

U-Shaped Relationship Between Greenhouse Gas Emission and Financial Performance: The Role of Voluntary Environmental Management System



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Abstract

The growing importance of corporate sustainability has increased interest in understanding how environmental performance and policies influence firms' Corporate Financial Performance (CFP). Therefore, our study investigates the non-linear relationship between GHG emissions and CFP, while assessing the moderating effect of Environment Management System (EMS) adoption among A-listed Indian firms. Thus, drawing on the Natural Resource-Based View (NRBV), the study argues that environmental sustainability activities enhance firms' ability to achieve sustainable competitiveness by improving resource efficiency. Using the panel data from 2017 to 2022, the study employs Panel Quantile Fixed Effects Regression (PQR) to capture heterogeneous effects across CFP levels. The findings reveal a significant inverse U-shaped relationship between GHG emissions and CFP, indicating that while moderate emission levels initially enhance profitability through production expansion and economies of scale, excessive emissions reduce financial performance due to rising environmental costs and operational inefficiencies. The results further show that EMS adoption positively affects environmental and financial performance. Additionally, the negative interaction between EMS and GHG emissions demonstrates that EMS adoption decreases firms' dependence on emission-intensive production by achieving the highest level of CFP at lower GHG emissions. These findings suggest that firms adopting structured environmental management systems achieve profitability through resource-efficient operations rather than causing higher environmental impact. The study contributes to the sustainability literature by demonstrating that EMS adoption acts as an organizational strategy that reshapes the GHG-CFP relationship, offering important implications for managers and policymakers seeking to enhance both environmental and economic performance.

Keywords: *Greenhouse gas emissions; Environmental management systems; Financial performance; Natural resource-based view; Panel quantile regression; Sustainability competitiveness.*

1. Introduction

Climate change has emerged as a significant source of financial and operational risk (Çoban & Topçu, 2013; Lewandowski, 2017). This forces firms to examine the relationship between emission mitigation strategies and long-term economic sustainability (Ghosh et al., 2023; Maji & Saikia, 2024). Consequently, firms are expected to achieve economic growth while simultaneously reducing their environmental footprint (Tuesta et al., 2020). Thus, firms are adopting voluntary environmental strategies, such as Environmental Management Systems (ISO 14001), not merely for regulatory compliance but also as strategic instruments to leverage competitive advantage (Kumar & Dua, 2021; Le & Nguyen-Phung, 2024). In this context, existing empirical research indicates that ISO 14001 certification serves as a unique organizational nonmarket strategy that increases financial returns by enhancing stakeholder involvement (Miroshnychenko et al., 2017). Thus, making the relationship between environmental performance and financial performance a central issue in corporate finance and sustainability research (Gerged et al., 2020).

Prior research provides mixed evidence on the relationship between greenhouse gas emissions and financial performance (Hernández-Vega, 2025; Ogunrinde et al., 2020). While some studies report a significant negative association between carbon output and market value (Delmas et al., 2015; Wang et al., 2013), others suggest that the financial benefits of emission reduction are realized only after a strategic lag of 1 to 2 years (Ajina et al., 2025; Pariag-Maraye et al., 2017). Furthermore, some scholars identify a non-linear relationship in which firms attain optimal financial outcomes only at intermediate levels of carbon performance, suggesting that the costs of mitigation may outweigh the benefits at certain operational thresholds (Misani & Pogutz, 2014).

These conflicting findings indicate that the relationship between GHG emissions and financial performance is considerably more complex than conventional linear models (Gerged et al., 2020). The assumption of linearity presumes that each additional unit of emissions exerts a constant economic effect on firm performance. However, firms may initially

benefit from production expansion despite increasing emissions, whereas beyond a certain level, environmental costs may outweigh operational benefits (Trumpp & Guenther, 2015). This suggests that the economic consequences of greenhouse gas emissions are likely to vary across different emission levels, highlighting the need to examine the relationship within a non-linear framework (Lewandowski, 2017; Trumpp & Guenther, 2015).

Although recent studies have examined the non-linear relationship between environmental and financial performance, three important gaps remain. First, the existing studies primarily focus on whether greenhouse gas emissions influence financial performance, while relatively few estimate the turning point at which emissions shift from contributing positively to adversely affecting profitability (Lewandowski, 2017; Trumpp & Guenther, 2015). Identifying this threshold is particularly important because it provides managers with an economically meaningful benchmark for balancing production growth and environmental sustainability (Gerged et al., 2020).

Second, previous studies largely examine Environmental Management Systems (EMS) as independent determinants of environmental or financial performance. Instead, they often overlook the contingent role of such systems as strategic moderators that can fundamentally reshape the causal relationship between GHG levels and CFP (Zhang et al., 2020). Environmental Management Systems are structured organizational mechanisms that institutionalize environmental planning, monitoring, pollution prevention, and continuous operational improvement (Riaz et al., 2021). While numerous studies report positive direct effects of EMS adoption (Gavronski et al., 2007), relatively little attention has been devoted to whether EMS fundamentally changes the way greenhouse gas emissions influence financial performance. From a strategic perspective, EMS may enable firms to improve profitability by enhancing resource efficiency rather than increasing environmental impact. Consequently, examining EMS as a moderating capability rather than merely an independent explanatory variable provides a richer understanding of firms' environmental-financial dynamics (Grisales et al., 2020).

Third, empirical evidence remains relatively limited for emerging economies such as India (Qadir & Gorman, 2008), where firms operate under rapidly evolving environmental regulations while simultaneously pursuing industrial expansion. India's commitment to carbon neutrality, increased environmental disclosure requirements, and the growing adoption of structured environmental management practices make it an appropriate setting for examining whether firms can simultaneously achieve environmental responsibility and financial performance (Dahiya & Singh, 2020). Evidence from

emerging markets is particularly valuable because institutional environments, regulatory enforcement, and corporate sustainability practices differ considerably from those observed in developed economies (Riaz et al., 2021).

Motivated by these gaps, this study examines whether greenhouse gas emissions exhibit a non-linear relationship with financial performance and whether Environmental Management Systems alter this relationship. Drawing on the Natural Resource-Based View (NRBV), the study conceptualizes EMS as a strategic organizational capability that enhances firms' ability to improve resource efficiency, reduce environmental risks, and sustain competitive advantage (Riaz et al., 2021). Unlike previous studies that rely primarily on conventional linear estimation techniques (Gavronski et al., 2007; He & Shen, 2017; Qadir & Gorman, 2008). This study employs panel quantile fixed-effects regression (Gerged et al., 2020) to assess the relationship between greenhouse gas emissions and financial performance across different levels of firm performance, while controlling for unobserved firm-specific heterogeneity. More importantly, the study estimates the turning point in greenhouse gas emissions, thereby identifying the optimal emission threshold beyond which environmental costs outweigh production-related benefits. Furthermore, by incorporating Environmental Management Systems as a moderating variable (Grisales et al., 2020), the study investigates whether environmental capabilities enable firms to achieve higher financial performance at comparatively lower emission levels.

Accordingly, the study seeks to address the following research questions:

RQ1: Do greenhouse gas emissions exhibit a non-linear relationship with firms' financial performance?

RQ2: Does Environmental Management System adoption improve firms' financial performance?

RQ3: Does Environmental Management System adoption moderate the relationship between greenhouse gas emissions and financial performance?

RQ4: Does Environmental Management System adoption improve firms' environmental performance?

This study makes four important contributions to the literature. First, it contributes to the environmental finance literature by demonstrating that the relationship between greenhouse gas emissions and financial performance exhibits an inverse U shape, thereby reconciling previously conflicting empirical findings (Ghosh et al., 2023; Le & Nguyen-Phung, 2024; Wang et al., 2013). Second, unlike earlier studies that primarily document the existence of non-linearity, the present study explicitly estimates the turning point, providing managers and policymakers with a measurable benchmark that identifies the emission level beyond which environmental costs dominate production-related benefits (Zhang et al., 2020). Third, the study extends the Environmental

Management System literature by demonstrating that EMS functions not merely as a direct determinant of firm performance but also as a strategic environmental capability that reshapes the relationship between greenhouse gas emissions and financial performance (He & Shen, 2017). Specifically, EMS lowers the emission threshold at which firms achieve maximum financial performance, suggesting that structured environmental management enables firms to improve profitability through resource-efficient production rather than emission-intensive growth. Finally, by employing panel quantile fixed effects estimation, the study captures heterogeneous effects across different performance levels, providing richer evidence than conventional mean regression models (Gerged et al., 2020) and offering new insights into how environmental capabilities influence financial outcomes across firms.

Using a balanced panel of Indian A-listed firms over the period 2017–2022, the empirical findings reveal a significant inverse U-shaped relationship between greenhouse gas emissions and financial performance. The results indicate that moderate levels of emissions initially contribute positively to profitability; however, financial performance declines once emissions exceed the estimated threshold (Gerged et al., 2020). Environmental Management Systems are found to influence both financial and environmental performance positively. More importantly, EMS significantly moderates the emissions–financial performance relationship by lowering the optimal emission threshold, indicating that firms adopting structured environmental management systems achieve superior profitability while relying less on emission-intensive production. These findings provide strong support for the Natural Resource-Based View, highlighting environmental capabilities as strategic organizational resources that simultaneously enhance environmental responsibility and financial performance.

The remainder of the paper is organized as follows. Section 2 presents the theoretical framework and the development of the hypothesis. Section 3 describes the research design, data, and methodology. Section 4 discusses the empirical findings and robustness analyses. Section 5 concludes the study by outlining its theoretical, managerial, and policy implications, together with directions for future research.

2. Theoretical Background and Hypothesis Development

2.1 Theoretical Background

Climate change has increased the strategic importance of environmental management mechanisms, thereby forcing firms to balance economic performance with environmental responsibility (He & Shen, 2017). While greenhouse gas (GHG) emissions are a key indicator of firms' environmental impact, their implications for financial performance remain theoretically ambiguous (Riaz et

al., 2021). On the one hand, higher environmental performance may reflect competitive advantage and operational expansion, thereby contributing to improved profitability (Fujii et al., 2012; Tzouvanas et al., 2019). On the other hand, excessive emissions expose firms to environmental risks, regulatory compliance costs, operational inefficiencies, and reputational concerns that can adversely affect financial outcomes (Delmas et al., 2015; Wang et al., 2013). Consequently, understanding how firms manage environmental challenges has become imperative for explaining financial performance ambiguity.

This study is grounded in the Natural Resource-Based View (NRBV) (Hart, 1995), which extends the traditional Resource-Based View by recognising environmental capabilities as strategic organisational resources that can generate sustained competitive advantage (Hart, 1995; Hart & Dowell, 2010). The NRBV argues that firms create long-term value by developing capabilities such as pollution prevention, resource efficiency, and environmental innovation (Hart & Ahuja, 1996). These capabilities enable firms to optimise resource utilisation, reduce waste, improve operational efficiency, and strengthen organisational resilience, thereby simultaneously enhancing environmental and financial performance (He & Shen, 2017; Qadir & Gorman, 2008). By integrating these environmental capabilities into corporate firms, they can better navigate the constraints imposed by traditional resource limitations while fostering systemic improvements in operational efficiency (Aslam et al., 2020; Sarfraz et al., 2023).

Environmental Management Systems (EMS) represent formal organizational capabilities that integrate environmental objectives into firms' operational and strategic decision-making (Grisales et al., 2020). By improving firms' ability to manage environmental risks and optimise resource utilisation, EMS strengthen operational efficiency while reducing the financial consequences associated with environmental degradation. Drawing on the NRBV, this study argues that environmental capabilities influence not only firms' financial performance directly but also the manner in which greenhouse gas emissions translate into financial outcomes (Hart & Dowell, 2010). Firms possessing stronger environmental management capabilities are expected to achieve superior financial performance while relying less on emission-intensive production processes. Accordingly, the NRBV provides a unified theoretical foundation for examining the non-linear relationship between greenhouse gas emissions and financial performance, the direct effect of Environmental Management Systems on financial performance, and the moderating role of EMS in shaping the emissions–financial performance relationship.

2.2 Literature Review & Hypothesis Development

2.2.1 Greenhouse Gas Emissions and Financial Performance

Greenhouse gas (GHG) emissions have become one of the most important indicators of firms' environmental performance, reflecting both production intensity and environmental impact. Despite growing academic interest, the relationship between GHG emissions and financial performance remains inconclusive (Riaz et al., 2021). Existing studies report conflicting findings: some suggest that higher emissions reduce profitability (Delmas et al., 2015; Wang et al., 2013) due to regulatory costs and stakeholder pressure, while others argue that carbon-intensive firms often achieve superior financial performance (Fujii et al., 2012; Tzouvanas et al., 2019) because higher emissions accompany increased production and economic activity. These contrasting findings indicate that the relationship between GHG emissions and financial performance is unlikely to be adequately explained by a simple linear relationship (Gerged et al., 2020; Trumpp & Guenther, 2015).

The Natural Resource-Based View (NRBV) (Hart & Dowell, 2010) provides a useful theoretical perspective for explaining this complexity. According to the NRBV, firms create sustainable competitive advantage through capabilities that enhance resource efficiency and environmental management (Hart, 1995). During the initial stages of production expansion, firms typically experience higher asset utilisation, greater economies of scale, and increased revenues (Fujii et al., 2012). Since higher production naturally entails greater energy consumption and emissions, moderate increases in GHG emissions may simply reflect productive economic activity rather than environmental inefficiency (Gerged et al., 2020). Consequently, firms may initially experience improvements in financial performance despite increasing emissions.

However, the benefits associated with production expansion diminish beyond a certain point. As emissions continue to increase, firms become increasingly exposed to environmental compliance costs, pollution-control investments, resource inefficiencies, and reputational risks (Delmas et al., 2015). Rising stakeholder expectations and stricter environmental regulations further increase the financial consequences of excessive emissions. At higher levels of emissions, these environmental costs begin to outweigh the operational benefits from production expansion, leading to declining profitability. Therefore, rather than exhibiting a constant relationship, GHG emissions are expected to have an inverse U-shaped association with financial performance (Lee & Li, 2022; Trumpp & Guenther, 2015), where profitability initially improves with increasing emissions before deteriorating after a threshold level.

Hypothesis 1: GHG exhibit an inverse U-shaped relationship with CFP.

2.2.2 Environmental Management Systems and Financial Performance

While greenhouse gas emissions reflect firms' environmental impact, organisations differ considerably in their ability to manage environmental challenges (Benzidia et al., 2024). Environmental Management Systems (EMS) provide firms with structured mechanisms for integrating environmental considerations into strategic planning, operational activities, and continuous performance improvement (Camilleri, 2022). Rather than viewing environmental management as a compliance obligation, EMS encourages firms to systematically monitor environmental performance (Tolosa et al., 2019), optimise resource utilisation, reduce waste, and improve production efficiency (Brammer et al., 2011). The Natural Resource-Based View suggests that these environmental capabilities represent valuable organisational resources that can generate competitive advantage (Sambasivan & Fei, 2007). Firms implementing EMS continuously improve operational processes through environmental monitoring, pollution prevention, employee involvement, and technological innovation (Tan, 2004). These practices reduce resource waste, improve energy efficiency, minimise production inefficiencies, and lower operating costs (Alemagi et al., 2006). Consequently, firms adopting EMS are expected to improve profitability through greater operational efficiency rather than relying solely on production expansion (Chowdhury et al., 2018; Saizarbitoria & Landín, 2011).

Furthermore, EMS promotes organisational learning by encouraging continuous evaluation of environmental objectives and production processes. Such learning facilitates innovation and process improvements that enhance both environmental and economic performance. Therefore, firms adopting Environmental Management Systems are expected to achieve superior financial performance relative to firms lacking structured environmental management practices.

Hypothesis 2: EMS adoption positively influences CFP.

2.2.3 Moderating Role of Environmental Management System

Although increasing greenhouse gas emissions may eventually reduce financial performance, the extent of this adverse effect is unlikely to be identical across firms. The Natural Resource-Based View argues that firms possessing stronger environmental capabilities are better equipped to manage environmental risks associated with production activities. Environmental Management Systems represent one such capability by enabling firms to systematically monitor emissions, improve resource efficiency, minimise waste, and

integrate environmental considerations into operational decision-making (Chowdhury et al., 2018; Saizarbitoria & Landín, 2011).

Unlike firms without structured environmental management, EMS-adopting firms do not depend solely on increasing production and resource consumption to improve profitability. Instead, they enhance operational performance through cleaner production methods, efficient resource utilisation, and continuous process improvements (Grisales et al., 2020). Consequently, EMS enables firms to generate financial value while simultaneously reducing environmental costs associated with higher emissions. As greenhouse gas emissions increase, firms lacking environmental management capabilities are likely to experience rapidly increasing compliance costs, operational inefficiencies, and stakeholder pressure, leading to declining financial performance (Delmas et al., 2015; Wang et al., 2013). In contrast, firms implementing EMS can better manage these environmental risks through proactive environmental planning and continuous operational improvements (Fujii et al., 2012; Tzouvanas et al., 2019). Therefore, EMS is expected to mitigate the adverse financial consequences of excessive greenhouse gas emissions by reducing firms' reliance on environmentally intensive production processes.

Accordingly, Environmental Management Systems are expected to alter the relationship between greenhouse gas emissions and financial performance by enabling firms to achieve superior profitability with comparatively lower environmental impacts (Grisales et al., 2020).

Hypothesis 3: EMS moderates the inverse U-shaped relationship between GHG and CFP such that the adverse effect of higher GHG on CFP is weaker for firms adopting EMS.

2.2.4 Environmental Management Systems and Environmental Performance

The development of environmental capabilities not only improves firms' financial outcomes but also enhances their environmental performance (Grewatsch & Kleindienst, 2015). Environmental performance reflects a firm's ability to minimise environmental impacts through efficient resource utilisation, pollution prevention, and reductions in greenhouse gas emissions. As environmental regulations become increasingly stringent, firms are expected to adopt structured environmental practices that facilitate continuous environmental improvement rather than merely comply with regulatory requirements (Grisales & Aguilera-Caracuel, 2019).

From the perspective of the Natural Resource-Based View, Environmental Management Systems represent strategic organisational capabilities that enable firms to improve environmental performance by institutionalising environmental management throughout their operations. Through systematic environmental planning, regular monitoring, internal audits, employee training, and continuous improvement initiatives, EMS encourages firms to identify opportunities to reduce emissions, improve energy efficiency, minimise waste generation, and adopt cleaner production technologies. Thus, embedding environmental management into organisational routines, EMS transforms environmental responsibility into an operational capability that supports continuous environmental improvement. Consequently, firms implementing Environmental Management Systems are expected to achieve superior environmental performance relative to firms without formal environmental management practices.

Hypothesis 4: EMS adoption positively influences environmental performance.

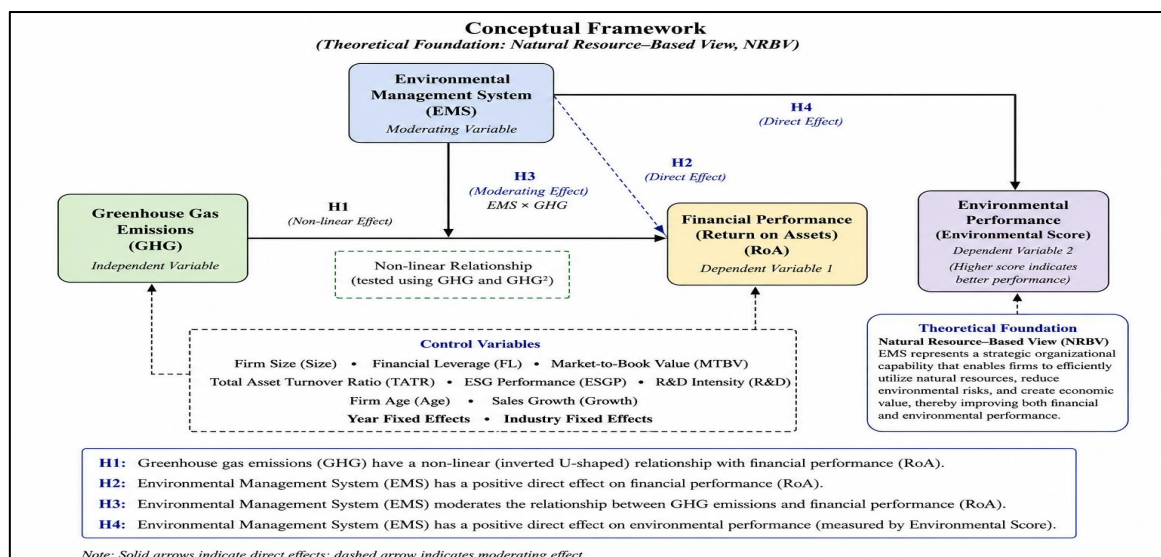


Figure 1: Conceptual Framework

3.Data and Methodology

3.1 Data

This study examines the relationship between greenhouse gas (GHG) emissions, Environmental Management Systems (EMS), and firm performance using a balanced panel of 92 A-listed Indian firms over the period 2017–2022, yielding 552 firm-year observations. Financial institutions, including banks and insurance companies, are excluded because of their distinct capital structures, regulatory frameworks, and relatively lower direct greenhouse gas emissions. Firm-level financial information was obtained from the Bloomberg database, while environmental variables, including greenhouse gas emissions, Environmental Management System (EMS) adoption, ESG scores, and Environmental Scores, were sourced from the Refinitiv ESG database. Firms with incomplete observations for the variables of interest were excluded to ensure consistency and reliability of the final sample.

Financial performance is measured using Return on Assets (ROA), calculated as net income divided by total assets. The primary explanatory variable is greenhouse gas emissions, measured as the natural logarithm of total greenhouse gas emissions ($\ln(\text{GHG})$). To examine the potential non-linear relationship between greenhouse gas emissions and financial performance, the squared term of greenhouse gas emissions ($\ln(\text{GHG})^2$) is included in the empirical specification. Environmental Management Systems (EMS) are measured as a dummy variable that equals one if a firm has adopted a formal Environmental Management System and zero otherwise. To examine the moderating role of EMS, an interaction term between EMS and greenhouse gas emissions ($\text{EMS} \times \ln(\text{GHG})$) is constructed. Environmental performance is measured using the Environmental Score obtained from Refinitiv ESG, where higher values indicate superior environmental performance.

Following prior environmental finance studies, several firm-specific characteristics are included as control variables to minimise omitted variable bias. These include Firm Size, measured as the natural logarithm of total assets; Financial Leverage (FL), calculated as total debt divided by total assets; Market-to-Book Value (MTBV), representing firms' growth opportunities; Total Asset Turnover Ratio (TATR), capturing operational efficiency; ESG Performance (ESGP), controlling for firms' overall sustainability performance; Research and Development (R&D) expenditure, reflecting innovation intensity; Firm Age, representing organisational maturity; and Growth, measured using annual sales growth. In addition, year fixed effects and industry fixed effects are incorporated to account for macroeconomic conditions and industry-specific heterogeneity.

3.2 Empirical Methodology

The study employs Panel Quantile Regression with Fixed Effects (PQR-FE) proposed by Powell (2022) to estimate the relationship between greenhouse gas emissions, Environmental Management Systems, and firm performance. Unlike conventional panel regression models that estimate the average conditional effect of explanatory variables, panel quantile regression allows the effects of greenhouse gas emissions to vary across different points of the conditional distribution of firm performance. This approach is particularly appropriate because firms with different levels of profitability may respond differently to environmental risks and sustainability practices.

The PQR-FE estimator controls for unobserved firm-specific heterogeneity while simultaneously estimating heterogeneous coefficients across the conditional distribution of the dependent variable. The analysis is conducted at the 10th, 25th, 50th, 75th, and 90th quantiles, enabling the study to examine whether the impact of greenhouse gas emissions and Environmental Management Systems differs between low-performing and high-performing firms. By capturing these heterogeneous effects, panel quantile regression provides richer insights than conventional mean regression models and offers a more comprehensive understanding of the relationship between environmental management and firm performance.

Therefore, to examine the non-linear relationship between greenhouse gas emissions and financial performance, the following baseline model is estimated:

$$CFP_{it} = \beta_0 + \beta_1 \ln(\text{GHG})_{it} + \beta_2 \ln(\text{GHG})_{it}^2 + \sum \beta_k \text{Controls}_{it} + \text{YearFE} + \text{IndustryFE} + \varepsilon_{it}$$

To examine whether Environmental Management System adoption moderates this relationship, the interaction model is estimated as follows:

$$CFP_{it} = \beta_0 + \beta_1 \ln(\text{GHG})_{it} + \beta_2 \ln(\text{GHG})_{it}^2 + \beta_3 \text{EMS}_{it} + \beta_4 (\text{EMS} \times \ln(\text{GHG}))_{it} + \sum \beta_k \text{Controls}_{it} + \text{YearFE} + \text{IndustryFE} + \varepsilon_{it}$$

Where, CFP_{it} represents firm financial performance (ROA and ROE), $\ln(\text{GHG})_{it}$ denotes the natural logarithm of greenhouse gas emissions, and $(\text{GHG})_{it}^2$ captures the non-linear effect of emissions. EMS_{it} is a dummy variable equal to one if the firm has adopted an Environmental Management System and zero otherwise.

The interaction term $(EMS \times \ln(GHG))_{it}$ captures whether EMS changes the relationship between GHG emissions and financial performance. The control variables include firm size, financial leverage, market-to-book value, total asset turnover ratio, ESG performance, R&D intensity, firm age, growth, year effects, and industry effects.

The turning point for non-EMS firms is calculated as:

$$TP_{Non-EMS} = -\frac{\beta_1}{2\beta_2}$$

For EMS firms, the coefficient of $\ln(GHG)$ becomes $(\beta_1 + \beta_4)$. Therefore, the turning point for EMS firms is calculated as:

$$TP_{EMS} = -\frac{\beta_1 + \beta_4}{2\beta_2}$$

The turning point indicates the level of GHG emissions at which ROA reaches its maximum before the marginal effect of emissions becomes negative.

Further, to examine the direct effect of Environmental Management Systems on environmental performance, the following model is estimated:

$$EP_{it} = \alpha_0 + \alpha_1 EMS_{it} + \sum \alpha_k Controls_{it} + YearFE + IndustryFE + \mu_{it}$$

Where, Environmental Performance (EP) is measured using the Refinitiv Environmental Score, with higher values indicating superior environmental performance. The remaining variables are defined as above.

4. Results and Discussion

Table 1 presents the descriptive statistics for the variables used in the study. The sample comprises 552 firm-year observations of Indian A-listed firms over the period 2017–2022. The average ROA and ROE are 8.831% and 15.832%, respectively,

indicating overall positive financial performance, although the relatively large standard deviations suggest considerable variation across firms. The mean value of $\ln(GHG)$ is 2.581, with substantial dispersion, indicating heterogeneity in firms' greenhouse gas emissions. Approximately 50.2% of the sampled firms have adopted an Environmental Management System (EMS), providing a balanced sample for comparing EMS and non-EMS firms. Among the control variables, the average Firm Size is 5.512, indicating moderate variation in firm scale across the sample. Financial Leverage (FL) averages 21.741%, although the relatively large standard deviation (18.836) suggests substantial differences in financing decisions among firms. The average Market-to-Book Value (MTBV) of 5.232 indicates that the sampled firms generally possess favourable growth opportunities, while the mean Total Asset Turnover Ratio (TATR) of 0.857 reflects differences in operational efficiency across firms.

The average ESG Performance Score (ESGP) is 50.971, with values ranging from 26.647 to 75.777, indicating considerable variation in firms' sustainability performance. The mean Firm Age of 1.600 (log-transformed) suggests that the sample predominantly consists of relatively mature firms. Approximately 52.7% of the firms report Research and Development (R&D) expenditure, reflecting a balanced distribution between innovative and non-innovative firms. Finally, the average Growth rate is 12.159%, although the wide range (–36.491% to 111.068%) highlights substantial differences in firms' growth trajectories. Overall, the descriptive statistics indicate sufficient cross-sectional variation in both financial and environmental variables, supporting the suitability of the sample for examining the non-linear relationship between greenhouse gas emissions and financial performance and the moderating role of Environmental Management Systems.

Table 1: Descriptive Statistics

Variables	N	Mean	SD	Min	Max
ROA	552	8.831	7.680	-8.383	29.885
ROE	552	15.832	13.582	-36.238	53.659
$\ln(GHG)$	552	2.581	1.132	0.431	4.799
$\ln(GHG)Sq$	552	7.941	6.407	0.186	23.027
EMS	552	0.502	0.500	0.000	1.000
Firm Size	552	5.512	0.552	4.337	6.903
FL	552	21.741	18.836	0.000	76.417
MTBV	552	5.232	5.919	0.357	36.378
TATR	552	0.857	0.504	0.106	2.497
ESGP	552	50.971	10.749	26.647	75.777
Firm Age	552	1.600	0.275	0.699	2.061
R&D	552	0.527	0.500	0.000	1.000
Growth	552	12.159	21.910	-36.491	111.068

Notes: This table reports the descriptive statistics for the variables used in the empirical analysis.

Source: Authors' calculations based on data obtained from Refinitiv ESG and Bloomberg.

Table 2 reports the Panel Quantile Regression results examining the non-linear relationship between greenhouse gas (GHG) emissions and corporate financial performance. Across all quantiles of both ROA and ROE, the coefficient of Ln (GHG) is positive and statistically significant, while the coefficient of Ln (GHG)² is negative and significant at the 1% level. These findings provide strong evidence of an inverse U-shaped relationship between GHG emissions and financial performance (Gerged et al., 2020; Trumpp & Guenther, 2015), thereby supporting Hypothesis 1. The results suggest that moderate increases in GHG emissions, associated with production expansion and economies of scale, initially enhance financial performance (Fujii et al., 2012; Tzouvanas et al., 2019). However, beyond a critical threshold, additional emissions reduce profitability as environmental compliance costs, operational inefficiencies, and stakeholder pressures outweigh production-related benefits (Delmas et al., 2015; Wang et al., 2013).

The estimated turning points further indicate that the optimal level of GHG emissions differs across performance quantiles (Gerged et al., 2020). For ROA, the turning points range from 3.38 at the lower quantile to 2.59 at the higher quantile, while for ROE they vary between 2.42 and 3.15. These findings imply that firms with stronger financial performance reach the optimal emission level at relatively lower GHG emissions, highlighting the importance of balancing production efficiency with environmental sustainability. Overall, the results are consistent with the Natural Resource-Based View (Hart, 1995; Hart & Dowell, 2010), which argues that environmental capabilities enhance firm performance only up to the point where the benefits of production expansion are exceeded by the costs associated with environmental degradation.

Figure 2 provides a graphical representation of the estimated quadratic relationship between GHG emissions and financial performance. The figure clearly illustrates the inverse U-shaped pattern, where financial performance initially increases with GHG emissions, reaches an optimal turning point, and subsequently declines as emissions continue to rise.

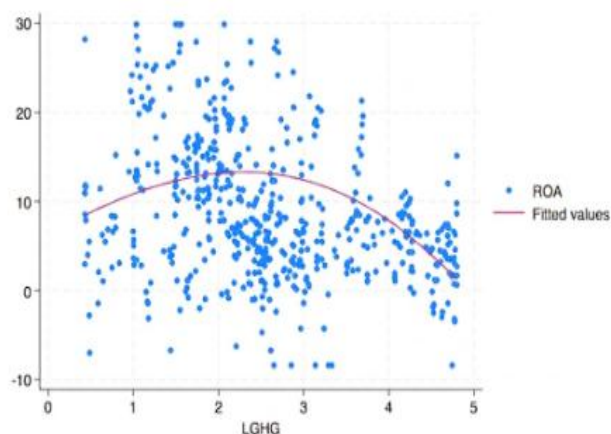
Table 2: The Non-Linear Relationship Between GHG and Corporate Financial Performance

Variables	ROA (Low)	ROA (Mid)	ROA (High)	ROE (Low)	ROE (Mid)	ROE (High)
ln(GHG)	2.23*** (0.17)	1.93*** (0.11)	2.64** (0.19)	1.07** (0.28)	2.32** (0.13)	7.77** (0.3)
Ln(GHG)Sq	-0.33*** (0.02)	-0.36*** (0.02)	-0.51*** (0.0)	-0.17** (0.08)	-0.48** (0.01)	-1.3** (0.0)
Firm Size	1.47** (0.056)	0.80*** (0.05)	3.29** (0.07)	3.86*** (0.2)	3.55** (0.06)	2.97** (0.1)
FL	-0.17*** (0.00)	-0.15*** (0.00)	-0.17** (0.00)	-0.11** (0.00)	-0.03* (0.00)	-0.02* (0.0)
MTBV	0.42** (0.007)	0.41** (0.002)	0.33** (0.00)	0.64** (0.01)	0.61** (0.01)	0.72** (0.0)
TATR	3.42*** (0.13)	4.73** (0.071)	4.71** (0.04)	10.9** (0.23)	11.6** (0.11)	11.6** (0.0)
ESGP	-0.0037 (0.00)	-0.0013 (0.00)	-0.002 (0.00)	-0.040* (0.0)	0.07** (0.0)	-0.04* (0.0)
R&D	1.12*** (0.08)	0.69*** (0.04)	0.37** (0.04)	1.08** (0.12)	1.96** (0.07)	-0.26* (0.1)
Firm Age	0.26*** (0.07)	-0.91*** (0.12)	-2.43** (0.26)	1.66*** (0.2)	-2.95** (0.12)	-3.7** (0.2)
Growth	0.024*** (0.0)	0.025** (0.0)	0.008* (0.00)	-0.009 (0.00)	0.0019 (0.00)	-0.01* (0.0)
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	552	552	552	552	552	552
Turning Point	3.38	2.68	2.59	3.15	2.42	2.99

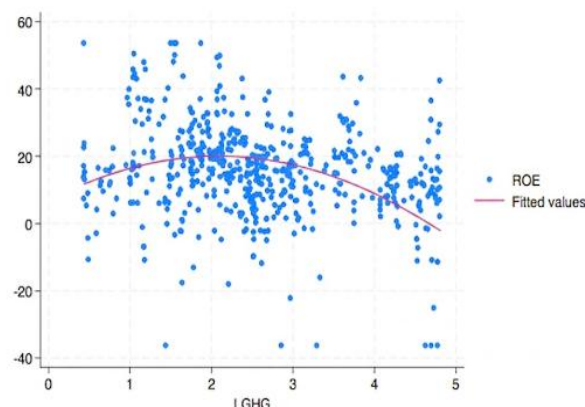
Notes: Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All models include year and industry fixed effects.

Source: Authors' calculations based on data obtained from Refinitiv ESG and Bloomberg.

Non-Linear Relationship between GHG and ROA



Non-Linear Relationship between GHG and ROE

**Figures 2: Inverse U-shaped relationship between greenhouse gas (GHG) emissions and CFP.**

Notes: The figure illustrates the estimated quadratic relationship between greenhouse gas emissions and corporate financial performance based on the Panel Quantile Regression estimates.

Source: Authors' illustration based on Panel Quantile Regression estimates

Table 3 reports the Panel Quantile Regression results examining the moderating role of Environmental Management Systems (EMS) in the relationship between greenhouse gas (GHG) emissions and financial performance (Camilleri, 2022). Consistent with H2, the coefficient of EMS is positive and statistically significant across most ROA quantiles (Chowdhury et al., 2018; Saizarbitoria & Landín, 2011), indicating that firms adopting Environmental Management Systems achieve superior financial performance than non-adopting firms (Brammer et al., 2011). This finding supports the Natural Resource-Based View (NRBV), which posits that structured environmental management enhances organizational capabilities through improved resource efficiency, pollution prevention, and operational effectiveness.

The interaction term ($EMS \times \ln(GHG)$) is negative and statistically significant across all ROA quantiles, providing strong support for H3 (Grisales et al., 2020). The results suggest that EMS weakens firms' dependence on emission-intensive production by reducing the positive marginal effect of GHG emissions on financial performance (Fujii et al., 2012; Tzouvanas et al., 2019). The turning-point analysis further reinforces this finding. Firms adopting EMS exhibit lower turning points (2.93, 2.08, and 2.29) than non-EMS firms (3.44, 2.98, and 2.82), indicating that EMS enables firms to attain maximum financial performance at comparatively lower levels of greenhouse gas emissions. This evidence suggests that structured environmental management improves resource efficiency and operational performance, allowing firms to generate profitability without relying on progressively higher emission levels.

For ROE, the moderating effect is less consistent across quantiles. While the interaction term is

significant, the lower quantile does not satisfy the conditions for an inverse U-shaped relationship because the coefficient of $\ln(GHG)^2$ is positive, resulting in no economically meaningful turning point. Consequently, the moderating effect is interpreted primarily using the ROA results, which provide stronger and more consistent support for the proposed hypotheses.

The control variables in Table 3 are largely consistent with the findings reported in Table 2. Firm Size, Market-to-Book Value, and Total Asset Turnover Ratio exhibit positive and significant coefficients, suggesting that larger firms with stronger growth opportunities and greater operational efficiency achieve superior financial performance. Financial Leverage is consistently negative, indicating that higher debt levels adversely affect profitability. The effects of ESG Performance, R&D intensity, Firm Age, and Growth vary across quantiles but remain broadly consistent with the baseline model, confirming the robustness of the estimated relationship.

Table 4 presents the Panel Quantile Regression results examining the relationship between Environmental Management Systems (EMS) and environmental performance. The coefficient of EMS is positive and statistically significant across all quantiles, providing strong support for Hypothesis 4. The findings indicate that firms adopting Environmental Management Systems achieve significantly higher environmental performance than non-adopting firms (Grewatsch & Kleindienst, 2015). This suggests that structured environmental management enhances firms' ability to improve environmental practices through better resource management, pollution prevention, and continuous

environmental improvement, consistent with the Natural Resource-Based View (NRBV).

The control variables generally exhibit consistent effects across quantiles. Firm Size and R&D are positively associated with environmental performance, indicating that larger and more innovative firms achieve higher Environmental Scores.

Market-to-Book Value is consistently negative, while the effects of Financial Leverage, Total Asset Turnover Ratio, Firm Age, and Growth vary across quantiles, reflecting differences in firms' environmental performance across the conditional distribution.

Table 3: The Non-Linear Relationship Between GHG and Corporate Financial Performance using EMS as Moderating Variable

Variables	ROA (0.25)	ROA (0.50)	ROA (0.75)	ROE (0.25)	ROE(0.50)	ROE(0.75)
ln(GHG)	1.86*** (0.1)	0.53** (0.09)	2.31*** (0.14)	0.15 (0.08)	2.12*** (0.26)	4.54** (0.18)
Ln(GHG)Sq	-0.27* (0.02)	-0.08* (0.01)	-0.41* (0.02)	0.12** (0.01)	-0.55** (0.05)	-0.8** (0.03)
EMS	0.81** (0.26)	2.56*** (0.09)	0.28* (0.26)	2.55*** (0.18)	-2.47** (0.17)	-1.17** (0.2)
EMS* Ln(GHG)	-0.28** (0.07)	-0.90** (0.04)	-0.43** (0.08)	-0.88** (0.05)	0.79*** (0.06)	0.19* (0.081)
Firm Size	1.25** (0.07)	1.09** (0.06)	3.69*** (0.1)	4.06** (0.071)	3.18** (0.079)	3.49** (0.03)
FL	-0.16** (0.0)	-0.15** (0.0)	-0.18** (0.00)	-0.12*** (0.0)	-0.02** (0.00)	-0.01** (0.0)
MTBV	0.39*** (0.00)	0.35** (0.00)	0.32** (0.004)	0.54** (0.008)	0.68** (0.006)	0.64** (0.00)
TATR	3.59*** (0.1)	5.06** (0.05)	4.59** (0.04)	11.5*** (0.04)	11.5*** (0.12)	12.6** (0.12)
ESGP	0.012** (0.0)	-0.01** (0.0)	-0.004 (0.00)	-0.047** (0.0)	0.08** (0.00)	-0.03** (0.0)
R&D	0.49** (0.06)	0.81** (0.05)	-0.04 (0.065)	1.68** (0.05)	1.67*** (0.12)	-0.22 (0.12)
Firm Age	-0.28* (0.09)	-0.37** (0.1)	-1.84** (0.17)	-0.037 (0.19)	-2.08** (0.17)	-2.4** (0.34)
Growth	0.024** (0.0)	0.014** (0.0)	0.004* (0.00)	-0.004* (0.0)	-0.001 (0.00)	-0.002 (0.0)
Time Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effect	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	552	552	552	552	552	552
Turning Point EMS	2.93	2.08	2.29	NR	2.65	2.96
Turning Point Non-EMS	3.44	2.98	2.82	NR	1.93	2.84

Notes: Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All models include year and industry fixed effects.

Source: Authors' own calculation

Table 4: The Relationship Between EMS and Environment Performance

Variables	ENV (Low)	ENV (Mid)	ENV (High)
EMS	7.02*** (0.26)	7.86*** (0.24)	5.23*** (0.25)
Firm Size	11.0*** (0.22)	11.2*** (0.22)	10.3*** (0.51)
FL	0.015 (0.012)	0.085*** (0.0085)	-0.036** (0.013)
MTBV	-0.63*** (0.022)	-0.61*** (0.029)	-0.46*** (0.058)
TATR	2.70*** (0.3)	-0.096 (0.77)	0.42 (0.98)
R&D	1.47*** (0.26)	6.64*** (0.51)	5.21*** (0.76)
Firm Age	5.79*** (0.22)	-2.50* (0.01)	0.048 (0.44)
Growth	-0.0042 (0.0029)	-0.061*** (0.0068)	-0.076*** (0.0094)
N	552	552	552

Notes: Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. All models include year and industry fixed effects.

Source: Authors' own calculations.

5. Conclusion, Implication and Future Research

Climate change has increased the importance of understanding how firms balance environmental responsibility with financial performance. Drawing upon the Natural Resource-Based View (NRBV), this study examined the non-linear relationship between greenhouse gas (GHG) emissions and financial performance. Additionally, we also assessed if Environmental Management Systems (EMS) influences both financial and environmental performance while moderating the GHG-financial performance relationship. Using a balanced panel of Indian A-listed firms from 2017 to 2022 and employing Panel Quantile Regression with Fixed Effects, the study provides evidence on the heterogeneous financial implications of environmental management practices.

The findings reveal that greenhouse gas emissions exhibit a significant inverse U-shaped relationship with financial performance, indicating that moderate levels of emissions associated with production expansion initially enhance profitability, whereas excessive emissions reduce financial performance as environmental costs. The study further demonstrates that firms adopting Environmental Management Systems achieve superior financial and environmental performance. Moreover, the moderating analysis shows that EMS weakens firms' dependence on emission-intensive production by reducing the emission threshold at which financial performance reaches its maximum. These findings suggest that structured environmental management enables firms to generate superior financial outcomes through greater resource efficiency rather than increased environmental impact.

The study makes several theoretical contributions. First, it extends the Natural Resource-Based View by demonstrating that environmental capabilities not only improve organizational performance directly but also reshape the relationship between environmental risk and financial outcomes. Second, by estimating the turning point of the non-linear relationship, the study advances the environmental finance literature beyond conventional linear analyses and provides a more nuanced understanding of how the financial implications of greenhouse gas emissions evolve as emission levels increase. Third, the findings establish Environmental Management Systems as strategic organizational capabilities that facilitate sustainable value creation by simultaneously enhancing financial and environmental performance.

The study also offers important managerial implications. Managers should recognize that environmental investments should not be viewed solely as compliance expenditures but as strategic capabilities that improve operational efficiency and long-term profitability. The estimated turning points provide practical guidance regarding the emission

levels beyond which additional emissions become economically detrimental, enabling firms to align production expansion with environmental sustainability. Furthermore, firms should prioritize the adoption of Environmental Management Systems as they promote cleaner production, improve resource utilization, strengthen environmental governance, and reduce dependence on emission-intensive growth strategies.

The findings also have important policy implications. Policymakers should encourage wider adoption of Environmental Management Systems through supportive regulatory frameworks, incentives, and capacity-building initiatives. Strengthening environmental disclosure requirements and promoting internationally recognized environmental management standards can improve corporate transparency while facilitating firms' transition towards sustainable production. Such initiatives would contribute to achieving national climate objectives without compromising corporate competitiveness or economic growth.

Despite its contributions, this study has several limitations. First, the analysis focuses exclusively on Indian listed firms, which may limit the generalizability of the findings to other institutional and regulatory environments. Second, the study measures Environmental Management Systems as a binary indicator and therefore does not capture differences in the maturity or effectiveness of implementation across firms. Third, although Panel Quantile Regression captures heterogeneity across firms, the analysis does not explicitly examine the dynamic evolution of environmental capabilities over time.

Future research may extend the analysis by conducting cross-country comparisons across developed and emerging markets to examine whether institutional quality influences the effectiveness of Environmental Management Systems. Future studies may also investigate the role of specific environmental regulations, carbon pricing mechanisms, and ESG-related governance practices in shaping the emissions-financial performance relationship. Finally, examining how digital technologies, artificial intelligence, and green innovation interact with Environmental Management Systems to improve both financial and environmental performance represents a promising avenue for future research.

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