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# Emissions vs. Earnings: Assessing the Financial Effects of Carbon Footprint in Malaysia's Manufacturing Sector

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| ARTICLE INFO | ABSTRACT |
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**Introduction**: Environmental sustainability is a critical concern, requiring enterprises to be accountable for carbon emissions. While existing research focuses on the energy sector, the manufacturing industry in Malaysia remains underexplored. Businesses are driven to reduce emissions by regulatory mandates and market expectations, often benefiting from improved financial performance

**Objectives**: This study investigates the sustainability practices of manufacturing firms listed on Bursa Malaysia and their impact on financial performance.

**Methods**: Using a random effects model, the study evaluates the relationship between carbon footprint and financial metrics, including Return on Assets (ROA), Return on Equity (ROE), and Return on Investment (ROI).

**Results**: The findings indicate that the null hypotheses for these financial indicators are accepted, suggesting no significant impact.

**Conclusions**: These insights highlight the need for more comprehensive strategies to enhance environmental and financial outcomes.

**Keywords:** Carbon Footprint, Financial Performance, Sustainability, Random Effect Model

## INTRODUCTION

The total greenhouse gas (GHG) emissions, both direct and indirect, generated by an individual, organisation, event, or product are collectively referred to as its carbon footprint (Product Carbon Footprint Label, 2024). While GHGs such as carbon dioxide, methane, and nitrous oxide play a crucial role in maintaining the Earth's temperature balance, the dramatic rise in their concentrations due to anthropogenic activities has disrupted this equilibrium. This has led to the excessive trapping of heat in the atmosphere and a consequential rise in global average temperatures, a phenomenon widely recognised as global warming. Notably, different GHGs vary in their heat-absorbing capacities and atmospheric lifespans, making some significantly more impactful than others (Education, 2023).

A comprehensive framework has been developed to classify and measure indirect emissions across fifteen categories, primarily within Scope 3 emissions. These include emissions from purchased goods and services (Category 1), capital goods (Category 2), and fuel- and energy-related activities not included in Scope 1 or 2 (Category 3). Other categories address upstream and downstream logistics, such as transportation and distribution (Categories 4 and 9), operational waste (Category 5), business travel (Category 6), employee commuting (Category 7), and leased assets (Categories 8 and 13). Additional sources include the processing and use of sold products (Categories 10 and 11), end-of-life treatment of products (Category 12), as well as emissions from franchises and investments (Categories 14 and 15). This classification provides organisations with a structured approach to assess and report indirect emissions, enabling a more accurate representation of their overall carbon footprint.

In Malaysia, the manufacturing sector faces mounting challenges in balancing environmental sustainability with financial performance. One of the most pressing concerns is carbon footprint management, which has come under

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increased scrutiny amid heightened regulatory demands and rising public awareness of environmental issues (Ismail & Imran, 2024). As a key contributor to national GHG emissions, the sector is under considerable pressure to demonstrate its commitment to sustainability.

Sustainability reporting has evolved into a critical aspect of corporate governance, driven by stakeholder demands for transparency and accountability. The global shift toward corporate social responsibility (CSR) has prompted businesses, including those in Malaysia, to adopt environmentally responsible practices and actively reduce their carbon emissions (CorporateRegister, 2008). While some firms have made meaningful progress, others lag. Therefore, it is essential to understand the extent to which an organisation's carbon footprint influences its financial performance, especially within carbon-intensive industries such as manufacturing.

## OBJECTIVES

This study aims to bridge a knowledge gap by examining how the corporate carbon footprint influences the financial performance of Malaysian manufacturing businesses. By studying the financial data and sustainability practices of companies operating in the manufacturing sector from 2020 to 2022, it also intends to provide significant insights into the potential benefits and problems connected with sustainability activities in the industry.

## METHODS

The population of this study includes all manufacturing firms listed on Bursa Malaysia from 2020 to 2022. A purposive sampling technique was applied, focusing completely on firms that voluntarily reveal carbon footprint data in their sustainability or ESG reports. Initial data comprised 1,107 firm-year observations. Nevertheless, 897 observations were excluded by the reason of the absence of carbon disclosure or non-public availability of sustainability reports. The last dataset comprises 210 firm-year data points obtained from a sample of 70 firms observed across a three-year timeframe. Annual reports and sustainability disclosures were sourced from Bursa Malaysia's official website and company websites. These reports served as the secondary data source for environmental and financial information.

The carbon footprint of each firm was measured through a systematic content analysis of their sustainability reports, focusing on disclosed greenhouse gas (GHG) emissions across all three scopes: Scope 1 (direct emissions), Scope 2 (indirect emissions from purchased energy), and Scope 3 (other indirect emissions). The total annual carbon footprint was calculated by aggregating emissions from these scopes. This approach aligns with established international standards and reporting frameworks such as the Global Reporting Initiative (GRI), the Carbon Disclosure Project (CDP), and others (Brightest, 2024).

Corporate financial performance was assessed using three accounting-based indicators: Return on Assets (ROA), Return on Equity (ROE), and Return on Investment (ROI). These metrics provide insights into operational efficiency, shareholder returns, and overall profitability, respectively.

This study incorporates several control variables informed by existing literature. Firm size, measured as the natural logarithm of total assets, is included to account for the fact that larger firms typically possess greater resources to invest in sustainability initiatives and may exhibit different reporting behaviours. Firm age, calculated as the number of years since the company's establishment, is considered, given that older firms may have more mature sustainability practices and greater financial stability. Additionally, industry subsector is accounted for to capture the heterogeneity within the manufacturing sector, acknowledging that variations in emissions and financial outcomes may arise from differences in subsector-specific characteristics. Together, these control variables enhance the robustness of the analysis by mitigating potential confounding effects and allowing a clearer understanding of the relationship between carbon disclosure and financial performance.

### Method of Analysis

Content Analysis was utilised to systematically examine the documented content within the sustainability reports of the listed manufacturing companies. This qualitative method focuses on measuring specific elements, particularly carbon dioxide ($CO_2$) emissions disclosures, including categories such as Scope 1, Scope 2, and Scope 3 emissions. By coding and categorising these disclosures, content analysis facilitates a comprehensive and transparent



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assessment of the companies' environmental reporting practices. This approach provides valuable insights into how firms communicate their carbon footprint, highlighting their environmental obligations and compliance with relevant reporting measures.

A descriptive analysis was also conducted to summarise and interpret the extent and nature of carbon footprint disclosures, including manufacturing firms in Malaysia. This method involves identifying trends and patterns in the data, such as the prevalence and detail of disclosures, and examining variations linked to firm characteristics, including size, age, and financial performance. Descriptive statistics lay the groundwork for a deeper investigation into the relationship between environmental transparency and corporate financial outcomes, allowing for a clearer understanding of common reporting behaviours within the sector.

Correlation Analysis was utilised to measure the strength and direction of relationships between carbon disclosure variables and financial performance metrics. The correlation coefficient, ranging from -1 to 1, quantifies this association: a coefficient of 1 indicates a perfect positive relationship, 0 denotes no relationship, and -1 signals a perfect negative relationship between variables. This analysis provides initial insight into whether greater carbon transparency correlates with improved financial performance.

Panel Data Analysis was the primary statistical technique applied to examine the dynamic relationship between carbon disclosure and financial performance over time. Panel data, comprising multiple observations on the same firms across three years (2020–2022), enables the integration of both cross-sectional and time-series information. This approach allows for more robust and efficient estimation by accounting for unobserved heterogeneity and temporal effects, thus enhancing the statistical validity of the study's findings. According to Asteriou (2006), panel data analysis is particularly advantageous for econometric studies, as it leverages variations across firms and time to provide deeper insights into policy impacts and corporate behaviours.

To estimate model parameters, the Random Effects Model (REM) was selected based on the Hausman test results (p = 1.000), which indicated the suitability of REM over the Fixed Effects Model (FEM) (Yuliadi & Yudhi, 2021). The model specification is as follows:

$$\mathbf{Y_{it}=\alpha+\beta \log (CO_{2eit}) + \gamma 1 \log (Firm\ Size_{it}) + \gamma 2 Firm\ Age_{it} + \mu i}$$

where $Y_{it}$ represents the financial performance of firm i at time t, log ($CO_{2eit}$) is the log-transformed carbon emissions, $X_{it}$ is a vector of control variables, including firm-specific size and age, α denotes unobserved firm-specific effects, β and γ are regression coefficients, and μit is the error term.

The Wald test was employed to evaluate the statistical significance of the carbon footprint variable's coefficient, testing the null hypothesis that the carbon emissions have no impact on financial performance.

**Measurement of Financial Performance**

In this study, we utilise accounting measures due to data limitations, as only a few manufacturing companies in Malaysia have voluntarily disclosed their carbon reporting information for the past three years. This is because, during this data collection period, the requirement for all publicly listed companies in Malaysia to disclose their carbon reporting comes into effect for FYE after December 31, 2024 (Bursa Malaysia, 2024).

Financial performance indicators such as return on assets (ROA), return on investment (ROI), and return on equity (ROE) are widely acknowledged by academics worldwide (Busch et al., 2020). These indicators measure the overall financial success of a business, and their high or low levels can be used to gauge the company's financial health. They remain unaffected by significant events that may have occurred within the company and possess qualities of objectivity, universality, and accessibility

For stakeholders in a company, return on assets (ROA) is one of the most crucial financial metrics because it is straightforward to compare (Lewandowski, 2015). ROA is defined by Misani and Pogutz (2015) as net income divided by total assets. A company's ROA tells management, investors, or analysts how well it can manage its assets to produce profits. ROA, indicated as a percentage, identifies a firm's carbon disclosure methods via its operational efficiency in making returns. ROA for public companies can vary substantially and is highly dependent on the industry in which they function. The better the company is, the higher its return on total assets. This is because it


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shows that the company is able to earn more money with a smaller investment (Hargrave, 2024). Magni and Peasnell (2012) support the use of total assets in calculating ROA as an effective measure of economic viability. In this study, ROA would help determine how effectively the manufacturing companies are utilising their assets while considering their carbon footprint. A high carbon footprint might imply higher operating costs or regulatory fines, potentially affecting asset utilisation. Chandra et al. (2021) highlighted that overall asset turnover significantly impacts ROA. ROA is calculated by:

$$ROA = \frac{\text{Net income for common stakeholders}}{\text{Total assets}}$$

Another measure of financial performance is the return on equity (ROE), calculated by dividing net income by shareholders' equity. Return on Equity (ROE) is a crucial metric that reflects a company's profitability and efficiency in utilising shareholders' equity. A high ROE suggests that a company is effectively generating profits from the capital invested by its shareholders (Waluyo & Widianingsih, 2020). ROE is important for understanding how the carbon footprint impacts the returns to investors. A higher carbon footprint could lead to increased costs or reduced revenues, impacting net income and thereby affecting returns to equity holders. It is calculated by dividing net income by average shareholders' equity, expressed as a percentage:

$$ROE = \frac{\text{Net Income}}{\text{Shareholders' equity}}$$

An effective indicator of an investment's profitability is the return on investment (ROI). The higher the ROI, the more profitable the investment is. ROI can be used to monitor an investment's progress over time, as well as to compare different alternatives and scenarios. OI can be used to evaluate the financial returns of specific investments aimed at reducing the carbon footprint, such as investing in energy-efficient technologies or renewable energy sources. It provides insight into the cost-benefit analysis of these investments and their impact on overall financial performance. By calculating ROI, manufacturers can conduct cost-benefit analyses to determine if investing in new equipment, processes, or technologies is financially viable.

$$ROI = \frac{\text{Profit}}{\text{Cost of investment}} \times 100$$

**Measurement of Carbon Disclosure**

Measuring an organisation's carbon footprint through its sustainability report involves a detailed and systematic analysis of the disclosed greenhouse gas (GHG) emissions data. This process begins with identifying relevant sections of the report that describe environmental impact, GHG emissions, carbon footprint metrics, sustainability initiatives, and energy consumption. The total carbon footprint is calculated by aggregating emissions across all three scopes: Scope 1 (direct emissions), Scope 2 (indirect emissions from purchased energy), and Scope 3 (other indirect emissions). These annual emissions disclosures are typically made publicly available through companies' ESG or sustainability reports, often accessible via Bursa Malaysia's annual reports for listed firms.

Sustainability reports serve as the primary mechanism through which organisations communicate their environmental risks, opportunities, and practices to stakeholders, facilitating informed decision making. Various globally recognised sustainability reporting standards guide the preparation and

content of these disclosures, including the European Sustainability Reporting Directive (EU CSRD), the International Sustainability Standards Board (ISSB), the Carbon Disclosure Project (CDP), the Task Force on Climate-related Financial Disclosures (TCFD), the Sustainability Accounting Standards Board (SASB), B Corp certification, and the Global Reporting Initiative (GRI) (Brightest, 2024). Despite the growing adoption of such frameworks, sustainability reporting still faces challenges related to transparency, consistency, and interoperability across organisations and jurisdictions. Nonetheless, most companies comply with local regulatory requirements or voluntarily choose specific frameworks to structure their reporting, which influences how sustainability performance is presented (Brightest, 2024). Leading reporting standards share several key features that enhance the effectiveness and relevance of

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sustainability disclosures. These include stakeholder engagement, whereby companies actively involve investors, customers, employees, and communities to address their concerns and expectations; transparency and accountability, which encourage firms to disclose not only achievements but also challenges, thus fostering trust and credibility; and the integration of sustainability into business strategy, which demonstrates how ESG initiatives align with long-term value creation and risk management, highlighting sustainability as an essential component of overall corporate governance and operational planning.

## RESULTS

Table 4.1 summarises the descriptive statistics for variables used in assessing the impact of carbon footprint on financial performance. The mean value of Log (CO2e) is 7.78, with a median of 8.00, suggesting a distribution slightly skewed to the left. Values range from 0.33 to 15.85, and a standard deviation of 3.93 indicates moderate variability. The slight negative skewness (-0.0816) and positive kurtosis reflect a distribution with mild asymmetry and heavier tails. The Jarque-Bera test confirms no significant deviation from normality.

The dataset shows an average firm age of 16.40 years, with a median of 16.00 and a range from 9 to 23 years. The standard deviation is 3.61, and the slight right skewness (0.1538) indicates mild asymmetry. For firm size, the mean Log (Size) is 16.82, with a median of 16.49 and values ranging from 10.41 to 23.46. The standard deviation is 2.78, with a slight left skew (-0.0271) and positive kurtosis, suggesting a peaked distribution with heavier tails. The Jarque-Bera test (p = 0.0732) indicates no significant deviation from normality.

The dataset reveals that firms have an average age of 16.40 years, with a median of 16.00 and a range between 9 and 23 years. A standard deviation of 3.61 and a skewness of 0.1538 suggest mild rightward asymmetry. Regarding firm size, the mean Log(Size) is 16.82, with a median of 16.49 and values spanning from 10.41 to 23.46. The standard deviation is 2.78, accompanied by slight left skewness (0.0271) and positive kurtosis, indicating a distribution with heavier tails and a sharper peak. The JarqueBera test (p = 0.0732) confirms that the distribution does not significantly deviate from normality.

The average return on equity (ROE) is computed as 14.20%, signifying that the company achieves an average return of 14.20% on its equity. The dataset's median value stands at 13.78%, indicating a slightly right-skewed distribution. ROE ranges from 2.28% to 33.70%, and the standard deviation of 6.73 implies a substantial degree of variability in ROE values. A skewness value of 0.38 suggests a rightward skew, indicating the existence of companies with above-average ROE. The positive kurtosis of 2.77 denotes fatter tails and a more peaked distribution compared to a normal distribution. The p-value derived from the Jarque-Bera test for normality amounts to 0.0644, surpassing the generally adopted significance level of 0.05. This outcome implies that the data does not deviate significantly from a normal distribution.

The mean return on investment (ROI) is 34.03%, reflecting a higher average return compared to ROA and ROE, with a median of 32.65%. ROI values range from 8.69% to 65.09%, and a standard deviation of 11.39 indicates substantial variability. A positive kurtosis of 3.16 suggests a distribution with heavier tails and a sharper peak than normal. The Jarque-Bera test yields a p-value of 0.05874, indicating no significant deviation from normality.

**Table 4.1**: Result of the Descriptive Analysis

| | Log ($CO_2e$) | ROA | ROE | ROI | Age | Log (Size) |
|---|---|---|---|---|---|---|
| **Mean** | 7.7839 | 10.3062 | 14.1999 | 34.0258 | 16.3969 | 16.8244 |
| **Median** | 8.0015 | 10.9212 | 13.7752 | 32.6536 | 16.0000 | 16.4875 |
| **Maximum** | 15.8495 | 38.0431 | 33.7006 | 65.0940 | 23.0000 | 23.4624 |
| **Minimum** | 0.3293 | -13.2132 | 2.2759 | 8.69246 | 9.0000 | 10.4103 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| **Std. Dev.** | 3.9332 | 8.7122 | 6.732 | 11.3877 | 3.6137 | 2.7757 |
| **Skewness** | -0.0816 | 0.1517 | 0.3842 | 0.39726 | 0.1538 | -0.0271 |
| **Kurtosis** | 2.9147 | 3.6736 | 2.7657 | 3.16144 | 2.2679 | 2.2686 |
| **Jarque-Bera** | 4.7068 | 4.7306 | 5.4862 | 5.66939 | 5.2284 | 16.8244 |
| **Probability** | 0.0950 | 0.0939 | 0.0644 | 0.05874 | 0.0732 | 16.4875 |
| **Observation** | 210 | 210 | 210 | 210 | 210 | 210 |

**Correlation Result**

The correlation analysis examines the relationships between financial performance indicators (ROA, ROE, ROI) and key variables including carbon emissions (Log(CO2e)), firm size (Log(Size)), and firm age (Age). Overall, the correlations are weak, indicating limited linear associations.

For ROA, a very weak positive correlation with carbon emissions (0.0457) suggests a marginal link between higher emissions and improved asset returns. Slightly negative correlations with firm size (0.0333) and age (-0.0951) imply that larger and older firms may experience modest declines in asset efficiency. This aligns with Siddique et al. (2021), who suggest that operational complexity and declining adaptability in older firms may affect performance. However, this contrasts with studies by Trumpp and Guenther (2015) and Busch and Lewandowski (2017), which highlight advantages of scale in larger firms. ROE demonstrates similarly weak correlations, with a negligible positive link to carbon emissions (0.0148) and small negative associations with firm size (-0.0616) and age (-0.0716). These findings indicate that older and larger firms may face challenges in maintaining equity returns, potentially due to bureaucratic inefficiencies or reduced innovation. ROI shows a slightly stronger positive correlation with carbon emissions (0.0936), hinting that firms with higher emissions may achieve marginally better investment returns, possibly reflecting the profitability of carbon-intensive industries.

Conversely, ROI's negative correlations with firm size (0.0998) and age (-0.0770) suggest that increased scale and maturity may reduce investment efficiency. Among the independent variables, correlations are also weak. Log (CO2e) shows minimal negative associations with firm size (-0.0419) and age (-0.0311), while firm size and age have a slight positive correlation (0.0512), indicating older firms are only marginally larger.

All three financial performance measures exhibit positive correlations with carbon emissions, implying that more carbon-intensive firms may also be more financially successful. This may reflect high-output, resource-intensive sectors that drive profitability despite environmental costs. In contrast, the negative correlations of firm size and age with financial performance suggest diminishing efficiency and increasing operational complexity in older, larger firms. These findings highlight a potential trade-off between financial performance and environmental responsibility. The modest positive link between emissions and profitability suggests that carbon-intensive practices may support short-term gains, whereas the declining performance of larger and older firms points to the strategic value of agility and innovation in sustaining financial health.

**Table 4.2**: Correlation Result

| Variable | Log (CO2e) | Log (Size) | Age |
|---|---|---|---|
| ROA | 0.0457 | -0.0333 | -0.0951 |
| ROE | 0.0148 | -0.0616 | -0.0716 |
| ROI | 0.0936 | -0.0998 | -0.077 |
| Log (CO2e) | 1 | -0.0419 | -0.0311 |
| Log (Size) | -0.0419 | 1 | 0.0512 |
| Age | -0.0311 | 0.0512 | 1 |

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### Hausman Test Result

In addition to distinguishing between fixed and random effects models, the Hausman test serves as a statistical criterion for model selection. The null hypothesis ($H_0$) posits that the random effects model is appropriate, and it is rejected if the p-value is less than 0.05. In this analysis, the Hausman test yields a p-value of 1.000, which exceeds the 5% significance threshold. Therefore, we fail to reject the null hypothesis and conclude that the random effects model is more suitable (Yuliadi & Yudhi, 2021). This outcome suggests that the unobserved individual-specific effects are uncorrelated with the explanatory variables, validating the use of the random effects model for estimating the relationships among the variables. As shown in Table 4.3, the p-value of 1.000 further supports the consistency and efficiency of the random effects model over the fixed effects model. This result implies limited variation in unobserved heterogeneity across cross-sectional units, reinforcing the model's appropriateness for this study.

**Table 4.3**: Correlated Random Effects- Hausman Test

| Correlated Random Effects - Hausman Test | | | | |
|---|---|---|---|---|
| Pool: Panel | | | | |
| Test cross-section random effects | | | | |
| Test Summary | Chi-Sq. Statistic | Chi -Sq. | d.f. | Prob. |
| Cross-section random | 0.000 | | 3 | 1.000 |

### Random Effect Result

The random effects regression analysis investigating the relationship between Return on Assets (ROA) and independent variables, Log ($CO_2e$), Log(Size), and firm age (Age), offers insightful findings. As detailed in Table 4.4, the intercept (C) is statistically significant (coefficient = 14.6385, p = 0.0000), suggesting a notable baseline level of ROA when all explanatory variables are held constant.

The coefficient for Log ($CO_2e$) is positive (0.1045), but not statistically significant (p = 0.1495), indicating no strong linear association between carbon emissions and ROA. This finding supports prior research, such as Trumpp and Guenther (2017), who proposed a U-shaped relationship, and Busch and Lewandowski (2018), who emphasised the industry-specific nature of carbon performance impacts. Log (Size) also shows a negative coefficient (-0.0832), yet it lacks statistical significance (p = 0.3546). This contrasts with studies like Capon et al. (1990), which report a positive relationship between firm size and financial performance due to scale advantages. The insignificance in this context may reflect industry-specific characteristics or firm heterogeneity.

Conversely, firm age exhibits a statistically significant and negative effect on ROA (coefficient = 0.2188, p = 0.0014), indicating that older firms tend to have lower asset returns. This aligns with findings by Loderer and Waelchli (2010) and Coad et al. (2010), who argue that ageing firms may suffer from reduced innovation, increasing bureaucracy, and declining productivity, ultimately constraining financial performance.

**Table 4.4**: Random Effect Regression Analysis (ROA)

| Variable | Coefficient | Std. Error | t-Statistic | Prob |
|---|---|---|---|---|
| C | 14.6385 | 1.9702 | 7.4298 | 0.0000 |
| Log ($CO_2e$) | 0.1045 | 0.0724 | 1.4442 | 0.1495 |
| Log (Size) | -0.0832 | 0.0898 | -0.9261 | 0.3546 |
| Age | -0.2188 | 0.0685 | -3.1947 | 0.0014 |

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As presented in Table 4.5, the intercept coefficient (C) is 18.5012, with a standard error of 1.5431. The t-statistic is 7.4298, indicating that the constant is statistically significant at the 1% level. This suggests that even when all independent variables are zero, the expected value of ROE is 18.5012.

The variable coefficient for Log CO2e is 0.0201, with a standard error of 0.0567. However, the t-statistic is 1.4442, and the p-value is 0.7232, indicating that the coefficient is not statistically significant at conventional levels ($p > 0.05$). Therefore, there is insufficient evidence to reject the null hypothesis that the coefficient is zero. This finding aligns with some studies that have reported an insignificant or mixed impact of carbon performance on financial metrics. Trumpp and Guenther (2017) found that the relationship between carbon performance and financial performance, measured by ROE, can be U-shaped. This implies that both low and high-carbon performers can achieve superior financial results, depending on the context. Busch and Lewandowski (2018) concluded that the impact of carbon performance on financial performance is industry-specific and depends on factors such as carbon emission and regulatory pressures. Industry-specific characteristics may influence the insignificant result in this study.

This variable has a coefficient of -0.1399 for Log Size with a standard error of 1.9885. The t-statistic is -0.9261, and the p-value is 0.0470, suggesting that the coefficient is statistically significant at the 5% significance level. The negative coefficient implies a negative relationship between the logarithm of size and ROE. Capon et al. (1990) conducted a meta-analysis that found a generally positive relationship between firm size and financial performance, suggesting that larger firms often benefit from economies of scale and market power, which can enhance profitability and ROE. However, the current study's results may reflect specific industry dynamics or operational challenges faced by larger firms, such as increased complexity and bureaucracy, which can hinder their ability to generate returns for shareholders.

This variable has a coefficient of -0.1265 for Age, with a t-statistic of -3.1947 and a p-value of 0.0185, indicating statistical significance at a 5% significance level. The negative coefficient suggests a negative relationship between age and ROE. Loderer and Waelchli (2010) found that older firms may experience diminishing returns due to increased bureaucracy, reduced growth opportunities, and a lack of strategic flexibility, which can adversely affect their ability to generate shareholder returns. Coad et al. (2010) indicated that the relationship between firm age and productivity follows an inverted U-shape, where younger firms may be more dynamic and adaptable, while older firms may struggle with declining efficiency and growth opportunities, ultimately impacting their ROE.

**Table 4.5**: Random Effect Regression Analysis
Dependent Variable: Return on Equity (ROE)

| Variable | Coefficient | Std. Error | t-Statistic | Prob |
|---|---|---|---|---|
| C | 18.5012 | 1.5431 | 7.4298 | 0.0000 |
| Log ($CO_2e$) | 0.0201 | 0.0567 | 1.4442 | 0.7232 |
| Log (Size) | -0.1399 | -1.9885 | -0.9261 | 0.0470 |
| Age | -0.1265 | -2.3577 | -3.1947 | 0.0185 |

The results unveil several significant insights in Table 4.6. Firstly, the intercept coefficient (C) of 42.0079 is statistically significant ($p = 0.0000$), indicating a robust association between the intercept and ROI. This suggests a baseline ROI even when other factors are held constant.

Examining individual coefficients, Log (CO2e) coefficient is positive at 0.2920 and statistically significant with a p-value of 0.0024. This suggests that Log CO2e has a significant positive linear relationship with ROI. Similarly, the

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Log (Size) coefficient is negative, -0.3829, and statistically significant ($p = 0.0013$), indicating that the logarithm of company size has a significant negative linear relationship with ROI.

Furthermore, the coefficient for Age is negative (-0.2194) and statistically significant ($p = 0.0158$), implying a significant negative linear relationship between the company's age and ROI. This suggests that older companies tend to have lower ROI than younger ones, all else equal.

**Table 4.6:** Random Effect Regression Analysis (ROI)

| Variable | Coefficient | Std. Error | t-Statistic | Prob |
|---|---|---|---|---|
| C | 42.0079 | 2.6100 | 16.0948 | 0.0000 |
| Log ($CO_2e$) | 0.2920 | 0.0959 | 3.0438 | 0.0024 |
| Log (Size) | -0.3829 | 0.1190 | -3.2181 | 0.0013 |
| Age | -0.2194 | 0.0907 | -2.4177 | 0.0158 |

## DISCUSSION

The manufacturing industry in Malaysia significantly contributes to the country's economic growth, job creation and improvement of livelihoods. However, it also contributes to greenhouse gas (GHG) emissions, with the manufacturing and construction industries being the third-largest sources of emissions in the country. This raises concerns about the impacts of carbon footprints on the financial performance of the manufacturing industry in Malaysia. This study advocates the perspective that carbon emissions from corporate activities can be reduced while simultaneously maintaining or enhancing the company's financial success. This is in line with the findings from this study, where there is a relationship between carbon footprint and financial performance. Investing in eco-friendly technologies and processes can create new revenue streams and improve efficiency (Neeveditah et al., 2017).

The findings on the impacts of carbon footprint on financial performance using panel data analysis. It provides a detailed analysis of the results, including a positive coefficient for $CO_2$ emissions, suggesting a positive relationship between carbon emissions and ROA. There is no statistically significant relationship between $CO_2$ emissions and ROE, suggesting that variations in $CO_2$ emissions do not significantly impact a firm's return on equity. However, a positive relationship is observed between $CO_2$ emissions and ROI, suggesting that firms with higher $CO_2$ emissions tend to have higher returns on investment.

### Policymaker

(i) Incentive for Green Technology Investment

The analysis indicates a positive correlation between carbon emissions and financial performance, specifically Return on Investment (ROI), suggesting that more profitable manufacturing firms tend to exhibit higher emission levels. This observation poses a significant challenge for policymakers striving to reconcile economic development with environmental sustainability. In contrast, the negative Correlations between financial performance and firm characteristics, namely, size and age, suggest that larger and older firms often face reduced profitability, potentially due to operational inefficiencies and increased costs.

In light of these findings, policymakers are urged to promote environmentally sustainable growth through targeted interventions. One approach is to introduce financial incentives, such as tax credits, subsidies, or grants, for firms participating in green technologies. These encouragements can offset the substantial upfront expenditures associated with sustainable practices and encourage broader adoption across the sector. Furthermore, increased collaboration for research and development (R&D) in green innovation is critical. Investment in R&D can lead to the development

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of advanced technologies that not only reduce environmental impact but also improve operational efficiency and long-term financial performance.

(ii) Stringent Environmental Regulations.

Stringent environmental regulations are essential to achieving long-term sustainability in the manufacturing sector. The implementation of carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, can effectively internalise the environmental costs associated with carbon emissions. These tools create financial incentives for firms to reduce emissions and invest in cleaner, more sustainable technologies. Additionally, establishing clear and enforceable emission reduction targets can compel firms to adopt environmentally responsible practices, ensuring alignment with both national and international climate objectives.

Furthermore, enhancing the transparency and standardisation of carbon emission reporting is vital. Improved disclosure of environmental performance enables investors and stakeholders to make informed decisions while promoting corporate accountability. By mandating comprehensive sustainability reporting, policymakers can foster a culture of environmental responsibility and drive progress toward a low-carbon economy.

**Future Research**

This study contributes to the growing body of knowledge on the relationship between carbon footprints and financial performance within Malaysia's manufacturing sector. Several avenues for future research emerged during the course of the analysis. Firstly, while this study focused on the immediate impact of carbon emissions on firm performance, future research could examine the long-term financial implications of carbon footprint management. Expanding the scope beyond the manufacturing industry in Malaysia to include other sectors and geographical contexts would provide a more comprehensive understanding of the dynamics between carbon disclosure and financial outcomes.

Moreover, future studies could investigate the specific carbon reduction strategies and sustainability initiatives adopted by firms and assess how these efforts influence financial performance. Exploring the mechanisms through which environmental practices impact profitability would offer valuable insights for both corporate strategy and policy design. Finally, further research should consider the potential trade-offs and synergies between carbon performance and key financial indicators, thereby supporting the development of sustainable investment strategies and enhancing the integration of environmental, social, and governance (ESG) factors in corporate decision-making.

**Limitations of the Study**

The availability and quality of data represent a significant limitation of this study. Accessing comprehensive, reliable, and up-to-date information on carbon emissions and financial performance across all relevant manufacturing firms in Malaysia remains a considerable challenge. Not all publicly listed companies engage in carbon emission disclosure, which restricts the sample size and potentially affects the representativeness of the findings. Moreover, the absence of a standardised reporting framework for carbon emissions and financial performance indicators across firms undermines the comparability and consistency of the data.

This study relied on self-reported disclosures, which may introduce reporting bias or inaccuracies in the measurement of both carbon footprint and financial outcomes. The dependence on publicly available data also limits the ability to capture other contextual or firm-specific variables that could influence financial performance.

In addition, the study's temporal scope was confined to a three-year period, which may be insufficient to capture the long-term financial impacts of carbon footprint management. The narrow timeframe restricts the generalisability of the findings across different economic cycles and industry contexts. Therefore, future research with extended time horizons and more robust data sources is essential to draw more conclusive insights.

**Conclusion**

The findings of this study provide critical insights into the relationship between corporate carbon footprints and financial performance within Malaysia’s manufacturing sector. The analysis reveals a noteworthy association


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between carbon emissions and financial indicators such as Return on Assets (ROA) and Return on Investment (ROI). Contrary to prevailing environmental concerns surrounding greenhouse gas (GHG) emissions, the results indicate that firms with higher carbon footprints tend to exhibit stronger financial performance. This paradox highlights the complex interplay between operational scale, environmental externalities, and profitability.

The identification of the inadequate prevalence of carbon disclosure with Malaysian manufacturing firms, with only 26% reporting their emissions (Ibrahim, Jais, Md Isa, & Ahmad Jaffary, 2024). This finding supports the assumptions of legitimacy theory, suggesting that many firms may encounter representative disclosure practices aimed at enhancing corporate image rather than providing substantive environmental transparency. Furthermore, the study underscores the absence of stringent monitoring frameworks governing carbon disclosure in Malaysia, which has hindered the widespread adoption of environmental practices. The study holds significant effects for numerous stakeholders. For stakeholders, the results underscore the importance of integrating environmental performance into investment decision-making, particularly considering hypothetical regulatory shifts and reputational risks. Policymakers are urged to strengthen environmental regulations and provide financial incentives, such as grants or tax relief, for investments in green technologies, thereby fostering sustainable industrial growth. For entrepreneurs, embracing sustainable practices not only promotes long-term operational efficiency but also positions firms to benefit from emerging eco-friendly initiatives and financial opportunities.

Finally, this study paves the way for future research by highlighting the need for longitudinal analyses to capture the long-term effects of carbon management on financial outcomes. Sector-specific investigations may also yield more nuanced insights into the heterogeneous impact of sustainability practices. Notwithstanding its contributions, the study is constrained by data limitations and a relatively short observation window of three years, which may not fully encapsulate the long-term dynamics of carbon performance and financial outcomes.

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