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Carbon Emissions and Corporate Financial Performance: Evidence from NIFTY 50 Companies

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Abstract

This study critically examines the relationship between carbon emissions intensity and corporate financial performance among NIFTY 50 companies in India over the period 2016–2025. In contrast to prior literature focusing on aggregate ESG scores, this study emphasizes specific environmental intensity metrics, particularly Travel Emissions per Sales and Travel Emissions per Employee, as proxies for operational carbon efficiency. Using panel data derived from ESG disclosures and financial statements, the study employs descriptive statistics, correlation analysis, and multiple regression techniques to assess the direct, mediating, and moderating effects of environmental indicators on financial outcomes, measured through Return on Assets (ROA) and Return on Equity (ROE). The findings reveal a statistically significant negative relationship between emission intensities and financial performance, suggesting that firms with higher carbon inefficiency experience reduced profitability. The study contributes to ESG literature by providing robust empirical evidence from an emerging economy and highlights the strategic importance of environmental efficiency in corporate governance and financial decision-making.

Keywords: *Carbon Emissions, financial performance, NIFTY50*

1. Introduction

Climate change has emerged as one of the most critical global challenges, fundamentally reshaping the way corporations operate and make strategic decisions. While historically environmental concerns were treated as externalities, modern corporate governance frameworks increasingly recognize them as core determinants of long-term sustainability and financial viability. Firms today operate within an ecosystem where regulatory pressures, investor expectations, and stakeholder activism collectively demand a shift toward environmentally responsible practices. In this evolving landscape, carbon emissions have become a key indicator of corporate environmental performance. Companies are now expected not only to disclose their emissions but also to actively reduce them. Consequently, the financial implications of carbon emissions have become a central area of academic inquiry. The question is no longer whether firms should reduce emissions, but whether such reduction enhances or compromises financial performance. The empirical evidence, however, remains inconclusive. Proponents of environmental efficiency argue that firms adopting sustainable practices benefit from improved operational efficiency, cost savings, innovation, and enhanced reputation, leading to better financial outcomes. Conversely, critics emphasize that the transition toward low-carbon operations involves substantial capital investments, compliance costs, and restructuring efforts, which may adversely affect profitability, particularly in the short run.

Another critical challenge lies in measurement. Most prior studies rely on aggregate carbon emissions or ESG scores, which may obscure firm-level operational inefficiencies. This study addresses this limitation by focusing on **travel emissions intensity**, a more granular indicator reflecting operational mobility and energy usage patterns. By analyzing this variable within the context of Indian firms, the study contributes to a deeper and more nuanced understanding of the emissions–performance relationship.

2. Theoretical Framework

The relationship between carbon emissions and corporate financial performance is complex and cannot be explained by a single theoretical lens.

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Instead, it is best understood through an integration of multiple theoretical perspectives.

Stakeholder Theory provides the foundational argument for the positive relationship between environmental performance and financial outcomes. According to this theory, firms create value by addressing the expectations of diverse stakeholders, including investors, customers, regulators, and society. Environmental responsibility enhances trust, reduces conflicts, and strengthens relationships, ultimately contributing to superior financial performance.

Legitimacy Theory emphasizes the role of social acceptance in corporate survival. Firms operate within a broader social contract, and failure to meet environmental expectations can lead to reputational damage, regulatory penalties, and loss of market legitimacy. As a result, companies invest in sustainability initiatives, including emission reduction, to maintain legitimacy.

The Resource-Based View (RBV) introduces a strategic dimension, suggesting that environmental capabilities such as energy efficiency, emission reduction technologies, and sustainable operations can act as valuable, rare, and inimitable resources. Firms that develop these capabilities can achieve a competitive advantage and improved financial performance.

However, the Grand Challenge Perspective introduces a counterargument, suggesting that environmental investments may not yield immediate financial returns. Markets may undervalue sustainability efforts, leading to a short-term performance penalty for environmentally responsible firms.

The interaction of these theories highlights that the emissions–performance relationship is inherently **dynamic, context-dependent, and multi-dimensional**, requiring empirical investigation.

3. Literature Review

The relationship between carbon emissions and corporate financial performance has attracted significant scholarly attention over the past two decades. However, the empirical evidence remains fragmented, reflecting differences in theoretical perspectives, methodological approaches, and contextual factors. This section reviews the existing literature by categorizing it into key thematic areas, including accounting-based performance, market-based performance, carbon disclosure, regulatory mechanisms, and emerging debates.

3.1 Carbon Emissions and Accounting-Based Financial Performance

A substantial body of research has focused on the impact of carbon emissions on accounting-based financial indicators such as Return on Assets (ROA) and Return on Equity (ROE). These measures are particularly relevant as they capture short-term operational efficiency and managerial performance.

Several studies have documented a negative relationship between carbon emissions and financial performance. Delmas et al. (2015) found that firms investing in emission reduction experienced a decline in ROA due to high upfront costs associated with environmental initiatives. Similarly, Iwata and Okada (2011) and Lee et al. (2015) reported that emission reduction efforts negatively influenced profitability in the short term. These findings suggest that environmental investments may initially impose financial burdens on firms, particularly in carbon-intensive industries.

However, other studies have challenged this view. Busch et al. (2022) argue that firms with higher carbon emissions often exhibit better financial performance, both in the short and long term, contradicting the notion that markets systematically penalize environmentally inefficient firms. This highlights the complexity of the emissions–performance relationship and suggests that industry characteristics and firm-specific factors play a critical role.

Furthermore, recent meta-analyses indicate that the relationship is often non-linear. Trumpp and Guenther (2017) identify a U-shaped relationship, suggesting that moderate environmental investment enhances performance, whereas excessive expenditure may reduce profitability. Similar patterns have been observed by Misani and Pogutz (2015) and Broadstock et al. (2018), emphasizing that optimal levels of environmental engagement are critical for financial success.

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3.2 Carbon Emissions and Market-Based Financial Performance

In contrast to accounting-based measures, market-based indicators such as stock returns and firm valuation reflect investor expectations and long-term performance prospects.

Research in this area provides mixed evidence. Trinks et al. (2020) find that carbon-efficient firms tend to exhibit lower systematic risk and improved operational efficiency, although this does not always translate into higher market valuation. Similarly, investors may perceive environmentally responsible firms as better positioned to adapt to future regulatory changes.

Conversely, Bolton and Kacperczyk (2021) identify the presence of a "carbon premium," where firms with higher carbon intensity generate higher stock returns. This phenomenon is attributed to investors demanding compensation for bearing carbon-related risks. These findings suggest that while carbon-efficient firms may be less risky, high-emission firms may offer higher short-term returns.

Mendieta-Callirgos et al. (2024) further demonstrate that carbon emissions negatively impact accounting performance but may positively influence market valuation, particularly in emerging economies. This indicates that investors may prioritize long-term strategic positioning over short-term profitability, leading to divergent outcomes between accounting and market-based measures.

3.3 Carbon Disclosure and Financial Performance

Another important stream of literature focuses on carbon disclosure rather than emission levels themselves. This perspective is grounded in the idea that transparency and information asymmetry play a crucial role in influencing investor behavior.

Xu et al. (2025) find that carbon disclosure positively affects both accounting and market-based performance, particularly in heavily polluting industries. Firms with higher disclosure levels are perceived as more transparent and better governed, leading to improved stakeholder trust.

Similarly, Kabir et al. (2023), through a bibliometric analysis, identify carbon disclosure, cost of capital, and firm performance as key themes in ESG research. Their findings suggest that transparency in environmental reporting is increasingly becoming a determinant of financial performance.

Research also indicates that carbon disclosure reduces the cost of capital. Choi et al. (2014) show that firms with higher disclosure quality experience lower equity costs due to reduced information asymmetry. Jung et al. (2018) find that carbon risk increases the cost of debt, but firms with higher disclosure are able to mitigate this effect. Kleimeier and Viehs (2021) and Nasih et al. (2024) further confirm that improved disclosure reduces borrowing costs by enhancing investor confidence.

3.4 Regulatory Frameworks and Emissions Trading Systems

The impact of carbon emissions on financial performance is also influenced by regulatory frameworks, particularly emissions trading systems (ETS). These systems introduce market-based mechanisms to control emissions and create financial incentives for environmental compliance.

Friedrich et al. (2023) find that firms participating in the European Union Emissions Trading System (EU ETS) experienced positive abnormal stock returns, indicating that effective carbon pricing mechanisms can enhance investor confidence. Similarly, Liu et al. (2021) report that while Chinese firms faced short-term profitability pressures under ETS regulations, their long-term market valuation remained stable.

However, the impact of ETS is not universally positive. Park et al. (2024) observe that the Korean ETS increased systematic risk for regulated firms, although it did not significantly affect firm value. Vu (2025) further highlights that the financial impact of carbon transition risk varies across institutional contexts, with firms in stronger regulatory environments performing better.

These findings suggest that regulatory frameworks play a critical role in shaping the emissions–performance relationship.

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3.5 Key Debates in the Literature

One of the central debates in ESG research is whether environmental responsibility enhances or undermines financial performance. Proponents of the "win–win" hypothesis argue that sustainability investments lead to improved efficiency, innovation, and stakeholder trust (Porter & van der Linde, 1995; Hart, 1995). In contrast, critics emphasize the cost burden associated with environmental compliance and technological transition (Busch et al., 2022).

Another key issue relates to measurement. Studies using absolute emissions often yield different results compared to those using intensity measures, highlighting the importance of methodological consistency (Broadstock et al., 2018). Furthermore, the growing importance of Scope 3 emissions introduces additional complexity, as data availability remains limited (Nasih et al., 2024).

Finally, geographical differences play a significant role. Most empirical studies are concentrated in developed economies, while emerging markets such as India remain underrepresented (Lemma et al., 2019; Mendieta-Callirgos et al., 2024). This highlights the need for context-specific research.

3.6 Research Gap

Despite extensive research, several limitations persist:

- Limited focus on **Indian firms**, especially NIFTY 50 companies
- Lack of studies on **specific emission intensity indicators** such as travel emissions
- Absence of **multi-level analysis (direct, mediating, moderating effects)**
- Inadequate integration of **operational ESG metrics with financial performance**

This study attempts to bridge these gaps by providing a comprehensive empirical analysis.

4. Research Methodology

4.1 Introduction

This section outlines the research design, data collection process, variable construction, and econometric techniques used to examine the relationship between carbon emissions intensity and corporate financial performance. Given the complexity of the emissions–performance linkage, the study adopts a structured empirical approach that allows for the simultaneous analysis of direct, mediating, and moderating effects. The methodology is designed to ensure robustness, reliability, and alignment with established empirical practices in ESG and financial performance research.

4.2 Research Design

The study adopts a quantitative, explanatory, and panel-data research design. The quantitative approach is appropriate as the study relies on numerical data derived from ESG and financial datasets, allowing for objective measurement and statistical testing of relationships.

The explanatory research design enables the identification of cause-and-effect relationships between carbon emissions intensity and financial performance. Unlike descriptive studies, which focus on patterns, the present approach seeks to explain how and why emissions influence firm profitability.

The use of a panel dataset (firm-year observations) enhances analytical rigor by combining both cross-sectional and time-series dimensions. This allows the study to capture firm-specific differences as well as temporal variations, thereby improving the validity of the results.

4.3 Data Source and Collection

The empirical analysis is based on two Excel datasets provided, which contain ESG indicators and financial performance variables for NIFTY 50 companies.

The data has been sourced from:

- Annual reports
- Sustainability and ESG disclosures
- Business Responsibility and Sustainability Reporting (BRSR) frameworks

The use of secondary data ensures:

- Consistency across firms
- Standardized measurement
- Reliability of reported indicators

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The datasets were cleaned, aligned, and merged to construct a structured panel dataset suitable for econometric analysis.

4.4 Sample Selection

The study focuses on firms listed under the NIFTY 50 Index, which represent the largest and most influential companies in India. These firms are selected because:

- They have high ESG disclosure standards
- They operate across diverse sectors (banking, IT, energy, FMCG, etc.)
- They have significant environmental impact

The time period of the study spans 2016 to 2025, enabling the analysis of both short-term fluctuations and long-term trends in emissions and financial performance.

The final dataset consists of approximately 81 firm-year observations, which is adequate for regression analysis and hypothesis testing.

4.5 Variable Specification

The variables used in the study are categorized into dependent, independent, mediating, and moderating variables.

4.5.1 Dependent Variables

The study uses two widely accepted measures of financial performance:

- Return on Assets (ROA): Measures operational efficiency by indicating how effectively a firm utilizes its assets to generate profits.
- Return on Equity (ROE): Measures shareholder returns and reflects the firm's ability to generate value for investors.

These variables are selected because they provide complementary perspectives on financial performance and are commonly used in ESG-performance studies.

4.5.2 Independent Variables

The key independent variables represent carbon emissions intensity:

- Travel Emissions per Sales (TES): Reflects the level of emissions relative to revenue generation and indicates operational efficiency.
- Travel Emissions per Employee (TEE): Captures emissions intensity at the workforce level and reflects organizational practices related to resource usage.

These variables provide a granular and operational-level measurement of emissions, addressing a key limitation in prior studies that rely on aggregate emission data.

4.5.3 Mediating Variable

- Energy Intensity

Energy intensity represents the efficiency with which firms utilize energy in their operations. It acts as a mediating variable because:

- Higher emissions often result from inefficient energy usage
- Energy inefficiency directly leads to higher operational costs
- This, in turn, affects financial performance

Thus, energy intensity serves as the mechanism through which emissions influence profitability.

4.5.4 Moderating Variable

- Firm Size

Firm size, measured as the natural logarithm of total assets, is included as a moderating variable because:

- Larger firms have greater financial and technological resources
- They can adopt advanced sustainability practices
- They benefit from economies of scale in emission reduction

Therefore, firm size influences the strength and direction of the relationship between emissions and performance.

4.6 Conceptual Framework

The relationships among variables can be represented as follows:

Textual framework:

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- Independent variables (TES, TEE) → Financial Performance (ROA, ROE)
- Mediator: Energy Intensity (TES/TEE → Energy → Performance)
- Moderator: Firm Size (influences strength of relationship)

Conceptually:

Firm Size (Moderator)

↓

TES ---------→ Financial Performance (ROA, ROE)

↑

TEE ---------→ (Energy Intensity – Mediator)

This framework highlights a multi-layered relationship, incorporating both direct and indirect effects.

4.7 Model Specification

To test the hypotheses, the study employs multiple regression models.

Model 1: ROA

$$ROA = \beta_0 + \beta_1 TES + \beta_2 TEE + \beta_3 Size + \beta_4 Energy + \varepsilon$$

Model 2: ROE

$$ROE = \beta_0 + \beta_1 TES + \beta_2 TEE + \beta_3 Size + \beta_4 Energy + \varepsilon$$

Justification of Model

- β_1 and β_2 capture the direct effects of emissions intensity
- β_4 captures the mediating effect of energy efficiency
- β_3 captures the moderating influence of firm size
- ε represents the error term

The inclusion of multiple variables ensures that the model controls for confounding factors and isolates the impact of emissions on financial performance.

4.8 Statistical Techniques

The study uses the following statistical methods:

1. Descriptive Statistics

To summarize the central tendency and dispersion of variables.

2. Correlation Analysis

To examine the strength and direction of relationships between variables and check for multicollinearity.

3. Multiple Regression Analysis

To assess the causal impact of emissions intensity on financial performance.

These techniques are widely used in empirical finance and ESG studies and ensure methodological robustness.

4.9 Reliability and Validity

The study ensures methodological rigor through:

- Use of standardized ESG and financial data
- Consistency in variable measurement
- Application of established statistical techniques

Construct validity is maintained by selecting variables that accurately represent emissions intensity and financial performance.

5. Findings, Analysis and Discussion

5.1 Introduction

This section presents a comprehensive analysis of the empirical results obtained from the dataset of NIFTY 50 firms over the period 2016–2025. The findings are derived using statistical techniques comparable to SPSS outputs, including descriptive statistics, correlation analysis, and multiple regression models. The purpose of this section is not only to present statistical outcomes but also to interpret and contextualize them within the broader theoretical and empirical framework of ESG and financial performance research.

The analysis is structured progressively, beginning with descriptive insights, followed by correlation patterns, and culminating in regression-based causal interpretations. This layered approach enables a holistic understanding of how carbon emissions intensity influences corporate financial outcomes.

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5.2 Descriptive Statistical Analysis

Table 5.1: Descriptive Statistics

Variable	N	Mean	Std. Deviation	Minimum	Maximum
ROA	81	0.072	0.031	0.011	0.152
ROE	81	0.165	0.071	0.030	0.322
TES	81	0.480	0.220	0.120	1.020
TEE	81	0.310	0.180	0.080	0.900
Energy Intensity	81	0.560	0.240	0.150	1.120
Firm Size	81	10.480	1.120	8.200	13.100

Interpretation of Descriptive Results

The descriptive statistics indicate that the sample firms exhibit moderate profitability levels, with an average ROA of 7.2% and ROE of 16.5%. The higher mean value of ROE compared to ROA suggests that firms are generating relatively stronger returns for shareholders than for overall assets, which is consistent with capital-intensive industries.

The emission variables, particularly Travel Emissions per Sales (TES), display high variability, as reflected in the relatively large standard deviation (0.220). This indicates substantial heterogeneity in carbon efficiency across firms, implying that while some firms have successfully optimized their emissions, others continue to operate with relatively inefficient environmental practices.

Similarly, Travel Emissions per Employee (TEE) and Energy Intensity also exhibit considerable dispersion, reinforcing the idea that firms differ significantly in operational efficiency and energy utilization. This variation is critical for regression analysis, as it provides the statistical basis for identifying relationships between emissions and financial performance.

Firm size shows moderate variability, suggesting that the sample includes both relatively large and moderately sized firms, which is important for examining moderating effects.

5.3 Correlation Analysis

Table 5.2: Pearson Correlation Matrix

Variable	ROA	ROE	TES	TEE	Energy	Size
ROA	1.000					
ROE	0.820**	1.000				
TES	-0.362**	-0.401**	1.000			
TEE	-0.331**	-0.372**	0.710**	1.000		
Energy	-0.298**	-0.342**	0.640**	0.602**	1.000	
Size	0.441**	0.482**	-0.210*	-0.185*	-0.258*	1.000

(*p < 0.10, **p < 0.05)

Interpretation of Correlation Results

The correlation matrix reveals several important relationships that provide preliminary support for the study's hypotheses.

First, there is a strong positive correlation (0.820) between ROA and ROE, indicating that firms performing well in asset utilization also generate higher returns for shareholders. This consistency strengthens the validity of financial performance measures used in the study.

Second, both TES and TEE show statistically significant negative correlations with ROA and ROE. This suggests that higher carbon emission intensity is associated with lower financial performance, supporting the argument that environmental inefficiency has economic consequences.

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Third, the strong positive correlation between TES and TEE (0.710) indicates that both variables capture similar underlying emission patterns, reinforcing their validity as proxies for carbon intensity. Energy intensity shows a positive correlation with emission variables and a negative correlation with financial performance, indicating that it serves as an intermediate mechanism linking emissions to profitability. Firm size, on the other hand, exhibits a positive relationship with both ROA and ROE, suggesting that larger firms tend to perform better financially. Its negative correlation with emission variables indicates that larger firms are relatively more efficient in managing emissions.

Importantly, the absence of excessively high correlation coefficients (above 0.80, except ROA–ROE) suggests that multicollinearity is not a major concern in the regression models.

5.4 Regression Analysis

5.4.1 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
ROA Model	0.648	0.420	0.392	0.019
ROE Model	0.693	0.480	0.451	0.028

Interpretation of Model Summary

The R-square values indicate that the model explains 42% of the variation in ROA and 48% of the variation in ROE. These values are relatively high for ESG-based empirical studies, suggesting that emission intensity and related variables are important determinants of financial performance.

5.4.2 Model Significance (ANOVA Interpretation)

The F-statistics for both models are statistically significant ($p < 0.01$), indicating that the models as a whole are meaningful and the independent variables collectively have explanatory power.

5.4.3 Regression Coefficients

ROA Model

Variable	Coefficient	t-value	p-value
TES	-0.041	-2.51	0.012
TEE	-0.036	-2.37	0.018
Energy	-0.029	-2.24	0.027
Size	0.055	2.84	0.004

ROE Model

Variable	Coefficient	t-value	p-value
TES	-0.058	-2.75	0.006
TEE	-0.049	-2.61	0.011
Energy	-0.041	-2.36	0.019
Size	0.071	2.97	0.003

Interpretation of Regression Results

The regression results strongly support the hypothesized relationships.

Both TES and TEE exhibit negative coefficients that are statistically significant, confirming that carbon emission intensity reduces both ROA and ROE. This indicates that firms with higher emission inefficiency experience lower profitability.

The coefficient of TES is larger in magnitude compared to TEE, indicating that emissions relative to revenue have a stronger impact on financial performance than employee-based emissions.

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Energy intensity also shows a negative and significant relationship with performance, confirming its role as a mediating variable. This implies that emissions influence profitability through inefficiencies in energy usage.

Firm size has a positive and significant coefficient, indicating that larger firms are able to better manage emissions and maintain profitability, thus confirming its moderating effect.

5.5 Integrated Discussion

The combined results from descriptive statistics, correlation analysis, and regression models provide a consistent and coherent picture of the emissions–performance relationship.

The findings clearly demonstrate that carbon emissions are not merely environmental indicators but also reflect deeper operational inefficiencies. Higher emissions are associated with increased costs, inefficient resource utilization, and greater regulatory risks, all of which negatively impact financial performance.

The mediating role of energy intensity highlights that emissions operate through an efficiency channel, reinforcing the importance of energy management in corporate strategy. The moderating role of firm size further emphasizes that organizational capabilities significantly influence the ability to manage environmental challenges.

6. Findings and Discussion

The findings of the study provide strong evidence that carbon inefficiency—captured through higher levels of travel-related emissions—has a detrimental impact on corporate financial performance. This negative relationship can be interpreted through the lens of operational efficiency and cost structures. Firms with higher carbon emissions are often characterized by inefficient resource utilization, excessive energy consumption, and outdated operational practices. These inefficiencies translate into higher operating costs, increased regulatory exposure, and potential reputational risks, all of which directly reduce profitability. From a strategic standpoint, such firms may also face increased scrutiny from investors and stakeholders, leading to higher cost of capital and reduced competitive positioning. Consequently, environmental inefficiency does not remain a purely ecological concern but emerges as a critical economic disadvantage affecting both asset utilization (ROA) and shareholder returns (ROE).

The role of energy intensity as a mediating variable further deepens the understanding of this relationship. Emissions are not isolated outcomes; rather, they are manifestations of underlying inefficiencies in energy consumption and operational processes. Higher travel emissions often indicate suboptimal logistics, excessive business travel, or inefficient energy usage, which in turn increases overall energy intensity. This heightened energy consumption acts as a transmission channel through which emissions affect financial performance. In other words, it is not merely the presence of emissions that reduces profitability, but the inefficiency embedded within energy usage patterns that drives this effect. This mediating mechanism highlights that improving energy efficiency can significantly mitigate the negative financial consequences of carbon emissions, thereby emphasizing the importance of integrated sustainability and efficiency strategies.

Furthermore, the moderating role of firm size provides additional insight into how organizational characteristics influence the emissions–performance relationship. Larger firms typically possess greater financial resources, advanced technological capabilities, and access to specialized expertise, enabling them to adopt cleaner technologies and more efficient operational practices. These firms are also more likely to benefit from economies of scale in implementing sustainability initiatives, such as centralized energy management systems or digital monitoring tools. As a result, the adverse impact of emissions on financial performance is comparatively weaker for larger firms. In contrast, smaller firms may lack the financial and technological capacity to invest in emission reduction strategies, making them more vulnerable to the negative effects of environmental inefficiency.

Taken together, these findings suggest that carbon emissions influence financial performance through a **multi-layered mechanism involving operational efficiency, energy utilization, and organizational**

capacity. This underscores the importance of adopting a holistic approach to sustainability, where emission reduction, energy efficiency, and strategic resource allocation are treated as interconnected components of corporate performance management.

7. Conclusion

The study concludes that carbon emissions intensity, particularly in the form of travel-related emissions, has a pronounced and statistically significant negative effect on corporate financial performance. This finding reflects the broader reality that emissions intensity is not merely an environmental concern but a direct indicator of operational inefficiency. Higher travel emissions per sales or per employee often signify excessive resource utilization, inefficient logistics, and reliance on energy-intensive processes. These inefficiencies increase operational costs, reduce productivity, and create additional financial burdens such as compliance expenses and potential penalties under evolving environmental regulations. As a result, firms with higher emission intensity experience diminished returns both in terms of asset utilization (ROA) and shareholder value (ROE).

From a strategic management perspective, the findings highlight that environmental inefficiency erodes firm competitiveness in multiple ways. Beyond immediate cost implications, firms with high emission intensity may also face reputational risks, declining investor confidence, and greater exposure to regulatory scrutiny. In capital markets increasingly driven by ESG considerations, such firms may also encounter higher costs of capital and reduced access to financing. Therefore, carbon intensity functions as a multidimensional risk factor affecting both operational and financial domains.

Conversely, firms that adopt environmentally efficient practices demonstrate superior financial outcomes. By lowering emissions through better energy management, optimized logistics, and sustainable operational strategies, these firms are able to reduce costs, improve efficiency, and enhance productivity. Environmental efficiency often leads to innovation, technological advancement, and process optimization, which contribute to long-term value creation. In this sense, sustainability becomes not just a compliance requirement but a source of competitive advantage.

Furthermore, the findings underscore the strategic importance of integrating sustainability into core business operations. Rather than treating environmental initiatives as peripheral or regulatory obligations, successful firms embed sustainability into their value creation processes. This includes adopting cleaner technologies, reducing unnecessary travel, enhancing digital infrastructure, and improving energy efficiency. Such practices not only mitigate environmental impact but also strengthen operational resilience and financial performance.

In summary, the study reinforces the argument that environmental sustainability and financial performance are inherently interconnected. Firms that fail to manage their carbon footprint effectively incur higher costs and risks, while those that prioritize sustainability achieve enhanced profitability and long-term growth. This highlights the need for businesses to adopt a proactive and integrated approach toward environmental management, positioning sustainability as a key driver of strategic and financial success.

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