_caps
        }

        # Calculate portfolio performance for this sector
        if sector_initial_market_caps: # Check if there are
market caps for this sector
            sector_portfolio_summary, _ =
calculate_portfolio_performance_buy_and_hold(
                {s: individual_stock_dfs[s] for s in
sector_symbols if s in individual_stock_dfs},

calculate_portfolio_weights(sector_initial_market_caps),
                YEAR_TO_ANALYZE
            )

            if sector_portfolio_summary:
                sector_return_percent =
sector_portfolio_summary['performance_percent_year']
            else:
                sector_return_percent = 0.0 # No performance if
portfolio couldn't be calculated
        else:
            sector_return_percent = 0.0 # No initial market caps
for the sector's symbols

        sector_performance_data.append({
            'Sector': sector,
            'Return (%)': round(sector_return_percent, 2),
            'Performance Relative to SET Index (%)':
round(sector_return_percent - set_yearly_performance_percent, 2)
        })

    # Convert results to DataFrame for display
```

```
    sector_perf_df = pd.DataFrame(sector_performance_data)
    sector_perf_df = sector_perf_df.sort_values(by='Return (%)',
ascending=False)

    print("\nTable X: Performance of Sector-Specific Portfolios
(Market Cap Weighted)")
    print(sector_perf_df.to_markdown(index=False))

    # --- Descriptive Analysis of Sector Performance ---
    print("\n--- Descriptive Analysis of Sector Performance ---")

    # Re-sort for narrative (already sorted by 'Return (%)'
above)
    sector_perf_df_narrative = sector_perf_df.copy()

    print(f"\nThe analysis of sector-specific, market-
capitalization-weighted portfolios reveals significant variations
in performance. The SET Index returned
{set_yearly_performance_percent:.2f}% during the study period.")

    # Iterate through sorted sectors to generate narrative
    for index, row in sector_perf_df_narrative.iterrows():
        sector = row['Sector']
        sector_return = row['Return (%)']
        relative_to_set = row['Performance Relative to SET Index
(%)']

        performance_description = ""
        if relative_to_set > 0:
            performance_description = f"outperforming the SET
Index by {abs(relative_to_set):.2f} percentage points."
        elif relative_to_set < 0:
            performance_description = f"underperforming the SET
Index by {abs(relative_to_set):.2f} percentage points."
        else:
            performance_description = "performing in line with
the SET Index."

        print(f"\n- **{sector}**: This sector generated a return
of {sector_return:.2f}%, {performance_description}")
        # You can add more specific insights here based on your
domain knowledge, e.g.,
        # "This performance may be attributed to X factors within
the sector."
        # If specific large companies dominated the sector's
performance, you could mention them here.

    print("\nOverall, the performance of portfolios constructed
solely from carbon-disclosing companies within specific
industries varied considerably, highlighting the heterogeneous
nature of returns even among environmentally transparent firms,
and indicating that sector plays a role in portfolio performance
relative to the market.")

    # --- Phase 3: Individual Stock Calculations and Final
Concatenation ---
    # Monthly performances for individual stocks were already
added to all_monthly_performances
```

```
    # in Phase 1 (inside the loop)

    for symbol, df in individual_stock_dfs.items():
        yearly_perf_data = calculate_yearly_performance(df,
symbol, YEAR_TO_ANALYZE)
        if yearly_perf_data:
            all_yearly_performances.append(yearly_perf_data)

    # Now, concatenate in the correct order: PORTFOLIO, then SET,
then individual stocks
    if not portfolio_monthly_df.empty:
        if not set_monthly_df.empty:
            all_monthly_performances =
pd.concat([portfolio_monthly_df, set_monthly_df,
all_monthly_performances])
        else:
            all_monthly_performances =
pd.concat([portfolio_monthly_df, all_monthly_performances])
    elif not set_monthly_df.empty:
        all_monthly_performances = pd.concat([set_monthly_df,
all_monthly_performances])


    # --- Output Results ---
    if not all_monthly_performances.empty:
        print("\n--- Monthly Price Performance for 2024
(Individual Stocks & Portfolio) ---")
        all_monthly_performances_with_month =
all_monthly_performances.reset_index()

        # Define sort keys for desired order: PORTFOLIO (0), SET
Index (1), then others (2)
        all_monthly_performances_with_month['sort_key'] =
all_monthly_performances_with_month['symbol'].apply(
            lambda x: 0 if 'PORTFOLIO' in x else (1 if 'SET
Index' in x else 2)
        )
        all_monthly_performances_with_month =
all_monthly_performances_with_month.sort_values(
            by=['sort_key', 'Month', 'symbol']
        ).drop(columns='sort_key')

        columns_to_display_monthly = ['Month', 'symbol',
'performance_percent']

print(all_monthly_performances_with_month[columns_to_display_mont
hly].round(2))

        output_filename_monthly =
f"monthly_performance_hybrid_in_year_{YEAR_TO_ANALYZE}.csv"

all_monthly_performances_with_month.to_csv(output_filename_monthl
y, index=False)
        print(f"\nDetailed monthly results saved to
{output_filename_monthly}")

    else:
```

```
        print("\nNo monthly performance data could be generated
for any symbol.")

    if all_yearly_performances:
        print("\n--- Yearly Performance Summary ---")
        yearly_perf_df = pd.DataFrame(all_yearly_performances)

        yearly_perf_df['portfolio_weight'] = pd.NA

        if portfolio_weights:
            for symbol, weight in portfolio_weights.items():
                yearly_perf_df.loc[yearly_perf_df['symbol'] ==
symbol, 'portfolio_weight'] = weight

        # Set weight for the 'PORTFOLIO' row itself
        yearly_perf_df.loc[yearly_perf_df['symbol'] == 'PORTFOLIO
(Buy and Hold - Initial Market Cap Weighted)',
'portfolio_weight'] = 1.0

        desired_columns_order = [
            'symbol',
            'year',
            'portfolio_weight',
            'first_price_year',
            'last_price_year',
            'performance_percent_year'
        ]

        existing_desired_columns = [col for col in
desired_columns_order if col in yearly_perf_df.columns]
        yearly_perf_df = yearly_perf_df[existing_desired_columns]

        yearly_perf_df['sort_key'] =
yearly_perf_df['symbol'].apply(
            lambda x: 0 if 'PORTFOLIO' in x else (1 if 'SET
Index' in x else 2)
        )
        yearly_perf_df =
yearly_perf_df.sort_values(by='sort_key').drop(columns='sort_key'
)

        yearly_perf_df = yearly_perf_df.set_index('symbol')
        print(yearly_perf_df.round(4))

        output_filename_yearly =
f"yearly_performance_in_year_with_portfolio_{YEAR_TO_ANALYZE}.csv
"
        yearly_perf_df.to_csv(output_filename_yearly)
        print(f"\nYearly summary saved to
{output_filename_yearly}")
    else:
        print("\nNo yearly performance data could be generated
for any symbol.")
```