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Carbon Emission Strategies and Enterprise Value: The Mediating Role of Return on Assets with Income Diversification Disclosure and Board Size as Control Variables

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Abstract

This study examines the impact of carbon emission policies on the market value of international oil and gas firms, utilizing Return on Assets (ROA) as a mediating variable. The sample comprises 97 publicly traded firms in 2023, with data sourced from annual reports, ESG reports, and market data. Strategies for carbon emissions, disclosures on revenue diversification, board size, return on assets (ROA), and Tobin's Q are evaluated using a PLS-SEM model, yielding a R^2 of 0.577 for Tobin's Q. Their robustness is evaluated by OLS regression incorporating nation fixed effects and clustering errors. The findings indicate that carbon emission methods exert a positive and significant influence on ROA and Tobin's Q (total effect on Tobin's Q = 0.146; $p < 0.05$), hence allowing the market to value more proactive decarbonization initiatives while concurrently enhancing operational performance. Conversely, ROA exerts a negative and significant influence on Tobin's Q (coefficient = –0.142; $p < 0.05$), establishing a partial mediation that diminishes the direct impact of carbon policy on market value. The disclosure of revenue diversification (≈ 0.663; $p < 0.01$) and board size positively influence Tobin's Q. These findings validate the significance of climate reporting and offer implications for boards, investors, and regulators.

Keywords: *Carbon Emission Strategy, Tobin's Q, ROA, Oil and Gas Companies, SEM-PLS.*

INTRODUCTION

The importance of carbon emission strategies in the oil and gas industry has gained significant attention in the context of global climate change and environmentally conscious. The oil and gas industry is a major contributor to greenhouse gas emissions, accounting for approximately 34% of global anthropogenic CO2 emissions as of 2020 (Arinze et al., 2024). This situation requires the implementation of efficient carbon emission measures to reduce environmental effects and

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comply with international climate accords, including the Paris Agreement, which seeks global carbon neutrality by the latter part of this century (Tang et al., 2024).

Implementing Carbon Capture and Storage technologies stands out as a highly promising strategy for reducing carbon emissions within the oil and gas sector. The CCS process involves the capture of CO2 emissions from industrial activities and the subsequent storage of this gas underground to inhibit its release into the atmosphere. This technology holds significant importance for oil sands production, as it has the potential to greatly reduce the greenhouse gas emissions linked to extraction and upgrading processes (Xing et al., 2021). Despite the potential benefits, challenges such as high initial costs and technological uncertainties hinder widespread adoption (Xing et al., 2021). Nevertheless, CCS remains a critical component of the industry's transition towards net-zero emissions, with projections suggesting that it could capture millions of tons of CO2 annually by 2060 (Handaja et al., 2024).

In 2023, the war between Russia and Ukraine markedly affected the oil and gas industry, shaping market behaviors and geopolitical tensions. Global energy supplies were affected by this conflict, leading to rises in crude oil prices and a greater reliance on alternative energy sources (Petrova, 2023). Within this environment, oil and gas firms are being prompted to enforce stronger carbon emission policies to lessen reliance on conventional fossil fuels and hasten the move toward renewable energy sources (Karpov et al., 2023).

Beyond CCS, the industry should also prioritize digital transformation and innovative strategies to increase carbon emission efficiency. Studies show that adopting digital strategies in the oil and gas sector can significantly cut carbon emissions by streamlining operations and promoting rapid technological development (Li et al., 2024). In addition, standalone oil and gas companies are being urged to boost their investments in initiatives aimed at reducing emissions, as concerns from stakeholders and perceptions of climate risks increasingly impact their operational decisions. Investing in this area is essential for promoting sustainable development and remaining competitive amid the rapidly evolving energy sector.

Furthermore, the oil and gas sector faces mounting pressure to implement climate change mitigation strategies that not only meet environmental regulations but also support wider environmentally conscious objectives. A review of practices within the industry highlights various approaches, including methane emission reduction initiatives and the integration of renewable energy sources (Kupa et al., 2024). These strategies are essential for reducing the industry's overall carbon footprint and transitioning towards cleaner energy sources, thereby addressing the urgent challenge of climate change (Ekemezie, 2024).

Large companies are increasingly being pressured by party concerned to adopt strategies that are environmentally conscious, particularly those focused on carbon emission mitigation. This pressure

arises from a growing awareness among consumers, investors, and regulatory bodies regarding the environmental impacts of enterprise activities, compelling firms to integrate Environmentally conscious into their core operations. For instance, Lin et al. emphasize that party concerned expect firms to fulfill both financial and moral responsibilities, which include adopting effective Environmentally conscious strategies that address environmental concerns (Lin et al., 2021). Furthermore, Santos et al. highlight the importance of Environmentally conscious reporting in the energy industry, indicating that party concerned are scrutinizing companies' environmental management practices more closely than ever (Santos et al., 2023). This trend is echoed by Young and Park, who assert that enterprise Environmentally conscious management must encompass non-financial activities, such as environmental protection, to meet party concerned expectations and ensure long-term viability (Ma & Park, 2021). Additionally, the research by Kwarto et al. highligths the importance of transparency in Environmentally conscious reporting, as party concerned are increasingly demanding accountability from oil and gas companies regarding their environmental impacts (Kwarto et al., 2024). Overall, the mounting pressure from party concerned is driving large companies to prioritize Environmentally conscious strategies, including robust carbon emission mitigation efforts, to enhance their reputation and ensure compliance with evolving environmental standards.

Carbon emission mitigation strategies not only fulfill enterprise social responsibility (CSR) but also have the potential to positively influence enterprise value, as measured by Tobin's Q, particularly in the oil and gas industry. Carroll and Shabana argue that effective CSR initiatives, which include Environmentally conscious strategies aimed at reducing carbon emissions, can enhance party concerned relations and improve social welfare, thereby contributing to a company's overall reputation and market performance (Carroll & Shabana, 2010). This alignment with party concerned expectations is crucial, as companies that actively engage in Environmentally conscious practices are perceived more favorably by investors and consumers, leading to enhanced enterprise value. Furthermore, Luo and Wu highlight that companies with strong environmental, social, and governance (ESG) ratings tend to experience greater accuracy in analysts' earnings forecasts, suggesting that Environmentally conscious efforts, including carbon emission mitigation, can lead to more favorable financial assessments and increased investor confidence (Luo & Wu, 2022). Moreover, the relationship between Environmentally conscious practices and enterprise performance is reinforced by findings from Lin et al., who demonstrate that positive enterprise Environmentally conscious strategies can significantly enhance firm value, indicating that companies that prioritize carbon emission reductions are likely to see improvements in their market valuation (Lin et al., 2021). This is further supported by Jadoon et al., who emphasize that high-quality Environmentally conscious reporting, which includes transparency

about carbon emissions and mitigation strategies, is positively correlated with the value relevance of enterprise Environmentally conscious performance (Jadoon et al., 2021). As party concerned increasingly demand accountability and transparency in enterprise practices, oil and gas companies that adopt comprehensive carbon emission mitigation strategies not only fulfill their social responsibilities but also position themselves for enhanced financial performance, as reflected in metrics like Tobin's Q.

The current literature has explored multiple factors influencing Tobin's Q, such as corporate governance and financial performance. Nonetheless, a significant gap exists in thorough investigations that directly link carbon emission strategies to this valuation metric. Tobin's Q acts as a measure of market performance and the long-term value of firms; however, the analysis of its relationship with the effects of effective carbon emission strategies on enterprise value in the oil and gas sector is still insufficiently explored. The precise mechanisms by which strategies for mitigating carbon emissions affect this relationship remain inadequately investigated. Furthermore, although certain studies have noted a positive relationship between corporate performance and environmentally sustainable practices, the specific impacts of carbon emission strategies on Tobin's Q within the oil and gas sector remain underexplored, highlighting a notable gap in the existing literature.

ROA used as an intervening variable. The influence of Return on Assets in the relationship between carbon emission strategies and Tobin's Q value for oil and gas companies remains underexplored, highlighting a notable deficiency in current research. While previous studies have established a connection between corporate social responsibility and financial metrics such as ROA, the specific mediating role of ROA in relation to carbon emission strategies and their impact on Tobin's Q remains to be comprehensively investigated. According to Marota, there is a positive correlation between social performance in enterprises and increases in ROA, which indicates that environmentally friendly practices can enhance financial performance (Marota et al., 2023). However, the literature lacks comprehensive analyses that exactly investigate how these improvements in ROA might subsequently influence Tobin's Q, which serves as an essential indicator of market valuation. Additionally, Emous et al. highlight the importance of carbon emissions reduction in enhancing financial performance indicators, including ROA, yet they do not delve into how these improvements translate into market value as represented by Tobin's Q (Emous et al., 2021). This gap highlights the necessity for additional empirical investigation to elucidate the mediating function of ROA in the connection between carbon emission strategies and enterprise valuation within the oil and gas sector, potentially offering significant insights for both scholars and industry professionals focused on environmental sustainability.

The emerging issue in the relationship between carbon emission mitigation strategies and the Tobin's Q value of global oil and gas

companies lies in the uncertainty surrounding the effectiveness of these strategies in addressing global market fluctuations, particularly during the Russia-Ukraine war in 2023. The conflict triggered disruptions in global energy supply, surging oil prices, and heightened geopolitical pressures, which affected companies' ability to consistently invest in carbon mitigation strategies (Sehgal et al., 2014). Conversely, while carbon mitigation strategies like Carbon Capture and Storage (CCS) technology can potentially enhance operational efficiency and improve Return on Assets (ROA), obstacles such as elevated implementation costs and technological constraints impede their widespread adoption (Xing et al., 2021). Moreover, escalating party concerned demands to achieve Environmentally conscious objectives in a volatile geopolitical landscape can confuse the correlation between carbon mitigation methods and business market value, as assessed by Tobin's Q (Karpov et al., 2023). This suggests that the function of ROA as a mediator in this relationship necessitates additional investigation to comprehend the dynamics among global uncertainty stemming from the Russia-Ukraine conflict.

It is crucial to consider the disclosure of income diversification and board size as control variables when investigating the mediating role of Return on Assets (ROA) in the relationship between carbon emission strategies and Tobin's Q values in oil and gas companies. Income diversification can significantly influence a firm's financial performance, as evidenced by Githaiga and Yegon, who found that diversification positively affects financial performance metrics like ROA in the banking industry (Yegon & Githaiga, 2019). However, the exact implications for oil and gas companies may differ, and further research is needed to generalize these findings across industries. Additionally, board size plays a crucial role in enterprise governance and decision-making processes. Research by Sany indicates that larger boards can more effectively oversee and implement Environmentally conscious initiatives, which may lead to improved financial performance as measured by ROA (Sany, 2024), the study focuses on non-financial companies in Thailand. Furthermore, the control of board size is supported by findings from Kılıç and Kuzey, who assert that board characteristics, including size, significantly influence carbon disclosures and, by extension, the effectiveness of carbon emission strategies (Kılıç & Kuzey, 2019). Therefore, incorporating these control variables is vital for accurately assessing the mediating effects of ROA on the correlation between carbon emission methods and Tobin's Q, as they provide a more comprehensive understanding of the factors that contribute to enterprise performance in the oil and gas industry.

The objectives of this study are to comprehensively examine how carbon emission strategies influence the financial performance of international oil and gas companies. Specifically, the study aims to assess the effect of these strategies on firms' Tobin's Q ratio, evaluate their impact on Return on Assets (ROA), and analyze the overall relationship between carbon emission initiatives and market valuation indicators across global oil and gas enterprises.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Tobin's Q value is defined as "the ratio of the market value of a firm's share capital to the replacement cost of the firm's share capital," indicating how well a company is valued in the market relative to its assets (Ali et al., 2016). Return on Assets (ROA) is described as "a financial ratio that indicates the profitability of a company in relation to its total assets," reflecting how efficiently a company utilizes its assets to generate earnings (Mohammad & Khan, 2024). A carbon emission mitigation strategy is defined as a structured method designed to decrease greenhouse gas emissions, with a particular focus on carbon dioxide (CO2), utilizing a range of approaches including technological advancements, adherence to regulations, and the implementation of sustainable practices. Such strategies are crucial for organizations, particularly those operating within the oil and gas sector, as they not only promote environmental sustainability but also improve the overall value of the enterprise. Research indicates that carbon emission strategies have a favorable impact on Tobin's Q, which serves as a measure of a company's market valuation in comparison to the cost of replacing its assets. Thus Zhou et al. demonstrate that effective carbon emission reduction initiatives can lead to improved financial performance and increased market valuation, as reflected in Tobin's Q (Zhou et al., 2023). This relationship is further supported by research indicating that companies that actively engage in carbon mitigation strategies tend to attract more investment and achieve higher market valuations, as party concerneds increasingly prioritize Environmentally conscious in their investment decisions (Abeydeera et al., 2019). Consequently, adopting strong carbon emission strategies is not just a matter of social responsibility; it is also a strategic business choice that can greatly improve the financial outcomes and market standing of oil and gas firms.

The implementation of carbon emission strategies positively influences the Tobin's Q value of oil and gas companies, as effective carbon management practices enhance enterprise reputation and party concerned trust, leading to improved market valuations (Tuesta et al., 2020). Therefore, it can be hypothesized that carbon emission strategies have a positive inlfuence on the Tobin's Q value in oil and gas companies. Hypothesis: Carbon emission strategies have a positive influence on the Tobin's Q value of oil and gas companies.

Evidence suggests a positive influence between carbon emission strategies and Return on Assets (ROA) in oil and gas companies. Thus research by Emous et al. indicates that firms that implement effective carbon emission reduction strategies not only enhance their environmental performance but also improve their financial metrics, including ROA, as these strategies often lead to cost savings and operational efficiencies (Boyson et al., 2017). This highligths the significance of Environmentally conscious initiatives in enhancing financial performance within the industry.

Hypothesis: Carbon emission strategies have a positive influence on the Return on Assets value of oil and gas companies.

The positive impact of ROA on Tobin's Q the oil and gas industry has been well-documanted. There is a significant positive relationship between ROA and Tobin's Q, indicating that higher profitability (Kılıç & Kuzey, 2019), as measured by ROA, is associated with an increase in market valuation, thereby enhancing the overall value of the company (Ishaq et al., 2021). This highligts the crucial role that financial plays in shaping market perception and the valuation of oil and gas companies.

The role of Return on Assets (ROA) as a mediator in the relationship between carbon emission strategies and Tobin's Q value of oil and gas companies has been supported by various studies. Wang and Li emphasize that "the carbon emission performance of an oil and gas producer is affected by many factors," suggesting that effective carbon emission strategies can lead to improved operational efficiencies, which in turn enhance ROA and subsequently influence Tobin's Q positively (Wang & Li, 2018). However, the exact mechanisms by which carbon emission strategies influence ROA and Tobin's Q require further exploration, as the study primarily discusses factors affecting carbon emission performance rather than directly linking it to financial metrics.

Additionally, Shi et al. note that "when the price of crude oil and natural gas rises, manufacturing enterprises tend to use more (relatively cheap) coal for the sake of reducing production cost," indicating that strategic decisions related to carbon emissions can impact financial performance metrics like ROA, which are crucial for determining market valuation (Shi et al., 2023). This highlights the complexity of the relationship between energy prices and carbon emissions, but it does not directly support the claim regarding ROA as a mediator. Lastly, Onmonya highlights that "the effect of enterprise governance on the ROA listed oil and gas firms was found to be negative and insignificant," suggesting that while governance factors may not directly influence ROA, the implementation of carbon emission strategies could serve as a critical factor in enhancing ROA, thereby affecting Tobin's Q (Onmonya et al., 2024). However, this reference primarily discusses enterprise governance rather than carbon emission strategies, which may limit its relevance to the claim being made. Collectively, while these pieces of evidence suggest a relationship between carbon emission strategies, ROA, and Tobin's Q, the direct mediation role of ROA in this context requires more robust evidence.

The positive impact of ROA on Tobin's Q in oil and gas companies underscores the crucial role of financial performance in market valuation, with several studies indicating that effective carbon emission strategies can enhance ROA, thereby positively influencing Tobin's Q, as well as highlighting the direct mediating role of ROA as an intervening variable ((Kılıç & Kuzey, 2019); (Wang & Li, 2018); (Shi et al., 2023); (Onmonya et al., 2024). Based on the preceding discussion, the following hypothesis can be formulated.

Hypothesis : There is a positive mediating role of ROA in the relationship between carbon emission strategy and the value of oil and gas companies.

Revenue diversification in oil and gas firms involves broadening income streams beyond conventional oil and gas extraction. This strategy incorporates alternative energy sources, services, and products, ultimately improving financial stability and resilience to market volatility. "The key factors that prompt oil and gas companies to adopt green diversification include the crisis in the fossil fuel market and the shifts in energy transition," highlighting the importance of diversifying revenue streams in response to changing market dynamics (Cherepovitsyn et al., 2023). Board size, on the other hand, is defined as "the total number of directors on the board," which can influence enterprise governance and decision-making processes, impacting overall firm performance (Jeroen et al., 2006).

The existence of a positive role of revenue diversification as a control variable in the relationship between carbon emission strategies and Tobin's Q values in oil and gas companies, with ROA as an intervening variable, is supported by several studies. Thus Kirichenko et al. emphasize that "the urgency of diversifying the existing activities of oil and gas companies is increasing," indicating that effective revenue diversification strategies can lead to improved financial performance and higher market valuations (Kirichenko et al., 2020). Furthermore, Norouzi highlights that "business diversification is an important indicator of an oil and gas company's preparedness for a low-carbon energy transition," suggesting that companies that diversify their revenue streams are better positioned to implement carbon emission strategies that enhance both ROA and Tobin's Q (Norouzi, 2021).

Similarly, the positive role of revenue diversification in the relationship between carbon emission strategies and Tobin's Q values, with ROA as an intervening variable, is further substantiated by research. For example, Fattouh et al. argue that "oil companies need to develop strategies that are likely to be successful under a wide set of possible future market conditions," which includes diversifying revenue to mitigate risks associated with carbon emissions and enhance financial performance (Fattouh et al., 2019). Additionally, Ingabo and Kihara assert that "diversification strategies lead to significantly increased financial performance," reinforcing the notion that revenue diversification can serve as a crucial factor in improving ROA and, consequently, Tobin's Q in the oil and gas industry (Ingabo & Kihara, 2018). Lastly, Al-Fattah notes that "the role of national oil companies continues to evolve," emphasizing that diversification is essential for adapting to changing market conditions and enhancing overall enterprise value (Al-Fattah, 2013).

Revenue diversification and board size in oil and gas companies serve as critical control variables in the relationship between carbon emission strategies and Tobin's Q value, with ROA acting as an intervening variable. This relationship is underscored by the urgency of the energy transition and the necessity to mitigate carbon emission risks, as highlighted by various scholars, including (Al-Fattah, 2013; Cherepovitsyn et al., 2023; Fattouh et al., 2019; Ingabo & Kihara, 2018;

Kirichenko et al., 2020; Norouzi, 2021). Based on the previous discussion, the conceptual framework for this study has been developed, as illustrated in Figure 1.

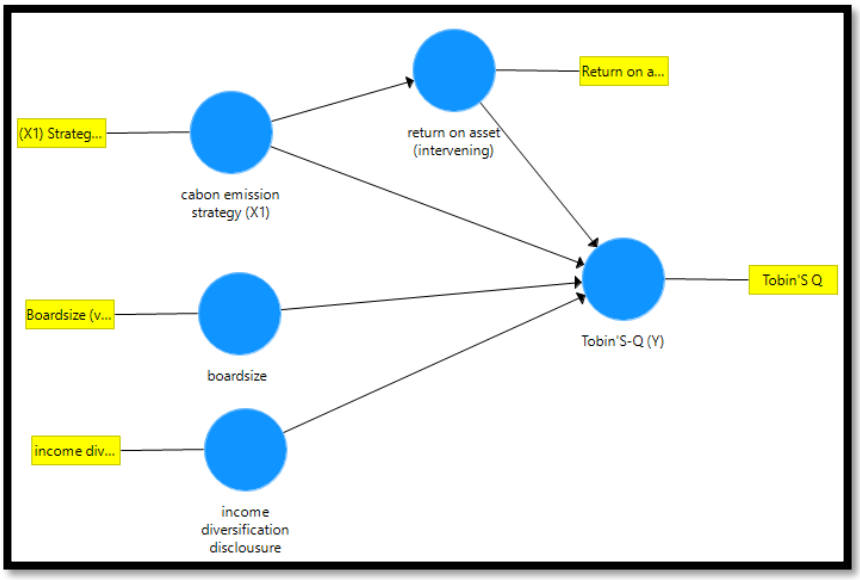

Figure 1. Conceptual Framework

METHOD

Data Collection

To achieve the research objectives, utilize annual data from world oil and gas companiesmarketcap.com website for 2023. In addition to the company's annual financial report, we also use the company's ESG report. Sampling using purposive sampling, the initial population is 350 world oil and gas companies in 2023, and the sample becomes 97 companies so that the financial reports used are 97 financial reports in 2023.

This study used a purposive sampling method based on data from 350 publicly listed oil and gas companies obtained from the *CompaniesMarketCap.com* database for the fiscal year 2023. After applying inclusion and exclusion criteria, a final sample of 97 companies was selected. Firms were included if they operated primarily in the oil and gas industry, were publicly listed, and had complete annual and ESG reports containing information on carbon emission strategies, income diversification, and board structure. Companies with incomplete data, those undergoing mergers or delisting, or those outside the main industry classification were excluded. The sample represents major oil and gas producers from North America, Europe, Asia, and the Middle East, ensuring data comparability and strengthening the study's external validity.

Data Analysis Method

The analysis of data was conducted using the Partial Least Squares–Structural Equation Modeling approach facilitated by SmartPLS version 3.2.8. This analytical approach was chosen because it effectively examines complex causal relationships involving mediation and control

variables, even when the data do not satisfy the assumption of multivariate normality. The analysis started with descriptive statistical methods to outline the features of the observed variables, such as their mean, standard deviation, minimum, and maximum values. The initial descriptive findings gave an overview of the dataset's distribution and variability ahead of the structural estimation.

The PLS-SEM analysis was carried out in two main phases: the structural model and the measurement model. To assess the validity and reliability of the measurement indicators in representing the corresponding latent constructs, the outer model was developed. The evaluation criteria comprised factor loadings, Average Variance Extracted, Composite Reliability, and Cronbach's Alpha, all of which aimed to verify that the indicators properly represented the theoretical dimensions of the study variables. In this research, all primary constructs are represented as single-indicator measures derived from externally defined financial metrics and disclosures. Carbon emissions strategy, ESG performance, revenue diversification disclosure, Tobin's Q, ROA, and board size are each captured by a single observed variable expressed as a ratio, index, or count derived from annual reports, ESG reports, and company market data. This approach aligns with previous research in accounting and finance, which generally treats accounting ratios and market-based indicators as directly observable constructs, rather than as latent constructs with multiple indicators.

In SmartPLS, when constructs are defined as single-indicator constructs, the software automatically produces values of 1.000 for Cronbach's alpha, rho_A, composite reliability, and AVE for each variable. These values result exclusively from the characteristics of the single indicator and should not be misconstrued as an indication of "perfect" internal reliability or convergent validity of the instrument. The reliability and validity of the measurements in this study are based more on: (i) the objective nature of the indicators, calculated from audited financial statements and published ESG disclosures, and (ii) the widespread use of these indicators in various previous empirical studies on firm value and environmental performance. Given the unique characteristics of the single indicator, conventional internal consistency assessments, including Cronbach's alpha, composite reliability, and average variance extracted (AVE), are less revealing. Consequently, the evaluation of the measurement model in this research prioritized conceptual clarity, consistency with existing literature, and the examination of multicollinearity. All Variance Inflation Factor (VIF) values were found to be beneath the widely accepted threshold, suggesting that significant multicollinearity problems were not present and affirming the appropriateness of the predictors for structural model estimation.

The outer model equations can be expressed as follows:

Outer Model Equations

Carbon Emission Strategy Disclosure (X1)

$X1 = \beta 1X1$ Equation (1)

ROA (Y2)

$Y2 = \alpha 3 + \theta 1Y1 + \psi 1C1 + \psi 2C2 + \varepsilon 3$ Equation (2)

Disclosure of Revenue Diversification Type - Sales (C1)

$C1 = \gamma 1C1$ Equation (3)

Board Size (C2)

$C2 = \gamma 2C2$ Equation (4)

After confirming the validity and reliability of the measurement model, the structural model (inner model) was estimated to investigate the causal relationships among latent variables. The analysis of the inner model concentrated on assessing the magnitude and significance of path coefficients, the model's explanatory power (R^2), and the effect sizes (f^2) of the exogenous constructs. The mediating role of Return on Assets (ROA) was evaluated using a bootstrapping technique with 5,000 resamples, which facilitated a robust estimation of the indirect effect between the carbon emission strategy and firm value. The structural relationships among the latent variables were articulated through the following inner model equations:

Inner Model Equations

Indirect Model

Indirect Relationship through Y1

$Y1 = \alpha 2 + \lambda 1X1 + \delta 1C1 + \delta 2C2 + \varepsilon 2$ Equation (5)

Effect of Y1 on Y2

$Y2 = \alpha 3 + \theta 1Z + \psi 1C1 + \psi 2C2 + \varepsilon 3$ Equation (6)

Direct Model

Direct Relationship for Y2

$Y2 = \alpha 1 + \beta 1X1 + \gamma 1C1 + \gamma 2C2 + \varepsilon 1$ Equation (7)

Total Model

Total Equation

Total effect of X1 on Y2 $= \beta 1 + (\lambda 1 \times \theta 1)$ Equation (8)

Finally, robustness tests were performed using Ordinary Least Squares (OLS) regression with country fixed effects and clustered standard errors to validate the consistency of the SEM results. The combination of PLS-SEM and OLS ensures both statistical reliability and theoretical robustness, providing a comprehensive understanding of how carbon emission strategies influence firm value directly and indirectly through financial performance (ROA), while accounting for the effects of income diversification and board size as control variables.

RESULTS AND DISCUSSION

Implications under IFRS S2. As jurisdictions endorse and implement IFRS S2, Cross-country differences in institutional features (e.g., enforcement strength, investor protection, climate policy stringency, and the presence of emissions-trading schemes) may moderate the value

relevance of emission related disclosures. Future research could exploit post-2024 setting and staggered endorsement to test whether comparability gains and transition-year reliefs strengthen (or attenuate) link we document. We expect stronger effects where reporting is mandatory, assurance is required, and enforcement is credible, particularly for firms with material transition-risk exposure in carbon-intensive industries.

The findings from the outer model assessment are displayed in the tables titled "Average Variance Extracted & Composite Reliability Test Results" and "Construct Reliability & Validity." These results indicate that all variables demonstrate high levels of reliability and validity. This point to that the research model has a very robust and consistent measurement structure. The VIF values also show favorable results (Table 1.). The values of rho_A and Composite Reliability at 1.000 indicate high consistency in the model's measurements, while an AVE of 1.000 demonstrates that each variable accounts for 100% of the variance of its indicators (all values are 1.000).

Table 1. Construct Reliability & Validity

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
ESG	1,000	1,000	1,000	1,000
KBJK.C.M.	1,000	1,000	1,000	1,000
STR.E.K.	1,000	1,000	1,000	1,000
TOBIN'S Q_	1,000	1,000	1,000	1,000

Note: All constructs in the model are specified as single-indicator constructs. Therefore, Cronbach's alpha, rho_A, composite reliability, and AVE values of 1.000 arise mathematically as a consequence of this specification and should not be interpreted as evidence of perfect internal reliability. The appropriateness of the measurements is based on the objective definition of the indicators and their widespread use in previous empirical research.

The findings from the assessment of the measurement model are presented in the "Construct Reliability & Validity" table. Given that all constructs within the PLS-SEM framework are defined as single-indicator constructs, SmartPLS generates Cronbach's alpha, rho_A, composite reliability, and AVE values of 1.000 for each variable. These figures are a consequence of the mathematical characteristics inherent to the single-indicator specification and do not imply that the measurements are devoid of error or possess flawless internal reliability.

The appropriateness of the measurements in this study is further supported by the objective nature of the indicators used—such as accounting ratios, market value measures, and disclosure indices—and by the fact that these indicators have been widely used in previous literature on firm value, environmental performance, and corporate governance. Furthermore, the multicollinearity diagnostic results indicate that all VIF values are below the commonly used critical limit, indicating the absence of interfering multicollinearity among the predictors. Thus, the measurement model is deemed adequate for use in estimating the structural relationship between carbon emission strategy, ROA, revenue diversification disclosure, board size, and firm value (Tobin's Q). Given the single-indicator construct specification, PLS-SEM

results can then be understood as a series of path relationships between observed variables that summarize a firm's carbon emission strategy, financial performance, and market value.

The assessment of the structural model, also referred to as the inner model, involved the analysis of path coefficients, R^2, Q^2, and the evaluation of statistical significance through bootstrapping techniques. The Normed Fit Index (NFI) value of 97.7% demonstrates a superior fit of the model in comparison to the baseline model. The R^2 value of 0.577 signifies that 57.7% of the variability in Tobin's Q is accounted for by the independent variables included in the model. Additionally, the adjusted R^2 of 0.559 suggests that the model retains a strong level of robustness even after considering the number of predictors employed. When utilizing a single-indicator construct specification, these findings can be interpreted as indicative of a path relationship among the observed variables that represent carbon emission strategy, financial performance (measured by Return on Assets, ROA), and the market value of the company.

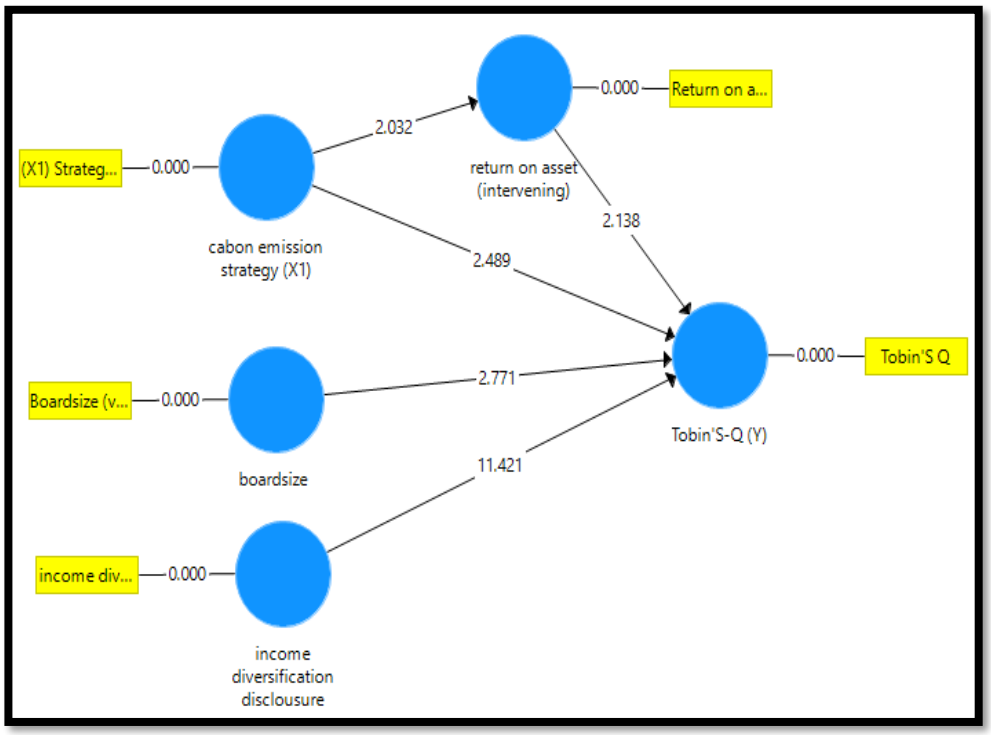

Figure 2. SEM PLS Output

For detailed values on direct, indirect, and total effects, refer to the appendix, Table "Indirect-Direct-Total Effects." The carbon emission strategy has a total effect of 0.146 on Tobin's Q, meaning that for every one-unit increase in the carbon emission strategy, Tobin's Q increases by 0.146 units. With a T-statistic value of 2.383 (> 1.96), this effect is statistically significant at the 5% significance level, indicating that the carbon emission strategy has a significant positive impact on firm value.

The 2023 Russia-Ukraine war profoundly influenced the global oil and gas sector, specifically concerning carbon emission policies and their effect on firm value, as quantified by Tobin's Q. These geopolitical tensions are pushing energy companies to accelerate the implementation

of decarbonization strategies, in response to pressure from concerned global stakeholders and to reduce the risks associated with dependence on fossil fuels. As the focus on energy security and resource diversification increased, oil and gas companies that proactively implemented carbon emission strategies were able to enhance their legitimacy and reputation with investors. This contributed increase relative to in the market value of these companies, evidenced by the significant positive relationship between the carbon emission strategy and Tobin's Q. This achievement underscores the significance of sustainable carbon management as a strategic approach to addressing the challenges arising from geopolitical conflicts. The correlation between carbon emission strategies and firm value within the oil and gas sector, particularly as indicated by Tobin's Q, has been established as significantly positive. Implementing effective carbon management strategies can enhance a company's legitimacy and reputation, subsequently leading to improved financial performance and market valuation. Furthermore, green strategies exhibit a substantial relationship with financial performance in industries characterized by high levels of pollution (Yuliana & Wedari, 2023). Similarly, White & Deweerdt (2024) shows that commitment to ambitious net-zero targets enhances a company's reputation and financial performance (White & Deweerdt, 2024). This underscores the strategic importance of carbon management in improving enterprise valuation. Furthermore, integrating carbon strategies into company operations faces close scrutiny from party concerned. Emphasize the importance of strategic planning for decarbonization to maintain competitive advantage during the energy transition (Romasheva & Cherepovitsyna, 2023).

Proactive responses to global carbon reduction initiatives can mitigate climate change risks and enhance a company's market value (Prasetyo & Putro, 2024). Additionally, strong enterprise governance contributes to improved carbon emission disclosures, as noted by Andrian and Kevin (2021) and Cherepovitsyn et al.(2023), who assert that diversification into low-carbon technologies drives better financial outcomes and higher valuations (Andrian & Kevin, 2021); (Cherepovitsyn et al., 2023). Thus, the carbon emission strategy not only impacts a company’s reputation but also enhances its attractiveness to investors.

The carbon emission strategy exhibits a total effect of 0.108 on the Return on Assets (ROA) of oil and gas companies, functioning as an intervening variable. This suggests that the strategy contributes positively, albeit to a limited extent. The T-statistic value of 1.984, which exceeds the threshold of 1.96, confirms the significance of this relationship at the 5% significance level. Evidence indicates that the proactive carbon emission strategy positively influences ROA, serving as a crucial intervening variable in the financial performance of oil and gas firms. This phenomenon can be attributed to the geopolitical uncertainties arising from the Russia-Ukraine conflict in 2023, which significantly impacted global energy markets and intensified the pressure on oil and gas companies to address climate and operational risks. In

this context, the strategy demonstrates a beneficial effect on ROA while playing a vital role as an intervening variable in financial performance. The reliance on fossil fuels during this crisis has led to increased scrutiny of corporate practices.

Study indicates that good environmental management, such as emission reduction and waste management, can lower operational costs and increase ROA (Afolabi et al., 2024). This is supported by the other findings, which show that green investments aimed at reducing carbon emissions contribute to improved financial performance (Ganda & Milondzo, 2018). Good environmental practices not only reduce the risks of compliance costs but also enhance operational efficiency, ultimately strengthening the company's financial results. Additionally, research reveals that carbon emission intensity has a significant impact on financial metrics such as Tobin's Q and ROA, even though total carbon emissions do not directly affect ROA (Koç & Ali, 2024). Further perspectives suggest that while high carbon emissions may offer short-term gains, long-term financial performance declines without strategic carbon management (Busch et al., 2022). Thus, proactive carbon emission management not only enhances environmental Environmentally conscious but also boosts long-term profitability in the energy industry.

On the other hand, ROA has a total negative effect of -0.142 on Tobin's Q, meaning that for every one-unit increase in ROA, Tobin's Q decreases by 0.142 units. The T-statistic value of 2.034 (greater than 1.96) indicates that this relationship is significant at the 5% significance level. This negative effect may be due to other factors, such as misalignment of asset use with market expectations or negative effects from the company's management strategies. The relationship between ROA and firm value, particularly in the context of Tobin's Q in the global oil and gas industry, shows that ROA has a significant negative effect on firm value. Geopolitical tensions have led to increased operational costs, such as spikes in raw material prices and logistics, which compress profit margins and reduce asset management efficiency. Additionally, the focus on energy diversification and the pressure to invest in low-carbon technologies to meet Environmentally conscious demands adds to the company's capital burden, reducing short-term profitability, as reflected in the decline in ROA. This decline directly impacts Tobin's Q, as investors tend to negatively evaluate companies with low profitability, even if the company's assets remain highly valuable. This war, with all its implications, exacerbates the challenges faced by the oil and gas industry in balancing financial performance with responses to external pressures.

The other findings show that a decrease in ROA correlates with a decrease in Tobin's Q, although this study addresses performance metrics in a broader context (Westerman et al., 2020). Moreover, the profitability of the oil and gas industry is pressured by increased debt levels and reduced asset multipliers, which negatively affect the company's valuation (Shimko, 2022). These findings are consistent with

Cletus et al., (2021) research, which states that environmental and compliance costs contribute to a decline in Tobin's Q, highlighting the importance of financial performance, including ROA, in maintaining firm value (Cletus et al., 2022). Strengthen this connection by showing that a decline in ROA can significantly reduce Tobin's Q (Kumar & K Sukumaran, 2016), while (Ahmed et al., 2021) confirm the negative impact of ROA on overall company performance metrics. These studies illustrate that decreasing profitability, combined with pressures from debt levels and environmental costs, complicates the relationship between ROA and Tobin's Q. Therefore, maintaining strong financial performance is crucial for oil and gas companies to preserve their firm value amidst the challenges of a constantly evolving industry.

The disclosure of revenue diversification as a control variable proves to have the most dominant total effect on firm value (Tobin's Q), with a coefficient of 0.663 and a T-statistic of 11.547 ($p < 0.01$), showing very high significance. Additionally, board size as a control variable also has a significant effect on Tobin's Q with a coefficient of 0.160 and a T-statistic of 2.682 ($p < 0.05$). By incorporating these two control variables, all three hypotheses tested were accepted, whereas initially only two hypotheses were accepted, and one was rejected.

CONCLUSION

The carbon emission strategy and Tobin's Q value of oil and gas industry companies have a positive and significant influence. Likewise, the relationship between carbon emission strategy and ROA of global oil and gas companies also has a positive and significant influence. Finally, the study shows that there is a significant negative influence in the relationship between ROA and Tobin's Q of global oil and gas companies.

The significant positive effect of carbon emission strategies on both Tobin's Q and ROA indicates that investments in Environmentally conscious practices not only help companies meet regulatory demands and maintain their reputation but also enhance financial performance and company value. An effective carbon emission strategy can be a competitive advantage in a market that increasingly demands responsible environmental business practices. Furthermore, the finding that ROA has a significant negative effect on Tobin's Q provides insight that an exclusive focus on short-term profitability may not always align with the company's market value, suggesting that companies need to balance priorities between operational efficiency and long-term investments.

This study has several limitations, including the focus on global oil and gas companies, which limits the generalizability of the findings to other industries, as well as the potential temporary impact of geopolitical factors, such as the Russia-Ukraine war in 2023, on the relationships between variables. In addition, the quantitative approach used has not explored qualitative factors such as local policies or investors' perceptions of Environmentally conscious in depth. Therefore, future research is recommended to expand the scope to other industry industries, consider moderation variables such as environmental

regulations, and integrate qualitative approaches to provide a more comprehensive understanding of the dynamics between carbon emission strategies, ROA, and company value.

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