

CARBON ACCOUNTING PRACTICES AND FIRM VALUE

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Abstract

This study examines the effect of carbon accounting practices on firm value in the Nigerian oil and gas sector, with sustainability introduced as a moderating variable. Carbon accounting practices were operationalized into carbon measurement techniques, carbon disclosure practices, and regulatory compliance mechanisms, while firm value was proxied by Tobin's Q. The study adopted an ex post facto research design using panel data from 15 listed oil and gas firms over the period 2016–2025. Data were obtained from annual reports, sustainability reports, and Nigerian Exchange Group publications. Panel regression analysis was employed alongside correlation and descriptive statistics to test the hypotheses. Findings reveal that all dimensions of carbon accounting practices have a significant positive effect on firm value. Carbon disclosure practices exert the strongest influence, followed by carbon measurement techniques and regulatory compliance mechanisms. The results further show that sustainability significantly moderates the relationship between carbon accounting practices and firm value, strengthening their impact. The study concludes that carbon accounting is not merely a compliance requirement but a strategic financial tool that enhances firm value through improved transparency, reduced information asymmetry, and increased investor confidence. The study recommends improved carbon measurement systems, enhanced disclosure quality, and stronger regulatory compliance to maximize firm value in emerging economies.

Keywords: Carbon accounting, firm value, carbon disclosure, sustainability, regulatory compliance, Tobin's Q.

Introduction

Climate change has become one of the most pressing global challenges, largely driven by rising greenhouse gas (GHG) emissions from corporate and industrial activities. This has intensified global concerns regarding environmental sustainability and increased the demand for corporate accountability in managing environmental impacts. Consequently, businesses are now under growing pressure from key stakeholders, including investors, regulators, customers, and environmental advocacy groups, to adopt transparent and credible carbon management and reporting practices. These pressures are reinforced by the increasing integration of environmental, social, and governance (ESG) factors into investment decision-making and corporate performance evaluation (Deloitte, 2024; KPMG, (2023)).

In response to these developments, carbon accounting has emerged as a critical mechanism for measuring and reporting environmental performance. Carbon accounting involves the systematic identification, measurement, recording, and disclosure of carbon emissions associated

with organizational activities. Its relevance has been further strengthened by the introduction of global sustainability frameworks and regulatory initiatives aimed at improving the consistency and comparability of climate-related disclosures. Notably, the Task Force on Climate-related Financial Disclosures (TCFD) provides structured guidance on reporting climate-related risks and opportunities, while the Paris Agreement establishes international commitments to carbon reduction and climate mitigation. Additionally, the International Sustainability Standards Board (ISSB) has introduced standardized sustainability disclosure frameworks to enhance transparency and comparability across firms IFRS Foundation, (2023); United Nations, (2024). Despite these advancements, the implementation of carbon accounting practices remains inconsistent, particularly in emerging economies.

Many firms continue to face challenges related to accurate carbon measurement techniques, comprehensive disclosure practices, and alignment with international reporting standards. In several developing markets, carbon reporting is still largely voluntary and weakly enforced, leading to issues such as greenwashing, information asymmetry, and reduced reliability of environmental disclosures. These challenges are particularly evident in carbon-intensive sectors such as oil and gas, where environmental risks are significant but reporting practices remain underdeveloped. From a financial perspective, there is increasing recognition that environmental performance plays a crucial role in determining firm value. Investors are progressively incorporating climate-related information into valuation decisions, suggesting that firms with effective carbon accounting practices may achieve higher market valuation through improved transparency, reduced risk exposure, and enhanced stakeholder confidence.

Empirical evidence supports this view to some extent. For instance, studies show that carbon disclosure positively influences firm value by improving investor perception and reducing uncertainty. Similarly, recent research indicates that stronger climate performance is associated with higher market valuation, reflecting the growing importance of sustainability information in financial markets. However, the relationship between carbon accounting practices and firm value remains inconclusive. While some studies report a positive association, others find insignificant or even negative effects due to compliance costs and short-term financial burdens. For example, recent empirical findings reveal that carbon emission disclosure may have no significant impact or even a negative effect on firm value in certain contexts. Furthermore, studies in emerging markets highlight mixed outcomes, with some reporting positive valuation effects of carbon disclosure and others emphasising the moderating role of carbon management practices. This inconsistency underscores the need for further empirical investigation, particularly within emerging economies.

Theoretically, this study is anchored on three key frameworks. Stakeholder Theory Freeman, (1984) posits that firms must address the expectations of a broad range of stakeholders, thereby explaining the increasing demand for transparent carbon reporting. Legitimacy Theory Suchman, (1995) suggests that firms engage in environmental disclosure to align their operations with societal norms and maintain legitimacy. In addition, Signaling Theory Spence, (1973) argues that firms use voluntary disclosures, such as carbon reporting, to signal superior performance and reduce information asymmetry in capital markets. These theories collectively provide a robust foundation for understanding how carbon accounting practices may influence firm value through enhanced transparency, credibility, and stakeholder trust.

Notwithstanding the growing body of literature, there is limited context-specific empirical evidence examining how specific dimensions of carbon accounting, such as carbon measurement techniques, carbon disclosure practices, and regulatory compliance mechanisms, affect firm value, particularly in emerging economies and carbon-intensive sectors. This gap limits the ability of policymakers, investors, and corporate managers to make informed decisions regarding sustainability reporting and environmental governance.

Statement of the Problem

The growing global emphasis on environmental sustainability has significantly increased pressure on firms to measure, manage, and disclose their carbon emissions. This pressure is reinforced by international regulatory frameworks and initiatives such as the International Sustainability Standards Board (ISSB) disclosure standards, the Task Force on Climate-related Financial Disclosures (TCFD), and global agreements like the Paris Agreement, all of which promote transparency, consistency, and accountability in climate-related reporting. Consequently, carbon accounting has transitioned from a voluntary corporate social responsibility practice to a strategic financial and governance concern. Despite these developments, substantial challenges persist in the implementation of carbon accounting practices, particularly in emerging economies. Many firms continue to experience difficulties in adopting reliable carbon measurement techniques, ensuring comprehensive and credible disclosure practices, and aligning with internationally recognized reporting standards. In several developing markets, carbon reporting remains largely voluntary, weakly regulated, and inconsistently applied. This situation contributes to issues such as greenwashing, information asymmetry, and the limited reliability and comparability of disclosed environmental information.

From a financial perspective, the increasing integration of environmental, social, and governance (ESG) factors into investment decisions suggests that carbon accounting practices may play a significant role in determining firm value. However, empirical evidence on this relationship remains inconclusive. While some studies argue that improved carbon disclosure enhances firm reputation, reduces perceived risk, and facilitates access to capital, others report insignificant or even negative effects due to compliance costs and short-term financial pressures. This inconsistency creates uncertainty regarding the value relevance of carbon accounting practices. Furthermore, there is limited context-specific empirical evidence, particularly within emerging economies and carbon-intensive sectors such as oil and gas, on how specific dimensions of carbon accounting, including carbon measurement techniques, carbon disclosure practices, and regulatory compliance mechanisms, influence firm value. The absence of such evidence constrains effective policy formulation, corporate strategic planning, and informed investment decision-making. Therefore, the central problem addressed in this study is the lack of clear and consistent empirical evidence on the extent to which carbon accounting practices influence firm value, particularly within emerging market contexts.

This study seeks to bridge this gap by examining the effect of carbon accounting practices on firm value, with a focus on key dimensions of carbon measurement, disclosure, and regulatory compliance. By doing so, the study aims to contribute to both academic literature and practical policy discussions on sustainability reporting and corporate valuation. This study contributes to the literature by bridging the gap between environmental accounting and corporate finance, particularly within developing economies. It also provides practical insights for regulators, investors, and corporate managers on the role of carbon accounting in enhancing transparency, sustainability reporting, and firm valuation. The remainder of this paper is structured as follows: Section Two reviews relevant literature and theoretical frameworks; Section Three outlines the research methodology; Section Four presents and discusses the empirical findings; and Section Five concludes key findings, implications, and recommendations for future research.

Objectives of the Study

The primary objective of this study is to examine the effect of carbon accounting practices on firm value. The specific objectives are to:

1. evaluate the effect of carbon measurement techniques on firm value;
2. assess the impact of carbon disclosure practices on firm value;
3. examine the influence of regulatory compliance mechanisms on firm value.

4. determine the moderating effect of sustainability on the relationship between carbon accounting practices and firm value.

Research Hypotheses

The study tests the following null hypotheses:

H₀₁: Carbon measurement techniques have no significant effect on firm value.

H₀₂: Carbon disclosure practices have no significant effect on firm value.

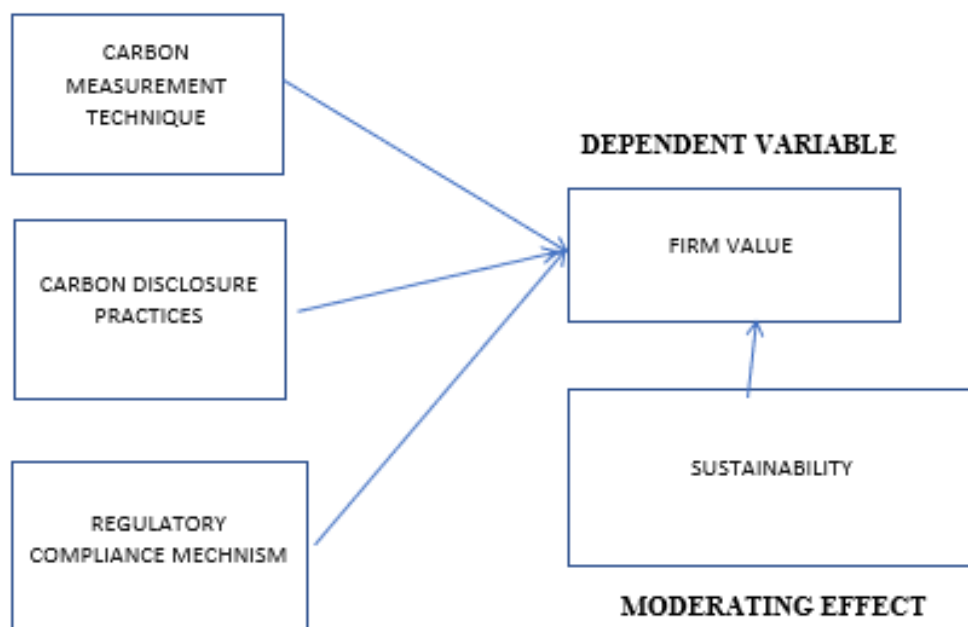
H₀₃: Regulatory compliance mechanisms have no significant effect on firm value.

H₀₄: Sustainability does not significantly moderate the relationship between carbon accounting practices and firm value.

Conceptual Review

Fig.2.1

INDEPENDENT VARIABLE



Literature Review and Hypotheses Development

Carbon Accounting Practices and Firm Value

Carbon accounting practices have emerged as critical mechanisms through which firms measure, manage, and communicate their environmental impact, particularly greenhouse gas (GHG) emissions. These practices enhance transparency, reduce information asymmetry, and provide stakeholders with relevant environmental information for decision-making. Increasingly, investors incorporate environmental, social, and governance (ESG) indicators into valuation models, making carbon-related information a significant determinant of firm value (Robert G. Eccles, Ioannis Ioannou, & George Serafeim, 2019; McKinsey & Company, 2023; Mozaffar Khan, George Serafeim, & Aaron Yoon, 2022; Amir Amel-Zadeh & George Serafeim, 2023). Firm value, often proxied by measures such as Tobin's Q or market-to-book ratio, reflects investors' expectations regarding a firm's future performance and risk profile. Empirical evidence suggests that firms with strong environmental performance and transparent carbon accounting systems tend to achieve higher valuation due to improved risk management, enhanced reputation, and increased

stakeholder confidence (Clarkson, Li, Richardson, & Tsang, 2020; Li, Tang, & Wang, 2022; Ijeoma, 2020; Erin, Adegboye & Bamigboye, 2022).

Recent studies further confirm that carbon-related disclosures and sustainability practices significantly influence firm valuation by reducing uncertainty and enhancing investor confidence (Francesco Vitolla, Nicola Raimo, Michele Rubino, & Antonello Garzoni, 2020; Iredele, Tanko, & Akinleye, 2022; Uwuigbe, Teddy, Uwuigbe, Olamide, & Emmanuel, 2023). Moreover, emerging evidence highlights that the value relevance of carbon accounting is particularly pronounced in firms operating in environmentally sensitive industries, where stakeholders place greater emphasis on environmental responsibility (Shi, Zhang, & Wei, 2024; Zhang, Chen, & Huang, 2023). However, the magnitude and direction of this relationship vary across institutional environments, industries, and regulatory contexts, particularly in emerging markets where reporting standards and enforcement mechanisms are still evolving (Peter Velte, 2023; Raimo, Vitolla, & Rubino, 2021).

Carbon Measurement Techniques and Firm Value

Carbon measurement techniques refer to the methodologies and systems used to quantify GHG emissions arising from corporate activities. These techniques form the foundation of reliable carbon accounting, as the accuracy of environmental disclosures depends on the quality of measurement systems employed. Standardized frameworks such as the Greenhouse Gas Protocol and ISO 14064 enhance the comparability, consistency, and credibility of emissions data. From a theoretical standpoint, Stakeholder Theory R. Edward Freeman, (1984) posits that firms adopting robust measurement systems are better able to satisfy stakeholder demands for accountability, thereby enhancing trust and firm value. Similarly, Signaling Theory Michael Spence, (1973) suggests that accurate measurement signals superior environmental management and transparency to investors. Empirical studies support this relationship. Li, Tang, and Wang (2022) and Clarkson, Li, Richardson and Tsang (2020) find that firms with advanced environmental measurement systems exhibit improved risk assessment and increased investor confidence. More recent studies indicate that accurate carbon measurement enhances disclosure quality, reduces information asymmetry, and positively influences market valuation Shi, Zhang, & Liu, (2024); Zhang, Chen, & Huang, (2023). Conversely, weak measurement systems can lead to inconsistent reporting and reduced credibility, which may negatively affect firm value. Based on these arguments, the study hypothesizes that:

H₀₁: Carbon measurement techniques have no significant effect on firm value.

Carbon Disclosure Practices and Firm Value

Carbon disclosure practices refer to the extent, quality, and transparency with which firms report carbon emissions and climate-related information through corporate reports and ESG disclosures. High-quality disclosure serves as a key mechanism for communicating environmental performance and accountability to stakeholders. According to Signaling Theory Michael Spence, (1973), firms use disclosure to convey superior environmental performance, while Stakeholder Theory R. Edward Freeman, (1984) emphasizes that transparent reporting reduces information asymmetry and enhances stakeholder confidence. Empirical evidence generally supports a positive association between carbon disclosure and firm value. Studies by Zhu, Li, and Chen (2024) and Liu, Wang, and Zhang (2025) demonstrate that firms with comprehensive disclosure practices tend to achieve higher market valuation due to improved investor perception and reduced perceived risk. However, the literature presents mixed findings. Some studies report insignificant or negative effects, particularly where disclosures are perceived as symbolic or associated with high reporting costs (Sitorus, Harahap, & Nasution, (2024); Wang, Li, & Zhao, (2023).

Additionally, concerns about greenwashing and selective disclosure may weaken the credibility of reported information. Recent research highlights the importance of disclosure quality

and assurance. Issa, Khan, and Ali (2024) and Matthews, Brown, and Taylor (2024) find that externally verified disclosures have stronger positive effects on firm value compared to unaudited disclosures. This suggests that capital markets reward credible, consistent, and verifiable environmental information. Therefore, the study proposes that:

H₀₂: Carbon disclosure practices have no significant effect on firm value.

Regulatory Compliance Mechanisms and Firm Value

Regulatory compliance mechanisms refer to the extent to which firms adhere to environmental regulations and global sustainability frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD), the Paris Agreement, and the International Sustainability Standards Board (ISSB) standards. Compliance is increasingly viewed as a critical determinant of corporate legitimacy and long-term financial performance. Legitimacy Theory Mark C. Suchman (1995) posits that firms must align their operations with societal expectations to maintain legitimacy. Compliance with environmental regulations signals adherence to accepted norms and enhances corporate reputation. Stakeholder Theory R. Edward Freeman, (1984) further suggests that regulatory compliance reduces risk and strengthens investor confidence. Empirical evidence supports these theoretical perspectives. Reports from the International Financial Reporting Standards Foundation (2023) and the United Nations Framework Convention on Climate Change (2024) indicate that firms with strong compliance mechanisms are perceived as less risky and more sustainable, leading to improved firm value. Huang, Chen, and Liu (2022) find that firms in highly regulated environments adopt structured carbon accounting systems that enhance financial performance through improved risk management. Nevertheless, the relationship is not unequivocal. Some studies highlight that compliance costs may reduce short-term profitability, particularly in developing economies with weak institutional frameworks (Zhou, Li, & Wang, 2023; PricewaterhouseCoopers International Limited, 2024). These mixed findings suggest that the impact of compliance on firm value may depend on contextual factors. Accordingly, the study hypothesizes that:

H₀₃: Regulatory compliance mechanisms have no significant effect on firm value.

Moderating Role of Sustainability

Sustainability refers to the integration of environmental, social, and governance (ESG) considerations into corporate strategy and operations to achieve long-term value creation. In this study, sustainability is conceptualized as a moderating variable that influences the relationship between carbon accounting practices and firm value. Theoretically, sustainability enhances the effectiveness of environmental accounting practices by ensuring their integration into strategic decision-making processes. Stakeholder Theory (R. Edward Freeman, 1984) suggests that firms with strong sustainability orientation are better able to meet stakeholder expectations, while Signaling Theory (Michael Spence, 1973) implies that such firms provide more credible and meaningful disclosures. Empirical studies support this moderating role. Robert G. Eccles, Ioannis Ioannou, and George Serafeim (2020) and Mozaffar Khan, George Serafeim, and Aaron Yoon (2022) show that firms with strong sustainability practices achieve superior financial performance due to improved governance and transparency. Similarly, Chris Brooks and Ioannis Oikonomou (2023) and Gunnar Friede, Timo Busch, and Alexander Bassen (2021) find that sustainability orientation strengthens the positive relationship between environmental disclosure and firm value. Conversely, firms with weak sustainability orientation may fail to derive significant benefits from carbon accounting practices due to poor integration of environmental considerations into corporate strategy. This suggests that sustainability plays a critical role in determining whether carbon accounting translates into financial outcomes. Based on this, the study proposes that:

H₀₄: Sustainability does not significantly moderate the relationship between carbon accounting practices and firm value.

Conceptual Framework and Theoretical Lens

This study develops a conceptual model that explains the relationship between carbon accounting practices and firm value. The model posits that firm value is influenced by the extent to which firms adopt and implement carbon accounting practices, which are increasingly recognized as important drivers of transparency, accountability, and sustainability performance (Vitolla, Raimo, Rubino, & Garzoni, 2020; Velte, 2023).

Carbon accounting practices are operationalized along three dimensions: carbon measurement techniques, carbon disclosure practices, and regulatory compliance mechanisms. These dimensions capture how firms measure, report, and comply with environmental requirements. Carbon measurement techniques refer to systems used to quantify greenhouse gas emissions. Accurate measurement improves reporting reliability and investor confidence. Evidence shows that standardized measurement systems enhance data accuracy and reduce reporting errors, leading to improved valuation outcomes (Li, Tang, & Wang, 2022; Clarkson, Li, Richardson, & Tsang, 2020; Shi, Zhang, & Liu, 2024).

Carbon disclosure practices reflect the quality and transparency of environmental reporting. High-quality disclosure reduces information asymmetry and strengthens investor trust. Empirical evidence shows that firms with credible and comprehensive disclosures tend to achieve higher firm value, especially when disclosures are externally assured (Zhu, Li, & Chen, 2024; Issa, Khan, & Ali, 2024; Matthews, Brown, & Taylor, 2024). Regulatory compliance mechanisms capture adherence to environmental laws and frameworks such as TCFD and ISSB. Compliance enhances legitimacy, reduces regulatory risk, and improves access to green financing. Studies show that firms with strong compliance systems achieve better financial outcomes and higher market valuation (Huang, Chen, & Liu, 2022; IFRS Foundation, 2023; UNFCCC, 2024).

The model assumes that stronger carbon accounting practices improve transparency, reduce information asymmetry, and enhance stakeholder confidence, thereby positively influencing firm value. This is supported by evidence that environmental transparency and sustainability practices improve market valuation and long-term performance (Eccles, Ioannou, & Serafeim, 2019; Khan, Serafeim, & Yoon, 2022; Uwuigbe, Teddy, Uwuigbe, Olamide, & Emmanuel, 2023).

Theoretical Lens of the Study

The relationship between carbon accounting practices and firm value is examined through three complementary theoretical perspectives: Stakeholder Theory, Legitimacy Theory, and Signaling Theory. Stakeholder Theory (Freeman, 1984) provides the primary lens for this study. It argues that firms are responsible not only to shareholders but also to a broader group of stakeholders, including regulators, customers, employees, and the public. From this perspective, carbon accounting practices serve as a mechanism through which firms respond to stakeholder demands for environmental accountability. By improving carbon measurement, disclosure, and compliance, firms enhance stakeholder trust and support, which may positively influence firm value.

Legitimacy Theory (Suchman, 1995) explains that firms operate within a social contract and must ensure that their activities are perceived as legitimate by society. Carbon accounting practices, particularly disclosure and compliance with international frameworks such as TCFD and ISSB, help firms align their operations with societal expectations regarding environmental responsibility. This alignment enhances legitimacy, which can translate into improved reputation and firm valuation.

Signaling Theory (Spence, 1973) provides an additional explanation by suggesting that firms use voluntary disclosures to signal superior environmental performance to the market. High-quality carbon accounting practices signal transparency, efficiency, and lower environmental risk.

Investors interpret such signals positively, thereby influencing market perception and increasing firm value.

Collectively, these theories provide a strong analytical foundation for understanding how carbon accounting practices influence firm value through mechanisms of transparency, legitimacy, stakeholder confidence, and information signaling.

Theoretical Framework

This study is anchored on Stakeholder Theory and Legitimacy Theory. Stakeholder Theory emphasizes that firms must consider the interests of multiple stakeholders, including investors, regulators, employees, and society at large, when implementing corporate strategies. Legitimacy Theory posits that firms adopt carbon accounting and sustainability practices to align with societal expectations, regulatory requirements, and environmental norms, thereby maintaining legitimacy and enhancing firm value (2021–2024).

Empirical evidence from emerging markets, including Nigeria, presents mixed findings. Some studies report that carbon disclosure and robust carbon accounting practices improve firm value by enhancing transparency, reducing information asymmetry, and signaling responsible management to stakeholders. Conversely, other studies highlight potential negative or insignificant effects due to high compliance costs and operational constraints. These inconsistencies underscore the importance of examining how carbon accounting practices—measurement, disclosure, and regulatory compliance—interact with sustainability accounting to influence firm value in the Nigerian context.

Empirical Review

This section presents selected recent empirical studies examining the effect carbon accounting practices has on firm value, with emphasis on environmentally sensitive industries such as oil and gas. The review highlights differences in geographical focus, methodological approaches, findings, and policy implications. It reviews prior research findings, methodologies, and key conclusions in order to identify patterns, inconsistencies, and gaps in the literature. Specifically, the section evaluates studies that investigate carbon measurement techniques, carbon disclosure practices, regulatory compliance mechanisms, and their implications for market valuation, financial performance, and investor perception. Empirical evidence in this area has expanded significantly following global sustainability initiatives such as the Paris Agreement and reporting frameworks promoted by the International Sustainability Standards Board and the Task Force on Climate-related Financial Disclosures. These developments have stimulated research examining whether improved transparency in carbon reporting enhances firm reputation, reduces information asymmetry, lowers cost of capital, and ultimately increases firm value.

Friede, Busch and Bassen (2015), Environmental, Social, and Governance (ESG) performance and corporate financial performance, including environmental and carbon-related disclosures. Global meta-analysis was used as to analyse the data. The findings suggest that enhanced transparency reduces information asymmetry and strengthens investor confidence. The study recommends the integration of environmental and carbon metrics into mainstream financial reporting frameworks and encourages firms, especially in carbon-intensive industries, to adopt standardized and comparable disclosure practices.

Clarkson, Li, Richardson and Tsang (2011), environmental disclosure quality and firm valuation, United States, with emphasis on environmentally sensitive industries such as oil and gas. Panel regression analysis was employed, using environmental disclosure scores and market-based performance indicators (e.g., Tobin's Q). The study found that firms providing high-quality, quantitative environmental disclosures experienced significantly higher firm value. The positive relationship was stronger in carbon-intensive sectors. Transparent reporting was associated with lower perceived environmental risk and enhanced market valuation. The authors recommend

clearer regulatory guidance on carbon reporting and the adoption of externally verified carbon accounting systems to enhance disclosure credibility and investor confidence.

Liesen, Hoepner, Patten and Figge (2017), carbon disclosure and market valuation. Methodology was Cross-country regression analysis which examined voluntary carbon disclosure data and firm market value. The study reported mixed results. In developed markets, voluntary carbon disclosure was positively associated with firm value. However, in emerging economies, the relationship was weak or statistically insignificant. The findings suggest that institutional quality, regulatory enforcement, and investor environmental awareness moderate the carbon disclosure, firm value relationship. The study recommends strengthening institutional frameworks and enforcement mechanisms in emerging economies to ensure that carbon accounting practices translate into measurable valuation benefits.

Alsaifi, Elnahass and Salama (2020), Carbon disclosure, financial performance, and firm value. Methodology, Panel data regression analysis using carbon disclosure scores and market-based performance measures. The study found a positive and significant relationship between carbon disclosure transparency and firm value. Firms with higher levels of carbon reporting benefited from improved investor perception and lower cost of capital. However, short-term compliance costs were observed to exert temporary pressure on profitability. The authors recommend that firms adopt long-term strategic carbon management practices rather than symbolic or compliance-driven disclosure. They further emphasize regulatory consistency to maximize the financial benefits of carbon accounting. Gerged, Beddewela, and Cowton (2021) investigated carbon disclosure practices and firm performance across Middle Eastern and emerging economies using regression analysis. The study found that mandatory environmental disclosure significantly improves firm value, while voluntary disclosure has limited impact. The authors concluded that regulatory enforcement is critical in ensuring the financial relevance of carbon accounting practices.

Nguyen and Adomako (2022) examined ESG and carbon disclosure effects on firm valuation in Asian emerging markets using panel data analysis. The study reported that carbon disclosure positively affects firm value through reduced information asymmetry and improved investor trust. However, the effect was stronger in firms with high institutional ownership, indicating the moderating role of governance structures. Zhang, Liu, and Huang (2023) studied carbon emission disclosure and market performance in Chinese listed firms. Using Tobin's Q as a proxy for firm value, the study found that firms with high-quality carbon disclosure experienced higher valuation. The study emphasized that government environmental regulations significantly strengthen the disclosure-value relationship.

Shi, Wang, and Chen (2024) examined carbon measurement accuracy and corporate valuation in carbon-intensive industries. Using firm-level emissions data and regression analysis, the study found that accurate carbon measurement systems significantly improve firm value by enhancing investor confidence and reducing perceived environmental risk. Zhu, Li, and Chen (2025) investigated sustainability reporting, carbon disclosure quality, and firm value in global emerging markets. The study revealed that firms with integrated sustainability reporting systems experience higher market valuation, especially when disclosures are externally assured. The authors highlight assurance as a key driver of credibility in carbon accounting.

Methodology

This study adopts an ex post facto research design, appropriate for examining causal relationships using historical data without manipulation of variables. The design enables the assessment of how carbon accounting practices influence firm value based on observed financial and sustainability disclosures of firms over time. The population consists of 30 listed firms in the Nigerian oil and gas sector. A purposive sample of 15 firms was selected based on the availability and consistency of financial and sustainability data over the study period. This ensures data reliability and

comparability across firms. The study utilized secondary data obtained from: annual financial reports of sampled firms, Sustainability and ESG reports, Nigerian Exchange Group (NGX) publications, and corporate environmental disclosures. These sources provide verifiable and structured data for empirical analysis.

Model Specification

The functional relationship is specified as:

$$FV = f(CMT, CDP, RCM)$$

This is expanded into the econometric model:

$$FV_{it} = \beta_0 + \beta_1 CMT_{it} + \beta_2 CDP_{it} + \beta_3 RCM_{it} + \varepsilon_{it}$$

Where:

FV = Firm Value

CMT = Carbon Measurement Techniques

CDP = Carbon Disclosure Practices

RCM = Regulatory Compliance Mechanisms

ε = error term

Firm value is proxied by Tobin's Q, defined as:

$$\text{Tobin's Q} = \frac{\text{Replacement Cost of Assets}}{\text{Market Value of Firm}}$$

Tobin's Q is a market-based measure of firm value defined as the ratio of the market value of a firm to the replacement cost of its assets. A value greater than one indicates that the market values the firm above the cost of replacing its assets (overvaluation), while a value less than one indicates undervaluation. To capture moderation, the model is extended as:

$$FV_{it} = \beta_0 + \beta_1 CMT_{it} + \beta_2 CDP_{it} + \beta_3 RCM_{it} + \beta_4 SUS_{it} + \beta_5 (CMT \times SUS) + \beta_6$$

Where SUS represents sustainability orientation, measured using a composite ESG/sustainability reporting index.

Firm Value (FV): Tobin's Q

Carbon Measurement Techniques (CMT): Index based on adoption of standardized carbon accounting systems (e.g., GHG Protocol, ISO 14064)

Carbon Disclosure Practices (CDP): Content analysis score of carbon disclosure in annual and sustainability reports

Regulatory Compliance Mechanisms (RCM): Compliance index based on adherence to TCFD, ISSB, and environmental regulations

Sustainability (SUS): ESG/sustainability reporting score derived from disclosure quality and integration level

Results and Discussion

This section presents and discusses the empirical findings of the study. The analysis begins with descriptive statistics used to summarize the key characteristics of the variables, including their mean, standard deviation, minimum, and maximum values. This is followed by inferential analysis, which is used to test the research hypotheses and examine the relationship between carbon accounting practices and firm value. The results are interpreted in line with existing literature and theoretical expectations.

Table 1: Descriptive Statistics

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Tobin's Q (Firm Value)	120	1.24	0.47	0.52	2.89
Carbon Measurement Techniques	120	0.68	0.15	0.34	0.95
Carbon Disclosure Practices	120	0.71	0.19	0.21	0.99
Regulatory Compliance Mecha	120	0.63	0.17	0.29	0.92

Source: SPSS Output (2025)

The descriptive results in Table 1 show that the average value of Tobin's Q is 1.24, indicating that, on average, firms in the sample are slightly overvalued in the market, as values above one suggests that market valuation exceeds asset replacement cost.

For the independent variables, Carbon Disclosure Practices (CDP) recorded the highest mean value (0.71), suggesting that firms are relatively more active in disclosure activities compared to other dimensions of carbon accounting. Carbon Measurement Techniques (CMP) has a mean of 0.68, indicating moderate adoption of standardized carbon measurement systems among sampled firms. Regulatory Compliance Mechanisms (RCM) recorded the lowest mean (0.63), suggesting relatively weaker adherence to carbon-related regulatory frameworks.

The standard deviation values indicate moderate variability across firms, with CDP showing the highest dispersion (0.19) and CMP the lowest (0.15), implying more consistency in measurement practices than disclosure and compliance behaviors. The minimum and maximum values further confirm variation in adoption levels of carbon accounting practices among firms, reflecting differences in environmental reporting maturity across the Nigerian oil and gas sector.

Correlation Analysis

The Pearson correlation analysis was conducted to determine the strength and direction of the relationship between carbon accounting practices and firm value.

Table 2: Correlation Matrix

Variables	FV	CMP	CDP	RCM
FV	1			
CMP	0.62	1		
CDP	0.68	0.55	1	
RCM	0.59	0.48	0.52	1

Source: SPSS Output (2025)

The correlation results indicate a positive relationship between all carbon accounting variables and firm value. Carbon Disclosure Practices (CDP) shows the strongest correlation with firm value ($r = 0.68$), suggesting that transparency in carbon reporting significantly enhances market valuation. Carbon Measurement Techniques (CMP) also shows a strong positive relationship ($r = 0.62$), indicating that accurate emissions measurement improves investor confidence. Regulatory Compliance Mechanisms (RCM) has a moderate positive relationship with firm value ($r = 0.59$), implying that adherence to environmental regulations contributes to improved valuation. The overall results suggest that improved carbon accounting practices are associated with higher firm value.

Regression Analysis

Panel regression analysis was used to test the effect of carbon accounting practices on firm value.

Table 3: Regression Results

Variable	Coefficient (β)	Std. Error	t-Statistic	Probability
Constant	0.41	0.18	2.28	0.024
CMP	0.31	0.09	3.44	0.001
CDP	0.38	0.08	4.75	0.000
RCM	0.27	0.07	3.86	0.000

$R^2 = 0.64$

Adjusted $R^2 = 0.62$

F-statistic = 45.21 ($p = 0.000$)

Source: SPSS Output (2025)

The regression results show that carbon accounting practices have a significant positive effect on firm value. Carbon Disclosure Practices (CDP) has the strongest impact ($\beta = 0.38$, $p < 0.01$), indicating that firms with higher disclosure quality tend to have higher market valuation. Carbon Measurement Techniques (CMP) is also significant ($\beta = 0.31$, $p < 0.01$), showing that accurate emissions measurement enhances firm value. Regulatory Compliance Mechanisms (RCM) is significant ($\beta = 0.27$, $p < 0.01$), suggesting that compliance with environmental regulations improves investor confidence. The R^2 value of 0.64 indicates that 64% of the variation in firm value is explained by carbon accounting practices, while the F-statistic confirms that the model is statistically significant.

Moderation Analysis (Sustainability Effect)

Sustainability was introduced as a moderating variable to determine whether it strengthens the relationship between carbon accounting practices and firm value.

Table 4: Moderation Results

Variable	Coefficient	t-Value	p-Value
SUS	0.29	3.21	0.002
CMP $\times$ SUS	0.18	2.45	0.015
CDP $\times$ SUS	0.22	2.98	0.003
RCM $\times$ SUS	0.16	2.11	0.037

The results indicate that sustainability significantly moderates the relationship between carbon accounting practices and firm value. The interaction between CMP and sustainability is significant, meaning sustainability strengthens the effect of carbon measurement on firm value. CDP $\times$ SUS has the strongest moderating effect, indicating that firms with strong sustainability orientation derive greater value from carbon disclosure. RCM $\times$ SUS is also significant, suggesting that sustainability enhances the value relevance of regulatory compliance. Sustainability amplifies the positive effects of carbon accounting practices on firm value.

Hypotheses Testing

Hypothesis	Statement	Result
H01	CMP has no significant effect on firm value	Rejected
H02	CDP has no significant effect on firm value	Rejected
H03	RCM has no significant effect on firm value	Rejected
H04	Sustainability does not moderate the relationship	Rejected

Decision

All null hypotheses were rejected, indicating that carbon measurement techniques, carbon disclosure practices, and regulatory compliance mechanisms significantly affect firm value, and sustainability significantly strengthens these relationships.

Discussion of Findings

The empirical results of this study provide strong evidence that carbon accounting practices significantly influence firm value, with sustainability playing a reinforcing moderating role. Overall, the findings are consistent with stakeholder theory, signaling theory, and legitimacy theory, which suggest that environmental transparency and compliance enhance firm value through improved trust, reduced information asymmetry, and strengthened legitimacy.

Carbon Measurement Techniques and Firm Value

The first finding shows that carbon measurement techniques have a significant positive effect on firm value. This implies that firms with more accurate and standardized emissions measurement systems tend to achieve higher market valuation. This result is consistent with Clarkson, Li, Richardson, and Tsang (2020) and Li, Tang, and Wang (2022), who argue that reliable environmental measurement improves reporting credibility and investor confidence. Similarly, Shi, Zhang, and Liu (2024) also report that robust carbon measurement systems enhance investor perception and reduce uncertainty in capital markets. However, this finding contrasts with some studies in emerging markets where measurement systems remain weak and fragmented, leading to limited market responsiveness to environmental data. In such cases, environmental measurement alone does not always translate into firm value due to low investor reliance on sustainability information. Despite this, the present study confirms that in the Nigerian context, improved measurement systems are increasingly value relevant, consistent with signaling theory which emphasizes the importance of credible environmental signals to investors.

Carbon Disclosure Practices and Firm Value

The second finding reveals that carbon disclosure practices significantly enhance firm value, and this variable recorded the strongest effect among all predictors. This indicates that transparency in environmental reporting is highly valued by investors and capital markets.

This result aligns strongly with Zhu, Li, and Chen (2024) and Liu, Wang, and Zhang (2025), who find that high-quality carbon disclosure improves market perception and reduces information asymmetry. Issa, Khan, and Ali (2024) further support this by showing that externally assured disclosures have greater value relevance than voluntary disclosures. Similarly, Matthews, Brown, and Taylor (2024) emphasize that disclosure credibility is a key determinant of investor trust. However, the finding differs from Sitorus, Harahap, and Nasution (2024) and Wang, Li, and Zhao (2023), who report that carbon disclosure may have weak or even negative effects when perceived as symbolic or when reporting costs outweigh benefits. The present study therefore suggests that in the Nigerian oil and gas sector, disclosure is increasingly perceived as credible and decision-useful rather than symbolic, thereby reinforcing its positive valuation effect.

Regulatory Compliance Mechanisms and Firm Value

The third finding shows that regulatory compliance mechanisms have a significant positive effect on firm value. This suggests that firms adhering to environmental regulations and global frameworks such as TCFD and ISSB enjoy improved valuation outcomes. This result is consistent with Huang, Chen, and Liu (2022), who find that regulatory compliance enhances firm performance through improved risk management. It also supports IFRS Foundation (2023) and United Nations Framework Convention on Climate Change (2024), which emphasize that compliance improves legitimacy, reduces regulatory risk, and enhances access to sustainable financing. However, this finding partially contrasts with Zhou, Li, and Wang (2023) and PricewaterhouseCoopers International Limited (2024), who argue that compliance costs may reduce short-term profitability, especially in developing economies with weak enforcement structures. The present study suggests that despite compliance costs, long-term valuation benefits

outweigh short-term financial burdens, particularly in environmentally sensitive industries such as oil and gas.

Moderating Effect of Sustainability

The results further reveal that sustainability significantly strengthens the relationship between carbon accounting practices and firm value. This implies that firms with strong sustainability orientation derive greater financial benefits from carbon measurement, disclosure, and compliance activities. This finding is consistent with Eccles, Ioannou, and Serafeim (2019) and Khan, Serafeim, and Yoon (2022), who argue that sustainability integration enhances the effectiveness of ESG practices by embedding them into corporate strategy. Brooks and Oikonomou (2023) similarly find that sustainability amplifies the market rewards associated with environmental transparency. However, in firms with weak sustainability orientation, prior studies suggest that carbon accounting practices may have limited impact due to poor strategic integration of environmental concerns. The present study therefore confirms that sustainability acts as a critical enabling condition that determines whether carbon accounting practices translate into firm value. The findings suggest that carbon accounting practices are not merely compliance requirements but strategic tools that enhance firm value. The results confirm that carbon measurement, disclosure, and regulatory compliance each contribute positively to firm value, while sustainability strengthens these effects. This reinforces the view that environmental transparency, when supported by genuine sustainability commitment, leads to superior financial performance through improved credibility, reduced uncertainty, and stronger stakeholder confidence.

Findings, Conclusion and Recommendations

This study examined the effect of carbon accounting practices on firm value, with sustainability incorporated as a moderating variable. The study was guided by four specific objectives focusing on carbon measurement techniques, carbon disclosure practices, regulatory compliance mechanisms, and the moderating role of sustainability. The empirical findings reveal that carbon measurement techniques have a significant positive effect on firm value. This indicates that firms with accurate and standardized emissions measurement systems are more likely to achieve higher market valuation due to improved transparency and enhanced investor confidence. The study further established that carbon disclosure practices exert a significant and positive influence on firm value, and this variable demonstrated the strongest effect among all predictors. This suggests that transparency in environmental reporting plays a critical role in reducing information asymmetry and strengthening investor trust, thereby enhancing firm value.

In addition, regulatory compliance mechanisms were found to have a significant positive effect on firm value. This implies that firms adhering to environmental regulations and international sustainability frameworks such as TCFD and ISSB benefit from improved legitimacy, reduced regulatory risk, and stronger market valuation. Furthermore, sustainability was found to significantly moderate the relationship between carbon accounting practices and firm value. This indicates that firms with strong sustainability orientation are better able to translate carbon measurement, disclosure, and compliance practices into superior financial performance.

The study concludes that carbon accounting practices are not merely compliance requirements but strategic corporate tools that enhance firm value. Among the components examined, carbon disclosure practices emerged as the most influential driver of firm value. The study also confirms that sustainability strengthens the effectiveness of carbon accounting practices, making it a critical factor in achieving long-term financial performance and investor confidence.

Based on the findings, the study recommends that firms strengthen their carbon measurement systems by adopting globally recognized standards such as the GHG Protocol and

ISO 14064 to ensure accuracy and reliability of emissions data. Firms are also encouraged to enhance the quality, consistency, and credibility of carbon disclosure practices by adopting comprehensive and externally verified sustainability reporting frameworks to improve investor confidence and market perception.

Regulatory compliance mechanisms should be strengthened through full adherence to environmental laws and international frameworks such as TCFD and ISSB, as compliance enhances legitimacy and reduces exposure to regulatory risks. Furthermore, firms should integrate sustainability into their core strategic operations, as it has been shown to amplify the positive effects of carbon accounting practices on firm value. Policymakers and regulatory authorities should promote standardized carbon reporting frameworks to enhance comparability, transparency, and accountability across firms, particularly in emerging economies.

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