



Insurance Sector Development and Carbon Dioxide Emissions in Nigeria

OSARIEMEN IRABOR OMORUYI-AIGBOVO

University of Benin, Benin City, Edo State, Nigeria

OMORUYI AIGBOVO

University of Benin, Benin City, Edo State, Nigeria

Abstract. In this study, the effect of insurance sector development on carbon dioxide (CO₂) emissions in Nigeria was investigated using annual data for the period 2000 to 2024. The primary objectives were to assess the impact of insurance sector development indicators [insurance penetration (IPE), insurance density (IDE) and insurance premium (GPR)] on CO₂ emissions. Based on the fact that the variables used in the present study were integrated of I(0) and I(1), the Autoregressive Distributed Lag (ARDL) technique was used to assess the effect of insurance sector development variables on CO₂ emissions while the data were estimated with the aid of Eviews 9.0 econometric software. Findings revealed that insurance penetration (IPE) and insurance density (IDE) has no significant impact on CO₂ emissions both in the short run and long run while Insurance premium (GPR) exerts a significant negative impact on CO₂ emissions in both in the short run and long run. Also, in terms of the control variables, economic growth and FDI exerts a significant negative impact on CO₂ emissions both in the short run and long run while renewable energy consumption (REC) failed the significant test both in the short run and long run. From the findings, this study concludes that insurance sector development plays a significant role in Nigeria's CO₂ emission. This is demonstrated by Insurance premium (GPR) which exerts significant negative impact on CO₂ emissions in both short and long run. The study recommends among others that insurers should explore more green products or sustainability-linked policies. In other words, policies that support green insurance initiatives and investments in low-carbon transition projects should be encouraged. Also, insurers should integrate climate risk assessments into underwriting.

Keywords: Carbon emissions, Green insurance, insurance density, Insurance penetration, ARDL

1. Introduction

In recent years, there has been emphasis on reducing carbon emissions in both developed and developing nations in order to slow down the rate of global warming and its associated impacts like rising sea levels, intense weather events and biodiversity loss. The issue of global warming has been a significant focus for environmentalists, economists, policymakers, and academics alike. This is due to the fact that environmental degradation and global climate change have the potential to impede or be likely affected by economic growth and sustainable development practices in both developed and developing economies. Academic studies have identified the rapid increase in greenhouse gases, particularly Carbon dioxide (CO₂) emissions, as the primary cause of the environmental challenges or climate change. Carbon dioxide is a major greenhouse gas that traps heat in the atmosphere. It has been revealed that the share of CO₂ emissions in total greenhouse gases corresponds to approximately 76% (Coşkuner et al., 2020; Anser et al., 2021; Aydin, et al., 2024). This problem does not only impact the environment but also directly affects the economy and social life. Hence, both developed and developing climate must work together in achieving the minimum carbon emissions required to sustain the climate and environmental needs (UNFCCC, 2021b).

Regulating CO₂ emissions is essential to ensure a sustainable environment that can support continued economic and social development. However, prior to implementing measures to regulate CO₂

emissions, it is of utmost importance to investigate the factors that contribute to CO₂ emissions. Researchers have identified various variables in different economic settings that are related to CO₂ emissions in order to assist policymakers in making decisions aimed at enhancing the desired level of environmental quality. The focus of this study is on insurance sector development. The nexus between the insurance sector and CO₂ emissions is a rapidly emerging area of concern and opportunity in the context of climate change and economic uncertainty. Climate change or global warming imposes direct impacts on insurance industry and these direct impacts are increasing premium rates, shifting additional risks to policy holders through higher deductibles and lack of insurance availability from the private sector for those living in the risky geographical zone (Ahmed, et al., 2013).

According to Bressan, (2025), insurers do not typically emit substantial greenhouse gases directly; however their underwriting and investment activities play a substantial role in enabling companies that emit substantial greenhouse gases. High exposure to climate risks increases awareness and demand for environmental policies. Countries with a developed insurance market are more resilient to climate disasters such as floods, droughts and storms. A developed insurance sector plays an institutional role in managing climate risks. Insurers collect information on risks, model climate catastrophes, and incorporate them into premiums. In this way, they can exert pressure on traditional forms of insurance, such as higher premiums for “dirty” activities, limiting coverage for CO₂ - intensive industries, and encouraging firms to adopt environmental standards. Insurance companies possess significant financial capacity through their investment portfolios. Regulatory frameworks can direct them toward green investments, including withdrawing capital from polluting sectors (coal divestment), investing in renewable energy sources and green infrastructure, and ensuring transparency and reporting on climate risks (Lojanica, et al., 2025).

From an economic perspective, the development of the insurance sector can have either a positive or negative impact on CO₂ emissions. The insurance sector, as part of the financial system, can accelerate industrial growth by financing heavy industries (fossil fuels), thereby increasing CO₂ emissions (scale effect). On the other hand, the insurance sector can finance clean technologies, thereby reducing CO₂ emissions (innovation effect). Hien et al. (2024) indicated that gross insurance premiums act as a mediator between GDP and various environmental indicators, including carbon dioxide emissions, greenhouse gas emissions, material resource use, and renewable energy. These

outcomes highlight the crucial role of insurance premium policies, environmental taxation, bank lending practices, and corporate debt management as key instruments for reducing the environmental impacts associated with sustainable development.

The effect of financial development measured by banking sector and stock market development variables on CO₂ emissions has been widely studied while not much is known about the effect of the insurance sector development on CO₂ emissions. The literature on this topic is very scarce. This study attempts to address this gap by contributing to the few current studies in Nigeria that use data from a relatively recent period, 2000 – 2024. Also, conflicting findings have trailed the few prior studies that have investigated the effect of insurance sector development on CO₂ emissions. For instance, researches like – Altarhouni, et al., (2021), Li, et al., (2022), Kolapo (2024), Leo et al. (2024), Samour et al., (2024) and Lojanica, et al., (2025), all found that insurance sector development exerts significant positive effect on CO₂ emissions, but the study conducted by Rizwanullah, et al., (2022) came up with contrary findings that insurance sector development exerts significant negative affect on CO₂ emissions. These different findings could be attributed to difference in variables used, technique in measurement of variables, scope adopted, and difference in estimation techniques employed in their studies. All these may have led to the mixed findings. The divergent and unsettled nature of these empirical studies creates a gap for further examination in this study.

The main objective of this research is to investigate the effect of insurance sector development on CO₂ emissions in Nigeria. The study's precise objectives are to: ascertain the influence of insurance penetration on CO₂ emissions in Nigeria; ascertain the impact of insurance density on CO₂ emissions in Nigeria; and determine the impact of insurance premium on CO₂ emissions in Nigeria. This study contributes to the conversation on insurance sector development - CO₂ emissions debate because there are not many studies of this kind that focus on Nigeria. The study will further update this body of literature. Policy makers and insurance sector may greatly benefit from this study's results by using them to more fully comprehend how insurance sector development affects CO₂ emissions and develop better CO₂ emissions reduction policies to enhance the desired level of environmental quality

The remainder of this paper is organized as follows in an attempt to meet the objective of this research. Section two contains a literature review, Section three covers the methodology, Section four has the results and discussion, and Section five contains the study's conclusion and recommendations.

2. Literature Review

2.1 Conceptual Review

2.1.1 Carbon dioxide (CO₂) Emissions: Carbon dioxide is one of the important man-made GHG (Green House Gases) produced by the burning of fossil or conventional sources of energy such as petroleum, coal, biomass etc. Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (World Bank, 2022).

2.1.2 Insurance Sector Development

Insurance sector development refers to a process that marks improvements in the quantity, quality and efficiency of the insurance sector. It entails the growth, improvement and progression of the insurance sector. The development of insurance sector covers regulatory framework, technological advancement, product innovation, market innovation and the entire industry efficiency (Rudra, et al., 2014). In this study, insurance penetration rate, insurance density and insurance premium are the metrics used to gauge how well the insurance sector is developed. These insurance sector development metrics are discussed below.

Insurance Penetration rate: Insurance penetration measures the contribution of insurance premium to the Gross Domestic Product (GDP) of a country in percentage terms. Insurance penetration rate is defined as a country's total insurance premiums as a percentage of its gross domestic product (GDP) and indicates how much the insurance sector contributes to the national economy (International Association of Insurance Supervisors, 2017). In the view of Olarewaju and Thabiso (2021), insurance penetration infers the contribution of the insurance sector to the Gross Domestic Products. The higher the penetration rate, the more developed the insurance market. In other words, insurance penetration rate measures the growth of insurance premium in relation to the growth in the GDP.

Insurance Density: Insurance density is the ratio of premiums collected by insurance companies to the country's population. In other words, it is the per capital premium for the country, calculated by dividing the total insurance premium by the population. It gives an indication of how much each of the people in a country spends on insurance in terms of premium. Insurance Density may be described as the size or number of people living a particular society or geographical location (Agbo & Agbaji, 2020).

Gross Premium: The insurance premium is the price a person pays for insurance protection. According to Garba and Abdulsalam (2018) premium is the rate that is charged to the insured, according to his or her expectations of loss or risk. In this study, the premium income is measured as the gross premium income of all the classes of insurance underwritten by the insurance company. Gross written premium is the total premium of an insurance contract before brokerage and discount is deducted.

2.2 Theoretical Review

Environmental Kuznets Curve (EKC) Hypothesis: The Environmental Kuznets Curve (EKC) hypothesis represents a pivotal theoretical model in environmental economics. The hypothesis, popularized by Grossman and Krueger (1991, 1993, 1995) and formalized by Panayotou (1995), posits that the relationship between economic growth and environmental degradation follows an inverted U-shaped curve. This relationship suggests that at the initial stages of economic development, environmental degradation intensifies due to the proliferation of industrial activities, deforestation, fossil fuel consumption, and unregulated resource extraction - phenomena often driven by rapid urbanization and industrialization. However, as income levels rise and countries reach a specific threshold (referred to as the turning point), a structural transition tends to occur. Economies shift from agriculture and heavy manufacturing to services and high-technology industries. This structural change is accompanied by increased environmental awareness, better regulatory enforcement, cleaner production techniques, and greater public demand for environmental protection, all of which collectively contribute to a gradual decline in environmental degradation (Grossman & Krueger, 1995; Hussen, 2005; Isibor & Aigbovo, 2025). The EKC framework is underpinned by three fundamental effects:

Scale Effect: As economies grow, the scale of production and energy consumption increases, leading to higher levels of pollution and natural resource depletion.

Composition Effect: Over time, the economic structure evolves, with a transition from pollution-intensive industries to cleaner sectors, such as services and technology-based production.

Technique Effect: Technological advancement and regulatory improvements lead to more efficient and cleaner production processes, reducing pollution intensity per unit of output.

Environmental Transition Theory: The Environmental Transition Theory (ETT) complements the EKC hypothesis by focusing on

the stages of environmental change during economic transformation. ETT suggests that environmental degradation is not uniform across all stages of development. In the early phases of urbanization and industrialization, rapid expansion in energy consumption and infrastructure development leads to significant environmental stress. However, as economies mature and achieve higher levels of per capita income, they become more capable of investing in sustainable practices and enforcing environmental regulations (Majeed & Mazhar, 2019; Li et al., 2021). ETT emphasizes the adaptive capacity of societies to transition from environmentally harmful to environmentally sustainable practices. The role of the financial system in this process is pivotal, as it provides the capital and incentives required for both technological adoption and structural shifts toward greener industries. ETT is particularly pertinent in the Sub-Saharan African countries where many economies are in early-to-intermediate stages of this transition and thus face critical decisions on how to balance economic growth with environmental sustainability.

2.3 Empirical Review

In this segment, the review of past empirical studies was carried out to provide justification for the need for this study. For instance, Shahbaz, et al., (2018) investigate the factors that determine carbon emissions in France. The empirical result shows that French carbon emissions are positively impacted by FDI while negatively impacted by energy consumption. Financial development reduces carbon emissions, enhancing the quality of the French environment. On the other hand, energy use and carbon emissions have a positive relationship. However, the environmental Kuznets curve is supported by the inverted-U link between economic growth and CO₂ emissions. Using the panel cointegration tests, Nguyen and Kakinaka (2019) examine the relationship between renewable energy consumption and carbon emissions for 107 economies for the period 1990 – 2013. In the case of low-income economies, they found a long-term positive influence from renewable energy consumption on CO₂ emissions, but a negative effect was reported in the case of high-income economies.

Altarhouni, et al., (2021) examined the effect of insurance market development on environmental degradation in Turkey for the period 1981 – 2016. The study utilizes the bootstrap Autoregressive Distributed Lag (ARDL) technique to explore the short and long run linkage between the examined variables. Also, the Granger causality test was used to explore the causality linkage among the selected variables. The findings reveal that economic growth and consumption of nonrenewable energy have

positive influence on CO₂ emissions. Furthermore, the findings show that the insurance market development has a positive influence on the levels of Turkey's carbon emissions; this finding is also confirmed through the economic growth channel.

Also, Appiah-Otoo and Acheampong (2021) investigate the effect of insurance sector development on CO₂ emissions in BRICS (Brazil, Russia, India, China, and South Africa) from 2000 to 2016 using the instrumental variable generalized method of moment's model. The findings indicate that, generally, insurance sector development spurs CO₂ emissions in BRICS. Specifically, a 10% rise in life insurance development increases BRICS CO₂ emission by 1%. Also, a 10% rise in non-life insurance development increases BRICS CO₂ emission by 4%. Finally, a 10% rise in the composite insurance development index increases BRICS CO₂ emission by 2%. The study further finds that population size, trade openness, and energy consumption drive CO₂ emission in BRICS, while economic growth mitigates CO₂ emission.

Koufioti, et al., (2022) studied the influence of insurance market penetration on CO₂ emissions, based on the hypothesis that economic growth and thus, insurance market growth, will increase CO₂ emissions. Economic growth was considered with GDP per capita, political stability index, economic and political globalization. Data was analyzed from 26 countries (European Union-EU, European Economic Area-EEA, single market and Turkey). Random effects regression was employed for the analysis. Findings reveal that CO₂ emissions are significantly and positively related to GDP per capita for Eastern, Southern and Western European countries, yet no significant relationship is presented for Northern countries. Renewable energy share presents a significant negative correlation with CO₂ emissions with a highest effect size for Eastern Europe, followed by Northern Europe and Western Europe while Southern Europe there is a smaller effect size. Interestingly, insurance market penetration as a percentage of GDP is strongly and positively related to CO₂ emissions for Eastern Europe and Western Europe, while smaller effects are detected for Northern Europe and Southern Europe. Northern European countries are the only group of countries that presents a positive significant correlation between renewable energy penetration and GDP and no significant relationship between insurance market penetration and GDP. Yet, countries of Eastern and Southern Europe present a negative relationship between renewable energy share and GDP per capita while there is a strong and positive relationship between insurance market penetration and GDP per capita. For Western Europe, no significant relationship is detected between GDP per capita and renewable energy

share, while there is a strong positive relationship with insurance market. By examining the pooled random effects model, it was found that the insurance market penetration effect was negative for northern countries and positive for all other country groups (non-significant for southern countries).

Furthermore, Rizwanullah, et al., (2022) studied the dynamic impacts of insurance sector development on CO₂ emissions of emerging economies for the period of 1991–2018, using the nonlinear autoregressive distributed lag (NARDL) approach. Findings show that increased life insurance sector development significantly reduces CO₂ emissions of Russia, China and South Africa and decreased life insurance sector development significantly enhances CO₂ emissions of Russia only. While China and South Africa have also reduced CO₂ emissions due to the negative shock of life insurance sector development in the long run. Findings also show that increased non-life insurance sector development boosts CO₂ emissions in Russia and China, while negatively significant in case of South Africa. Moreover, decreased non-life insurance sector development reduces CO₂ emissions in Russia, India and China and positively significant in case of South Africa in long run. The short-run outcomes are also country-specific in their analysis.

Similarly, Li, et al., (2022) investigates the nonlinear impact of insurance sector development on CO₂ emissions for five high-polluting economies over data ranging from 1990 to 2019. The study employs a panel and time series NARDL framework. Finding reveals that insurance sector development has asymmetric effects on CO₂ emissions. It is inferred from the findings that a positive shock in insurance sector development increases CO₂ and a negative shock in insurance sector development decreases CO₂ in the long run in high-polluting economies. Regarding country-wise analysis, findings reveal that a positive shock in insurance sector development increases CO₂ in the USA, Russia and Japan, but a negative insurance sector development shock decreases CO₂ in the USA and India in the long run

Also, Kolapo (2024) examine the effect of insurance density on environmental quality in Nigeria from 1990 to 2021. The ARDL technique is used to look at the relationship between the research variables across the short and long run. The study showed that insurance sector density energy and renewable energy consumption increase environmental quality in Nigeria by reducing CO₂ emission. The study also demonstrated that Nigeria's expanding economy (in terms of trade and economic growth) increases CO₂ emission, thus affecting the quality of the environment.

Leo et al. (2024) examined the relationship between global GHG emissions and insurance premium pricing, with a special focus on implications for climate risk mitigation in Organisation for Economic Co-operation and Development (OECD) countries. A regression analysis was performed using historical premium data from Organisation for Economic Co-operation and Development (OECD) countries and globally GHG emissions data to investigate the relationship between these variables. The findings show a substantial positive association between GHG emissions and insurance premiums, implying that rising levels of GHG emissions are associated with higher premium prices.

Samour et al. (2024) examined the effect of insurance market development on the UAE's environmental quality from the period 1985 to 2019. The study used an advanced approach to confirm the cointegrating relationship among selected variables: bootstrap Autoregressive Distributed Lag (ARDL) technique. The empirical outcomes reveal that renewable energy consumption stimulates environmental quality in the short and long run. Furthermore, empirical outcomes show that insurance market development has a positive effect on the level of environmental quality in the country.

Lojanica, et al., (2025) examines the impact of insurance market development on Carbon dioxide (CO₂) emissions and economic growth in the European Union (EU-15) and Central and Eastern European (CEE-11) countries over the period 1996–2022. Long-run relationships are analysed using panel cointegration tests and Mean Group (MG), Pooled Mean Group (PMG), and Dynamic Fixed Effects (DFE) estimators. At the same time, causal links are assessed through the Granger non-causality test. Results show that in EU-15 countries, insurance development positively affects both environmental quality via reduced CO₂ emissions and economic growth. In CEE-11 countries, a positive effect on growth is confirmed, but no significant environmental impact is observed.

Bressan (2025) examines the effect of greenhouse gas emissions on the financial stability of insurance companies in all segments of insurance and from all geographic regions in the world from 2004 to 2023, using the panel data regressions. The main finding is that insurers who increase their greenhouse gas emissions become financially unstable. This result is consistent across all three scopes (scope 1, scope 2, and scope 3) of emissions. Furthermore, the findings reveal that this impact is related to reserves and reinsurance. Specifically, reserves increase with greenhouse gas emissions, while premiums ceded to reinsurers decline.

Isibor and Aigbovo (2025) investigates the impact of financial sector development on environmental degradation in selected Sub-Saharan African

countries, with a specific focus on the roles of credit to the private sector and broad money supply. The study utilizes a balanced panel dataset covering seven countries—Côte d'Ivoire, Ghana, Kenya, Mauritius, Namibia, Nigeria, and South Africa—over the period 1993 to 2021. Employing the Panel Autoregressive Distributed Lag (P-ARDL) framework, the analysis captures both short-run dynamics and long-run equilibrium relationships, while panel Granger causality tests are used to explore directionality between variables. The findings reveal that in the short run, broad money supply significantly reduces CO₂ emissions, while credit to the private sector has no immediate effect. In the long run, however, credit allocation contributes positively to ecological footprint per capita but reduces the broader ecological footprint index, suggesting mixed environmental implications depending on credit allocation and institutional context. The study also identifies bidirectional causality between financial development and CO₂ emissions, underscoring the feedback loop between economic activity and environmental pressure.

3. Methodology

The study used the ex-post research design. The working population of the study consists of the entire listed insurance sector in Nigeria. The sample period covered ranges from 2000 to 2024. The researcher used secondary source of data from the Central Bank of Nigeria (CBN) Statistical Bulletin, (2024 and World Bank – World Development Indicator (WDI, 2024) for the purpose of this study. Owing to the linearity of the model formulated to investigate the effect of insurance sector development on CO₂ emissions in Nigeria, descriptive statistics, correlation matrix, co-integration, Autoregressive Distributed Lagged (ARDL) method of estimation technique was employed in obtaining the numerical estimates of the parameters in the model. The objectives of the study were accomplished by analyzing the models with the help Autoregressive Distributed Lag (ARDL) technique of estimation using E-views 9.0 econometric software.

3.1 Theoretical Framework

The theoretical framework of this study is anchored on the Environmental Transition Theory (ETT). ETT suggests that environmental degradation is not uniform across all stages of development. In the early phases of urbanization and industrialization, rapid expansion in energy consumption and infrastructure development leads to significant

environmental stress. However, as economies mature and achieve higher levels of per capita income, they become more capable of investing in sustainable practices and enforcing environmental regulations (Majeed & Mazhar, 2019; Li et al., 2021). ETT emphasizes the adaptive capacity of societies to transition from environmentally harmful to environmentally sustainable practices. The role of the financial system (in this study, the insurance sector) in this process is pivotal, as it provides the capital and incentives required for both technological adoption and structural shifts toward greener industries. A well-functioning insurance sector provides benefits to the other agents of the financial system because they can get help from funds obtained through insurance premiums (Din et al., 2017). However, the most essential function of insurance sector development is risk minimisation for businesses. Insurance enhances risk-free business continuity, which is another crucial factor in boosting economic growth. Insurance provides risk-free income and wealth for individuals and businesses (Senol et al., 2020, Cummins and Rubio-Misas, 2021).

3.3 Model Specification

In order to investigate the nexus between insurance sector development and CO₂ emissions, a modified version of the model used by Samour et al., (2024) was specified. In Samour et al. (2024) model, insurance market development was proxy with insurance penetration while economic growth, renewable energy consumption and non-renewable energy consumption were the control variables in their model but in this study insurance sector development was proxy with insurance penetration, insurance density and insurance premium while economic growth, foreign direct investment and renewable energy consumption were included as the control variables. The functional form of our model is specified:

$$CO_2 = f(IPE, IDE, GPR, RGDP, FDI, REC) \dots\dots\dots(1)$$

The above functional model is further stated in stochastic form as:

$$CO_2 = \beta_0 + \beta_1 IPE_t + \beta_2 IDE_t + \beta_3 GPR + \beta_4 RGDP + \beta_5 FDI + \beta_6 REC + \varepsilon_{\mu_t} \dots\dots\dots(2)$$

The equation is specified in implicit form using Autoregressive Distributed Lag (ARDL) Model as follows:

The equation can be specified explicitly in the short-run as follows:

$$CO2_t = \beta_0 + \sum_{i=1}^q \beta_1 \Delta CO2_{t-1} + \sum_{i=1}^q \beta_2 \Delta IPE_{t-1} + \sum_{i=1}^q \beta_3 \Delta IDE_{t-1} + \sum_{i=1}^q \beta_4 \Delta GPR_{t-1} \\ + \sum_{i=1}^q \beta_5 \Delta RGDP_{t-1} + \sum_{i=1}^q \beta_6 \Delta FDI_{t-1} + \sum_{i=1}^q \beta_7 \Delta REC_{t-1} \\ + \varepsilon_t \dots \dots \dots (3)$$

The long run equilibrium impact of insurance sector development on economic growth is re-casted as follows to capture the error correction mechanism (ECM) that adjust the economy back to equilibrium in the event of shock. Thus, re-specifying equation (3) to incorporate the effect of shock which is captured by ECM and it is specified as follows:

$$CO2_t = \beta_0 + \sum_{i=1}^q \beta_1 \Delta CO2_{t-1} + \sum_{i=1}^q \beta_2 \Delta IPE_{t-1} + \sum_{i=1}^q \beta_3 \Delta IDE_{t-1} + \sum_{i=1}^q \beta_4 \Delta GPR_{t-1} \\ + \sum_{i=1}^q \beta_5 \Delta RGDP_{t-1} + \sum_{i=1}^q \beta_6 \Delta FDI_{t-1} + \sum_{i=1}^q \beta_7 \Delta REC_{t-1} + \phi ECM_{t-1} \\ + \varepsilon_t \dots \dots \dots (4)$$

Where:

CO2 = CO₂ emissions

IPE = Insurance penetration

IDE = Insurance density

GPR = Insurance premium

RGDP = Economic growth

FDI = Foreign direct investment

REC = Renewable energy consumption

ε = Stochastic disturbance term acting as a surrogate for other factors not captured in the model

ECM = $(CO2_{t-1} - \theta_{xt})$, the error correlation term is the extracted residuals from the regression of the long-run equation,

= the speed of adjustment parameter with negative sign

β_0 = Constant/slope

3.4 Measurement of Variables and Expected Sign

Table 1 defines the variables that were used, together with the a priori expectation and the name of the previous researcher that used the variable in their study.

Table 1: Variable Measurements and Expected Sign

Variables	Variable Type	Measurement	A-priori Expectation	Previous Study that Utilised the Variable
CO ₂ Emissions (CO ₂)	Dependent	Carbon emission (metric tons per capita (kt)		Isibor & Aigbovo (2025)
Insurance penetration (IPE)	Independent	Measure as total insurance premiums as a percentage of its gross domestic product (GDP)	(+ or -)	Koufioti et al., (2022)
Insurance density (IDE)	Independent	Calculated by dividing the total insurance premium by the population	(+ or -)	Kolapo (2024)
Insurance premium (GPR)	Independent	Measured as the logarithm of gross premium written by the insurance industry in Nigeria	(+ or -)	Leo et al. (2024)
Economic growth (RGDP)	Independent (control variable)	Measured as the annual change in real GDP: $GDP_t - GDP_{t-1} / GDP_{t-1}$	(+ or -)	Lojanica, et al., (2025)
Foreign direct investment (FDI)	Independent (control variable)	Calculated as the ratio of foreign direct investments (FDI) to GDP, or the net inflows of investment divided by GDP	(+)	Shahbaz, et al.,(2018)
Renewable energy consumption (REC)	Independent (control variable)	Measure as combustible renewables and waste (% of total energy)	(+)	Samour et al. (2024)

Source: Author's compilation (2026)

4. Presentation and Discussion of Results

4.1 Descriptive Statistics

To summarise the data, the basic characterization of the datasets is conducted using descriptive statistics. Table 4.1 shows the annualised summary data for all variables in the study for the period 2000 to 2024.

Table 4.1: Descriptive Statistics

	CO2	IPE	IDE	GPR	RGDP	REC	FDI
Mean	0.632800	0.258000	446.2828	1.014000	397363.6	83.82965	1.326000
Median	0.610000	0.250000	447.1000	0.990000	423525.3	84.02920	1.380000
Maximum	0.820000	0.360000	695.7200	1.460000	562147.4	88.74930	2.900000
Minimum	0.500000	0.180000	178.7800	0.620000	179675.5	79.65420	-0.040000
Std. Dev.	0.082589	0.056199	153.7054	0.177670	122758.5	2.168168	0.829869
Skewness	0.878637	0.299007	-0.009306	0.304915	-0.387485	0.299258	0.254440
Kurtosis	2.823694	1.816135	1.956399	3.925291	1.740481	2.638799	2.002247
Jarque-Bera	3.249056	1.832453	1.134843	1.279225	2.278090	0.509050	1.306741
Probability	0.197005	0.400026	0.566985	0.527497	0.320125	0.775285	0.520289
Sum	15.82000	6.450000	11157.07	25.35000	9934091.	2095.741	33.15000
Sum Sq. Dev.	0.163704	0.075800	567008.5	0.757600	3.62E+11	112.8228	16.52840
Observations	25	25	25	25	25	25	25

Source: Author's computations, (2026) using Eviews 9.0

The descriptive statistics result in Table 4.1 revealed that the ratio between mean and median for all the variables (except RGDP) is approximately one. The mean value of economic growth (RGDP) is higher than that of carbon dioxide emissions (CO2). This implies the average income generated from production and consumption activities exceeded the CO2 emission that is associated with these activities. The standard deviation shows that dispersion of the variables from their respective mean values is high. This implies a wide variation within the values of each series of the variables. The skewness values showed that apart from insurance density (IDE) and economic growth (RGDP) that are negatively skewed, all the other variables were positively skewed. The Kurtosis values for gross premium (GPR) was greater than the acceptable level of 3, implying that the series for GPR is highly peaked (leptokurtic), that is, it had more value that is greater than its respective sample mean. However, the Kurtosis values for all the other variables (CO2, IPE, IDE, RGDP, REC and FDI) are flat (plytokurtic). The Jarque-Bera test probability values for all the seven (7) variables - CO2, IPE, IDE, GPR, RGDP, REC and FDI are normally distributed because their corresponding probability value is > 0.05 . Hence, normalizing the deviation of these variables from their mean becomes imperative by ascertaining their stationarity status.

4.2 Correlation Analysis

It is imperative to investigate the degree and direction of association between the variables in the study. These investigations are carried out using correlation analysis. Table 4.2 shows the results of the correlation test.

Table 4.2: Correlation Result

Correlation Probability	CO2	IPE	IDE	GPR	RGDP	REC	FDI
CO2	1.000000 -----						
IPE	0.460884 0.0204	1.000000 -----					
IDE	-0.686825 0.0001	-0.227314 0.2745	1.000000 -----				
GPR	-0.775142 0.0000	-0.101821 0.6282	0.615119 0.0011	1.000000 -----			
RGDP	-0.692845 0.0001	-0.867491 0.0000	0.399976 0.0476	0.367976 0.0703	1.000000 -----		

REC	0.002228	0.514051	-0.095575	0.262093	-0.443007	1.000000	
	0.9916	0.0086	0.6495	0.2056	0.0266	-----	
FDI	0.181456	0.789505	0.114731	0.069942	-0.753977	0.525246	1.000000
	0.3854	0.0000	0.5850	0.7397	0.0000	0.0070	-----

Source: Author's Computations, (2026) using Eviews 9.0

The correlation result in Table 4.2 shows that there is a significant positive association between carbon dioxide emissions (CO₂) and insurance penetration (IPE). This implies that increase in IPE significantly increased CO₂ during the studied period. However, IDE, GPR and RGDP have significant negative relationship with CO₂. This implies that increase in IDE, GPR and RGDP significantly reduced CO₂ during the studied period as indicated by their corresponding negative coefficients. Renewable energy consumption (REC) and foreign direct investment (FDI) have insignificant direct relationship with CO₂. Meaning that, an Increase in these variables has no significant association with carbon dioxide emissions (CO₂). The relationship between the independent variables shows a similar pattern, that is, some are significantly and negatively related while others are significantly and positively related. Furthermore, Table 4.2 also revealed the absence of multi co-linearity problem among explanatory variables since no correlation coefficient between explanatory variables is > 0.80 as suggested by Gujarati (2008).

4.3 Unit Root Testing

Time series data are always associated with the problem of non-stationarity. This could decrease the validity of forecast based on such data. In order to overcome this problem, this study used the standard Augmented Dickey-Fuller (ADF) test to examine the stationarity or otherwise of the data in this study. Tables 4.3 display the ADF test results of the series at level and first differences so as to capture the variables stationarity.

Table 4.3: Unit Root Test Result

Variables	Augmented Dickey-Fuller (ADF) Test		
	At level	1 st Difference	Order of Integration
CO ₂	-32492*	-2.0841	I[0]
IPE	-1.4258	-4.8347*	I[1]
IDE	-1.8525	-3.6918*	I[1]
GPR	-5.6109*	-3.0105*	I[1]
RGDP	-2.1711	-3.0719*	I[1]
REC	-1.8849	-5.7394*	I[1]
FDI	-0.7134	-8.0514*	I[1]

Source: Researcher's Computation (2026) Using E-views 9.0 Software. Note: * & ** indicate significance at 1 and 5 percent levels.

The results of the estimated Augmented Dickey-Fuller (ADF) tests shown in Table 4.3 clearly indicate that data on the variables such as IPE, IDE, RGDP, REC and FDI were not stationary in their level form. However, CO₂ and GPR were stationary at level. At the first difference, only CO₂ emission was not stationary. This implies that the data employed for the econometric analysis in this research are the combination of I(0) and I(1). As a consequence of the test results indicates that the variables are integrated of I(0) and I(1) and that none of the variables are integrated of I(2) or higher, we proceed with the ARDL co-integration technique since it can cope with whether all variables are I(0), all are I(1), or a mixture of both. This implies performing a co-integration test utilising the ARDL co-integration bounds test approach proposed by Pesaran, Shin, and Smith (2001).

4.4 Bounds Tests for Co-integration

Following the order of integration, a robust ARDL bound testing technique for cointegration was employed to examine if a long run equilibrium relationship exists between the explained variable CO₂, and the explanatory variables in the ARDL model. This is presented in Table 4.4.

Table 4.4: ARDL Bounds Test for Co-integration-Selected Model [ARDL (1, 0, 0, 1, 0, 1, 1)]

ARDL Bounds Test		
Test Statistic	Value	k

F-statistic	6.794241	6
-------------	----------	---

Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Source: Researcher's Computation (2026) Using E-views 9.0 Software

The criterion for the co-integration bounds test involves comparing F-statistics to critical values. Tables 4.4 show that the test is highly significant at the 1% level. The null hypothesis of no long run co-integration would be rejected because the value in the upper and lower Critical Bounds at 10%, 5%, 2.5%, and 1% level of significance is lower than the value in the F-statistic (6.79). As a result, there is a cointegrating link between the variables in the model. Therefore, the findings in Table 4.4 support the existence of a long-run relationship between carbon emissions and the explanatory variables (IPE, IDE, GPR, RGDP, REC and FDI). Thus, there is the presence of cointegrating relationship among the variables in the model. This outcome necessitates the estimation of the short and long run relationship between the dependent and independent variables.

4.5 VAR Lag Order Selection Criteria

To estimate the appropriate number of lags for the model, an unrestricted Vector Autoregression (VAR) lag selection criterion was applied to the time series data and the outcome is shown in Table 4.5.

Table 4.5: Akaike optimal Lag Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	43.61766	NA*	0.002575	-3.134805	-2.840292	-3.056671
1	45.46206	2.612898	0.002416*	-3.205172*	-2.861573*	-3.114015*

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Source: Author's computations, (2026) using Eviews 9.0.

Table 4.5 shows that the lowest result for each estimator occurs under lag one (1). In this study, the AIC criterion was adopted based on the results to determine the optimum lag duration of the ARDL model. As a common result of the AIC criterion, the ARDL (1, 0, 0, 1, 0, 1, 1) model was chosen. Thus, in the ECM model, the AIC lag structure in Table 4.5 identifies and recommends one (1) lags as the best lag structure.

4.6 ARDL Analysis (Short-Run and Long-Run Estimation)

In Table 4.6, the results of the nexus between carbon dioxide emissions and the explanatory variables in Nigeria is summarised for both the short run and long run.

Table 4.6: Short-Run Error Correction Model and Long-Run Results

Dependent Variable: CO2							
Method: ARDL							
Model Selection Criteria: AIC							
Model Selected: ARDL 1, 0, 0, 1, 0, 1, 1							
Short-Run Parameters				Long-Run Parameter			
Variables	Coeff.	t-stat	Prob.	Variables	Coeff.	t-stat	Prob.
D(IPE)	0.173636	0.638262	0.5344	IPE	0.137731	0.632805	0.5378
D(IDE)	0.000117	1.423871	0.1780	IDE	0.000093	1.367646	0.1946
D(GPR)	-0.218608	-2.978860	0.0107*	GPR	-0.265595	-4.562852	0.0005*
D(RGDP)	-0.000001	-3.392385	0.0048*	RGDP	-0.000001	-3.904905	0.0018*
D(REC)	-0.002771	-0.677874	0.5097	REC	0.003661	0.832521	0.4201
D(FDI)	-0.049526	-2.641592	0.0203**	FDI	-0.079500	-3.544476	0.0036*
CointEq(-1)	-0.260693	-6.158886	0.0000	C	0.906515	2.701019	0.0182

Source: Researcher's Computation (2026) Using E-views 9.0 Software. Note: *and ** indicates 1% and 5% significant level

The result in Table 4.6 reveals that insurance premium (GPR), economic growth (RGDP) and foreign direct investment (FDI) pass the significant test at the one and five percent level in the short run and long run. This means that these variables contributed to CO₂ consistently during the study period. They are statistically significant and so important for policy recommendations. Furthermore, insurance penetration (IPE), insurance density (IDE) and renewable energy consumption (REC) failed their significance test in the short run and long run. This means that during the study period, these variables did not significantly influence CO₂ emissions in both the short and long run. They are not statistically significant; hence they are unimportant for policy recommendation. The coefficient of error correction term [CointEq(-1)] is observed to have the predicted sign (negative) and is statistically significant at the 1% level, and it indicates how quickly the variables adapt to equilibrium. The ECM(t-1) or CointEq(-1) coefficient of -0.260693 is significant at the 1% level and indicates how fast the variable adjust to equilibrium. The coefficient of -0.260693 suggests that 26% of the deviation from equilibrium is corrected within one year.

4.7 Diagnostic and Stability Test

To ensure the robustness, reliability and validity of the ARDL results obtained from the empirical analysis, the following tests were conducted; Ramsey RESET stability test, Breusch–Godfrey Serial Correlation LM test and Breusch-Pagan-Godfrey heteroskedasticity test. The results of the test are presented Tables 4.7

Table 4.7: Result of the diagnostic test for ARDL model (1, 0, 0, 1, 0, 1, 1)

Diagnostic Tests (Test Statistics)	Test	Coefficient	P-value	Decision
Breusch-Pagan-Godfrey	Heteroskedasticity	0.9272	0.5390	No Heteroskedasticity problem
Breusch-Godfrey LM (F-Stat.)	Serial Correlation	2.1553	0.1622	No Serial correlation
Ramsey RESET Test	Model Specification Error: t-stat. F-Stat.	0.0868 0.0075	0.9322 0.9322	Equation is correctly specified
Jarque-Bera statistic	Normality Test	0.6764	0.7130	Residuals are normal

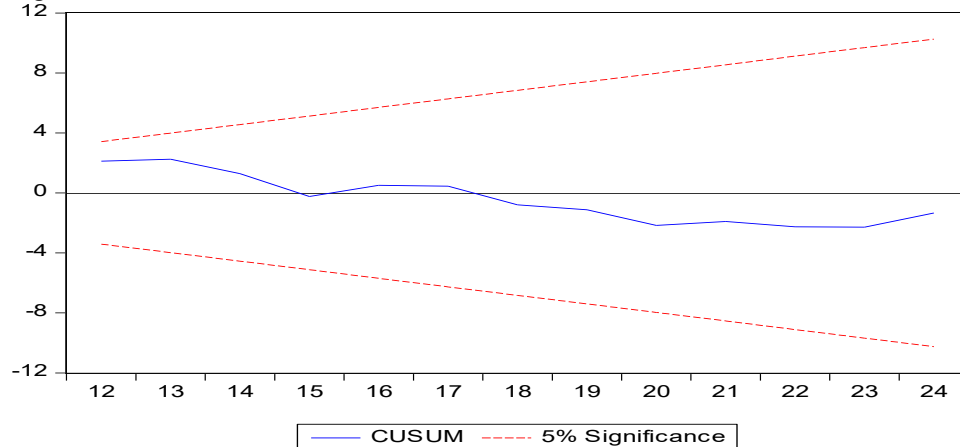
Source: Author's computation, (2026) using Eviews 9.0

The Breusch-Pagan-Godfrey heteroskedasticity test results in Tables 4.7 shows that the probability values (0.5390) is greater than 0.05 ($p > 0.05$) level of significance which imply that the null hypothesis of no heteroskedasticity problem cannot be rejected. Thus, this necessitates the acceptance of null hypothesis and therefore concludes that the models have no heteroskedasticity problem. Similarly, Breusch-Godfrey Serial Correlation LM test results in in Tables 4.6 shows that the probability values (0.1622) is greater than 0.05 ($p > 0.05$) level of significance which imply that the null hypothesis of no serial correlation cannot be rejected. Thus, this necessitates the acceptance of null hypothesis and therefore concludes that the model has no serial correlation problem (That is, there is no serial correlation between the independent variables and disturbance term). Also, Ramsey RESET test shows that the models are free of specification errors since both the probability of the t-statistic and F-statistic of the Ramsey RESET test in Tables 4.7 is greater than 0.05 ($p > 0.05$), hence, relevant variables were not omitted, the functional form of the model is correct or the model was correctly specified in its linear form. Finally, the normality test results in Tables 4.7 revealed that the Jarque-Bera statistic has $p > 0.05$, which means that the null hypothesis that the distribution was normally distributed is accepted.

A stability test of the long run and short run coefficients using the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMQ) was performed. Accordingly, the parametric stability can be tested using cumulative of the recursive residuals (CUSUM) as well as the cumulative sum of squares of recursive residual (CUSUMQ)

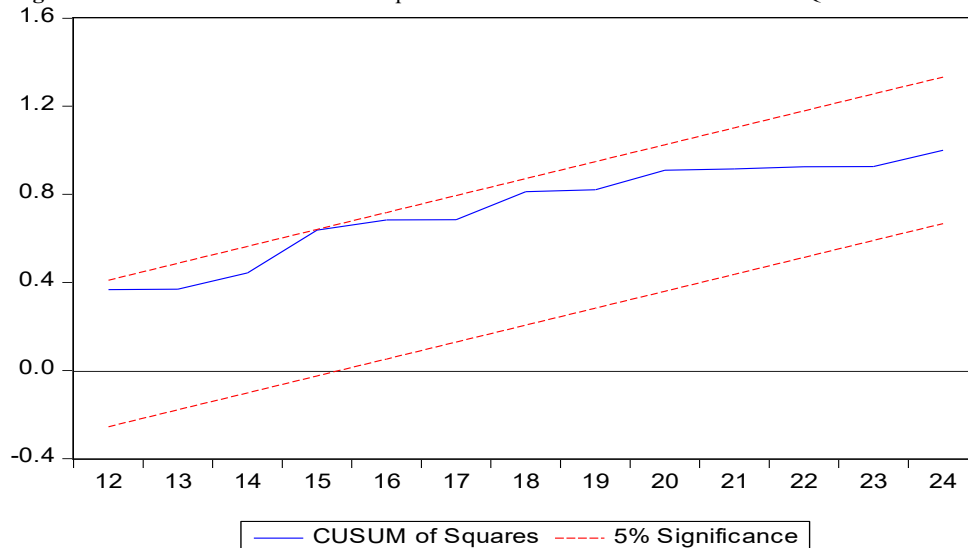
(Figures 1 and 2). CUSUM and CUSUMQ statistics are plotted against the critical bound of 5 percent significance and if the plot of these statistics remains within the critical bound of 5 per cent significance level, the null hypothesis, which states that all coefficients in the error correction model are stable, cannot be rejected. In other words, if the blue line crosses redline which is critical line and never returns back between two critical line, we accept the null hypothesis of the parameter instability whereas the cumulative sum goes inside the area (can returns back) between the two critical lines, then there is parameter stability in the short-run and long-run. The null hypothesis is that the coefficient vector is the same in every period. As shown in the graphs, the plots of CUSUM and CUSUMQ residuals are within the boundaries. Thus, the plots of CUSUM and CUSUM SQUIRE test statistics rests neatly within the boundaries at 5% significant level. This implies that the parameters of the models have remained stable within its critical bounds. Hence, we can conclude that long-run estimates are stable and there is no structural break.

Figure 1: Plot of Cumulative Sum of Recursive Residuals - CUSUM



Source: Author's computation, (2026) using Eviews 9.0

Figure 2: Plot of Cumulative Sum of Squares of Recursive Residuals - CUSUM SQUARE



Source: Author's computation, (2026) using Eviews 9.0

4.8 Discussion of Findings

The effect of all the independent variables on carbon emission (CO_2) in both the short and long run period are similar, although in different magnitude. Insurance penetration (IPE) has an insignificant positive impact on carbon dioxide emissions in both the short and long run. Thus, a unit increases in IPE result to 0.173636 and 0.137731 insignificant increases in CO_2 in the short and long run respectively. This implies that insurance penetration

is not a key insurance sector development variable that drives carbon emissions in Nigeria within the studied period. The insignificant result might be due to the fact that insurance penetration in Nigeria is still low; hence its overall effect on carbon emissions in Nigeria is minimal. These finding is contrary, to the result of Koufioti et al., (2022), Rizuwanullah et al., (2022) and Samour et al., (2024) who reported a significant positive link between insurance penetration and CO_2 emissions.

Furthermore, the empirical finding indicates that the coefficient of insurance density (IDE) exerts an insignificant positive impact on CO₂ emissions in both the short and long run. A unit increase in IDE result to 0.000117 and 0.000093 insignificant increases in CO₂ in the short and long run respectively. Hence, insurance sector development (in terms of density) is not a key insurance sector development factor that influences carbon dioxide emissions in Nigeria within the period of the study. This finding is not in consonance with that of Kolapo (2024) who reported a significant positive link between insurance density and CO₂ emissions.

From the results, insurance premium (GPR) has significant negative impact on CO₂ emissions in the short and long-run. A unit increase in GPR result to -0.218608 and -0.265595 significant increases in CO₂ emission in the short and long run respectively. The implication of a significant negative effect of insurance premium (GPR) on CO₂ emission is that increase in insurance premium (GPR) will reduce CO₂ emission in Nigeria. Higher premiums lead to lower CO₂ emissions because insurance firms are pricing in environmental risks or promoting green behavior. The insurance premium (GPR) result from this study does not align with that of Leo et al., (2024) who reported a significant positive relationship between insurance premium (GPR) and CO₂ emissions in their study.

Economic growth (RGDP) has significant negative impact on CO₂ emissions in both the short and long run. This implies that a unit increase in economic growth result to -0.000001 significant decreases in CO₂ emission in both the short and long run. The likely reason for this might be that Nigeria's growth is driven by services or clean technology and not heavy industry. This finding is in tandem with Koufioti et al., (2022) who reported a significant negative link between economic growth and CO₂ emissions in their study. The finding is however contrary to that of Altarhouni et al., (2021) and Kolapo (2024) who reported a significant positive relationship between economic growth CO₂ emissions.

Renewable energy consumption (REC) has no significant effect on CO₂ emissions both in the short and long run period. However, the short run result was negative while that of the long run was positive. Hence, a unit increase in renewable energy consumption insignificantly reduces CO₂ emissions by -0.002771 in the short run and increases CO₂ emissions by 0.003661 in the long run. The implication of this finding is that renewable energy consumption is not a key factor that influences CO₂ emissions in Nigeria within the studied period. The negative influence of renewable energy consumption, emphasize the necessity of

implementing ecologically friendly measures in both energy sectors (particularly, the need to increase the share of renewable energy in total energy use) and international trade. This finding is in tandem with Shahbaz et al., (2018) who reported a significant negative effect of renewable energy consumption on CO₂ emissions. However, this finding is contrary to that of Nguyen and Kakinaka (2019) who reported a significant positive link between REC and CO₂.

Finally, FDI has significant negative influence on CO₂ emission both in the short and long run period. This implies that FDI is a key variable that influences CO₂ emission during the period under consideration. The finding is contrary to that of Shahbaz et al., (2018) who found that FDI positively and significantly influences CO₂ emissions in their study.

5. Conclusion and Recommendation

5.1 Conclusion

This study set out to investigate how Nigeria's CO₂ emission is impacted by insurance sector development. The variables used to proxy insurance sector development were insurance penetration (IPE), insurance density (IDE) and insurance premium (GPR). The CO₂ metric ton per capita was used to proxy carbon dioxide emissions. The Autoregressive Distributed Lag (ARDL) estimation technique was used to examine the effect of insurance sector development variables on CO₂ emissions using annual data for the period 2000 to 2024. The analysis was conducted using the econometric software E-view 9.0. The results show that while insurance penetration (IPE) and insurance density (IDE) has no significant impact on CO₂ emissions in Nigeria, Insurance premium (GPR) has a significant impact on CO₂ emissions. Also, in terms of the control variables, economic growth and FDI exerts a significant negative impact on CO₂ emissions while renewable energy consumption failed the significant test. According to the study's findings, insurance sector development plays a significant role in Nigeria's CO₂ emission. This is demonstrated by the Insurance premium (GPR) which exerts significant negative impact on CO₂ emissions.

5.2 Recommendations

Based on the findings of this study, the following policy recommendations are suggested:

Since the study reveals that insurance penetration (IPE) and insurance density (IDE) has insignificant positive effect on CO₂ emissions, the study recommends that insurers should explore more green products or sustainability-linked policies. In

other words, policies that support green insurance initiatives and investments in low-carbon transition projects should be encouraged. Also, insurers should integrate climate risk assessments into underwriting.

Insurers should invest their premium in low-carbon projects so that it will continue to reduce CO₂ emissions in Nigeria. In addition, the Nigerian government should reward low-carbon growth strategies.

It's also important for government to address grid integration by improving infrastructure for renewables to displace fossil fuels in Nigeria; this will enable renewable energy to contribute meaningfully to the reduction of CO₂ emissions in Nigeria.

Lastly, Nigeria government should incentivize foreign investment in renewables, clean technology, or sustainable industries. Also, FDI benefits should be tied to environmental standards or green commitments.

References

- Agbo, I. U., & Agbaji, B. C. (2020). Assessment of impact of insurance density on insurance performance 1996-2018: Nigeria perspective. *International Journal of Management Science and Entrepreneurship*, 19(7), 92 – 104.
- Ahmed, S., Siwar, C., & Sarkar, K. S. M. (2013, October). Impact of environmental change on insurance industry. In M. M. Billah (ed.), 1st Insurance and Takaful International Symposium: Symposium conducted at the Universiti Kebangsaan Malaysia, Bangi, Selangor.
- Akpan, G. E., & Akpan, U. F. (2012), Electricity consumption, carbon emissions and economic growth in Nigeria. *International Journal of Energy Economics and Policy*, 2(4), 293-308.
- Altarhouni, A.; Danju, D.; Samour, A. (2021). insurance market development, energy consumption, and turkey's CO₂ emissions. New perspectives from a bootstrap ARDL Test. *Energies*, 14(7830), 1 - 13. <https://doi.org/10.3390/en14237830>
- Anser, M. K., Syed, Q. R. & Apergis, N. (2021). Does Geopolitical Risk Escalate CO₂ Emissions? Evidence from the BRICS Countries. *Environmental Science and Pollution Research*, 28(35), 48011-48021. <https://doi.org/10.1007/s11356-021-14032-z>
- Appiah-Otoo, I., & Acheampong, A.O. (2021). Does insurance sector development improve environmental quality? Evidence from BRICS. *Environmental Science and Pollution Research*, 28(23), 29432–29444. <https://doi.org/10.1007/s11356-021-12760-w>
- Aydın, Ş., Öztutuş, F. & Polat, İ. H. (2024). The impact of financial development, foreign direct investment and geopolitical risk on CO₂ Emissions: Evidence from Turkey. *Fiscaeconomia*, 8(3), 1617-1640. Doi: 10.25295/fsecon.1513450
- Bressan, S. (2025). Greenhouse gas emissions and the financial stability of insurance companies. Preprints. <https://doi.org/10.20944/preprints202506.1945.v1>
- Coşkun, C., Paskeh, M. K., Olasehinde-Williams, G. & Akadiri, S. S. (2020). Economic and Social Determinants of Carbon Emissions: Evidence from Organization of Petroleum Exporting Countries. *Journal of Public Affairs*, 20(3), e2092. <https://doi.org/10.1002/pa.2092>
- Garba, J., & Abdulsalam, H. (2018). Factors affecting the patronage of insurance services in Borno state, Nigeria. *International Journal of Economic Development Research and Investment*, 2(1), 1-11.
- Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American Free Trade Agreement. (NBER Working Paper No. 3914). <https://doi.org/10.3386/w3914>
- Grossman, G. M., & Krueger, A. B. (1993). Environmental impacts of a North American Free Trade Agreement. In P. M. Garber (Ed.), *The U.S.–Mexico Free Trade Agreement* (pp. 13–56). MIT Press.
- Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *The Quarterly Journal of Economics*, 110(2), 353–377.
- Hien, T. T. L., Tri, H. T., & Tuong Van, P. T. (2024). Role of insurance in promoting sustainable development in OECD countries: Mediation analyses. *WSB Journal of Business and Finance*, 58(1), 151–166.
- Hussen, A. M. (2005). *Principles of environmental economics and sustainability: An integrated and ecological approach*. Routledge.
- International Association of Insurance Supervisors (2017). Insurance Core Principles, Retrieved from www.iaisweb.org/page/supervisory-material/icp-on-line-tool.
- Isibor, B. O., & Aigbovo, O. (2025). Assessing the environmental impacts of financial sector development: Evidence from credit allocation and monetary expansion in Sub-

- Saharan Africa. *Journal of Academic Research in Economics*, 17(3), 487 – 514.
- Kolapo, F. T. (2024). A Time-series analysis of insurance sector density and environmental quality in Nigeria. *Journal of Economics, Finance and Management Studies*, 7(8), 5217 – 5225.
- Koufioti, G., Kounios, A., Madiinos, D., & Paraskevadaki, E. (2022). The effect of insurance market penetration on CO₂ emissions. A panel data analysis of European countries. International Conference on Applied Business and Economics held at the University of Malta's Valletta Campus. Organized by the University of Malta and the International Strategic Management Association.
- Leo, J., Banick-Raj, A., Velankanni, A., & Nandakumar, C. D. (2024). Climate risk management in insurance: Exploring the relationship between global greenhouse gas emissions and premium pricing. *International Journal of Intelligent Systems and Applications in engineering*, 12 (22s), 441 – 444.
- Li, R., Lin, L., Jiang, L., Liu, Y., & Lee, C.-C. (2021). Does technology advancement reduce aggregate carbon dioxide emissions? Evidence from 66 countries with panel threshold regression model. *Environmental Science and Pollution Research*, 28(17), 19710–19725. <https://doi.org/10.1007/s11356-020-11955-x>
- Li, X., Ozturk, I., Ullah, S., Andlib, Z., & Hafeez, M. (2022). Can top-pollutant economies shift some burden through insurance sector development for sustainable development? *Economic Analysis and Policy, Elsevier*, 74(C), 326-336. DOI: 10.1016/j.eap.2022.02.006
- Lojanica, N., Stancic, V., & Gricar, S. (2025). Insurance, environment, and growth: A panel study across European countries. *Journal of Risk and Financial Management*, 18(12), 703. <https://doi.org/10.3390/jrfm18120703>
- Majeed, M. T., & Mazhar, M. (2019). Financial development and ecological footprint: A global panel data analysis. *Pakistan Journal of Commerce and Social Sciences*, 13(2), 487–514.
- Nguyen, K.H.; Kakinaka, M. (2019) Renewable energy consumption, carbon emissions, and development stages: Some evidence from panel cointegration analysis. *Renew. Energy*, 132(1), 1049–1057.
- Olarewaju, O., & Thabiso, M. (2021). Determinants of insurance penetration in West African countries: A panel autoregressive distributed lag approach. *Journal of Risk and Financial Management*, <https://doi.org/10.3390/jrfm14080350>
- Panayotou, T. (1995). Environmental degradation at different stages of economic development. In I. Ahmed & J. A. Doeleman (Eds.), *Beyond Rio: The environmental crisis and sustainable livelihoods in the Third World* (pp. 13 – 36). Macmillan Press.
- Rizwanullah, M., Nasrullah, M. & Liang, L. (2022). On the asymmetric effects of insurance sector development on environmental quality: Challenges and policy options for BRICS economies. *Environmental Science Pollution Research* 29, 10802–10811. <https://doi.org/10.1007/s11356-021-16364-2>
- Rudra, P. P., Sahar, B., & Marepalli, U. K. (2014). The dynamics of insurance sector development, banking sector development and economic growth: Evidence from G-20 countries. *Global Economics and Management Review*, 19(2), 16 – 25.
- Samour, A., Onwe, J. C., Inuwa, N., & Imran, M. (2024). Insurance market development, renewable energy, and environmental quality in the UAE: Novel findings from a bootstrap ARDL test. *Energy & Environment*, 35(2), 610 – 627.
- Shahbaz, M., Tiwari, A., K., & Nasir, M. (2018). The effects of financial development, economic growth, coal consumption and trade openness on CO₂ emissions in South Africa. *Energy Policy*, 61(1), 1452 - 1459.
- UNFCCC (2021). United Nations Framework Convention on Climate Change <https://cdm.unfccc.int/methodologies/documentation/index.html>
- World Bank (2022). World development indicators. World Bank Open Data. Available online: <https://databank.worldbank.org/source/world-development-indicators>.