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# Toward a Greener Energy Sector: Examining the Nexus of Environmental Taxes, Green Innovation, and Carbon Disclosure in Nigeria

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**ABSTRACT**

This study examined the impact of environmental taxes (EN_TAX) and green innovation (GREEN_INN) on emissions disclosure of high energy intensity firms in Nigeria. Considering a sample of 376 firm years observations. The energy firms were sorted across different sectors. The data was analyzed using a generalized method of moment (GMM). The coefficient of regression established that EN_TAX exerts a negative and significant effect on emission disclosures, implying that high environmental and energy taxes discourage companies from full emission disclosure. In contrast, the result of green innovation (GREEN_INN) indicates a significant positive coefficient on emissions disclosure, demonstrating that investment in green technologies and renewable energy reduces carbon emissions and environmental degradation. The findings imply that preference should be given to research and investment in renewable energy technologies to enhance sustainable environment. Our results provide guiding evidence to regulators and corporate policy makers with a framework to promote sustainable environmental and SDG on clean energy.

**Keywords:** Environmental Tax, Green Innovation, Carbon Emissions, Sustainability, Renewable Energy
**JEL Classifications:** Q58, Q55, Q48, M41

## 1. INTRODUCTION

A sustainable and clean environment has continued attracting global attention, with more emphasis on carbon emissions due to the activities of high-energy-intensity firms. These firms are characterized by high pollution, depleting resources, and climate change, posing the need for environmental policies, including renewable energy, energy taxes, and green technologies. Enforcing energy taxes is expected to reduce ecological degradation caused by high-energy-intensity firms. These firms played a significant role in increasing national growth, contributing a great share to Nigeria's gross domestic product (GDP) and national income (Omoregie, 2019). However, despite the enormous economic benefit and significance, the sector continues to experience numerous sustainability issues that pose a serious negative implication for environmental management, economic consequences, and vulnerability, among others (Badejo et al., 2017; Nuhu et al., 2022). Therefore, the industry's economic benefits are also associated with environmental degradation, pollution, injustice social disturbances resulting in economic inequality, especially in the oil host region of the Niger Delta (Okotie et al., 2018; Omoregie, 2019).

Efforts to address the challenges and provide a more feasible, sustainable solution toward the development of the sectors continue to receive serious attention both locally and internationally, considering the level of environmental deprivation, social inequality, and injustice, and the need for a more sustainable solution amidst global demand and pressure (Emodi and Boo, 2015). The oil-rich area (Niger Delta), with an abundance of Nigeria's oil and gas activities, has been experiencing a series of communal clashes and conflict, environmental degradation, and poor socio-economic conditions (Badejo et al., 2017; Badru et al., 2017). These issues are caused by gas flaring, oil spills, and oil theft that have taken a heavy toll on natural habitats and ecosystems, threatening biodiversity and contaminating the fishing area and water sources, thereby undermining the economic activities of the local communities that rely on fishing and agricultural activities for their survival (Badejo et al., 2017).

Moreover, the issue of marginalization, non-employment of the host community, and lack of corporate social responsibility projects have added to the tensions and grievances among the community, leading to community unrest and social conflict (Courson, 2011; Habiba, 2018).

Against this concern, there is a growing need to develop a multidimensional sustainability approach to managing Nigeria's energy sector (Habiba, 2018). Such an approach should go beyond a single factor (Emodi and Boo, 2015; Ite, 2007; Musa et al., 2016). By adopting a multidimensional approach model that addresses the complexity and interplay between the economic, social, and environmental factors, this approach aims to propose a sustainable model that fosters and shapes greenhouse gas emissions. This research aims primarily to explore avenues for enhancing sustainability by examining how environmental taxes and green innovation investment are linked with greenhouse gas emissions.

While previous studies document effective insights into sustainability practices in Nigeria, there is still no wider research that has examined the role of multidimensional factors on carbon emission disclosure and practices. Therefore, this research contributes to the growing field of environmental sustainability, energy and renewable taxes, and carbon emission disclosure. The remaining section of the paper includes a literature review in Chapter 2, methodology in Section 3, Section 4 contains a basic linear regression analysis and discussion of the main findings, Section 5 outlines a summary, conclusion, research implications, and suggestions for future studies.

## 2. LITERATURE REVIEW

### 2.1. Sustainability Drivers and Strategies

To improve emission reduction and promote the use of renewable energy, scholars have emphasized the necessity of meaningful community development, stakeholder involvement, and corporate social responsibility (CSR) frameworks (Abdurrahman et al., 2022; Ite, 2007). In addition to these methods, the capacity of strategic sustainability frameworks like the Sustainability Balanced Scorecard (SBSC) to include social, economic, and environmental factors into business decision-making has been acknowledged.

For instance, Jassem (2018) highlighted how various SBSC types can impact environmental investment decisions, a crucial driver for sustainable practices, especially in energy-intensive sectors, while Jassem et al. (2022) carried out a systematic review that connects SBSC architectures to enhanced environmental performance. Through the integration of sustainability into internal performance management and accountability systems, these strategic tools enhance current CSR and stakeholder-based frameworks.

### 2.2. Emission Disclosure

Carbon emissions can be defined as gases containing carbon emitted into the Earth's atmospheric layers, which are commonly derived from the combustion process (Kang et al., 2012; Nchofoung et al., 2023). This emission could either be an industrial greenhouse gas or a natural greenhouse gas. Human activities cause industrial greenhouse gas. Emission disclosure is an important component of environmental reporting, indicating a firm's sustainability and transparency. The Global Reporting Initiative (GRI) and the United Nations Sustainable Development Goals (SDGs) guidelines initiate the emission disclosures checklist. The GRI standard checklist provides the recommended disclosures that are important for achieving Sustainable Development Goals. Specifically, GRI 305 issued guidelines on how firms disclose their carbon emissions, such as nitrogen oxides (NOX), greenhouse gas emissions (GHG), and sulfur oxides (SOX) to achieve sustainability.

### 2.3. Environmental Management

Prior studies have recorded the occurrence of gas flaring, oil spills, and other environmental concerns, leading to contamination of water and soil, particularly in industrial areas (Ite et al., 2018). Some studies suggest the need for an efficient framework consisting of regulatory, industrial, technological, and global best practices to lessen environmental risks and foster sustainable development (Aven et al., 2007); (Jibril, 2024; Jibril et al., 2023). Studies have demanded a focus on a more integrated and all-inclusive approach to decision-making, which factors in the long-term influences of energy firms' activities on emission reduction and environmental sustainability (Churchill et al., 2019; Salihi et al., 2024). These scholars have recorded the benefits of adopting reporting frameworks for reporting greenhouse emissions, with an emphasis on performance indicators to trace progress and ensure transparency and accountability disclosure practices (Moses et al., 2024).

### 2.4. Environmental Taxation and Carbon Emissions Disclosure

Commercial activities by companies, specially manufacturing and oil and gas companies, are the major sources of environmental pollution, leading to excessive carbon dioxide emissions. Such practices have drawn the attention of the world to the status of environmental degradation. An environmental tax has been suggested as a tool for reducing carbon emissions and improving corporate sustainability (Bala et al., 2024). Prior scholars have explored the connection between EN_TAX and emission disclosure, citing its relevance in corporate sustainability. Li et al.,

(2021) describe environmental tax as a sustainable and reliable policy for reducing carbon emissions intensity. The scholar admitted that environmental policy reduced and constrained the degradation of the environment.

Several other studies (Lambertini et al., 2020; Yunzhao, 2022) have admitted that high EN_TAX revenues promote green investment, a massive reduction in emissions, and less utilization of non-renewable energy. The work of Xu and Zhang (2025) asserts that carbon dioxide emissions pose serious challenges to environmental sustainability, suggesting that environmental charges and recovery fees improve resource efficiency and achieve ecological balance. In Nigeria, Bala et al. (2024), using data from Nigerian Exchange Limited, suggested that an increase in energy tax is more likely to achieve a sustainable environment. Other evidence suggests that the environmental tax was instituted as a control mechanism for reducing the magnitude of carbon dioxide and environmental pollution (Farooq et al., 2023).

On the other hand, some scholars admitted that a high energy tax is more likely to cause firms to engage in excessive operations to recover their costs, leading to a significant increase in environmental pollution (Doğan et al., 2022; Yu et al., 2021). Consistently, Zhang et al. (2022) supported the argument that high environmental tax burdens may discourage sustainable practices since the cost of such tax is a burden against the profit of the operators. Given the above argument, this article hypothesizes that:

- $H_1$: Environmental tax has a significant influence on emissions disclosures.

### 2.5. Green Innovation and Emission Disclosure

The connection between green innovation and carbon emission disclosure has continued to receive significant consideration due to its importance in climate sustainability and renewable energy (Bala et al., 2024; Salihi et al., 2024; Song and Yu, 2018). Existing studies disclose how firms incorporated sustainable practices in response to global attention and regulatory pressure. Green technologies and renewable energy tend to reduce carbon dioxide and develop energy efficiency processes (Aliani et al., 2024). Firms with significant investments in green innovation are more likely to disclose information relating to environmental commitment (Ho et al., 2023; Zhao et al., 2024). Green innovations are also admitted to contributing to the core competence of firm efficiency and sustainable performance. Likewise, Sari et al. (2024) examine the link between carbon emissions and green innovation using data from Indonesia. The authors establish that green innovation invariably decreases carbon dioxide and improves environmental disclosure.

On the other hand, it is difficult to establish the role of green innovation on carbon emission reduction, as the consequence of green innovation diminishes the short-run returns (Lanoie et al., 2011). Furthermore, Herman and Xiang (2019) and Lanoie et al. (2011) assert that the cost of induced innovation resulting from environmental regulations may not lead to poor returns, as the goal of forced innovation is contrary to the overall firm objective. The above discussion indicates an inverted connection between green innovation and emission disclosures. Thus, this study postulates as follows:

- $H_2$: There exists a significant connection between green innovation and emission disclosures.

### 2.6. Research Conceptual Framework

Figure 1 below shows a conceptual framework that illustrates the hypothesized relationship among the study's core variables: Environmental taxes and green innovation as the independent variables, and carbon emission disclosure as the dependent variable.

## 3. RESEARCH DESIGN AND SAMPLE

In this article, we examine the multidimensional factors that reduce the frequency of carbon emissions and enhance sustainability practices in Nigeria. The sample constitutes 376 firm-year observations of companies with emission intensity operating in different sectors of the economy for the period between 2014 and 2021. These companies account for 336 million tons of greenhouse gas emissions (GHG) (Federal Ministry of Environment, 2021). The firms tend to impact the environment due to $CO_2$ emissions resulting from the excessive usage of fossil fuels (Jibril, 2024). Table 1 presents the selected companies utilized in this article.

### 3.1. Measurement of the Dependent Variable: Carbon Emission Disclosure

Carbon emission disclosure is the dependent variable. Emission disclosure is captured using a content analysis of the annual report and accounts of the sampled companies. The Global Reporting Initiative (GRI) standard checklist provides the standard index for measuring emission disclosure. Consistent with Jibril et al. (2023) and Jibril (2024) using the GRI checklist, a three-step measurement was used. Companies are assessed 0 if no emission disclosure is reported, 1 if the disclosure is not in line with the GRI, 2 if it is partially in line with the GRI standard, and 3 if it is fully in line with the GRI standard (Table 2).

### 3.2. Measurements of Explanatory Variables

The explanatory variables constitute environmental taxes and green innovation as the independent variables, while audit quality,

**Figure 1:** Research Framework

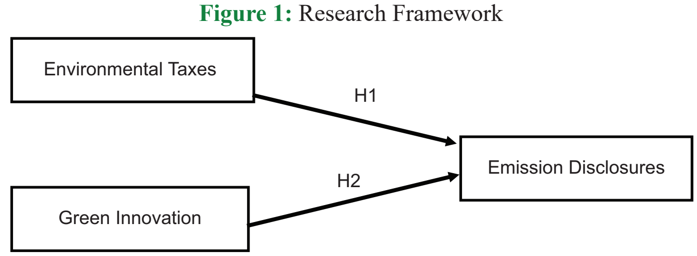


**Table 1: Selected listed non-financial firms**

| Serial number | Sectors | Number |
|---|---|---|
| 2 | Conglomerate | 6 |
| 1 | Agriculture | 5 |
| 3 | Construction | 7 |
| 4 | Consumer Goods | 12 |
| 6 | Industrial | 9 |
| 7 | Oil and Gas | 8 |
| Total | | 47 |

**Table 2: Measurement of emission disclosure metrix**

| Dependent variables acronym | | Measurement | Sources |
|---|---|---|---|
| Direct (Scope 1) GHG emissions | GRI-305-1 | 1–3=Companies That disclose EDE Information in their Annual report, 0 = Otherwise | Hossain et al., 2023; Jibril, 2024 |
| Energy indirect (Scope 2) GHG emissions | GRI-305-2 | | |
| Other indirect (Scope 3) GHG emissions | GRI305-3 | | |
| GHG emissions intensity | GRI-305-4 | | |
| Reduction of GHG emissions | GRI-305-5 | | |
| Emissions of ozone-depleting substances (ODS) | GRI-305-6 | | |
| Nitrogen oxides (NOX), Sulfur oxides (SOX), and other significant air emissions | GRI-305-7 | | |

**Table 3: Definition and measurement of variables**

| Variable name | Abbreviation | Measurement | Sources |
|---|---|---|---|
| Environmental tax | En_tax | This is the proportion of total energy taxes, Transportation, resources and pollution taxes against the total Gross domestic product | OECD (Bala et al., 2024) |
| Green innovation | Green_Inn | It is calculated using the natural logarithm of the amount invested in research and development expenditure by the public listed companies | Dicuonzo et al., 2022; Salihi et al., 2024 |
| Firm size | FSZ | This is considered the natural logarithm of the firm's total Assets | Jibril, 2024 |
| Firms age | Age | This is measured as the number of years companies have after listed in the Nigerian exchange limited | Bala et al., 2024 |
| Financial leverage | Lev | This is the proportion of interest-bearing liabilities against the total assets of the firm. | Sani et al., 2021 |
| Audit quality | BIG 4 | This is measured as a dummy variable of 1 if the firm is audited by Big 4 and 0 if otherwise. | Bala et al., 2020 |

firm size, firm age, and financial leverage were included as control variables. Table 3 provides a detailed description of both the independent and control variables' measurements.

## 4. EMPIRICAL RESULTS

This section presents empirical models for testing our hypotheses using a system generalized method of moments (GMM). The approach corrects for unobserved heteroscedasticity and the Nikel bias. The method also controls for bidirectional causality that may exist between two or more predictor variables (Nchofoung et al., 2023). As in Kang et al. (2012), Wang et al., (2023). We rely on the Method of Moments to solve these problems. The empirical model is presented in equation 1. Where GHGD represents greenhouse gas emissions disclosure, EN_Tax stands for environmental tax, Green-Inn represents green innovation, and FSZ represents a natural log of total assets to capture the size of the firm. Age represents the firm's years after listing, Lev stands for financial leverage to capture the proportion of debt financing. Big 4 is the last control variable, which represents audit quality.

$$GHGD = \beta + \beta_1\text{-}EN\_Tax_{it} + \beta_2\,GREEN\_INN_{it} + \beta_3 FSZ_{it} + \beta 4\,AGE_{it} + \beta_7 LEV_{it} + \beta_7 Big4_{it} + €I \quad (1)$$

### 4.1. Descriptive Statistics

Table 4 presents details of the descriptive analysis of environmental taxes and innovation on greenhouse gas emission disclosure. As shown in Table 4, the average means of carbon emission disclosure stands at 26.4%, with a minimum value of 0% and a maximum value of 58% in some instances. This implies that 26% of the sampled firms complied with the GRI standard on emission disclosure.

On the sustainability variables, EN_TAX has an average score related to 0.2% of total GDP, with a minimum score of 1% and a maximum value of 3%. The average Green_Inn is shown to be 0.948, with a minimum score of 0.825 and a maximum value of 2.978. This implies that energy firms invest a substantial portion of their funds in innovative activities. Regarding the control variables, FSZ has an average score of 7.277, with a minimum score of 4.758 and a maximum value of 9.143. The average age is 44.078, indicating that firms are listed for 44 years on the Nigerian exchange limited (NGX). Leverage represents total interest liabilities. From Table 3, the mean score of LEV shows an average value of 0.532, which depicts that leverage accounts for 53% of the total capital structure of the firms. Regarding the Big4, the results show that BIG4 firms audited 59% of the listed companies during the period.

**Table 4: Descriptive statistics**

| Variable | Observations | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| GHGD | 376 | 0.264 | 0.181 | 0.000 | 0.583 |
| Ent_Tax | 376 | 0.020 | 0.005 | 0.010 | 0.030 |
| Green_inn | 376 | 0.948 | 0.825 | 0.250 | 2.978 |
| AQ | 376 | 0.586 | 0.493 | 0.000 | 1.000 |
| F-size | 376 | 7.277 | 0.986 | 4.758 | 9.143 |
| Age | 376 | 44.078 | 19.362 | 5.000 | 98.000 |
| Lev | 376 | 0.532 | 2.194 | 0.032 | 19.557 |

GHGD: Greenhouse emission disclosure, ENT_TAX: Environmental tax, GREEN_INN: Green innovation, Renewable energy, AQ: Audit quality, F-size: Firm size, Age: Firms age, Lev: Financial Leverage, while ***, **, ** Stands for 1%, 5% and 10%, Significance levels

### 4.2. Correlation Result

Table 5 presents the matrix of the Pearson correlation coefficient of environmental tax, green innovation and carbon emission disclosure. The result in Table 5 indicates that the highest correlation coefficient is 34.23% between leverage and firm size. The coefficients suggest that none of the regressors is highly correlated with one another (Hair et al., 2014; Li et al., 2021).

**Table 5: Correlation matrix result**

| Variable | EM_DIS | EN_TAX | Green_Inn | A Q | FSIZE | Age | Lev |
|---|---|---|---|---|---|---|---|
| EM_DIS | 1 | | | | | | |
| En_tax | −0.0359 | 1 | | | | | |
| Green_inn | −0.002 | −0.009 | 1 | | | | |
| AQ | 0.2362 | −0.0226 | −0.0022 | 1 | | | |
| Fsize | 0.0309 | 0.0329 | −0.033 | 0.3129 | 1 | | |
| Age | 0.1048 | 0.0865 | 0.042 | 0.1489 | 0.1645 | 1 | |
| Lev | −0.0879 | 0.0099 | −0.0811 | −0.1874 | −0.3423 | −0.1152 | 1 |

GHGD: Greenhouse emission disclosure, ENT_TAX: Environmental tax, GREEN_INN: Green innovation, Renewable energy, AQ: Audit quality, F-size: Firm size, Age: Firms age, Lev: Financial leverage, while ***, **, ** stands for 1%, 5% and 10%, Significance levels

Consequently, the connection between independent variables is within the required statistical threshold (Hair et al., 2014; Salihu et al., 2015; Suranta et al., 2020).

### 4.3. Cross-Sectional Dependency Test Result

Table 6 presents the CDS outcomes; the results indicate the existence of cross-sectional dependency among the predictors EMDIS, EN_TAX and GREEN_INN. This implies that normal fixed-effect and random-effect regression may not be feasible. Hoechle (2007) documents that cross-sectional dependency constitutes a problem for panel datasets. To mitigate this problem, the research models were estimated using the Generalized Method of Moments (GMM). We applied GMM to cure the potential endogeneity and to provide dynamic and reliable inferences that are free from serial and autocorrelation inherent in the panel data (Bala et al., 2020; Sani et al., 2020; Wang et al., 2023).

### 4.4. GMM Regression Result

Estimates the overall effect of environmental tax and green innovation on carbon emission disclosure using the generalized method of movement (GMM). GMM is used to correct the potential endogeneity inherited in the panel data. Table 7 presents the result parameters; the results reveal that environmental tax (EN_TAX) has a strong negative ($\beta = -1.580$, $P = 0.000$) influence on carbon emission disclosure. This means that enforcing a higher energy tax may lead companies to hide some information relating to fossil consumption to avoid future taxes. The outcome supported the earlier studies on environmental sustainability, such as Zhang et al. (2022) who urged that EN_TAX increases firms' tax expenses, forcing firms to choose earnings management to minimize the level of tax liabilities. This means that excessive energy tax payment is tantamount to achieving sustainable development goals, especially SDG 7, affordable and clean energy.

In contrast, the results of green innovation (GREEN_INN) and carbon emission disclosure indicate a significant positive coefficient ($\beta = 0.009$, $P = 0.000$) with carbon emission disclosure (EMISDIS). This result implies that investment in renewable technologies enhances environmental disclosure, reduces emissions, and promotes sustainability. These findings confirm the position of Salihi et al. (2024), who established that GREEN_INN contributes significantly to reducing carbon emissions. This implies that investment in green technology produces a cleaner environment, enhances renewable energy consumption, and promotes a sustainable environment (Churchill et al., 2019). This outcome supports the reduction of carbon emissions, leading

**Table 6: Cross-sectional dependency result**

| Variable | CD-test | P-value | Average joint | Mean ρ | Mean abs(ρ) |
|---|---|---|---|---|---|
| GHGD | 0.026 | 0.000 | 8.000 | 0.000 | 0.150 |
| Ent_tax | 0.994 | 0.000 | 8.000 | 1.000 | 1.000 |
| Green_inn | −1.027 | 0.000 | 8.000 | −0.010 | 0.420 |
| Aq | −0.029 | 0.977 | 8.000 | 0.000 | 0.000 |
| Lev | −0.173 | 0.863 | 8.000 | 0.000 | 0.420 |
| Fsize | 13.360 | 0.000 | 8.000 | 0.150 | 0.660 |
| Age | 81.174 | 0.000 | 8.000 | 0.910 | 0.910 |

GHGD: Greenhouse emission disclosure, ENT_TAX: Environmental tax, GREEN_INN: Green innovation, Renewable energy, AQ: Audit quality, F-size: Firm size, Age: Firms age, Lev: Financial Leverage, while ***, **, ** stands for 1%, 5% and 10%, Significance levels

to the actualization of SDG 7, which is targeted at ensuring affordable and clean energy, enhancing energy efficiency, and expanding energy infrastructures (Churchill et al., 2019; Dicuonzo et al., 2022).

As for the control variables, the research discovered that audit quality (BIG 4) has a direct positive and significant influence ($\beta = 0.025$, $P = 0.000$) on emission disclosure. This justifies that companies audited by BIG 4 auditors tend to disclose good information relating to carbon dioxide emissions. In contrast, the coefficients of FSIZE ($\beta = -0.004$, $P = 0.000$), AGE ($\beta = -0.001$, $P = 0.000$), and LEV ($\beta = -0.002$, $P = 0.000$), are positive and significant with emission disclosure. This signifies that larger companies with high debt are more likely to have less disclosure relating to carbon emissions.

### 4.5. Robustness Checks using an Alternative Measurement of the Dependent Variable

A robust test was conducted to check the consistency of our main analysis. The sensitivity analysis is performed on environmental governance as a dependent variable; environmental governance is determined based on firm-year scores on environmental reporting. The score indicates a firm's commitment to environmental sustainability and a firm's ability to account for both the company's and industry's best practices. Table 8 presents the result of the robust analysis. Like the main result, the findings on environmental taxes indicate a significant negative effect on environmental sustainability ($\beta$−2.110, $P = 0.000$). This is consistent with the result of the main analysis presented in Table 6. Consistent with previous literature, the robust result supported the argument that high environmental tax burdens may discourage sustainable practices and emission disclosure (e.g., Zhang et al. 2022).

**Table 7: GMM regression result of environmental tax, green innovation and emission disclosure**

| EMB | Coefficient | Standard error | Z | P>z | [95% confidence interval] | |
|---|---|---|---|---|---|---|
| L1 | 0.877 | 0.002 | 451.900 | 0.000 | 0.873 | 0.880 |
| EN_TAX | −1.580 | 0.068 | −23.310 | 0.000 | −1.713 | −1.447 |
| GREEN_ INN | 0.009 | 0.001 | 10.610 | 0.000 | 0.007 | 0.010 |
| AQ | 0.025 | 0.003 | 7.690 | 0.000 | 0.019 | 0.032 |
| Fsize | −0.004 | 0.001 | −5.370 | 0.000 | −0.005 | −0.003 |
| Age | −0.001 | 0.000 | −10.160 | 0.000 | −0.001 | −0.001 |
| Lev | −0.002 | 0.000 | −14.470 | 0.000 | −0.002 | −0.001 |
| _cons | 0.108 | 0.006 | 17.090 | 0.000 | 0.096 | 0.121 |
| AR 1 | 0.001 | | | | | |
| AR 2 | 0.238 | | | | | |
| Sergent test | 0.787 | | | | | |
| Hensen test | 0.835 | | | | | |
| Prob Chi2 | 0.000 | | | | | |

GHGD: Greenhouse emission disclosure, ENT_TAX: Environmental tax, GREEN_INN: Green innovation, Renewable energy, AQ: Audit quality, F-size: Firm size, Age: Firms age, Lev: Financial Leverage, while ***, **, ** stands for 1%, 5% and 10%, Significance levels

**Table 8: Robust regression result of environmental tax, green innovation and sustainability disclosure**

| | Coefficient | Standard error | z | P>z | 95% Confidence interval | |
|---|---|---|---|---|---|---|
| L1. | 0.607 | 0.020 | 30.84 | 0.000 | 0.569 | 0.646 |
| EN_TAX | −2.110 | 0.317 | −6.660 | 0.000 | −2.732 | −1.489 |
| GREEN_INN | 0.040 | 0.007 | 5.714 | 0.000 | 0.053 | 0.027 |
| AQ | 0.103 | 0.024 | 4.300 | 0.000 | 0.056 | 0.151 |
| Fsize | 0.037 | 0.006 | 5.780 | 0.000 | 0.024 | 0.049 |
| Age | 0.004 | 0.000 | 12.370 | 0.000 | 0.004 | 0.005 |
| Lev | 0.003 | 0.000 | 6.440 | 0.000 | 0.002 | 0.003 |
| _cons | −0.295 | 0.038 | −7.720 | 0.000 | −0.370 | −0.220 |
| AR 1 | 0.004 | | | | | |
| AR 2 | 0.135 | | | | | |
| Sergent test | 0.909 | | | | | |
| Hensen test | 0.514 | | | | | |
| Prob Chi-square | 0.000 | | | | | |

GHGD: Greenhouse emission disclosure, ENT_TAX: Environmental tax, GREEN_INN: Green innovation, Renewable energy, AQ: Audit quality, F-size: Firm size, Age: Firms age, Lev: Financial leverage, while ***, **, ** stands for 1%, 5% and 10%, Significance levels

On the other hand, the robust analysis in Table 8 yields a positive coefficient between green innovation and environmental sustainability ($\beta = 0.040$, $P = 0.000$). The results aligned with the findings of Churchill et al. (2019), supporting that firms engaging in green innovation are more likely to reduce environmental emissions and degradation. Therefore, the robust results enhance the consistency and credibility of the overall findings, indicating that our model is free from bias or measurement errors. These results provide a documented reference for policy formulation on environmental sustainability and clean energy.

## 5. CONCLUSION AND POLICY IMPLICATIONS

In this article, we contributed to a contemporary debate of sustainability issues in Nigeria's energy companies. The article examined the connection between environmental taxes, green innovation and emissions disclosure using a dynamic Generalized Method of Moments that cured the potential endogeneity. The outcome indicates that environmental taxes (EN_TAX) exert a significant negative influence on carbon emission disclosure. This suggests that excessive charges on non-renewable energy may discourage firms from being transparent on carbon emission disclosure.

In contrast, the result of green innovation (GREEN_INN) shows a significant positive coefficient of carbon emissions disclosure, implying that green technology investment enhances transparent disclosure of carbon emissions, which implies a reduction in carbon emissions. In sum, our research provides insight that green innovation and environmental taxes are two multidimensional approaches to a sustainable environment and clean energy. Hence, the government at national and international levels should initiate and support investment in green and renewable energy to bring down the level of carbon dioxide.

The findings of this study have some policy implications for policy and practice. The result of environmental taxes documents that excessive charges may discourage companies from transparent emission practices, suggesting the need for a moderate energy tax policy that incentivizes compliance. Our result on green innovation implies that regulators should prioritize support on research in clean technologies and renewable energy to enhance corporate sustainability. Therefore, an integrated policy that blends innovation and moderate tax regimes will create holistic ecosystems and promote effective emission disclosure.

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