

Moderating Role of Firm Size on Carbon Accounting and Financial Performance of Listed Firms in Nigeria

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Abstract: *This study investigates corporate carbon accounting and financial performance of listed manufacturing firms in Nigeria. The study used quantitative research design and data were collected from primary and secondary sources. The primary data comprised of structured questionnaire from a sample of 312 accountants in listed manufacturing firms in Nigeria. Data collected from the respective respondents were analysed by applying structural equation modelling through the employment of SmartPLS version 4. The findings from the data analysis suggested a positive and insignificant relationship between scope of carbon emissions, emission sources, emission categories and emission factors positively and insignificantly impact on return on assets of listed manufacturing firms in Nigeria. Also reporting boundaries and firm size negatively and insignificantly influence return on assets. On the basis of the findings, the study concluded that carbon emission accounting influences the financial performance of listed manufacturing firms in Nigeria. Hence, the study recommended amongst others that managers of listed manufacturing firms should consider carbon mitigation strategies seriously since carbon emissions negatively influence shareholder value. This means that managers can enhance shareholders' value by undertaking emission abatement policies to boost their financial and market performance.*

Keywords: Carbon Accounting, Financial Performance, Emission Sources and Factors.

INTRODUCTION

Carbon accounting is becoming a very essential area of research in accounting. He et al (2021) stated that countries across the world have implemented a diverse means to support organisations on ways to minimise carbon emissions and lessen the cost of climate change. Additionally, Hazaea et al (2023) argued that most of the stakeholders are applying pressure as a result of the

consequence about future carbon laws and material exposures and vulnerability of climate change jeopardizing infrastructures of nations. Nations have improved on business sustainability regulations in modern times as conventional to countrywide sustainable development objectives and international sustainability standards (He et al, 2021). Additionally, stakeholders' wish for better environmental consciousness entail that carbon performance is a significant factor in most firms' long-term survival (Zhou et al., 2016). Consequently, businesses are more and more under strict pressure to reveal all climate change hazards (Eleftheriadis & Anagnostopoulou, 2015). Hence, a considerable amount of research on least developed, developing, and highly industrialized countries is being carried out to recognize the variables that encourage and/or hinder corporate carbon performance (Kumarasiri & Jubb, 2016). He et al (2023) explained that Corporate carbon accounting does not only contribute to minimization of carbon emissions but also facilitates to improving the financial performance of firms by increasing competition and making value addition for organisations financially and socially, which increases sustainability. Greenhouse gas (GHG) emission has turned to be one of the most important threats for the continuation of existence on planet earth. The unnecessary concentration of GHG in earth's atmosphere providing unfavorable cost in the ecosystem and humanity, creating the occurrence of climate change (Liu et al., 2015). Firms have constantly provided an essential function in facing the challenges of global warming due to the fact that they are one of the major emitters of GHG. In recent times, stakeholders have commenced bring to bear pressures on firms to reduce their GHG emissions (Comyns, 2016). Therefore, firms are now likely to play a very important role in minimising their GHG emissions and in contributing towards stabilizing climate change (Luo & Tang, 2014).

Carbon accounting studies in the world has ignited extensive interest by accounting professionals and scholars. Alsaifi et al. (2020) stressed that corporate carbon accounting has advanced quickly in modern times. He et al (2023) also emphasized that there is a rapid advancement in carbon accounting as it is one of the main areas in the development of sustainability management as a result of the requirements of climate change, which search for the contemporary techniques and systems. Le Breton and Aggeri (2018) study of carbon accounting discovered that the discipline of carbon accounting is up-and-coming, and consequently there is enormous interest from researchers to know the subject from its various aspects, particularly with its relationship to environmental changes. Nartey (2018) highlighted that corporate carbon accounting is viewed as part of sustainability accounting, as it offers vital information on emissions in environmental changes that benefit the management of organizations in a manner that contribute to attaining sustainability. He et al (2023) further emphasized that this is one of the key factors to enlighten the interest of researchers in modern years in corporate carbon accounting. Soni and Bhanawat (2018) noted that the need to be familiar with the functions of corporate carbon accounting in minimizing carbon emissions has made accounting professionals to carry out several studies to achieve financial growth and survival. The authors further emphasized that due to climate change, firms are facing a lot of issues connected to GHG emission accounting, which could be the reason for the increase in the subject. Kanur et al(2024) emphasized that carbon accounting measures organisations' carbon dioxide equivalent emissions, as well as their supply chains, where there are intrinsic issues in data collection, given it is outside the direct control of the organisation. The authors further noted that this type of accounting consist of a broad variety of actions, such as

measuring and reporting GHG emissions at different stages. Carbon accounting has achieved rising awareness as a means for firms to determine, handle, and decrease their GHG emissions and whole carbon footprint. This is particularly pertinent to emissions-intensive sectors such manufacturing, where carbon accounting can maintain emission decreases across manufacturing processes (Kaur et al, 2022; Roman-White et al, 2021).

Carbon elimination is progressively creating its approach into conventional climate governance. Doelman et al., (2020) established that as nations and firms hold net-zero emission objectives, the desire to eradicate huge amounts of carbon from the atmosphere is attracting an indirect if not constantly key pillar of improvement plans. This advancement improves a number of well-known apprehension about the possibility of planned adverse emission expertise (Low & Schäfer, 2020; Waller et al., 2020) and the expected ecological and social fairness effects of their achievement (Doelman et al., 2020). According to Abbasi et al, (2019), with the speedy growth of worldwide industrialization, the ecological problems brought by fossil energy use have steadily threaten the sustainable development of human being in any given society. Abbasi et al., (2020); Abbasi et al, (2019) demonstrated that in the current past, universal carbon dioxide emissions have far gone beyond the self-purification capability of the world. According to Saeed et al, (2022), a sequence of unusual ecological alteration occurrence impact on universal temperature has had a far reaching influence on the firm development of human society as the manufacturing industries pay no attention to the ecological system of the world. Abbasi et al., (2021a) noted that while due to the significance of carbon dioxide emissions on sustainable development, it is essential to make policies to decrease carbon emissions and make energy consumption uninteresting from sources with soaring carbon emissions to make certain that carbon dioxide emission is minimised to the achievable level.

A variety of nations are faced with a key challenge of ensuring sustained economic growth and development at the same time also tackling climate change (Choudbary et al, 2019). The issue of the climate crisis is more often than not caused by excess CO₂ emissions. Nations' economic boom implies better utilization of energy, which leads to additional carbonic acid gas emissions, therefore carbon emissions are closely associated with firm growth (Niyozima et al, 2021). Waller et al., (2020) argued that numerous plans are presently being implemented, with superior results, principally in the manufacturing sector. According to Niyozima et al (2021), to attain the objectives and the contributions of renewable energies to appropriate energy balance that nations have set themselves, it will be essential to complete and make stronger present methods for supporting energy usage. According to Gorus and Aydin, (2019), there are a numerous studies investigating the relationship between CO₂ emissions accounting.

The nexus between CO₂ emission accounting and financial performance has long been the heart of substantial research in accounting (e.g Qiu et al., 2016; Stechemesser and Guenther, 2012; Hartmann et al., 2013' Ascui, 2014; and Haslam et al.; 2014). Gallego-Álvarez et al. (2014) study revealed that GHG emissions ratio does not have either a positive or negative impact on the financial performance (FP) of firms. Misani and Pogutz (2015) investigation disclosed that carbon-intensive manufacturing businesses, for which reduction of GHG emissions is a extremely key issue, and the study outcome suggested that firms achieve the maximum FP when their disclosed

GHG emissions are neither low nor high, but intermediate. Lewandowski (2017) study disclosed that carbon emission improvement has a linear and significantly positive association to return on sales but is negatively correlated to Tobin's q. Consequently, a research that examines the nexus between carbon accounting and organization growth is very scarce. Owing to the scarcity and the gap, there is a need to investigate the association between carbon (CO₂) accounting system implementation and return on equity (ROE) of listed manufacturing firms in Nigeria. The specific objectives are as follows:

1. investigate the effects of scope of emissions on return on equity (ROE) of listed manufacturing firms in Nigeria;
2. evaluate the effects of emission sources on return on equity (ROE) of listed manufacturing firms in Nigeria;
3. examine the effects of emission categories on return on equity (ROE) of listed manufacturing firms in Nigeria;
4. investigate the effects of reporting boundaries on return on equity (ROE) of listed manufacturing firms in Nigeria;
5. investigate the effects of emission factors on return on equity (ROE) of listed manufacturing firms in Nigeria;
6. to investigate the moderating influence of firm size on the relationship between corporate carbon emission accounting and return on equity (ROE) of listed manufacturing firms in Nigeria.

The following null hypotheses were tested in this study:

H₀₁: Scope of emission do not positively and significantly impact on return on equity (ROE) of listed manufacturing firms in Nigeria.

H₀₂: Emission sources do not positively and significantly impact on return on equity (ROE) of listed manufacturing firms in Nigeria;

H₀₃: Emission categories do not positively and significantly impact on return on equity (ROE) of listed manufacturing firms in Nigeria;

H₀₄: Reporting boundary do not positively and significantly impact on return on equity (ROE) of listed manufacturing firms in Nigeria;

H₀₅: Emission factors do not positively and significantly impact on return on equity (ROE) of listed manufacturing firms in Nigeria;

H₀₆: Firm size do not positively and significantly moderate on the relationship between corporate carbon emission accounting and return on equity (ROE) of listed manufacturing firms in Nigeria.

Literature Review

Conceptual Framework

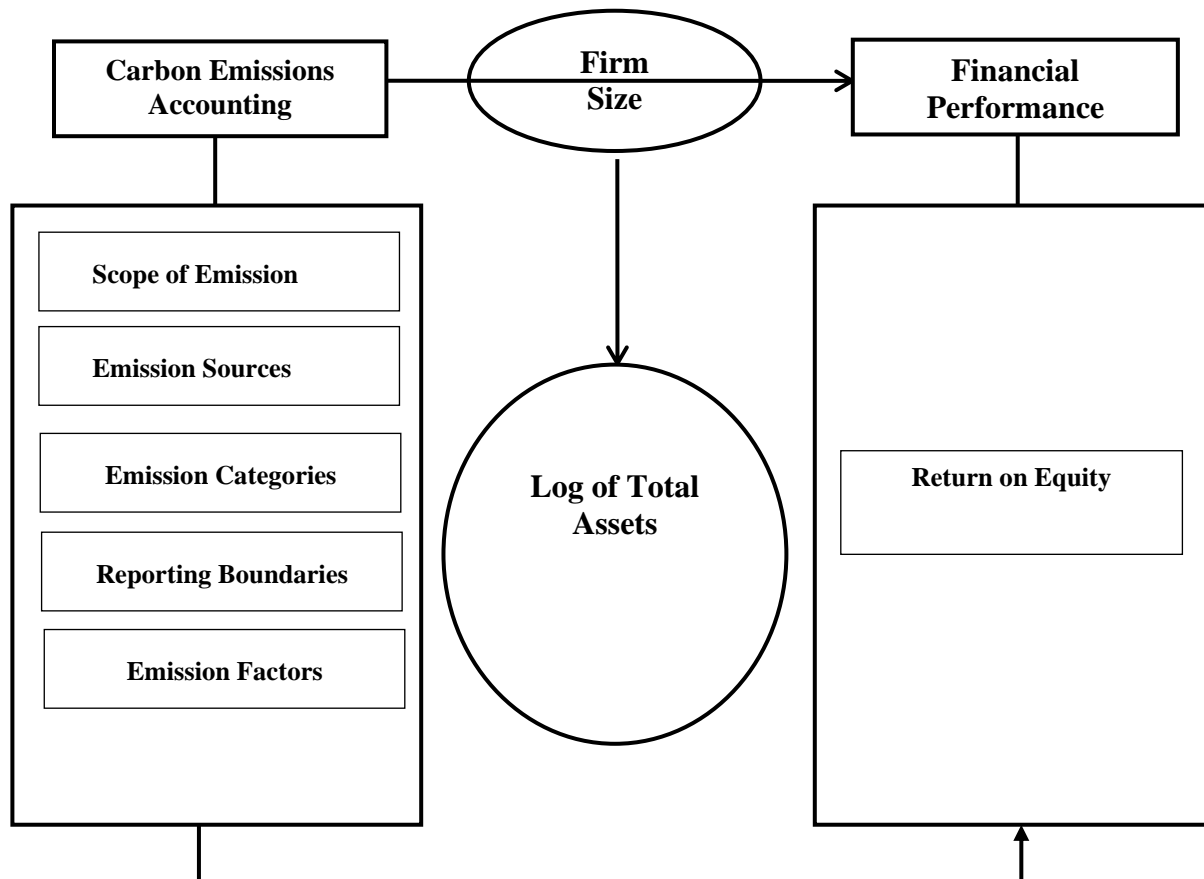


Figure 1: Conceptual Framework

Concept of Carbon Accounting: The concept of carbon accounting which is also called green house gas (GHG) accounting is a field of accounting that is used in calculating GHG emissions from an organization's activities with the purpose of minimizing emissions and achieving net zero. Tang

(2019) described carbon accounting as a field of accounting that uses accounting procedures and methods in order to record, collect, and perform the necessary analysis of climate changes; verify the information; and report on the basic elements of assets, liabilities, expenses, and revenues that have a relationship. Stechemesser & Guenther (2012) described carbon accounting as the recognition of the non-financial and financial assessment and the monitoring of GHG on all levels of the value chain and the recognition, evaluation and monitoring of the effects of these emissions on the carbon cycle of ecosystems. Similarly, Mariowe and Clarke (2022) noted that carbon accounting considers inventories of GHGs, and the monitoring and decision-making related to mitigating and offsetting emissions. It potentially also includes monitoring climate impacts and related adaptation actions. Kanur et al (2024) explained that carbon accounting provide the calculation of an organisation's GHG emissions, usually expressed in terms of carbon dioxide equivalent. Kanur et al (2022) explained that carbon accounting measures the carbon dioxide equivalent emitted by any organisation. Also, Tang and Xu (2017) described a product's carbon footprint as the total carbon dioxide emissions and other GHGs during a product's life cycle. Consequently, Kanur et al (2024) explained that carbon accounting is principally a means for evaluating the environmental effect of an organization. Lee (2012) noted that carbon accounting uses carbon emissions data as a dimension for energy use and therefore discloses the increasing carbon risks. Kanur et al (2024) further noted that carbon accounting not only measures emissions but also provide a measure of an organisation's susceptibility to the issues caused by carbon emissions. Hence, carbon accounting is an instrument to measure climate related risks. Buritt and Schattegger (2014) described carbon accounting as indicators of greenhouse gases produced by organizational activities. This definition according to Roman-White (2021) explained that carbon accounting can accelerate GHG emission estimates and distinguish supply chain by enlightening organizations about moving to a minimum carbon in the future. Lee (2012) suggested that systematic carbon accounting and monitoring does assists to identify current carbon disclosure and serves as the beginning for the advancing policies and plans for carbon management. Consequently, Kanur et al (2024) argued that carbon accounting performs a major function in the general emissions management and sustainability. In addition, Tanç and Gököğlan (2015) stressed that carbon accounting is known for its importance in following emissions across complex supply chains. The authors further stated that carbon accounting is used to estimate ecology of agricultural commodity supply chains, similarly Tian and Sarku (2023) noted that carbon emission accounting is used to measure embodied emissions in large-scale trade flows. According to Hazaea et al (2023), there are three main scopes of GHG emissions that firms must report. These are direct emissions such as those from manufacturing processes and corporate vehicles; indirect emissions from purchased energy such as electricity and heating and indirect supply chain emissions from sources not owned or controlled by the firm such as suppliers. Mariowe and Clarke (2022) stressed that there are two methods of carbon accounting, namely, consumption-based emission inventories and production-based emission inventories. Kramers et al. (2013) in Mariowe and Clarke (2022) affirmed that the selection of whether to apply consumption-based or production-based is one of the most basic decisions in accounting for emissions within a town. Accounting research maintained that a huge difference of results between each type, with consumption-based resulting in a much higher emission value (Baltar de Souza Leão et al., 2020). Harris et al, (2020) suggested that the ability to select production-based instead of consumption based, permits stakeholders to

take too lightly their effect on consumption. A common framing that incorporates both production and consumption-based emissions is scope 1, 2, and 3 emissions (Linton et al., 2022).

Concept of Financial Performance: The concept of financial performance (FP) is the extent to which financial objectives are being achieved. According to Ibrahim and Abdullahi, (2019), financial performance is the capacity of an organisation to maximize its cost of operations, efficiently use its assets and maximizes the value of shareholders. Appah (2022) stated that FP shows the effectiveness and efficiency of management in the use of corporate resources for the maximization of the wealth of all stakeholders in an organization. Similarly, Appah and Tebepah (2023) described FP as the measurement of the firm's earnings, profits and appreciation in its value which is disclosed by the rise in the market value of shares. Appah et al (2024a) and (2024b) described FP as the financial indicator used by organizations to measure the financial health of firms. The authors further argued that such health can be measured using ROA and ROE. Appah (2022) argued that there are several measures of FP. The author stated that there are several dimensions that can be used to measure FP at different times by different organizations, depending on the business' nature of activity. Consequently the most suitable index of FP is profitability which is usually measured in financial terms. Hence, the frequently used measures of profitability include net profit, return on asset, return on equity, current ratio, etc. (Appah, 2022). Hence, this current study used and ROE as indicators of FP. **Return on equity (ROE)** is a measure of financial performance calculated by dividing net income by shareholders 'equity because shareholders 'equity is equal to a company's assets minus its debt, ROE could be thought of as the return on net assets. Return on equity (ROE) is a ratio that provides investors with insight into how efficiently a company (or more specifically, its management team) is handling the resources that shareholders have contributed to it (Sani et al, 2019; Panigrahi & Vachhani, 2021). In other words, it measures the profitability of a corporation in relation to stockholders' equity. The higher the ROE, the more efficient a company's management is at generating income and growth from its equity financing. ROE is often used to compare a company to its competitors and the overall market (Appah et al, 2024a; 2024b).

Concept of Firm Size: Firm Size: The size of a firm influences financial performance once proper strategic tax planning exists. Hence, the size of a firm and capacity in terms of the availability of human resources available to the firm is believed to directly influence the extent tax planning practice (Nwaobia et al, 2016). According to Salawu and Adedeji (2017), the effectiveness of the board depends on its size. This is because the size of the board does influence the management policy of the company. Nwaobia, et al (2016) argue that bigger firms can achieve better tax planning practice due to the amount of resources and incentives available to them. Oeta, et al (2019); Timothy et al (2020) findings suggest a positive insignificant relationship between firm size and financial performance of a firm. On the contrary, Nwaobia et al (2016) showed a negative association between firm size and value of a firm. This is because big size creates additional costs arising from diseconomies of scale. Firm size is proxied as the natural log of total assets.

Theoretical Review: This theory is grounded on stakeholder theory. The theory was developed by Freeman (1984) to explain that the main reason that firms exist is to serve the interest of those

with a stake in the future of the organization and not the interest of the shareholder (Onyeman & Major, 2021). According to Appah (2022), stakeholder theory explain clearly the morals and values as a major characteristic of managing firms, and that attention to the interests and well-being of those who can help or prevent the achievement of corporate objectives as the the main issue of the theory (Onyeman & Major, 2021). Hence, this theory is a management theory that explains the morals and values in organisations as well as the responsibilities of managers to balance the interest of shareholders and stakeholders (Binh & Anh, 2017). The stakeholder theory can be examined from two approaches. According to Onyema and Major (2021), these approaches are descriptive stakeholder approach and normative stakeholder approach. According to Kaczmarek et al (2014), the descriptive stakeholder theory identifies and classifies the different constituents of an entity without assigning any value statements regarding the legitimacy of their claims or power (Onyema & Major, 2021). Defond and Lennox (2011) state that the normative stakeholder theory grants stakeholders intrinsic value claims due to the moral rights of any person affected by organizational conduct. According to Onyema and Major (2021), the main questions of the normative stakeholder theory is the consideration of the rights and duties of the various actors involved and how a fair balance of interests of different stakeholders can be achieved. Mansell (2013) explain that stakeholder theory provide a precept undermining the principles free market economy, thus understanding it as a threat to political and economic freedom (Onyema and Major, 2021). The theory provides a shared sense of value distribution instead of entitling shareholders to all of it (Naebel & Nuff, 2017). Wagana and Karanga (2015) also explains that to achieve corporate board effective and financial performance, stakeholder theory advocated for a corporate board size that integrates and facilitates the combination of the various interests mostly those that enhances corporate financial performance. As a consequence, improving stakeholders' participation in corporate governance should result in increased corporate financial performance of firms (Banda, 2019). The stakeholder theory is highly important in carbon accounting because it recognizes that various groups have a vested interest in an entity's carbon performance. The stakeholder theory in carbon accounting encourages transparency and disclosure of carbon information; assist prioritise carbon reduction initiatives that meet stakeholder needs; facilitates engagement and collaboration with stakeholders on carbon issues and enhances accountability and responsibility for carbon actions.

Empirical Review

Egbunike & Emudainohwo (2017) investigated the role of carbon accountant in the corporate carbon management system in Nigeria. The study employed mixed method of research design with the use of qualitative and quantitative methods. The population consisted of listed firms on the Nigeria Exchange Group (NGX) from 2011 to 2016 and purposive sampling technique was used. The study used ROE as dependent variable while environmental social disclosure as independent variable with community involvement, employee health and safety, corporate governance, research and development with other related environmental information as dimensions and firm size as control variable. The mixed data collected was analysed using univariate analysis, and multivariate analysis. The results indicated a significant relationship between carbon accounting and corporate financial performance of manufacturing firms listed on the NGX from 2011 to 2016.

Siddque et al (2021) carried out an investigation of carbon disclosure, carbon performance and financial performance using international dataset. The study employed ex post factor research design and secondary sources of data were used while univariate and multivariate analysis was employed with the regression analysis indicated that carbon disclosure positively affect carbon performance and carbon disclosure negatively (positively) influence financial performance in the short term (long term).

Galama & Scholtens (2024), studied a meta analysis of greenhouse gas emissions and financial performance. The study included 74 effect sizes from 34 studies, consisting of 107605 observations for the period 1997–2019. The study suggested a significant relationship between GHG emissions and financial performance of listed companies. Consequently, the study revealed that firms with lower emissions have enhanced financial performance. The study found that the type of emission or financial performance measurement is not significant and sector to which the firms in the study sample belong does not matter. Hence, the study suggested that the relationship between GHG emissions and financial performance is particularly obvious for firms operating in nations with the most strict carbon emission policies.

Lestari et al (2024) analysed carbon emission disclosures and firm financial performance of IDX firms in Indonesia from 2020 – 2022. The study population consisted of energy sector firms listed on BEI 2020 – 2022 and purposive sampling technique was used to arrive at a sample of 54 observations of 18 firms for 3 years. The study used secondary data collected from the publications of financial reports, annual reports and sustainability reports for each energy firm listed on the Indonesia Stock Exchange (BEI) and the data collected were analysed using descriptive statistics and SEM PLS method. The SEM PLS analysis suggested that a positive and significant association between carbon performance and green product innovation on carbon emissions disclosure; a negative and insignificant association between environment cost on carbon emissions disclosure; a negative and significant influence of carbon performance and financial performance; a positive and significant association between environmental cost and financial performance; a negative and insignificant association between green product innovation and financial performance; a positive and significant association between disclosure of carbon emissions and financial performance; a positive and significant association between carbon performance and green product innovation on financial performance through green house gas emission disclosure and a negative and insignificant association between environmental cost on financial performance through green house gas emission disclosure of listed energy sectors firms on IDX from 2020 – 2022.

Methodology

This study adopted cross sectional survey research design and the target population consisted of all accountants employed in listed manufacturing firms in Nigeria. A sample size of 610 accountants employed as staff of sampled manufacturing firms using purposive sampling technique. In selecting the sample for the study, a stratified sampling procedure was applied on the basis of the 61 listed manufacturing firms and the justification for using the stratified sampling procedure was to adequately accommodate the different levels of accounting staff of the sampled firms. This study used primary data obtained from respondents' answers to the questionnaire sent.

Meanwhile, the data source was obtained from the responses received from the questionnaires administered to the accounting and finance department of listed manufacturing firms in Nigeria. The major instrument for data collection in this study was a survey questionnaire titled “Corporate Accounting Carbon and Financial Performance Questionnaire (COCAMFAPQ). A total of ten (10) questionnaires per firm were sent to the accounting units of the sixty (61) manufacturing firms listed on the Nigeria Exchange Group (NGX) making a total observation of six hundred and ten (610). The constructs were measured using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). However, when questionnaires were distributed to respondents of the study for data collection, only 362 persons responded to the questionnaire. A total of 312 questionnaires were used for data analysis. As a result, 248 respondents failed to return the questionnaires, and 50 questionnaires were not properly filled by the respondents. The measurements of these constructs were self-developed from existing scientific literature of corporate carbon accounting (e.g. Abbasi et al, 2021a; 2021b; Alsaifi et al, 2020; Egbunike & Emudainohwo, 2017; He et al, 2022; Kaur et al, 2024; Lewandowski, 2017; Lestari et al, 2024; Nartey, 2018) and financial performance (e.g. Appah, 2022; Appah et al, 2024a, 2024b; Appah & Tebepah, 2023; Boshnak, 2021; Banda, 2019). The study used content validity to validate items in the questionnaire in which the instrument were given to professional accountants (members of ICAN and ANAN) in Bayelsa State who read through and make required corrections. The second process was to validate the instrument where the questionnaire was pre-tested and the responses from the respondents was used to improve on the items. The study questionnaire used the test-retest reliability. The instrument was administered to 15 of the target subjects who were not part of the respondents and after a period of two weeks, the same instrument was again given to the same 15 respondents to ascertain the reliability. Consequently, Cronbach Alpha coefficient was used to determine the statistical reliability of the research instrument. The method of data analysis shall be executed using a multivariate analysis and the SmartPLS version 4 for structural equation modelling (SEM). The justification for using Stata is to permit the researchers to apply multivariate regression, while SmartPLS with the use of structural equation modelling is to establish the indirect test of mediation analysis and to clearly demonstrate the direction of arrows for the hypotheses postulated in the study via the path diagram.

Results and Discussions

Table 1: Adjusted R-Square

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T statistics	P values
Return on Equity	0.592	0.606	0.044	13.364	0.000

Source: Authors' Computation (2024)

The study investigated the relationship between corporate carbon emissions accounting and financial performance (measured by ROE) of listed manufacturing firms in Nigeria, with firm size

Publication of the European Centre for Research Training and Development-UK acting as a moderating variable. The adjusted R² of 0.592 indicates that the model explains 59.4% of the variance in ROE.

Table 2: Bootstrapping Output with Carbon Emissions and Return on Asset

Variables	B	Std. Deviation	T Statistics	P values	Remarks
Scope of Emission -> Return on Equity	1.739	1.863	0.934	0.351	H1 Not Supported
Emission Sources -> Return on Equity	1.275	1.423	0.896	0.370	H2 Not Supported
Emission Categories -> Return on Equity	4.157	3.887	1.070	0.285	H3Not supported
Reporting Boundaries -> Return on Equity	- 2.476	2.073	1.195	0.232	H4 Not Supported
Emission Factors -> Return on Equity	2.207	1.459	1.513	0.130	H5 Not Supported
Firm Size -> Return on Equity	6.731	3.705	1.817	0.069	H6 Not supported
Firm Size x Scope of Emission -> Return on Equity	- 0.637	0.565	1.127	0.260	H7
Firm Size x Emission Sources -> Return on Equity	- 0.591	0.421	1.403	0.161	H8
Firm Size x Emission Categories -> Return on Equity	- 0.271	1.146	1.108	0.264	H9
Firm Size x Reporting Boundaries -> Return on Equity	1.018	0.610	1.669	0.095	H10
Firm Size x Emission Factors -> Return on Equity	- 0.641	0.435	1.471	0.141	H11

Source: Authors' Computation (2024)

The first hypothesis (**H1**), which proposed that Scope of Emission positively and significantly impact on ROE of listed manufacturing firms in Nigeria, the result was not significant ($\beta = 1.739$, $t = 1863$, $p = .351$), leading to the rejection of **H1**. For **H2**, concerning Emission Sources and their expected positive impact on ROE, the result was not significant ($\beta = 1.275$, $t = 0.896$, $p = .370$), thus **H2** was not supported either. For **H3**, which proposed that Emission Categories have a significant positive effect on ROE, the result was not significant ($\beta = 4.157$, $t = 1.070$, $p = .285$),

meaning **H3** was not supported. The fourth hypothesis, **H4**, which suggested that Reporting Boundaries would have a significant negative effect on ROE, showed a negative relationship, though it was not statistically significant ($\beta = -2.476$, $t = 1.195$, $p = .0232$), and therefore **H4** was not supported. Similarly, **H5**, which predicted that Emission Factors would have a significant positive effect on ROE, was also not supported ($\beta = 2.207$, $t = 1.513$, $p = .130$). In terms of firm size, **H6** proposed that it would have a significant positive effect on ROE. However, this was not supported by the data ($\beta = 6.731$, $t = 1.817$, $p = .069$), meaning **H6** was also not supported.

The moderation analysis showed mixed results. **H7**, which posited that Firm Size moderates the relationship between Scope of Emission and ROE, was not supported ($\beta = -0.637$, $t = 1.127$, $p = .260$). For **H8**, which suggested that Firm Size moderates the relationship between Emission Sources and ROE, the result was also negative and non-significant ($\beta = -0.591$, $t = 1.403$, $p = .161$), meaning **H8** was not supported. **H9** hypothesized that Firm Size moderates the relationship between Emission Categories and ROE. The result was negative and non-significant ($\beta = -1.271$, $t = 1.108$, $p = .268$), so **H9** was not supported. The moderation of Firm Size on the relationship between Reporting Boundaries and ROE, proposed in **H10**, showed a positive moderating effect approaching significance ($\beta = 1.018$, $t = 1.669$, $p = .095$), though **H10** was not fully supported. **H11**, which predicted a moderating effect of Firm Size on the relationship between Emission Factors and ROE, showed a negative but non-significant effect ($\beta = -0.641$, $t = 1.471$, $p = .141$), leading to the rejection of **H11**. Generally, these results suggest that while corporate carbon emissions accounting factors did not significantly influence financial performance directly, firm size played a limited moderating role in some cases.

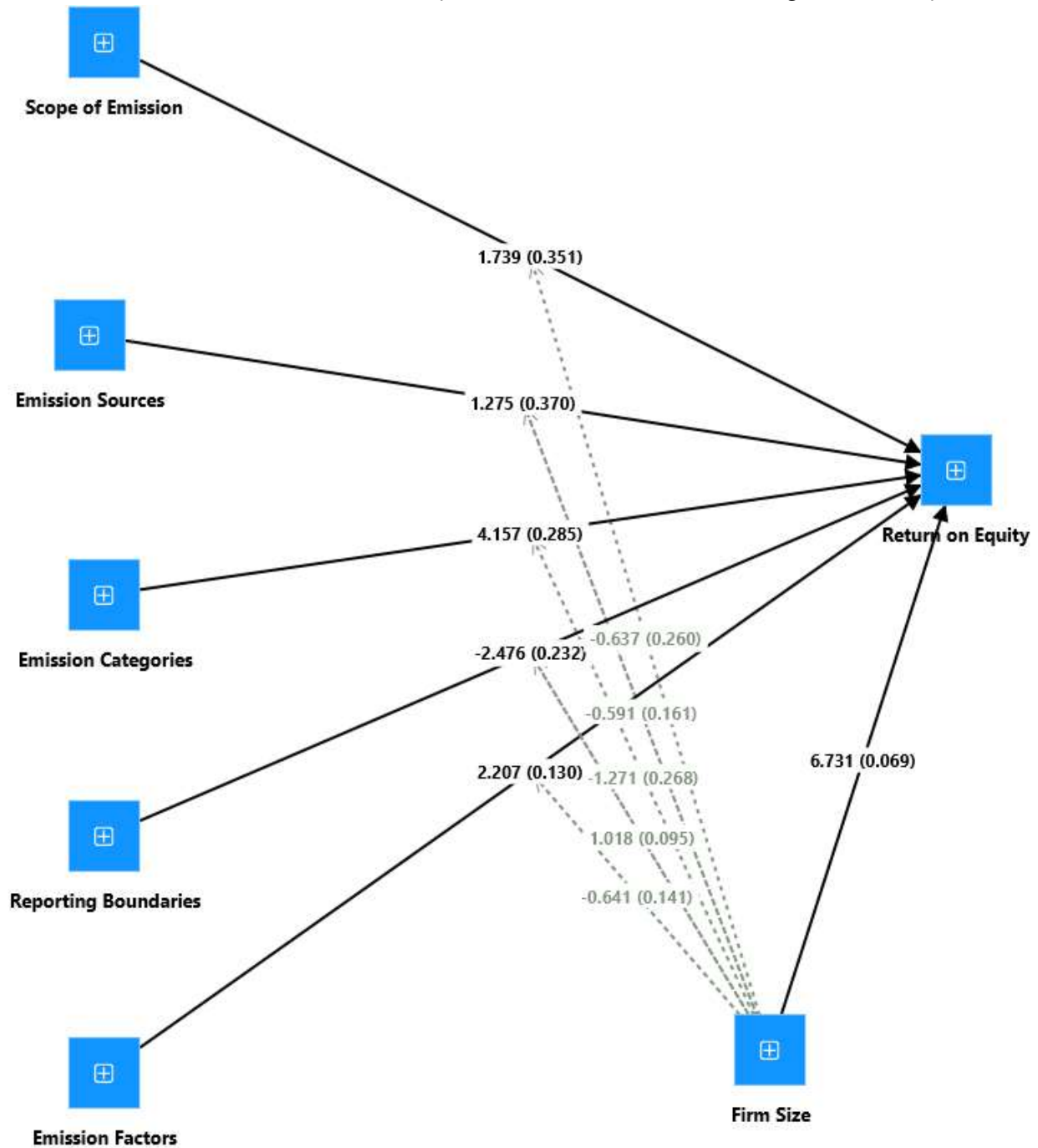


Figure 2: Process-Based Approach of Smart PLS

Discussion of Results

The study makes significant contributions to the existing body of literature on carbon accounting and financial performance of listed firms. Firstly, the result demonstrated that scope of carbon emissions positively and insignificantly impact on return on equity of listed manufacturing firms in Nigeria. Thus, the scope of carbon emissions refers to the classification of green house gas (GHG) emissions into three categories, based on their source and relationships to an organisation's activities. Although prior studies have not examined the nexus between scope of carbon emissions and return on assets, the position of Lestari et al (2024) implied that green house gas emission disclosure have a negative and insignificant association between environmental cost on financial performance through green house gas emission disclosure of listed energy sectors firms on IDX from 2020 – 2022. Conversely, the investigation carried out by Song et al (2017) in Chinese listed firms between 2007 and 2011 suggested that environmental management positively and significantly enhances financial performance. The study further suggested that environmental investment uses capital and resources, indicating that environmental management does not significantly influence financial performance in the current financial year – rather, it does influence the financial performance in subsequent year. Hence, the empirical evidence of the current study underpins the assertion of Lestari et al (2024) and further indicates that scope of carbon emissions impact on return on assets of listed manufacturing firms.

The other findings of the investigation show that emission sources, emission categories, and emission factors positively and insignificantly impact on return on equity of listed manufacturing firms in Nigeria. The findings of this study agree with the study conducted by Gallego-Álvarez et al. (2015) that investigated the influence of carbon dioxide emissions on financial and operational performance of 89 international firms from 2006 to 2009; the results demonstrate a decrease in emissions that create a positive improvement on financial performance. Generally, the study reveals that firms that promote greater environmental behaviour in order to achieve superior financial performance. Similarly, Wang et al (2016) study carried out to show the relationship between carbon performance and financial performance of US S&P 500 firms. The findings demonstrate a positive association between carbon performance and financial performance. However, the findings differs with the study conducted by Wang et al. (2014) of the association between GHG emissions and financial performance of 69 Australian public firms listed on the ASX 200. The findings of their study demonstrate a negative connection between financial performance and carbon performance. Therefore, the empirical evidence of the current study support the assertion that emission sources, emission categories, and emission factors influences financial performance of listed manufacturing firms.

The findings of this study also suggest that reporting boundaries negatively and insignificantly impact on return on equity of listed manufacturing firms in Nigeria. The result of this study is consistent with the study of Wang et al. (2014) of the association between GHG emissions and financial performance of 69 Australian public firms listed on the ASX 200. The findings of their study demonstrate a negative connection between financial performance and carbon performance. However, the findings disagree with the study conducted by Gallego-Álvarez et al. (2015) that investigated the influence of carbon dioxide emissions on financial and operational performance of 89 international firms from 2006 to 2009; the results demonstrate a decrease in emissions that create a positive improvement on financial performance. Generally, the study reveals that firms that promote greater environmental behaviour in order to achieve superior financial performance. Similarly, Wang et al (2016) study carried out to show the relationship between carbon performance and financial performance of US S&P 500 firms. The findings demonstrate a positive association between carbon performance and financial performance.

Summary of findings, Conclusion and Recommendations

This study investigated the moderating influence of firm size on the association between carbon accounting and financial performance of listed manufacturing firms in Nigeria. The results from the bootstrapping output suggested a positive and insignificant relationship between scope of carbon emissions and return on equity of listed manufacturing firms in Nigeria; emission sources positively and insignificantly impact on return on equity of listed manufacturing firms in Nigeria; emission categories positively and insignificantly impact on return on equity of listed manufacturing firms in Nigeria; and emission factors positively and insignificantly impact on return on equity of listed manufacturing firms in Nigeria. On the basis of the findings, the study concluded that carbon emission accounting impacts on the return of equity of listed manufacturing firms in Nigeria. Hence, the following recommendations were reached:

1. Managers of listed manufacturing firms involved should consider carbon mitigation strategies seriously since carbon emissions negatively influence shareholder value. This means that managers can enhance shareholders' value by undertaking emission abatement policies to boost their financial and market performance.
2. Manufacturing firms should adapt to conditions that include long-term changing dynamics of the natural environment that would give confidence and accounting and finance systems should not only cover short-term outcomes and management of short-term costing, reporting and disclosure but also long-term climate risks,
3. Regulatory authorities should formulate appropriate carbon emission policies that would enhance the financial performance of listed firms. For example, a section of the national climate fund should be given as subsidized loans that are aimed at environmental projects and green firms. Hence, regulators can support financial stability by providing more incentives for investment in low-carbon-emitting technologies.

4. Companies that are rent-seeking, firms that have higher general and administrative expenses, have higher emissions. Therefore, investors should carefully consider such firms as a place for their valuable investments.
5. In addition, regulatory authorities such as NASREA should institute appropriate penalties for carbon emission and stronger penalty for failure to disclose carbon emission information should also be utilized.

Implication of the Study and Area of Further Study

The findings of this study are expected to have vital implications for policy makers and practitioners. Stakeholders of businesses such as managers, shareholders, institutional investors, regulators and so on, can use the outcome of this investigation to better understand the connection and interconnections between carbon accounting and financial performance of listed firms. This understanding will facilitate them to make better business and investment decisions. This finding can be very useful to business managers to make decisions regarding their carbon disclosure and carbon performance activities. This finding will encourage managers to decrease carbon emissions of their businesses so as to improve the performance of their business. It would also improve the image of the business to stakeholders such as customers and the general public. This study also disclosed a negative association between carbon emissions and financial performance, i.e. if a business improves its carbon disclosure, its financial performance will worsen. This finding will assist firms' management evaluate the potential advantages of disclosing carbon activities. Finally, carbon accounting is one of the instruments that are applied in decision-making presently in firms that are interested in climate change and environmental conservation; the development of this type of accounting would add economic value to firms and public institutions.

This study provided vital and insightful findings, but with limitations. The study applied self-reports only due to difficulty in obtaining record-based data. Therefore, longitudinal design can be employed with waves of data collection through an appropriate instrument. Further studies can also investigate the connection between carbon emissions accounting on carbon and financial performance of listed firms in Nigeria. Also it is recommended to add other variables related to the green economy in addition to the variable of carbon emission accounting practices This research is only limited investigating the association between carbon accounting and financial performance, so that further studies are expected to add variables others related to environmental disclosures that can affect the value of firms. Further studies are also advised to be able to develop indicators based on the more recent Carbon Disclosure Project questionnaire and wider scope of disclosure of carbon emissions and conduct investigations in other corporate sectors that have a high level of environmental sensitivity, resulting in more varied results.

Declaration of Potential Conflict

We declare that there is no potential conflict to the publication of this paper and that the authors make equal contribution to this study.

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