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Analyzing the Relationship Between Carbon Emissions Reduction Strategies and Financial Performance in Multinationals

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ABSTRACT

This study investigates the relationship between carbon emissions reduction strategies and short-term financial performance in multinational corporations (MNCs) operating in North America. By utilizing panel data from 103 firms over the period 2013 to 2023, the research employs dynamic panel Generalized Method of Moments (GMM) and Ordinary Least Squares (OLS) regression techniques. The analysis reveals a statistically significant negative impact of emissions reduction efforts on short-term firm value, measured by Tobin's Q ($\beta = -1.411$, $p < 0.01$). These results suggest that while carbon reduction initiatives are essential for long-term environmental sustainability, they impose immediate financial costs and operational restructuring that can reduce firm market valuation in the short term. Additionally, firm-level characteristics significantly mediate this impact. Specifically, firm size ($\beta = 2.324$, $p < 0.05$), capital intensity ($\beta = –0.355$, $p < 0.05$), and leverage ($\beta = 1.745$, $p < 0.05$) demonstrate a nuanced relationship between firm structure and the financial implications of environmental strategies. Model diagnostics confirm robustness: all Variance Inflation Factor (VIF) values are below 5, indicating no multicollinearity among explanatory variables. Furthermore, the Arellano-Bond test confirms no first-order serial correlation in the differenced residuals (AR (2) m-statistic = –1.253, $p = 0.2102 > 0.05$), validating the GMM model specification. The findings underscore the importance of complementary policy measures—such as financial incentives, regulatory clarity, and transitional support frameworks—to mitigate short-term financial disincentives for firms adopting emissions reduction strategies. These insights offer valuable guidance to policymakers, institutional investors, and corporate managers navigating the balance between environmental responsibility and financial accountability.

Keywords: *Carbon Emissions, Emissions Reduction Strategies, Financial Performance, Multinational Corporations, Sustainability, and Corporate Environmental Responsibility*
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INTRODUCTION

Climate change is progressing at an unprecedented rate, thereby intensifying the frequency and severity of natural disasters and extreme weather events (IPCC, 2023; Climate Impact Partners, 2023). This increasing climate volatility poses substantial risks to businesses, not only threatening physical assets and operational continuity but also endangering employee safety and well-being. The Intergovernmental Panel on Climate Change (IPCC, 2021) has attributed the intensification of climate change largely to anthropogenic emissions. As countries define and pursue their Nationally Determined Contributions (NDCs), businesses are similarly expected to align their operations with global climate goals. With 195 nations committed to emission reduction targets, the transition to a net-zero economy is rapidly gaining momentum (IPCC, 2015).

Corporate responsibility in climate action is now more critical than ever. Notably, between 1998 and 2015, just 100 companies were responsible for 71% of global greenhouse gas (GHG) emissions (CDP, 2017). As such, companies face mounting pressure from stakeholders—including governments, investors, customers, suppliers, and employees—to reduce their environmental footprints (Jones et al., 2017). Climate change has evolved from a purely environmental concern into a broader socio-economic issue, threatening productivity and global economic growth (Arena, Azzone, & Mapelli, 2018; Bui & de Villiers, 2017a). In this evolving context, corporations are expected to report not only their financial performance but also their social and environmental impact (Arena et al., 2018; Bui & de Villiers, 2017a). However, the path toward corporate sustainability is shaped by a dynamic and, at times, regressive policy environment. For instance, political reversals such as the United States' prior withdrawal from the Paris Agreement and persistent skepticism around climate change continue to affect the stability of federal climate policies (Schonhardt, Colman, & Mathiesen, 2025). In parallel, some financial institutions have begun to withdraw support from NetZero initiatives, signaling inconsistency in institutional commitment to carbon neutrality. These developments underscore the complexity of the external environment, where climate policies and stakeholder expectations are fluid and occasionally contradictory.

While the urgency to reduce emissions is clear, the financial implications of such efforts are less well understood. Despite growing interest in sustainability and integrated reporting (Bebbington & Larrinaga, 2014; de Villiers, Venter, & Hsiao, 2017), there remains considerable ambiguity around the financial outcomes of carbon reduction strategies. As firms incorporate sustainability into corporate strategy, the balance between environmental goals and financial performance becomes a key area of concern (Lestari et al., 2019). Recent political and financial shifts have revealed the vulnerabilities of corporate sustainability initiatives, which are influenced not only by global climate frameworks and stakeholder pressures but also by the reversibility of regulatory and financial support (Schonhardt et al., 2025). This research addresses a critical gap by analyzing the relationship between carbon emissions reduction strategies and short-term financial performance in multinational corporations. It explores how the implementation of such strategies influences immediate financial outcomes, offering insight into the potential trade-offs and synergies that multinationals encounter when aligning environmental goals with financial objectives.

Although a growing body of literature investigates the link between sustainability initiatives and corporate financial performance, findings remain mixed, particularly when it comes to short-term impacts within multinational corporations (MNCs). Some studies indicate that carbon emissions reduction strategies can lead to immediate benefits such as operational efficiency and cost savings (Busch et al., 2022), while others highlight the substantial upfront costs and regulatory complexities that may undermine financial performance in the short run (Ganda & Milondzo, 2018; Damert et al., 2017). For multinational corporations—key contributors to global greenhouse gas emissions—these tensions are especially pronounced. Operating across diverse regulatory and market environments, MNCs must navigate inconsistent carbon policies, rising stakeholder expectations, and increasing demands for transparency in environmental, social, and governance (ESG) performance (Daddi et al., 2018). Implementing carbon reduction strategies often entails investments in renewable energy, energy-efficient technologies, and supply chain transformation—initiatives that carry financial risks and uncertain short-term returns (Damert et al., 2017).

Meanwhile, consumer and investor behavior continue to shift in favor of companies with credible climate commitments. Brands that fail to meet ESG expectations risk reputational damage, investor disinterest, and competitive disadvantage (Helfaya, Whittington, & Alawattage, 2019). In response to these pressures, many MNCs are pursuing various carbon mitigation strategies driven by compliance mandates, market opportunities, and corporate responsibility goals (Bui & de Villiers, 2017; Borghei et al., 2018). Despite this momentum, empirical research assessing the short-term financial outcomes of such strategies remains limited. Key financial performance metrics—such as return on equity (ROE), return on assets (ROA), and Tobin's Q—offer potential insights into the trade-offs involved, yet the causal relationship between emissions reduction and financial performance over short timeframes remains poorly understood (Iswati, 2018; Ganda, 2018; Bugshan et al., 2024). This gap presents a critical challenge for MNC decision-makers seeking to balance environmental objectives with economic viability. While some research suggests that sustainability actions may yield short-term financial benefits despite initial costs (Delmas et al., 2015), the evidence is not yet definitive. Without clearer data, many firms may hesitate to adopt ambitious climate strategies, potentially undermining both business resilience and global climate goals (Ambec & Lanoie, 2008). This study seeks to fill that gap by empirically analyzing the relationship between carbon emissions reduction strategies and short-term financial performance in multinational corporations. By focusing on short-run financial indicators, the research aims to inform both corporate strategy and policymaking, offering practical guidance on how environmental and economic goals can be aligned more effectively.

LITERATURE REVIEW

North America Multinational Corporations

North American multinational corporations (MNCs) operate across diverse countries through their subsidiaries, contributing to regional development while influencing international businesses (Kolk & Pinkse, 2005). Their ability to adapt and innovate in response to global challenges has made them key players in tackling critical issues, such as climate change. The regulatory landscape in North America is a crucial factor influencing the sustainability strategies of multinational corporations (MNCs). Governments in the region have implemented robust policies, such as the U.S. Clean Air Act, which enforces emissions standards, and Canada's carbon pricing mechanisms, which incentivize reductions in greenhouse gas emissions (Delmas & Toffel, 2008). These regulatory frameworks compel corporations to adopt cleaner technologies and processes and encourage innovation in sustainability practices. For instance, many MNCs have integrated renewable energy solutions and energy-efficient technologies into their operations to comply with these policies while achieving cost savings and operational efficiency (Delmas & Toffel, 2008). By adhering to these stringent requirements, corporations are better equipped to navigate the complexities of environmental compliance and capitalize on the opportunities a low-carbon economy presents.

Stakeholder influence is another critical factor shaping the environmental strategies of North American multinational corporations (MNCs). Consumers, investors, and advocacy groups increasingly demand transparency and accountability regarding corporate sustainability initiatives (Reid & Toffel, 2009). North American MNCs set corporate responsibility and environmental performance benchmarks through regulatory compliance, stakeholder engagement, and innovative sustainability practices. By leveraging their influence and resources, these corporations meet immediate operational goals and contribute to the broader agenda of sustainable development and global climate action.

Overview of 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.

Hossain & Farooque (2019) investigate global firms adopting environmental strategies to reduce carbon emissions. Their research reveals that companies that integrate renewable energy and carbon offset initiatives into their operations experience long-term benefits, including enhanced brand reputation and increased stakeholder trust. They argue that such proactive carbon management approaches are essential for sustainable business growth in a competitive global market. Luo, Lan, & Tang (2019) emphasize incentivizing multinational corporations to disclose carbon-related information, particularly in the CDP Global 500 Report context. The study finds that transparent reporting on carbon emissions reduction efforts is driven by regulatory pressures, investor demands, and the desire to maintain a competitive advantage. The authors conclude that such disclosures promote accountability and enable firms to attract environmentally conscious investors and customers, thus aligning financial performance with sustainability goals.

Figure 26 Key Carbon Reduction Strategies

Source: Adeola's Modification of Key Carbon Reduction Strategies

Carbon Reduction Strategies

One of the most effective approaches for reducing emissions involves investing in renewable energy sources such as solar, wind, and geothermal. Companies also adopt cleaner technologies to reduce reliance on fossil fuels, thereby mitigating their carbon output. He et al. (2016) highlight that green projects reduce emissions and improve operational efficiency, contributing to enhanced financial performance. MNCs implement sustainability practices across their supply chains, including optimizing logistics, sourcing environmentally friendly materials, and minimizing waste. Naranjo-Tuesta et al. (2020) emphasize that sustainable supply chain practices are essential for achieving significant carbon reductions while maintaining operational efficiency. Walmart, for example, has adopted extensive supply chain sustainability measures to reduce transportation-related emissions and packaging waste. Many corporations focus on enhancing energy efficiency within their operations. This includes upgrading equipment, retrofitting facilities, and adopting energy-saving technologies. Damert et al. (2017) state that energy efficiency measures reduce emissions and lower operational costs, offering immediate financial benefits. Some companies engage in carbon offset programs to neutralize their emissions. These programs involve investing in reforestation projects, renewable energy initiatives, or carbon credit schemes. These efforts enable firms to balance emissions that cannot be eliminated while contributing to global environmental goals (Lewandowski, 2017).

Transparent carbon reporting, which includes disclosing emissions data and setting reduction targets, has become a standard practice for many multinational corporations (MNCs). Such disclosures enhance stakeholder trust and align corporate actions with societal expectations. Siddique et al. (2021) emphasize that transparent reporting is a crucial component of Environmental, Social, and Governance (ESG) strategies, enabling firms to attract investors who are sustainability conscious. Many companies are integrating circular economy practices, such as recycling, reusing, and remanufacturing materials. These efforts significantly reduce waste and carbon emissions while promoting resource efficiency (Busch et al., 2022). Carbon reduction strategies provide several benefits, including cost savings, improved brand reputation, and enhanced regulation compliance (Rokhmawati et al., 2017). However, they also present challenges, such as high initial investments, complex regulatory landscapes, and the need for organizational changes to integrate sustainability into core business strategies (Damert & Baumgartner, 2018).

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 financial health by providing insights into how sustainability initiatives influence profitability, efficiency, and market valuation. ROA measures a company's ability to generate earnings relative to its assets, reflecting operational efficiency. In their study, Zamil & Hassan (2019) and Delmas et al. (2015) show that while GHG emission reductions may negatively impact ROA in the short term due to high implementation costs, short-term benefits can emerge from operational improvements. ROE evaluates how effectively a company uses shareholder investments to generate profit. Ganda & Milondzo (2018) 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. ROS measures the efficiency of generating profit from sales revenue. Rokhmawati et al. (2017) demonstrated a positive association between GHG emission reductions and ROS, 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 ROA, 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.

METHODOLOGY

This study follows a panel regression design as the most appropriate method to analyze the relationship between sustainability practices (e.g., Emission Scores) and financial performance (e.g., Return on Equity, Return on Assets, Tobin's Q) in North American multinational corporations (MNCs) over 10 years. Panel regression is a robust statistical method for analyzing datasets consisting of multiple entities observed over time (Baltagi, 2005). Panel regression was developed to overcome the limitations of purely cross-sectional or time-series analysis by combining the strengths of both approaches. Its flexibility and ability to control individual heterogeneity make it widely used in econometrics, finance, and business research (Hsiao, 2003). Studies like

Clarkson et al. (2015) and Siddique et al. (2021) effectively employed panel regression to examine the relationship between sustainability practices and financial performance, demonstrating its efficacy in capturing the dynamic effects of sustainability initiatives over time. The data analysis involves using fixed or random effects models to control unobserved heterogeneity among firms and time-invariant factors (Siddique et al., 2021). By operationalizing this research questions "*How do strategies for reducing carbon emissions affect the short-term financial performance of MNCs in North America, as measured by Return on Assets (ROA), Return on Equity (ROE), and Tobin's Q?*" and hypothesis "*There is no statistically significant relationship between carbon emissions reduction strategies and changes in the short-term financial performance of multinational corporations (MNCs), as measured by key financial indicators (e.g., Return on Assets (ROA), Return on Equity (ROE), or Tobin's Q)*" through this design, the researcher evaluates the effects of carbon emission reduction on the short-term financial performance of North American MNCs, while controlling for the role of moderating variables such as ESG score, firm size, leverage, and capital intensity.

The study's sample comprises 103 multinational corporations (MNCs) based in North America. These MNCs were selected to represent diverse industries, including manufacturing, technology, energy, finance, and consumer goods. They were chosen based on their substantial scale, operational diversity, and significant regional influence. This study gathered a secondary data from multiple trusted and established sources to ensure a comprehensive analysis of the relationship between carbon reduction strategies and the financial performance of multinational corporations (MNCs) in North America. The secondary data sources include Refinitiv Eikon (Refinitiv, 2023), Capital IQ, and public financial databases (Bloomberg, 2023; Gray et al., 1995; Clarkson et al., 2008). Financial performance data for MNCs were sourced from reputable financial databases such as Thomson Reuters and S&P Capital IQ (Thomson Reuters, 2024; S&P Global, 2024). These databases provide detailed financial metrics such as Return on Assets (ROA), Return on Equity (ROE), Tobin's Q, and other key performance indicators, all of which are essential for assessing the financial health and profitability of MNCs (Damodaran, 2021; Berk & DeMarzo, 2020; Khan et al., 2016; Eccles et al., 2014). These metrics help analyze the relationship between carbon reduction strategies and the short-term financial performance of multinational corporations (MNCs) in North America. By utilizing these reliable and comprehensive databases, the study ensures access to accurate, consistent, and up-to-date financial data for the selected sample of MNCs (Kenton, 2023).

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 $L_{it} = f(K'_{it})$ ……………………………………………….…(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).

$$\text{Financial Performance}_{it} = \partial_0 + \partial_1 \text{Carbon Emmisions Scores}_{it} + \partial_2 \text{ESG}_{it} + \partial_3 \text{Size of Company}_{it} + \partial_4 \text{Capital Intensity}_{it} + \partial_5 \text{Leverage}_{it} + \mu_{it}$$

The financial performance indicators are Tobin's Q ratio, Return on Assets (ROA), and Return on Equity (ROE). Below are the model specifications concerning the three financial performance indicators:

$$\text{Tobin Q}_{it} = \partial_0 + \beta_1 \text{ES}_{it} + \beta_2 \text{ESG}_{it} + \beta_3 \text{SIZ}_{it} + \beta_4 \text{CI}_{it} + \beta_5 \text{LEV}_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots \quad (1)$$

$$\text{ROA}_{it} = \partial_0 + \beta_1 \text{ES}_{it} + \beta_2 \text{ESG}_{it} + \beta_3 \text{SIZ}_{it} + \beta_4 \text{CI}_{it} + \beta_5 \text{LEV}_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots \quad (2)$$

$$\text{ROE}_{it} = \partial_0 + \beta_1 \text{ES}_{it} + \beta_2 \text{ESG}_{it} + \beta_3 \text{SIZ}_{it} + \beta_4 \text{CI}_{it} + \beta_5 \text{LEV}_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots \quad (3)$$

The dynamic panel GMM form of modelling the research question is given below as:

$$\text{Tobin Q}_{it} = \partial_0 + \partial_1 \text{Tobin Q}_{i(t-1)} + \partial_2 ES_{it} + \partial_3 ESG_{it} + \partial_4 SIZ_{it} + \partial_5 CI_{it} + \partial_6 LEV_{it} + \varepsilon_{it} \quad (1)$$

$$ROA_{it} = \partial_0 + \partial_1 ROA_{i(t-1)} + \partial_2 ES_{it} + \partial_3 ESG_{it} + \partial_4 SIZ_{it} + \partial_5 CI_{it} + \partial_6 LEV_{it} + \varepsilon_{it} \quad (2)$$

$$ROE_{it} = \partial_0 + \partial_1 ROE_{i(t-1)} + \partial_2 ES_{it} + \partial_3 ESG_{it} + \partial_4 SIZ_{it} + \partial_5 CI_{it} + \partial_6 LEV_{it} + \varepsilon_{it} \quad (3)$$

In this model, financial performance is represented by three dependent variables: Tobin's Q (Tobin Q_{it}), Return on Assets (ROA_{it}), and Return on Equity (ROE_{it}). The key independent variable is the firm's carbon emissions score (ES_{it}) which captures the effectiveness of carbon emissions reduction strategies. To control for other firm-specific factors that may influence financial performance, the model includes company size (SIZ_{it}), environmental sustainability rating (ESG_{it}), capital intensity (CI_{it}), and leverage (LEV_{it}) as control variables. The subscript *i* denotes the firm, and *t* denotes the time period, reflecting the panel data structure of the analysis. The error term consists of two components: the firm-specific effect and the idiosyncratic error term .

In dynamic panel regression estimated using the Generalized Method of Moments (GMM), the validity and robustness of the model are evaluated using diagnostic tools, particularly the J-statistics. The J-statistics, derived from the Hansen or Sargan test of over-identifying restrictions, assesses whether the instrumental variables (IVs) used in the estimation are valid, specifically, whether they are uncorrelated with the error term and correctly excluded from the regression model. A non-significant J-statistic (p-value > 0.05) indicates that the instruments are valid and do not over-identify the model, thus supporting the reliability of the GMM estimates. However, if the J-statistic is statistically significant, it may signal that the instruments are invalid or over-specified, potentially leading to biased results.

In the context of this study, which explores the relationship between carbon emissions reduction strategies and the financial performance of multinational corporations (MNCs), the dynamic panel GMM models include lagged dependent variables—ROA, ROE, and Tobin's Q—to capture the persistence of financial performance over time. This lag structure introduces endogeneity because past values of the dependent variable are likely to be correlated with the error term. Therefore, the model requires appropriate instruments to address this issue. In line with the Arellano and Bond (1991) framework, lagged levels of the dependent variables (such as $ROAi_{(t-2)}$, $ROEi_{(t-2)}$, and Tobin's $Qi(_{t-2})$) are used as instruments for their first-differenced forms. Additionally, to further strengthen the estimation, the Blundell and Bond (1998) System GMM approach allows for the use of lagged first differences as instruments for the levels equations, especially when variables display high persistence. Moreover, the independent variables, such as carbon emission score (ES), environmental sustainability score (ESG), firm size (SIZ), capital intensity (CI), and leverage (LEV), are either treated as endogenous or predetermined based on their potential correlation with the error term. Their lagged values are employed as instruments for potentially endogenous regressors like ES and ESG. If assumed exogenous, control variables such as SIZ, CI, and LEV may be used as their own instruments. If not, their appropriate lagged values serve as instruments. This structured instrumentation ensures that the model accounts for unobserved heterogeneity, autocorrelation, and heteroskedasticity typical of firm-level panel data.

DATA ANALYSIS AND DISCUSSION

Table 1 Summary of Descriptive Statistics

Variable	*Mean*	*Std. Dev.*	*Skewness*	*Kurtosis*
Tobin's Q	*1.82*	*1.87*	*6.83*	*81.18*
ROE	*0.46*	*2.78*	*10.07*	*105.53*
ROA	*0.06*	*0.046*	*1.02*	*5.27*
Capital Intensity	*0.99*	*0.67*	*2.70*	*11.18*
Emissions Score	*-0.62*	*1.67*	*-2.11*	*8.67*
Leverage	*0.49*	*0.92*	*6.26*	*52.30*
Firm Size (log)	*9.81*	*1.53*	*0.49*	*3.66*
ESG Score	*-0.52*	*0.62*	*-1.43*	*5.40*

Table 1 provide the descriptive overview of the dataset, by summarizing financial performance indicators, ESG scores, emission scores, and other firm-specific characteristics. This section highlights the dataset's distribution, central tendencies, and variability, offering insights into the nature of the data used for subsequent analysis. 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) and Return on Assets (ROA) show average values of 0.456 and 0.061, respectively, suggesting modest profitability among the firms. Both metrics exhibit strong positive skewness and kurtosis, especially ROE, 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 (likely reverse-coded since it's negative on average at -0.617) shows large variability and strong negative skewness (-2.11), suggesting that a few firms have exceptionally good emissions 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. 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.

Analysis of Research Question

How do carbon emissions reduction strategies predict changes in the short-term financial performance of North American MNCs?

This study investigates whether environmental initiatives—specifically carbon emissions reduction—affect the short-term financial outcomes of North American multinational corporations (MNCs). The focus is on understanding if firms' environmental responsibility aligns with market valuation in the near term. Two estimation techniques are applied to ensure model robustness: Ordinary Least Squares (OLS) and Dynamic Panel Generalized Method of Moments (GMM)**.** The following subsections outline the diagnostic tests and regression results that inform this relationship.

Analysis of Tobin's Q Financial Performance Model

Analysis of Variance Inflation Factor (VIF) – Tobin's Q

Table 2 Variance Inflation Factor (VIF) Summary Tobin's Q

Variable	VIF
LFIRM_SIZE	1.59
TOBINS_Q	1.30
EMISSIONS	1.18
LEVERAGE	1.12
CAPITAL_INTENSITY	1.06

The result in Table 2 shows no evidence of multicollinearity among the independent variables included in the Tobin's Q model. Variance Inflation Factor (VIF) values for all predictors—Firm Size (VIF = 1.59), Tobin's Q (VIF = 1.30), Emissions (VIF = 1.18), Leverage (VIF = 1.12), and Capital Intensity (VIF = 1.06)—fall well below the commonly accepted threshold of 5. This threshold, established in the econometrics literature, is widely used to detect multicollinearity, which can distort the accuracy of regression coefficients and inflate standard errors, thereby undermining the reliability of inferential statistics (Kutner et al., 2004; O'Brien, 2007). The low VIF values in this model suggest that each explanatory variable provides unique information about the dependent variable (Tobin's Q), and that the variables are not linearly dependent on one another to a problematic degree. Consequently, the regression estimates are stable, and the interpretation of individual coefficients is more robust and reliable. This absence of multicollinearity enhances the credibility of subsequent hypothesis testing and model diagnostics, indicating that the regression results are unlikely to be influenced by redundant or overlapping information among the predictors (Emous et al., 2021). In the context of policy and managerial decision-making, the lack of multicollinearity affirms that emissions reduction strategies, firm size, capital structure, and production intensity exert distinct and measurable impacts on firm valuation—an important consideration when assessing trade-offs between environmental initiatives and short-term financial performance.

Table 3 Test Results for Panel Unit Root for Tobin's Q Financial Performance

Method	Statistic	P-value	Interpretation
Levin, Lin & Chu (LLC)	-7.32454	0.0000	Reject H_0 Stationary
ADF - Fisher Chi-square	266.611	0.0028	Reject H_0 Stationary
PP - Fisher Chi-square	333.649	0.0000	Reject H_0 Stationary

Table 3 presents the results of three widely used panel unit root tests—Levin, Lin & Chu (LLC), Augmented Dickey-Fuller (ADF) - Fisher Chi-square, and Phillips-Perron (PP) - Fisher Chi-square—applied to the Tobin's Q variable across the panel dataset. The purpose of conducting these tests is to determine whether the series is stationary, a key precondition for valid regression modeling in panel data analysis. Non-stationary data can produce spurious regression results and undermine the validity of statistical inferences.

All three tests reject the null hypothesis (H_0) of a unit root (i.e., non-stationarity) at the 1% significance level. Specifically: The LLC test statistic is –7.32454 with a p-value of 0.0000, indicating strong evidence that

Tobin's Q does not contain a unit root and is stationary across entities and over time. The ADF-Fisher Chi-square test yields a test statistic of 266.611 with a p-value of 0.0028, further reinforcing the conclusion that the Tobin's Q variable is stationary. The PP-Fisher Chi-square test produces an even stronger test statistic of 333.649 and a p-value of 0.0000, which corroborates the findings of the LLC and ADF tests. These consistent results across multiple unit root tests provide robust evidence that the Tobin's Q variable is stationary in level form. Stationarity implies that the statistical properties of the series—such as its mean, variance, and autocorrelation structure—remain constant over time. Therefore, no transformation (such as first differencing or detrending) is required before incorporating Tobin's Q into the regression models. This outcome is particularly important for econometric modeling using panel data methods such as fixed effects or random effects, as non-stationarity can lead to biased and inconsistent parameter estimates. The stationarity of Tobin's Q, as confirmed by these tests, validates the application of panel estimators without the need for differencing and supports the reliability of subsequent analyses using this dependent variable (Kao, 1999; Pedroni, 2004). From a substantive perspective, the stationarity of Tobin's Q suggests that the financial performance of the multinational corporations (MNCs) in the dataset exhibits consistent behavior over the observed period. This reinforces the robustness of the study's findings regarding the short-term financial impact of carbon emissions reduction strategies.

Comparison of Ordinary Least Squares and Dynamic Panel GMM Tobin's Q

Table 4 Summary Comparison of OLS and Dynamic Panel GMM Tobin's Q

Variables	**OLS Coefficient**	**Dynamic Panel GMM Coefficient**
Log Emissions Impact	-0.203	-1.411
Log Firm Size Impact	+0.567	+2.324
Capital Intensity Impact	-0.303	+0.355
Leverage Impact	-0.103	+1.745
Instrument Validity (J-stat)		(p = 0.166 > 0.05)

Table 4 presents a summary comparison of the OLS and Difference GMM results. In the static OLS and difference GMM models as presented in Table 4, the emissions score (used as a proxy for a firm's commitment to reducing carbon emissions) is statistically significant and negatively associated with Tobin's Q. A 1% increase in the Emission Score is associated with a 0.203 decrease in Tobin's Q in the OLS model, and a 1.411 decrease in the GMM model. The negative coefficients suggest that, at least in the short run (OLS). The researcher used the dynamic effects (GMM) to account for endogeneity to validate the result, and the decline in Tobin's Q was reduced a bit.

A 1% increase in firm size is associated with a 0.567 increase in Tobin's Q under OLS, and a much larger 2.324 increase under GMM. The more potent effect in the GMM model suggests that size becomes an even more important strategic asset over time, potentially due to economies of scale, more substantial investor confidence, or better access to capital markets.

Capital Intensity (-0.303) indicates that higher capital intensity is associated with a decrease in Tobin's Q in the short term. The GMM result shows a positive (+0.355), meaning that a rise in capital intensity may result in a short-term impact. Leverage (0.103) shows a slight negative impact in the short term but a substantial (+1.745) positive effect over time, suggesting that well-managed debt enhances short-term firm value. Instrument Validity (J-statistic): $p = 0.166 > 0.05$ indicates that the instruments used in the GMM estimation are valid, and the model does not suffer from overidentification bias, a good sign for reliability.

Table 5 Empirical Findings and Hypothesis Decision (Tobin's Q)

Model	p-value	Interpretation
OLS	0.0098	Significant negative effect
GMM	< 0.01	Significant negative effect

Table 5 presents the empirical findings and decision on the hypothesis for Tobin's Q financial performance model. Table 5 reveals that the P-values for both models are statistically significant ($p < 0.05$). The direction of the relationship is negative. Therefore, the researcher rejects the null hypothesis (H_0) of OLS (P-value 0.0098 and GMM 0.01), and concludes that there is no statistically significant relationship between carbon emissions reduction strategies and changes in the short-term financial performance of multinational corporations (MNCs), as measured by Tobin's Q.

The analysis reveals that carbon emissions reduction strategies are negatively associated with the short-term financial performance of North American multinational corporations (MNCs), as measured by Tobin's Q. In the OLS model, the emissions score—a proxy for the firm's commitment to reducing carbon emissions—has a negative and statistically significant coefficient (–0.203, $p < 0.01$), indicating that more aggressive emissions reduction strategies are correlated with lower firm value in the short term. This relationship is further reinforced in the dynamic Generalized Method of Moments (GMM) model, where the coefficient becomes even larger (–1.411, $p < 0.01$). These findings suggest that while emissions reduction efforts reflect a firm's short-term sustainability commitment, they may incur short-term costs, such as capital investments, technology upgrades, or process changes, that temporarily reduce market valuation (Zamil & Hassan, 2019; Delmas et al., 2015).

This result is consistent with existing literature, which notes that sustainability strategies often yield benefits in the long term, rather than immediate short-term effects. For instance, Clark, Feiner, and Viehs (2015) found that ESG practices improve operational performance over time. Eccles, Ioannou, and Serafeim (2014) reported that sustainability-focused firms will outperform their competitors over time.

Analysis of Return on Equity (ROE) Financial Performance Model (Model 2)

Table 6 Analysis of Variance Inflation Factor (VIF) – ROE

Variable	VIF
Leverage	3.05
ROE	2.96
Firm Size	1.31
Emissions Score	1.18
Capital Intensity	1.15

Table 6 presents the Variance Inflation Factor (VIF) analysis for the variables included in the Return on Equity (ROE) model. The VIF values for all variables, including Leverage (3.05), ROE (2.96), Firm Size (1.31), Emissions Score (1.18), and Capital Intensity (1.15), are all below the commonly accepted threshold of 5. This indicates that there is no significant multicollinearity among the explanatory variables. In other words, the predictors are not highly correlated with each other, which ensures that the estimated coefficients in the ROE model are reliable and not distorted by multicollinearity issues. This enhances the validity of the regression results and supports the robustness of the model's findings.

Table 23 Panel Unit Root results for Return on Equity (ROE):

Test Method	Statistic	P-value	Interpretation
Im, Pesaran and Shin W-stat	–1.93109	0.0267	Reject H_0 Stationary
ADF - Fisher Chi-square	250.673	0.0182	Reject H_0 Stationary
PP - Fisher Chi-square	371.133	0.0000	Reject H_0 Stationary

Table 7 presents the results of panel unit root tests conducted on the Return on Equity (ROE) variable across a dataset of 103 firms from 2013 to 2023. The stationarity of ROE is crucial for valid regression analysis, as non-stationary variables can lead to spurious relationships and unreliable estimates. The tests applied include the Im, Pesaran and Shin W-stat, ADF Fisher Chi-square, and PP Fisher Chi-square tests. All three tests produce p-values below the 0.05 significance level, leading to the rejection of the null hypothesis that ROE contains a unit root. This indicates that ROE is stationary in the panel dataset, meaning its statistical properties such as mean and variance are constant over time. Consequently, the researcher can confidently proceed with regression modeling using ROE without the need for differencing or further transformations to achieve stationarity.

Table 8 The Summary Result of OLS vs. GMM - ROE

Model Type	**Coefficient on Emissions Score**	**P-value**	**Interpretation**
OLS	–0.0178	0.8188	Not Significant
Difference GMM	+0.7534	0.0000	Significant

Table 8 presents the model analysis for the impact of emissions reduction strategies on ROE. For the OLS model in Table 8, the emissions score has a coefficient of (–0.0178), with a P-value of (0.8188). The result shows that a 1% increase in emission reduction is associated with a (-0.0178) decrease in ROE, and there is a significant relationship between emissions strategies and ROE under the static model. Therefore, the researcher fails to reject the null hypothesis since the P-value exceeds the 5% significance level.

Using the first difference level GMM to control for endogeneity shows a positive coefficient of 0.7534 for emission reduction, with a P-value of 0.0000, resulting in a 1% increase in emission reduction associated with a 0.7534 increase in ROE. There is no significant relationship between emissions strategies and ROE. This shows that more substantial emissions reduction commitments are associated with higher short-term returns on equity once internal dynamics are controlled. Eccles et al. (2014) demonstrate that sustainability-focused firms outperform their peers in financial terms. Similarly, Flammer (2013) finds that investors value proactive environmental practices. Clark et al. (2015) affirmed that ESG strategies are connected to operational performance over time.

In contrast, the difference GMM results provide enough evidence to reject the null hypothesis (H_0). Therefore, there is no evidence to confirm that carbon emissions reduction strategies have a statistically significant impact on the short-term financial performance of North American MNCs, as measured by ROE. The researcher concludes that environmental investments can deliver measurable financial benefits and enhance shareholder value in the short term if appropriate strategies are considered (Eccles et al., 2014; Flammer, 2013).

Analysis of Return on Equity (ROE) Financial Performance Model (Model 3)

Table 24 *Analysis of Variance Inflation Factor (VIF)* – for ROA Model

Variable	**VIF**
Firm Size	1.45
ROA	1.25
Capital Intensity	1.19
Emissions Score	1.18
Leverage	1.13

Table 9 presents the Variance Inflation Factor (VIF) results for the Return on Assets (ROA) model. The VIF values for all variables—including Firm Size, ROA, Capital Intensity, Emissions Score, and Leverage—are well below the commonly accepted threshold of 5. This indicates that there is no significant multicollinearity among the explanatory variables. In other words, these variables are sufficiently independent of each other, ensuring that their inclusion in the regression model will not bias the results or inflate the standard errors. Consequently, the regression estimates derived from this model are reliable and valid for interpreting the relationships involving ROA.

Table 25 The Panel Unit Root Test result for ROA

Test Method	**Statistic**	**P-value**	**Interpretation**
Levin, Lin & Chu (LLC)	–8.58997	0.0000	Reject H_0 Stationary
ADF - Fisher Chi-square	299.816	0.0000	Reject H_0 Stationary
PP - Fisher Chi-square	296.032	0.0000	Reject H_0 Stationary

Table 10 presents the results of panel unit root tests conducted to assess the stationarity of the Return on Assets (ROA) variable. The three tests used—Levin, Lin & Chu (LLC), ADF-Fisher Chi-square, and PP-Fisher Chi-square—all produced p-values well below the 0.05 significance level. This consistent outcome across different tests leads to the rejection of the null hypothesis, which posits the presence of a unit root (non-stationarity). Therefore, the researcher concludes that the ROA variable is stationary in the panel dataset. Stationarity is crucial for ensuring valid regression analysis, as non-stationary variables can cause spurious results and unreliable inferences.

Table 26 *Model Comparison: OLS vs. GMM on ROA*

Model	**Coefficient on Emissions Score**	**P-value**
OLS	–0.0036	0.0655
Difference GMM	–0.0074	0.0774

Table 11 compares the coefficients for OLS and GMM for the ROA model. The result shows that the coefficients for OLS (–0.0036) and first-level difference GMM (–0.0074) for ROA are negatively correlated. The finding indicates that a 1% increase in emission reduction is associated with a (–0.0036) decrease in ROA for OLS, while a 1% increase in emission reduction is associated with a (–0.0074) decrease in ROA for first-level difference GMM. The OLS P-values (0.0655) and GMM P-values (0.0774) are insignificant. This implies that there is a statistically significant relationship between carbon emissions reduction strategies and changes in the short-term financial performance of multinational corporations (MNCs), as measured by ROA as a result of transitional costs, clean technology investments, process restructuring, or ESG compliance burdens (Grewatsch & Kleindienst, 2017; Lo & Sheu, 2007).

Table 27 Summary of Emissions Score Effects on Short-Term Tobin's Q ROE and ROA

Dependent Variable	**Model Type**	**Coefficient on Emissions Score**	**P-value**	**Interpretation**
Tobin's Q	OLS	–0.2030	0.0098	Significant
Tobin's Q	GMM	–1.4112	< 0.01	Valid
ROE	OLS	–0.0178	0.8188	Not Significant
ROE	GMM	+0.7534	< 0.01	Valid
ROA	OLS	–0.0036	0.0655	Not Significant
ROA	GMM	–0.0074	0.0774	Valid

Table 12 summarizes the findings of the effects of emissions score on short-term financial performance. This implies a 1% increase in carbon emissions reduction commitment (proxied by the emissions score) corresponds to approximately a 0.01 × coefficient unit change in the dependent variable. In the Tobin's Q GMM model, the coefficient of -1.4112 means that a 1% increase in emissions commitment leads to an estimated 0.0141 decrease in Tobin's Q.

In the ROE GMM model, a 1% increase in the log of emissions score is associated with an estimated 0.0075 increase in ROE. Similarly, a 1% increase in emissions reduction commitment for ROA leads to a change of –0.000074 in ROA under the GMM specification. These findings suggest that while the magnitude of change may appear small in absolute terms, the direction and significance of the coefficients offer meaningful insight into how carbon emissions reduction strategies affect short-term financial performance. Market-based metrics like Tobin's Q respond negatively, while profitability indicators such as ROE benefit from emissions reductions when internal dynamics are accounted for (Eccles et al., 2014; Flammer, 2013; Clark et al., 2015).

Table 28 Summary of Hypothesis Testing for the Research Question

Hypothesis (H_0)	**Test Outcome**	**Decision**
There is no significant relationship between emissions scores and Tobin's Q.	Rejected ($p < 0.01$ in both models)	Reject H_0
There is no significant relationship between emissions scores and ROE.	Rejected in GMM, not in OLS	Reject H_0 (Diff. GMM)
There is no significant relationship between emissions scores and ROA.	Not rejected (both models $p > 0.05$)	Fail to reject, H_0

Table 13 summarizes the hypothesis testing results for the Research Question, which investigates the existence of a statistically significant relationship between carbon emissions scores and short-term financial performance indicators—specifically Tobin's Q, Return on Equity (ROE), and Return on Assets (ROA). The findings reveal that the null hypothesis of no significant relationship between emissions scores and Tobin's Q is rejected at the 1% significance level under both the Ordinary Least Squares (OLS) and Generalized Method of Moments (GMM) estimation techniques. This outcome indicates a strong and consistent negative association between carbon emissions reduction efforts and market-based valuation. The result suggests that, in the short term, firms engaging in emissions-reducing activities may experience a decline in investor-perceived value, potentially due to concerns over increased operational costs or delayed returns on sustainability investments.

For ROE, the null hypothesis is rejected in the GMM model but not in the OLS model. This discrepancy highlights the importance of accounting for firm-level dynamics, endogeneity, and unobserved heterogeneity when analyzing profitability. The GMM findings imply that once these factors are controlled for, emissions strategies are positively associated with ROE, suggesting that firms may achieve better internal operational efficiency or reputational gains that enhance profitability despite market skepticism. In contrast, the relationship between emissions scores and ROA is statistically insignificant in both estimation techniques, as p-values exceed the 0.05 threshold. This implies that emissions reduction strategies do not have a measurable effect on overall asset efficiency in the short term. A plausible explanation is that transition and implementation costs may neutralize gains, especially in capital-intensive multinational firms. Overall, the results from Table 13 support the notion that while emissions reduction efforts may initially depress firm valuation, they can enhance internal financial performance under dynamic conditions. However, the inconsistent effect across different financial indicators underscores the complex and multidimensional nature of the link between environmental strategies and firm performance.

CONCLUSION AND POLICY IMPLICATIONS

This study examined the relationship between carbon emissions reduction strategies and the short-term financial performance of multinational corporations (MNCs) operating in North America. Utilizing robust econometric techniques, including Ordinary Least Squares (OLS) and dynamic panel Generalized Method of Moments (GMM), the findings consistently reveal a statistically significant negative association between emissions reduction efforts and short-term firm value, as measured by Tobin's Q. This suggests that while environmental initiatives may enhance long-term sustainability, they tend to impose immediate costs or operational adjustments that can reduce financial performance in the short run.

The results underscore a critical tension faced by firms striving to balance environmental responsibility with shareholder expectations for near-term profitability. Larger firm size appears to buffer some of these short-term financial pressures, potentially due to greater resource availability and market confidence. Additionally, variables such as capital intensity and leverage show differential effects over time, indicating complex dynamics between firm characteristics and financial outcomes during environmental transitions.

From a policy perspective, these findings have several important implications. First, regulators and policymakers should recognize that aggressive carbon reduction policies may initially challenge firm profitability, particularly for smaller or resource-constrained firms. To facilitate smoother transitions, incentives such as tax credits, subsidies for green technologies, or phased compliance timelines could be critical in alleviating short-term financial burdens. Second, investors and financial analysts should consider the temporal dimension of sustainability investments, understanding that early financial setbacks might precede longer-term value creation. Encouraging patient capital and integrating environmental, social, and governance (ESG) criteria into investment strategies could support more sustainable business practices without compromising financial stability.

Finally, multinational firms should strategically plan emissions reduction initiatives by aligning them with their broader financial and operational capabilities, leveraging firm size advantages, and optimizing capital and debt structures to absorb short-term costs. Transparent communication with stakeholders about the expected timeline for environmental investments to translate into financial returns can foster trust and maintain investor confidence. Overall, this study highlights the need for an in-depth approach to environmental policy and corporate strategy—one that balances immediate financial realities with the imperative of short-term sustainability for the benefit of firms, investors, and society.

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