Examining The Moderating Effects of the Multinational Corporations' Characteristics on the Link Between Carbon Emissions and Financial Performance

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ABSTRACT

This study investigates the moderating effects of firm-specific characteristics on the relationship between carbon emissions reduction strategies and financial performance among North American multinational corporations. Using panel regression models—including Pooled Least Squares (PLS), and Fixed Effects (FE)—the analysis focuses on two key financial indicators: Return on Equity (ROE), and Tobin's Q. The results reveal that leverage and capital intensity significantly moderate the impact of emissions strategies on ROE, with leverage showing a positive long-term interaction effect ($+0.327$, $p < 0.01$) and capital intensity exhibiting a negative long-term effect (-0.106, $p < 0.01$). ESG score consistently moderates the carbon's emissions–Tobin's Q relationship, thereby weakening market valuation responses (FE coefficient = -0.132, $p < 0.01$). Additionally, the short-term analyses indicate that emissions reduction strategies may reduce Tobin's Q (OLS coefficient = -0.249, $p < 0.01$), reflecting initial market skepticism, while simultaneously improving ROE ($+0.057$, $p < 0.01$) in the long-run, thereby suggesting internal efficiency gains. Firm size does not significantly moderate these relationships. The findings highlight the nuanced and time-dependent financial effects of sustainability initiatives, emphasizing the need for policymakers and investors to consider firm heterogeneity in evaluating the economic impact of carbon reduction efforts.

Keywords: *Finance, Multinational Corporations (MNCs), Moderating Effects, Carbon Emissions, Financial Performance, Sustainability Strategies, and Firm Characteristics*

INTRODUCTION

The escalating urgency surrounding global climate change has propelled corporate carbon reduction strategies to the forefront of both environmental and economic discourse. Multinational corporations (MNCs), especially those headquartered in North America, are increasingly under pressure to embed sustainability within their core operations. With their vast global footprints and substantial resource consumption, MNCs hold considerable influence in achieving international climate goals and mitigating the environmental crises of the 21st century. Even before 2015, the growing scientific consensus about human-induced greenhouse gas (GHG) emissions had triggered widespread calls for environmental action (IPCC, 2021). While early corporate efforts to reduce emissions emerged in response, they were often fragmented, voluntary, and primarily motivated by corporate social responsibility (CSR) rhetoric rather than enforceable mandates. In the absence of strong regulatory frameworks and amid modest stakeholder expectations, many companies approached sustainability as a reputational tool rather than a strategic priority. This highlighted the need for more robust governance structures to align business operations with environmental imperatives.

A major shift occurred in 2015 with the adoption of the Paris Agreement, which united nations around the goal of limiting global warming to well below 2°C—and preferably to 1.5°C—above pre-industrial levels. Achieving this would require deep reductions in emissions across all sectors and a global move toward net-zero emissions by 2050 (UNFCCC, 2015). Importantly, the agreement acknowledged the essential role of the private sector, prompting governments and businesses to intensify their climate commitments. North American corporate giants such as Google, Microsoft, and Walmart responded with bold pledges for carbon neutrality and significant investments in renewable energy. However, the path to integrating carbon neutrality into business strategies was fraught with challenges. Financial uncertainties posed by high initial costs of green technologies, such as renewable infrastructure and energy-efficient systems, created tensions with traditional financial objectives (Arena et al., 2018). Moreover, inconsistencies in regional policies—such as differing carbon pricing schemes across Canadian provinces—further complicated multinational operations (Winter, 2020). Technological limitations also remained a barrier, especially in sectors lacking scalable decarbonization solutions.

In spite of these obstacles, the Paris Agreement catalyzed a new era of corporate climate action. It provided clarity and direction, encouraging MNCs to align their long-term goals with global climate objectives. Governments introduced tax incentives and subsidies to ease the financial burden of transitioning to low-carbon systems, while new financial tools like green bonds and sustainability-linked loans offered incentives for environmental performance (Logutov, 2023). As a result, the period between 2015 and 2020 witnessed a sharp rise in stakeholder expectations. The 2017 Carbon Majors Database revealed that a small number of corporations were responsible for a disproportionate share of global emissions, spurring public pressure for greater transparency and accountability (Jones et al., 2017). Investors began incorporating environmental, social, and governance (ESG) criteria into financial analyses, driven by awareness of the regulatory and reputational risks associated with poor environmental performance. Concurrently, consumers—particularly younger generations—increasingly preferred sustainable products, reinforcing market incentives for corporate environmental responsibility (Arena et al., 2018).

Between 2020 and 2023, climate action among MNCs accelerated further. The COVID-19 pandemic exposed global vulnerabilities and reinforced the necessity for resilient and sustainable economic systems (Bui & De Villiers, 2017). Sustainability became a cornerstone of many national recovery strategies, supported by stronger regulations and expanded green incentives. Initiatives such as the European Green Deal and U.S. green energy policies demonstrated this shift in global economic governance (Nepal et al., 2024). While some MNCs achieved cost savings through energy efficiency and circular economy practices, others—especially in high-emission industries—faced steep implementation costs and operational disruptions (Bhattacharyya & Khan, 2023). Nevertheless, sustainability emerged as a core strategic driver. MNCs increasingly adopted science-based targets (SBTs), bolstered ESG reporting, and implemented advanced carbon accounting systems to demonstrate alignment with global climate goals (Zhao et al., 2022). These measures not only improved transparency and stakeholder trust but also supported data-driven decision-making.

In the face of this progress, balancing ambitious environmental goals with economic performance remains a critical challenge. While nearly 65% of North American MNCs had set emission reduction targets by 2020—many aiming for net-zero by 2050—the financial and operational complexities of implementation persist (Busch et al., 2022). The adoption of renewable energy, energy-efficient technologies, and carbon capture systems often entails significant upfront capital investments, sometimes exceeding $100 million for large firms. This is particularly burdensome for capital-intensive sectors like manufacturing (He, Tang, & Wang, 2013). Meanwhile, consumer demand, investor scrutiny, and market competition continue to drive MNCs toward sustainability, with 72% of major North American corporations now publishing environmental disclosures (Jones et al., 2021). Analytical tools such as life cycle assessments (LCA) and science-based targets have become essential for tracking progress and ensuring compliance with global standards.

Although a significant research gap remains in understanding how the unique characteristics of MNCs influence the relationship between their carbon emissions and financial performance. While existing literature has explored the broad effects of sustainability on corporate outcomes, few studies have examined how factors such as firm size, industry sector, geographic diversification, and governance structures moderate this relationship. These characteristics are especially relevant for MNCs operating across multiple regulatory and cultural contexts, where environmental and financial decisions must be carefully calibrated. Without a nuanced understanding of these moderating effects, policymakers and business leaders risk implementing one-size-fits-all strategies that fail to address the complex realities of multinational operations. Therefore, examining how MNC-specific attributes shape the emissions–performance link is critical for developing effective, tailored approaches to corporate sustainability that balance environmental responsibility with economic viability.

LITERATURE REVIEW

Financial Performance Metrics in Multinational Corporations

Financial performance metrics are crucial for assessing the effectiveness of carbon emission reduction strategies in multinational corporations (MNCs). These metrics reflect a company's short-term and long-term financial health, providing insights into how sustainability initiatives influence profitability, efficiency, and market valuation. In their study, Zamil and Hassan (2019) and Delmas et al. (2015) ROE evaluates how effectively a company uses shareholder investments to generate profit. Ganda and Milondzo (2018) also found a negative

relationship between carbon emissions and ROE, indicating that firms with high emissions face reduced profitability due to regulatory penalties and reputational risks. ROE measures the efficiency of generating profit from sales revenue. Rokhmawati et al. (2017) demonstrated a positive association between GHG emission reductions and ROE, emphasizing that eco-friendly practices resonate with consumers and enhance revenue generation. Tobin's Q, a market-based metric, measures the ratio of a company's market value to its replacement cost of assets. Delmas et al. (2015) found that while emission reductions may initially decrease operational metrics, such as ROE, they positively influence Tobin's Q by improving investor confidence and market valuation. Stock performance reflects investor sentiment and market perception. Wen et al. (2020) found that participation in carbon markets positively impacts stock returns, driven by reduced regulatory risks and an enhanced market reputation.

Carbon Emission Reduction Strategies

Carbon emission reduction strategies are components of corporate sustainability efforts, particularly for multinational corporations (MNCs), which significantly contribute to global greenhouse gas (GHG) emissions. These strategies encompass various initiatives to minimize carbon footprints, align corporate practices with environmental goals, and address stakeholder demands for accountability and transparency (see Figure 2.1 for more details).

Ganda (2018) examines the relationship between carbon emission reduction strategies and firm performance in the South African mining sector. The study highlights that implementing energy-efficient technologies and transitioning to cleaner energy sources can significantly enhance operational efficiency while reducing carbon footprints. Ganda emphasizes that these strategies contribute to environmental sustainability and improve profitability through cost savings and regulatory compliance.

Intersection of Carbon Emission Strategies and Financial Performance

The intersection of carbon emission strategies and financial performance underscores the intricate relationship between sustainability initiatives and economic outcomes in multinational corporations (MNCs). This relationship varies based on the type of strategy, implementation costs, and time horizon. Carbon emission reduction strategies often involve high upfront costs for technology upgrades, process optimization, and compliance efforts.

Delmas et al. (2015) and Nguyen (2018) emphasized that these initial expenses can strain profitability metrics, such as ROA and ROI. However, operational efficiencies and regulatory compliance can help offset some of these costs, resulting in moderate short-term financial benefits (Damert et al., 2017). In the long term, carbon reduction strategies contribute to sustained financial gains by enhancing brand reputation, mitigating climate-related risks, and improving market valuation. Borghei et al. (2018) found that GHG disclosures positively influence financial performance in subsequent years, aligning with investor demands for transparency and accountability. Similarly, Delmas et al. (2015) reported that improved environmental performance increases Tobin's Q, demonstrating long-term market confidence. The financial impact of carbon strategies varies across industries. In highly regulated sectors like energy and manufacturing, proactive sustainability practices lead to competitive advantages by mitigating regulatory risks (Clarkson et al., 2015; Wen et al., 2020).

Conversely, in less regulated industries, the financial benefits of carbon strategies may be limited due to lower stakeholder pressure (Ganda & Milondzo, 2018). Investors and markets increasingly value companies with strong carbon management practices. Wen et al. (2020) observed that firms participating in carbon markets experience higher stock returns, reflecting a reduction in carbon risk and increasing investor confidence. However, Griffin et al. (2017) highlighted that markets penalize firms with poor GHG performance, underscoring the need for transparency in carbon disclosures. Sustainability practices, such as adopting energy-efficient technologies and optimizing supply chains, directly reduce costs and enhance operational efficiency. Shrivastava (1995) and Porter and Linde (1995) argue that well-designed sustainability initiatives drive innovation, reduce transaction costs, and improve profitability.

Case Studies of Carbon Emission Reduction Strategies in North America

Walmart: Sustainable Supply Chain Initiatives

Walmart, one of the largest multinational retailers in North America, has integrated carbon emission reduction into its core operational strategies. The company's Project Gigaton, launched in 2017, aims to reduce one billion metric tons of greenhouse gas (GHG) emissions from its global supply chain by 2030. This initiative focuses on sustainable supply chain management, including optimizing logistics, reducing packaging waste, and promoting the adoption of renewable energy among suppliers.

Walmart's commitment to sustainability aligns with the findings of Damert et al. (2017), which emphasize that energy-efficient practices and supply chain optimization lead to operational cost savings and improved profitability. Furthermore, the company's emphasis on transparent carbon reporting reflects Borghei et al.'s (2018) assertion that GHG disclosures enhance stakeholder trust and long-term financial performance.

Tesla: Innovation in Renewable Energy and Electric Vehicles

Tesla, a North American leader in clean energy and electric vehicle manufacturing, has built its business model around reducing carbon emissions. By developing proprietary battery technologies and renewable energy solutions, Tesla has positioned itself as a pioneer in sustainable innovation. Tesla's strategy demonstrates the principles outlined by Porter and Linde (1995), which argue that well-structured sustainability initiatives drive innovation and competitive advantage. The company's market success and stock performance align with Wen et al.'s (2020) findings, which indicate that firms actively participating in carbon reduction initiatives tend to enjoy higher stock returns and market valuations.

Microsoft: Carbon Negativity Commitment

Microsoft has pledged to achieve carbon negativity by 2030 and eliminate all carbon emissions it has generated since its founding by 2050. This commitment includes investments in renewable energy, carbon capture technologies, and sustainability-focused innovations. Microsoft's approach aligns with Shrivastava's (1995) argument that proactive compliance with sustainability goals fosters innovation and operational efficiency. Additionally, Griffin et al. (2017) suggest that firms with strong carbon management practices attract investor confidence, which is reflected in Microsoft's robust market performance and ESG ratings.

ExxonMobil: Navigating Carbon Regulation in the Energy Sector

ExxonMobil, one of the largest energy corporations in North America, has faced significant scrutiny over its carbon emissions. The company has invested in carbon capture and storage (CCS) technologies to comply with regulatory requirements and has participated in carbon offset programs. While ExxonMobil's efforts align with regulatory compliance, studies like Clarkson et al. (2015) caution that firms in highly regulated industries may face increased costs associated with carbon management. However, by adopting proactive strategies, ExxonMobil aims to mitigate regulatory risks and maintain its market position.

General Motors: Transition to Electric Vehicles

General Motors (GM) has committed to achieving carbon neutrality by 2040 and plans to phase out internal combustion engine vehicles by 2035. The company has significantly invested in electric vehicle (EV) development and renewable energy to reduce its carbon footprint. GM's transition aligns with findings from Delmas et al. (2015), which indicate that emission reduction efforts may initially impact operational metrics, such as ROA, but ultimately contribute to long-term market valuation. GM's focus on renewable energy and innovation reinforces Borghei et al.'s (2018) findings that carbon-related disclosures and initiatives positively influence financial outcomes over time.

These case studies highlight North American MNCs' diverse approaches to integrating carbon emission reduction strategies into their operations. While the financial implications vary based on industry, strategy, and regulatory environment, these companies demonstrate that sustainability initiatives can align with environmental and financial objectives, supporting long-term resilience and growth.

METHODOLOGY

This study employs a panel regression approach to investigate how firm-level characteristics moderate the relationship between carbon emissions reduction strategies—measured by emissions scores—and financial performance indicators such as Return on Equity (ROE), Return on Assets (ROA), and Tobin's Q in North American multinational corporations (MNCs) over a 10-year period. Panel regression is a robust econometric

technique suitable for longitudinal data involving multiple firms observed across time, allowing control for both firm-specific effects and temporal dynamics (Baltagi, 2005; Hsiao, 2003). This method overcomes limitations of purely cross-sectional or time-series models by capturing heterogeneity across entities and time periods.

The analytical framework integrates fixed effects and pooled least squares (PLS) regression models, augmented with interaction terms to assess the moderating influence of key firm characteristics, namely ESG scores, firm size (log-transformed), financial leverage, and capital intensity. The choice of fixed or random effects models follows standard specification tests to best control for unobserved heterogeneity and time-invariant factors within firms (Siddique et al., 2021). The research question operationalized in this design is: *How do MNC characteristics moderate the effect of carbon emissions reduction strategies on short- and long-term financial performance as measured by ROE, ROA, and Tobin's Q?* Correspondingly, the hypothesis tested states: *At least one firm characteristic significantly moderates the relationship between carbon emissions strategies and financial performance.*

The sample consists of 103 North American MNCs representing a diverse range of industries—including manufacturing, technology, energy, finance, and consumer goods—selected based on operational scale, sector representation, and regional influence. Secondary data were obtained from multiple authoritative financial and sustainability databases, including Refinitiv Eikon (Refinitiv, 2023), Capital IQ, Bloomberg (2023), Thomson Reuters, and S&P Capital IQ (Thomson Reuters, 2024; S&P Global, 2024). These sources provide comprehensive financial metrics—ROE, ROA, Tobin's Q—and emissions scores, as well as ESG ratings and firm-specific financial indicators essential for modeling and interaction analysis (Damodaran, 2021; Berk & DeMarzo, 2020; Eccles et al., 2014).

Dependent Variable: Financial Performance

The dependent variable in this study is Financial Performance. Financial performance is assessed using traditional accounting and value-based measures. Traditional accounting measures, such as Return on Equity (ROE), provides a historical perspective on a company's profitability and operational efficiency. At the same time, Tobin's Q captures a firm's value-based measure. Using traditional and value-based measures provides a more comprehensive understanding of financial performance. Traditional measures focus on short-term profitability, whereas value-based measures capture the long-term economic value created for shareholders. This dual perspective is especially relevant when evaluating the impact of carbon emissions reduction strategies on financial performance (Eccles et al., 2014).

Return on Equity (ROE), often classified as both a traditional and a value-based measure, is particularly useful for evaluating long-term shareholder value. It is a key metric for growth-focused investors seeking insights into capital returns (Damodaran, 2021). It is calculated by dividing net income by shareholders' equity.

Tobin's Q measures a company's market value relative to its asset value.

The formula for Tobin Q $= \dfrac{Market\ Value\ Assets}{Replacement\ of\ Cost\ of\ Assets}$

Simplified Version $= \dfrac{Market\ Value\ of\ Equity + Book\ Value\ of\ debt}{Book\ value\ of\ Assets}$

Where,

Market value of Equity (MVE) = Share price multiplied by number of outstanding shares (i.e., Share price * number of outstanding shares), Book Values of Total debt (D) = short-term debt plus long-term debt (i.e., Short-term debt + long term debt), and A= Book value of Assets.

$$Tobin's\ Q = \frac{MVE + D}{A}$$

Tobin's Q helps investors decide whether to invest in a company. It is also used to estimate the fair value of the stock market as a whole (AccountingInsights Team, 2024).

This approach is needed within the context of North American multinational corporations, as previous studies have typically focused on one set of measures without incorporating both perspectives (Edward et al., 2021). By applying this holistic evaluation, the study provides a more transparent and balanced understanding of how carbon reduction strategies impact financial outcomes. The findings aim to provide actionable insights for corporate managers, investors, and policymakers, thereby supporting more informed decision-making.

Independent Variables

Emission Score (CE): This is a proxy for Carbon emission reduction strategies. It is defined as a company's commitment and effectiveness in reducing environmental emissions in its production and operational processes (Refinitiv Ekon, 2023). Prior literature has used various measures to assess carbon emission reduction strategy such as total emissions (Matsumura et al., 2014; Wang et al., 2014), GHG emission-to-sales ratio (Gallego-Álvarez et al., 2014; Hassan & Romilly, 2018; Bui et al., 2020), sales-to-GHG emission ratio (Nishitani & Kokubu, 2012), and variation in GHG emissions (Gallego-Álvarez et al., 2015; Lewandowski, 2017). Emission score evaluation is based on publicly reported data and is designed to provide transparency and measure a company's performance in reducing carbon emissions (Ehlers et al., 2023; Kiesel & Schnitzler, 2024). Carbon emissions are considered a key indicator of a company's environmental impact. In the context of this study, it is hypothesized that a company's carbon emissions reduction strategy could directly affect its financial performance. Reducing carbon emissions might lead to cost savings, regulatory advantages, or improved corporate image, which could enhance financial performance (Makan & Kabra, 2021; Busch et al., 2022).

Control/Moderating Variables

This study examines four key control variables, which also serve as moderating factors in this study. The control/moderating variables include the following: ESG Scores, Company Size, Capital Intensity, and Leverage. These variables are selected due to their potential influence on the relationship between carbon reduction strategy and the financial performance of multinational corporations (MNCs) (Ibishova, Misund, & Tveteras, 2024). In traditional research, these variables (i.e., ESG Scores, Company Size, Capital Intensity, and Leverage) are treated as control variables. In contrast, in this particular research, the same variables are treated as moderating variables.

The ESG scores reflect a company's commitment to sustainable practices across environmental, social, and governance dimensions (Treepongkaruna et al., 2024). It is a proxy for the company's overall sustainability efforts, which could positively or negatively influence financial performance. Companies with higher ESG scores are generally associated with better long-term financial outcomes due to increased stakeholder trust, improved operational efficiency, and enhanced brand reputation (Borghei et al., 2018; Siddique et al., 2021).

Company size is often considered a moderating factor because larger companies may have different financial dynamics than smaller ones. Larger firms typically benefit from economies of scale, easier access to capital, and greater market power, which may affect their ability to implement carbon reduction strategies effectively. Additionally, larger companies often face greater stakeholder scrutiny, influencing their sustainability efforts and financial performance. Measures the amount of capital investment required to generate a dollar of revenue, calculated as Average Total Assets divided by Net Revenue (Adriana & Dewi, 2019; Nangih et al., 2020). Capital intensity measures the amount of capital investment required to generate a dollar of revenue, calculated as Average Total Assets divided by Net Revenue. Capital-intensive companies rely heavily on physical assets and may face higher costs when implementing carbon reduction initiatives (Kumar, 2018). As a result, their financial performance can be influenced by the degree of capital intensity. Companies with high capital intensity may have different cost structures and profitability potentials than those with lower capital intensity (Busch et al., 2022). Leverage measures the proportion of a company's capital from debt relative to equity. Highly leveraged firms may experience significant financial risks but could also benefit from the tax advantages of debt financing. Leverage can affect financial performance by influencing a company's cost of capital, risk profile, and ability to withstand economic downturns (Alsaifi et al., 2020; He et al., 2013).

While previous studies (Clarkson et al., 2011; Adriana & Dewi, 2019; Alsaifi et al., 2020; He et al., 2013; Nangih et al., 2020) have often treated these variables as control variables to minimize irrelevant influences, this research treats them as both control and moderate factors. This distinction is crucial as moderating factors influence financial outcomes and shape the strength and direction of the relationship between carbon reduction strategy and financial performance (Kumar, 2018; Busch et al., 2022). By recognizing the moderating roles of ESG Score, Company Size, Capital Intensity, and Leverage, the study addresses a significant gap in the literature and contributes to a comprehensive understanding of the financial outcomes of corporate sustainability initiatives.

Model Specification

The Panel Least Square regression (PLS) model was employed to analyze the research question and hypothesis. The PLS regression is specified below.

The PLS regression model is stated as $\quad L_{it} = f(K'_{it})$ ……………………………………….…(1)

Where L_{it} is the dependent variable and K'_{it} is the vector of the regressors (i.e., explanatory variables). Panel study in the model is denoted by it . The i is about the multinational corporations, while t is the time period. The model is composed of many companies or corporations (cross sections) over a period (e.g., 10 years).

The general model analyzing the moderating effect of multinational corporations' characteristics on the relationship between carbon emissions and financial performance is expressed as:

Financial Performance$_{it}$ = $\alpha_0 + \alpha_1 CES_{it} + \alpha_2 ESG_{it} + \alpha_3 SIZE_{it} + \alpha_4 CI_{it} + \alpha_5 LEV_{it} + \alpha_6 (CES \times ESG)_{it} + \alpha_7 (CES \times SIZE)_{it} + \alpha_8 (CES \times CI)_{it} + \alpha_9 (CES \times LEV)_{it} + \mu_{it}$

Where:

- CES_{it} = Carbon Emissions Score
- ESG_{it} = ESG performance score
- $SIZE_{it}$ = Size of the company (e.g., log of total assets)
- CI_{it} = Capital intensity
- LEV_{it} = Leverage ratio
- $(CES \times ESG)_{it}$, etc., represent the interaction (moderating) terms
- μ_{it} = error term

The three financial performance indicators considered are Tobin's Q, Return on Assets (ROA), and Return on Equity (ROE) (Adeniyi, 2025). The three model specifications are as follows:

TobinQ$_{it} = \alpha_0 + \alpha_1 CES_{it} + \alpha_2 ESG_{it} + \alpha_3 SIZE_{it} + \alpha_4 CI_{it} + \alpha_5 LEV_{it} + \alpha_6 (CES \times ESG)_{it} + \alpha_7 (CES \times SIZE)_{it} + \alpha_8 (CES \times CI)_{it} + \alpha_9 (CES \times LEV)_{it} + \mu_{it}$

ROA$_{it} = \alpha_0 + \alpha_1 CES_{it} + \alpha_2 ESG_{it} + \alpha_3 SIZE_{it} + \alpha_4 CI_{it} + \alpha_5 LEV_{it} + \alpha_6 (CES \times ESG)_{it} + \alpha_7 (CES \times SIZE)_{it} + \alpha_8 (CES \times CI)_{it} + \alpha_9 (CES \times LEV)_{it} + \mu_{it}$

ROE$_{it} = \alpha_0 + \alpha_1 CES_{it} + \alpha_2 ESG_{it} + \alpha_3 SIZE_{it} + \alpha_4 CI_{it} + \alpha_5 LEV_{it} + \alpha_6 (CES \times ESG)_{it} + \alpha_7 (CES \times SIZE)_{it} + \alpha_8 (CES \times CI)_{it} + \alpha_9 (CES \times LEV)_{it} + \mu_{it}$

To further address potential heterogeneity across firms and over time, a fixed-effects panel model was also specified. This model accounts for unobserved firm-specific and year-specific effects:

TobinQ$_{it} = \alpha_0 + \alpha_1 CES_{it} + \alpha_2 ESG_{it} + \alpha_3 SIZE_{it} + \alpha_4 CI_{it} + \alpha_5 LEV_{it} + \alpha_6 (CES \times ESG)_{it} + \alpha_7 (CES \times SIZE)_{it} + \alpha_8 (CES \times CI)_{it} + \alpha_9 (CES \times LEV)_{it} + +IndustryFixedEffect_i + YearFixedEffect_t + \varepsilon_{it}$

ROA$_{it} = \alpha_0 + \alpha_1 CES_{it} + \alpha_2 ESG_{it} + \alpha_3 SIZE_{it} + \alpha_4 CI_{it} + \alpha_5 LEV_{it} + \alpha_6 (CES \times ESG)_{it} + \alpha_7 (CES \times SIZE)_{it} + \alpha_8 (CES \times CI)_{it} + \alpha_9 (CES \times LEV)_{it} + +IndustryFixedEffect_i + YearFixedEffect_t + \varepsilon_{it}$

ROE$_{it} = \alpha_0 + \alpha_1 CES_{it} + \alpha_2 ESG_{it} + \alpha_3 SIZE_{it} + \alpha_4 CI_{it} + \alpha_5 LEV_{it} + \alpha_6 (CES \times ESG)_{it} + \alpha_7 (CES \times SIZE)_{it} + \alpha_8 (CES \times CI)_{it} + \alpha_9 (CES \times LEV)_{it} + +IndustryFixedEffect_i + YearFixedEffect_t + \varepsilon_{it}$

In the fixed effects models above, CES_{it} = Carbon Emission Score is the primary independent variable; ESG_{it}, $SIZE_{it}$, CI_{it}, and LEV_{it} are firm-specific characteristics acting as moderators; The interaction terms $(CES \times Moderator)_{it}$ examine how firm characteristics modify the impact of carbon emissions on financial performance; IndustryFE$_i$ and YearFE$_t$ control for unobservable industry- and time-specific heterogeneity; and ε is the stochastic error term. This fixed-effects specification is aligned with Millimet and Bellemare (2023), who advocate for its ability to manage heterogeneity bias. It is also consistent with Chen et al. (2023), who emphasized panel regression in assessing the long-term financial effects of corporate carbon reduction strategies.

RESULTS AND DISCUSSION

Table 1

Summary of Descriptive Summary of Study Variables

Variable	Mean	Standard Deviation	Skewness	Kurtosis
Tobin's Q	1.82	1.87	6.83	81.18
ROE	0.46	2.78	10.07	105.53
Independent Variable				
ESG Score	-0.52	0.62	-1.43	5.40
Moderating Factors				
Capital Intensity	0.99	0.67	2.70	11.18
Leverage	0.49	0.92	6.26	52.30
Firm Size (log)	9.81	1.53	0.49	3.66

The dataset spans from 2013 to 2023 with 103 firm-year observations. Tobin's Q, a measure of firm value, has a mean of 1.82, indicating that on average, firms are valued above their replacement cost. However, the high skewness (6.83) and kurtosis (81.18) reveal substantial variability and the presence of extreme outliers. Return on Equity (ROE) shows average values of 0.456, suggesting modest profitability among the firms. This metric (ROE) exhibits strong positive skewness and kurtosis, thereby pointing to some firms with very high profitability. Capital Intensity has a mean of 0.985, with a wide range, indicating significant differences in capital investment strategies across firms. The Emissions Score or ESG Score (log-transformed or standardized) is slightly negative on average (-0.52), with a left skew (-1.42), implying that more firms score below the mean in ESG performance. Leverage averages 0.485, indicating a moderate debt level relative to assets, though with right-skewed distribution and high kurtosis (52.30), implying some highly leveraged firms. Firm Size (log-transformed) has a mean of 9.81, with low skewness and kurtosis, suggesting it's relatively normally distributed.

Table 2

Moderating Effects on the Relationship Between Emissions Score and ROE (Using P-Values)

Moderator Variables	Interaction Term	p-value (OLS)	p-value (FE)
ESG Score	LEMISSION_SCORE* LESG_SCORE	0.2738	0.4138
Firm Size (log)	LEMISSION_SCORE* LFIRM_SIZE	0.7640	0.9412
Leverage	LEMISSION_SCORE* LEVERAGE	0.0000	0.0000
Capital Intensity	LEMISSION_SCORE* CAPITAL_INTENSITY	0.1191	0.0004

Table 2 presents the interaction effects between carbon emissions score and various multinational corporations' characteristics on Return on Equity (ROE), using both Ordinary Least Squares (OLS) and Fixed Effects (FE) estimators. The aim is to assess whether firm-level characteristics moderate the relationship between carbon emissions and financial performance, specifically ROE. Among the moderators tested— leverage, capital intensity, ESG score, and firm size—only leverage and capital intensity show statistically significant interaction effects in the fixed effects model.

Leverage emerges as a significant and positive moderator (p = 0.0000), indicating that firms with higher financial leverage experience greater returns on equity from carbon emissions reduction strategies. This suggests that leveraged firms, possibly due to increased scrutiny from lenders and stakeholders or the need to meet debt

obligations, may be more effective in translating sustainability efforts into improved financial performance. The positive interaction implies that these firms can leverage their environmental strategies to enhance shareholder value. In contrast, capital intensity shows a significant but negative interaction effect with emissions score ($p = 0.0004$). This indicates that more capital-intensive firms derive less financial benefit—in terms of ROE—from their emissions reduction efforts. High capital intensity often involves substantial fixed assets and infrastructure investments, which may limit the speed or magnitude of financial returns from environmental strategies. These firms may require longer investment horizons before seeing the financial payoff from sustainability initiatives.

On the other hand, ESG score and firm size do not exhibit significant moderating effects. Despite their positive or small coefficients, their respective p-values (ESG score = 0.4138; firm size = 0.9412) are well above conventional significance thresholds, suggesting that neither the overall ESG commitment of a firm nor its size meaningfully alters the relationship between carbon emissions and ROE in this context. Overall, these results support the rejection of the null hypothesis and affirm that firm-specific characteristics—particularly leverage and capital intensity—play a meaningful role in shaping how carbon emissions reduction strategies affect financial performance. This highlights the importance of considering organizational context when evaluating the business case for sustainability.

Table 3

Interaction Term Coefficients for Moderating Variables (PLS)-ROE

Moderator Variables	Interaction Term	Coefficient (OLS)	Coefficient (FE)
ESG Score	LEMISSION_SCORE * LESG_SCORE	–0.1883	+0.0568
Firm Size (log)	LEMISSION_SCORE * LFIRM_SIZE	+0.0205	–0.0019
Leverage	LEMISSION_SCORE * LEVERAGE	–0.4842	+0.3266
Capital Intensity	LEMISSION_SCORE * CAPITAL_INTENSITY	–0.1105	–0.1059

The results presented in Table 3 highlight how firm-specific characteristics moderate the relationship between carbon emissions scores and Return on Equity (ROE), with a focus on differences between short-term and long-term effects. In the short term, as captured by the pooled OLS model, leverage emerges as a statistically significant moderator with a negative coefficient (–0.4842). This suggests that firms with higher financial leverage may struggle to immediately convert emissions reduction strategies into improved ROE, likely due to short-term financial constraints or the upfront costs associated with sustainability initiatives. However, in the long term, as indicated by the fixed effects model, the sign of the leverage coefficient reverses to positive (+0.3266), while remaining significant. This shift implies that, over time, leveraged firms are better able to capitalize on emissions strategies, potentially due to improved operational efficiency, stakeholder trust, and long-term returns on sustainable investments. Capital intensity, which is not significant in the short term, becomes a significant and negative moderator in the fixed effects model (–0.1059). This suggests that firms with higher capital intensity experience reduced profitability from carbon reduction strategies over time, possibly because of the prolonged investment cycles and large fixed costs that slow financial returns.

In contrast, ESG score and firm size show no significant moderating effects in either the short or long term. Their coefficients are small and inconsistent in direction, and the associated p-values remain well above conventional thresholds, indicating a lack of influence on the emissions–ROE relationship. Overall, the findings emphasize that the financial effects of carbon emissions strategies are not uniform across all firms. Leverage plays a critical moderating role in both the short and long term, while capital intensity matters primarily over extended periods. These results underscore the need to account for corporate characteristics when assessing the effectiveness and financial implications of sustainability initiatives, particularly as they evolve over time.

Analysis of Moderating Effects on the Relationship Between Emissions Score and Tobin's Q

Table 4

Interaction Term Coefficients (Fixed Effects)-Tobin's Q

Moderator Variable	Interaction Term	Coefficient (OLS)	Coefficient (FE)
ESG Score	LEMISSION_SCORE * LESG_SCORE	–0.2486	–0.1319
Firm Size (log)	LEMISSION_SCORE * LFIRM_SIZE	+0.1764	+0.0594
Leverage	LEMISSION_SCORE * LEVERAGE	–0.0582	+0.0165
Capital Intensity	LEMISSION_SCORE * CAPITAL_INTENSITY	–0.1899	–0.0688

The moderating effects analysis presented in Table 4 examines how selected firm-level characteristics moderate the relationship between carbon emissions scores and Tobin's Q—a market-based measure of financial performance. The focus is on four moderators: ESG score, firm size, leverage, and capital intensity. The results, drawn from both pooled OLS and fixed effects (FE) panel regression models, offer insights into how these characteristics influence the emissions–Tobin's Q relationship. Across both models in Table 4, ESG score exhibits a negative interaction effect with emissions score (–0.2486 in OLS; –0.1319 in FE), suggesting that firms with higher ESG commitments may see a reduced positive effect—or even a dampening effect—of carbon emissions strategies on market valuation. One interpretation is that the market may already price in the ESG performance of these firms, thereby minimizing the marginal benefit of additional emissions reductions. However, without statistical significance values, we cannot determine whether this effect is meaningful or simply statistical noise.

Firm size, on the other hand, shows a positive interaction with emissions scores (+0.1764 in OLS; +0.0594 in FE), indicating that larger firms may derive slightly more value (in terms of Tobin's Q) from carbon reduction efforts. This could be because larger corporations have better resources, visibility, or stakeholder engagement mechanisms, allowing them to extract more reputational or financial value from sustainability strategies. However, the small magnitude of the fixed effects coefficient suggests the effect may be limited in the long term. Leverage presents a mixed and minimal effect. While the OLS model shows a negative coefficient (–0.0582), the fixed effects model indicates a slight positive interaction (+0.0165), implying that leverage has little to no consistent influence on how emissions reduction strategies affect Tobin's Q. These small coefficients suggest that financial structure does not strongly alter investor perceptions of sustainability-linked value creation in this context.

Finally, capital intensity consistently demonstrates a negative interaction effect (–0.1899 in OLS; –0.0688 in FE), indicating that capital-intensive firms may receive less market valuation benefit from emissions reductions. This may be due to high fixed costs and the longer timeframes needed for sustainability investments to yield visible returns, which may not be fully appreciated by the market in the short term or even in panel assessments. Overall, the results suggest that among the tested moderators, firm size may offer modest advantages in leveraging emissions strategies for market valuation, while capital intensity may limit those benefits. ESG commitment and leverage show less consistent or weaker moderating effects on Tobin's Q. This highlights that market-based financial outcomes from carbon reduction efforts are nuanced and may depend significantly on firm characteristics such as operational scale and capital structure.

Table 5

Interaction Term P-value (PLS)-Tobin's Q

Moderator Variable	Significant in OLS?	Significant in FE?	Interpretation
ESG Score	(p = 0.008)	(p = 0.000)	ESG score significantly weakens Tobin's Q response to emissions strategy
Firm Size (log)	(p = 0.011)	(p = 0.2754)	Moderation is significant in the short term but not robust over time
Leverage	(p = 0.5098)	(p = 0.7898)	No evidence that leverage moderates the emissions impact on Tobin's Q
Capital Intensity	(p = 0.008)	(p = 0.2693)	Capital intensity moderates in the short term but not significantly in the long term

The analysis presented in Table 5 evaluates whether firm-level characteristics moderate the relationship between carbon emissions strategies and Tobin's Q, a market-based measure of firm value. Using both Pooled OLS (short-term) and Fixed Effects (long-term) models, the findings reveal how ESG score, firm size, leverage, and capital intensity influence this relationship. ESG score emerges as a consistent and statistically significant moderator in both models (p = 0.008 in OLS; p = 0.000 in FE). However, the direction of the interaction indicates that higher ESG scores weaken the positive effect of emissions strategies on Tobin's Q. This may suggest that for firms already deeply engaged in ESG practices, additional improvements in carbon emissions may have diminishing marginal returns in terms of market valuation—perhaps because such improvements are expected and already priced in by investors.

Table 5 reveals that Firm size is a significant moderator in the short term (p = 0.011 in OLS), but this effect is not robust over time (p = 0.2754 in FE). This implies that while larger firms may initially gain greater investor recognition or reputational benefits from emissions reductions, these advantages may not persist in the long run. The market may adjust its expectations as sustainability becomes embedded in large firms' operations. Capital intensity also shows a statistically significant moderating effect in the short term (p = 0.008 in OLS), but this effect fades over time (p = 0.2693 in FE). This suggests that firms with high capital intensity may face delayed financial benefits from emissions reduction due to the long-term nature of investments in fixed assets and infrastructure.

Leverage, however, does not significantly moderate the relationship between emissions scores and Tobin's Q in either model (p = 0.5098 in OLS; p = 0.7898 in FE), indicating that a firm's debt level does not meaningfully influence how the market perceives its carbon reduction efforts. Because not all moderating variables show consistent or significant effects, the study fails to reject the null hypothesis (H_0)—meaning that only some firm-level characteristics significantly influence the emissions–Tobin's Q relationship. The strongest and most consistent moderator is the ESG score, reinforcing findings from prior literature (e.g., Eccles et al., 2014), which emphasize that the market's valuation of sustainability strategies is contingent on a firm's broader ESG commitment. These findings underscore the importance of firm-specific contexts—especially ESG engagement—when assessing the financial impact of environmental initiatives.

Table 6

Moderating Effects Across Financial Performance Measures

Moderator Variable	*Significant on ROE*	*Significant on Tobin's Q*	*Interpretation*
ESG Score	none	(Both OLS & FE)	ESG score consistently strengthens or influences emissions impact on market-based performance (Tobin's Q)
Firm Size (log)	none	(OLS only)	Moderation is short-term (Tobin's Q) but not robust across all models
Leverage	OLS & FE		Strong effect in ROE; not impactful for market value (Tobin's Q)
Capital Intensity	FE only	OLS only	Weakens the emissions impact mostly in ROE and short-term Tobin's Q

Table 6 provides a comparative summary of how various firm-level characteristics moderate the relationship between carbon emissions reduction strategies and three financial performance measures: Return on Equity (ROE), and Tobin's Q. The results indicate that each financial measure is significantly influenced by at least one moderating variable, leading to the rejection of the null hypothesis across all models. ESG score stands out as the most consistent moderator, significantly influencing Tobin's Q (in both OLS and Fixed Effects models). This suggests that a firm's broader ESG engagement enhances the effectiveness of emissions reduction strategies, particularly in strengthening the accounting-based performance market-based valuation (Tobin's Q). ESG commitment appears to be a reliable signal to investors and stakeholders, reinforcing the financial credibility of sustainability actions.

Firm size exhibits a more variable influence. It significantly moderates the Tobin's Q in the short term (OLS), but does not significantly affect ROE. This inconsistency suggests that the moderating role of firm size depends on both the time horizon and the type of financial metric considered. Larger firms may experience short-term reputational gains in market valuation but require more time for those benefits to be reflected in operational metrics.

Leverage plays a particularly important role in moderating ROE, where it is significant in both OLS and Fixed Effects models. This implies that highly leveraged firms may experience greater variation in equity returns based on the success of their emissions strategies, likely due to higher financial scrutiny and pressure to deliver shareholder value. However, leverage does not significantly affect Tobin's Q, indicating that capital structure does not materially influence investor perception of emissions efforts. Capital intensity is significant for ROE (in the long term) and for Tobin's Q (in the short term). The results indicate that capital-intensive firms tend to derive less financial benefit from emissions strategies, likely due to delayed payoffs and structural cost constraints associated with heavy investments in fixed assets.

Above all, the findings show that firm-specific characteristics—particularly ESG score, leverage, and capital intensity—play important but differentiated roles in shaping how carbon emissions strategies translate into financial performance. ESG engagement is a strong and consistent driver of both market and operational value, while leverage and capital intensity exert more influence on profitability metrics like ROE. These insights affirm that the effectiveness of sustainability efforts is highly context-dependent, underscoring the need for investors and managers to assess emissions strategies in light of firm-specific financial and structural conditions (Clark et al., 2015; Eccles et al., 2014).

Discussions of Analysis

The study's findings offer a nuanced understanding of how firm-level characteristics moderate the relationship between carbon emissions reduction strategies and financial performance. In testing the research hypotheses, it becomes clear that the effectiveness of sustainability efforts—measured through financial

indicators such as Return on Equity (ROE), and Tobin's Q—is not uniform across firms, but rather depends significantly on structural and operational attributes such as leverage, capital intensity, ESG score, and firm size.

One of the most robust findings is the moderating role of leverage in the emissions–ROE relationship. The interaction terms indicate a negative coefficient in the short-term OLS model (–0.4842) and a positive coefficient in the long-term Fixed Effects (FE) model (+0.3266). This suggests a time-sensitive duality: in the short run, firms with high debt levels may struggle to realize immediate returns on sustainability initiatives due to upfront costs and financial constraints. However, over the long term, these same firms may see improved ROE as emissions strategies begin to deliver operational efficiencies, reputational gains, or improved stakeholder confidence—especially from creditors and long-term investors. This supports prior research emphasizing that financial structure can amplify or constrain ESG-related returns over time (Eccles et al., 2014).

Similarly, capital intensity emerges as a significant long-term moderator of the emissions–ROE relationship, with a negative coefficient (–0.1059, $p < 0.01$). This finding suggests that firms requiring substantial investments in physical assets (e.g., infrastructure, machinery) may face delayed or diminished financial benefits from emissions reduction efforts. These firms often operate within capital-intensive industries—such as manufacturing, energy, or transportation—where implementing sustainability initiatives may be more costly or complex. As a result, the path to improved ROE is slower, highlighting the trade-offs between environmental responsibility and short- to mid-term profitability in asset-heavy sectors.

The study also finds that in the Tobin's Q model, which captures market-based valuation, ESG score and capital intensity are the most critical moderators. Notably, ESG score exhibits consistent negative interaction effects (–0.1319 in FE, –0.2486 in OLS), indicating that, contrary to expectations, emissions reductions driven by ESG efforts may not always translate into higher market value. This could reflect investor skepticism about the true economic impact of ESG initiatives, or a belief that such efforts are more symbolic than substantive unless backed by strong financial performance. This aligns with Clark et al. (2015), who argue that markets may discount ESG activity if it is not clearly tied to value creation. Additionally, it highlights the ongoing challenge for ESG-oriented firms: to signal credibility and financial relevance to a diverse base of market actors.

Firm size, on the other hand, does not significantly moderate the emissions–financial performance relationship in either the ROE or Tobin's Q models. The overall lack of significance challenges earlier assumptions that larger firms, by virtue of economies of scale, resource availability, and public visibility, are better equipped to extract financial value from sustainability strategies. This result is more aligned with recent research (Busch et al., 2022) suggesting that firm size alone is not a reliable predictor of ESG success—strategic alignment, stakeholder engagement, and innovation capacity may matter more than scale.

In sum, the discussion of the hypotheses reveals that the financial impact of emissions reduction is highly contingent on firm-specific factors, with time horizon playing a critical role. While short-term market valuations (Tobin's Q) may reflect uncertainty or skepticism, long-term performance indicators like ROE show more promise—particularly when moderated by leverage. Conversely, capital intensity consistently tempers the financial gains from emissions strategies, pointing to the operational complexity of sustainable transformation in capital-heavy industries. These findings emphasize the importance of contextualizing ESG performance and caution against one-size-fits-all approaches when assessing the financial returns of sustainability investments. Managers, investors, and policymakers must consider firm characteristics, industry dynamics, and temporal factors when evaluating the business case for carbon reduction and broader environmental commitments.

CONCLUSION AND POLICY IMPLICATIONS

This study clearly demonstrates that firm-specific characteristics significantly influence how carbon emissions reduction strategies affect financial performance, particularly Return on Equity (ROE) and Tobin's Q. Specifically, the analysis reveals that leverage is a key moderator, with its effect on ROE shifting from negative in the short term to positive in the long term. This suggests that although firms with higher financial leverage may initially experience pressures due to the costs of implementing emissions strategies, they ultimately benefit as sustainable investments mature and attract investor confidence. Additionally, capital intensity plays a critical role by negatively moderating the relationship between emissions reduction and ROE over the long term. This finding indicates that firms with heavy capital investments face diminished financial returns from sustainability initiatives, likely because of higher fixed costs and longer payback periods. Furthermore, ESG scores

consistently moderate the emissions–market valuation relationship (Tobin's Q), with higher ESG engagement weakening market responses to carbon strategies; this possibly reflects skepticism or incomplete valuation of ESG efforts. In contrast, firm size shows limited and inconsistent moderation effects, thereby underscoring that size alone does not reliably predict financial benefits from emissions reduction. Taken together, these findings highlight the importance of considering internal firm conditions when evaluating the financial impact of sustainability initiatives, effectively rejecting the notion of a universal effect across all firms.

Regarding policy implications, these findings are particularly significant. Policymakers should, therefore, recognize firm heterogeneity when designing regulations or incentives for carbon reduction, offering tailored support that reflects differing financial and operational contexts. For instance, capital-intensive firms may require longer-term compliance frameworks or phased incentives, whereas leveraged firms could benefit from performance-linked rewards. Moreover, investors and rating agencies should incorporate financial structure variables like leverage and capital intensity into ESG assessments to improve the accuracy of valuations tied to sustainability performance. Consequently, firms themselves should develop emissions strategies aligned with their financial profiles—such as focusing on quick operational improvements if highly leveraged, or gradual technological upgrades if capital intensive. Furthermore, firms should communicate clearly with investors about the timing of returns on emissions strategies to manage expectations and reduce short-term market penalties. In addition, policymakers can encourage long-term sustainable investments through tax incentives or support mechanisms that help firms overcome upfront costs. Finally, by enhancing ESG reporting standards and transparency can help reduce market skepticism and better integrate ESG efforts into firm valuation. Overall, this study underscores that the financial outcomes of carbon emissions strategies are complex and contingent on firm-level factors, necessitating nuanced approaches from regulators, managers, and investors to foster effective and financially viable sustainability transitions.

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