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TRADE OPENNESS, FOREIGN DIRECT INVESTMENT, ENERGY CONSUMPTION, ECONOMIC GROWTH, AND ENVIRONMENTAL QUALITY: EMPIRICAL EVIDENCE FROM NIGERIA

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Abstract

The study examines the impacts of trade openness, foreign direct investment, gross domestic product, renewable and non-renewable energy consumption on carbon emission in Nigeria. Johansen cointegration test as well as Vector Error Correction Model (VECM) was deployed for the study. The study established that GDP growth, FDI, trade openness and non-renewable energy have long run negative impact on environmental quality whereas renewable energy consumption was discovered to improve the quality of the environment in the long run. The study recommends that law makers should articulate laws that discourage environmental pollution and reinforces the use of renewable energy. Budget allocation to renewable energy projects should be beef up while firms that deals on renewable energy should be allowed tax holiday. Foreign investment policies should be well articulated in ways that does not compromise the quality of the environment.

Key words: Carbon Emission, FDI, Trade Openness, Energy, GDP, EKC Model

1. Introduction

The goal of every government is not only to increase the level of economic prosperity but also to ensure a better quality of life for its citizens. While gross domestic product (GDP) is a good determinant of economic prosperity, environmental quality can be considered a good indicator of the quality of life of citizens. A higher level of GDP is mostly preceded by an increase in economic activities in the manufacturing, transportation, and service sectors leading to an increase in energy utilization which is believed to be associated with carbon emission. Besides, foreign direct investment through trade openness is believed to accelerate GDP growth in Africa albeit with its attending consequences. Though trade openness affects the economy by increasing the volume of economic activities, it equally alters the composition of the economic activities and allows for a change in production techniques (Grossman & Kueger, 1991) which may affect the environment either positively or negatively. An increase in energy consumption in the process of generating a higher level of GDP results in carbon emission which is believed to be responsible for environmental pollution. Building a prosperous economy by growing the GDP is desirable but the unintended consequences on the environment are critical to the quality of life of the people. Growing the Nigerian economy while maintaining sustainable environmental quality is the primary motivation of the study.

The increasing level of interest in climate change by world leaders is a testimony to the necessity of a better and quality environment. There seems to be a consensus that greenhouse gas occasioned by increasing levels of carbon emission contributes to global warming thereby compromising the quality of the environment. How to reduce carbon emission which is a major component of

greenhouse gas has taken the front burner in public discussion and academic literature recently.

In Africa particularly, there is an increasing need to grow the economy evidenced by GDP growth. Economic growth notwithstanding is mostly characterized by an increase in economic activities, industrialization, and energy consumption which in turn increase carbon emissions. The level of carbon emission is worst in Nigeria because of the evidence of gas flaring resulting from crude oil exploitation in the Niger Delta region and inefficient emission laws caused by weak institutions.

Despite being a signatory to the Kyoto Protocol in 1997, the Doha Amendment in 2012, the Paris Agreement in 2015, and enacting national emission policies, the level of gas flaring and carbon emission in Nigeria remains unabated. As Nigeria pursues the goal of economic growth, there is a need to channel effort towards environmentally friendly growth free from carbon emissions to attain sustainable development. The environmental Kuznets Curve hypothesis states that environmental pollution increases at the earlier stage of economic growth reaches a certain peak and then begins to decline subsequently. Validating the first stage of the EKC hypothesis is one of the objectives of this study. Growing the Nigerian economy while minimizing carbon emissions and ensuring better environmental quality aimed at attaining sustainable development is the second concern of this study. Decomposing energy consumption into renewable and non-renewable energy to ascertain their separate effect on environmental quality in Nigeria is one of the uniqueness of this study. Incorporating foreign direct investment in the economic growth and carbon emission nexus is another peculiarity of the study.

The study is therefore subdivided into different sections. Section two presents the literature review, section three deals with methodology and model specifications, and section four presents' empirical results and discussion, and section five focuses on conclusion and recommendations.

2. Literature Review

2.1 Theoretical Framework

The Environmental Kuznets Curve Hypothesis (EKC) is apt for this study. EKC establishes a quadratic relationship between environmental pollution and economic growth. It posits that environmental pollution rises at the early stage of economic growth and development. The rise in pollution reaches a certain peak, after which it starts declining (Grossman & Krueger, 1991). The theory presumes that economic growth enhances the quality of the environment rather than diminishes the quality of the environment in the long run. The EKC model regresses environmental pollution against GDP, the square of GDP $(GDP)^2$ and GDP cube $(GDP)^3$ with the expectation that the estimate of GDP will have a positive sign while the estimate of $(GDP)^2$ and GDP^3 will have negative signs. A country's pollution level is a function of its stage of economic development.

2.2 Empirical Review

Odusanya, Adegboyega, and Kuku (2014) examined the Effect of environmental quality on health care spending in Nigeria spanning the period 1990 to 2015. The study used Autoregressive Distributive Lag (ARDL) bounds test to analyze data collected from Central Bank Statistical bulletin of various years. The result from the study showed that Per capita, carbon emissions in metric tons increase health care spending in Nigeria during the period under review. The implication is the imperative of study that investigate the causes of emission and how to reduce emission so as to minimize health care spending.

Dogan, and Seker (2016) studied the effect of real income, trade, renewable and non-renewable energy on carbon emissions in the European Union. The study utilized the Dynamic Ordinary Least Square (DOLS), Fully Modified ordinary Least Square (FMOLS) and Dumitrescu-Hurlin causality test. The outcome of the study indicated that renewable energy, and trade mitigate carbon emission while non-renewable energy increases carbon emission. A two-directional causality between renewable energy and carbon emission was established

by the study. The study also revealed that a one directional causality ran from real income to carbon emission; from carbon emission to non-renewable energy; and from trade openness to carbon emission. Given that the prevailing situation in the European Union varies from that of Nigeria, the need to investigate the dynamic relationship of the variables using Nigeria scenario becomes pertinent for this study.

Archeampong (2018) investigated the dynamic relationship between economic growth, carbon emission and energy consumption in Sub-Sahara Africa (SSA), Middle East, Middle East and North Africa (MENA), Asia Pacific, and Caribbean Latin America between the period 1990 to 2014. The study employed the use of Panel Vector Autoregression (PVAR) and System Generalized Method of Moment (SGMM) in its analysis. The results indicated that economic growth have negative impact on carbon emission at global level; carbon emission causes economic growth in Sub Sahara Africa (SSA) while it causes negative growth at global, MENA, Asia Pacific and Caribbean America level. The study also established that energy consumption positively cause carbon emissions in MENA but cause carbon emission negatively in SSA, and Caribbean Latin America. The need to investigate the interrelationship amongst the variables under investigation in Nigeria is justified by the conflicting results from the different blocks and countries.

Chontanawat (2019) examined the dynamic relationship between energy consumption, carbon emission, and economic output in the Association of South Asian Nations (ASEAN) within the period 1971 to 2015. The study utilized cointegration and causality model. The findings revealed that there is a long run relationship and causality among variables. It further established that energy consumption and output have significant positive impacts on carbon emissions. The study also found that non-renewable energy, economic growth, and urbanization have positive and significant effect on ecological footprint (EF). Long run bidirectional causality among economic growth, non-renewable energy, urbanization and EF was discovered. It also found one directional causality that runs from renewable-energy to EF. The present study tends to include other variables such as trade openness and foreign direct investment in the relationship. It equally varies the technique of analysis and employed the use of up-to-date data for its analysis.

Ibukun and Osinubi (2020) considered the effect of environmental quality and economic growth on health expenditure in African countries. The study deployed the use of Pooled ordinary Least square (POLS) and fixed random effect and dynamic system GMM. The result showed that economic growth and decline in environmental quality increase health expenditure. This study investigates the variables that causes decline in environmental quality, with the aim of mitigating the effect, and consequently reducing health expenditure.

Ganda (2021) examined the effect of health care spending on environmental quality. The study adopted the use of Fully Modified Ordinary Least Square (FM-OLS), Vector Error Correction Model (VECM), Granger causality and Dumistrescu-Hurlin causality test. Two directional causalities between current health expenditure, private health expenditure and domestic and carbon emission was established. It also established that health expenditure significantly and negatively affect carbon emission. This has policy implication for health care spending and environmental quality. A study aimed at reducing carbon emission which by implication will reduce heath expenditure is imperative.

Cao et al (2021) looked at the impact of globalization, institutional quality, economic growth, electricity and renewable energy consumption on carbon emissions in Organization of Economic Cooperation and development (OECD) countries. The study used Kao, Westerlund and Pedroni cointegration and Pooled Mean Group (PMG). The findings revealed that cointegration exist amongst used variables. Renewable energy, globalization, institutional quality reduces carbon emission while financial development, stock market, electricity consumption and economic growth accelerate carbon emissions. The present study decomposed globalization into trade openness and foreign direct investment for better perspective and understanding.

Ul Hassan, Ussain and Ali (2021) studied the effect of economic growth and income inequality on environmental quality in 5 south Asian for Regional Cooperation (SARC) countries using fixed income model. The findings revealed a significant positive correlation between FDI and carbon emission. It also found that the correlation between education and carbon emissions is significantly negative. It further established a significantly positive correlation between population density and carbon emission. This study takes the relationship amongst the variable further than mere correlation to establishing a long run relationship among them.

Sheraz, Deyi, Ullah and Ullah (2021) examined the effect of globalization on financial development, energy consumption, human capital and carbon emissions in G20 countries. The study used the Fixed effect OLS, Discoll-Kraay Standard error approach and Dumitrescu and Hurtins (2012) panel causality test. The results showed that financial development and human capital decrease carbon emissions. Evidence of bidirectional causality between GDP and energy consumption was established. Finding the direction of causality between GDP is important but determining the short and long run effects of GDP on carbon emissions especially for Nigeria has profound policy implication for sustainable development for the future.

Bosah, Li, Ampofo and Liu (2021) studied the effect of energy consumption, economic growth, and urbanization on carbon emission in 15 nations using panel cointegration test and PMG-Auto regressive Distributive Lag (ARDL) estimation. The findings revealed that energy consumption is responsible for carbon emission in both short run and long run. It also showed that economic growth causes environmental distortion in the long run. It revealed a significant cointegration relationship between carbon emissions and economic growth including an N-shape relationship between economic growth, and carbon emissions in both short and long run. Control of corruption enhances carbon emission significantly in the long run. Regulatory quality has no significant effect on carbon emissions in both short run and long run. The findings of this study are profound but validating them in Nigeria's context is the objective of this present study.

Khan, et al (2021) considered the asymmetrical non-linear effect of energy consumption, trade openness and economic development on environmental quality in Pakistan using Non-Linear Autoregressive Lag (NARDL) model. The result of the study revealed the existence of both asymmetric and symmetric cointegration amongst variables. It further revealed that a negative shock to foreign direct investment (FDI) asymmetrically cause carbon emission while GDP symmetrically affect carbon emission. Negative shock to trade affects carbon emission as well. The current study considers the holistic effects of FDI and trade openness on carbon emission and not merely the effects of the shock to them.

Li et al (2022) studied the effect of international remittance inflow, population growth, energy utilization and technological innovation on environmental quality in Ghana. Robust econometrics method that controls for endogeneity, heteroscedasticity and serial correlation was used. The result showed that financial inflow, population growth, and energy utilization affect environmental quality negatively while technological innovation improves environmental quality. The current study employs FDI instead of financial inflow; it further decomposes energy utilization into renewable and non-renewable energy consumption with a view to ascertaining their separate effects on carbon emissions.

Jiang and Khan (2022) considered the impact of renewable energy consumption and technological innovation on carbon emission in Belt and Road Initiative countries using two-step difference and two-step system GMM. The outcome of the study revealed that technological innovation increases renewable energy consumption which in turn reduces carbon emission significantly. Thou the study insinuated reduction of carbon emissions by renewable energy but the relationship however was not direct. The current study seeks to establish direct relationship between renewable energy and carbon emissions.

Usman, Kousar, Yaseen, and Nadeem (2022) examined the effect of financial development, economic growth, energy consumption and trade on carbon emission in Pakistan. The study adopted the ARDL bounds testing model for its analysis. The result indicated that financial development and renewable energy improve environmental quality while economic growth, non-renewable energy utilization, and trade openness diminish the environmental quality in the short run. One directional granger causality run from economic growth, trade openness, and non-renewable energy use to carbon emission according to the study. The current study incorporates other variables of interest not captured by this study and also applies to Nigeria, with distinct geographical and economic peculiarity relative to Pakistan.

Alam (2022) considered the effect of trade, energy consumption, and economic growth on environmental quality in Bahrain. The study deployed the use of ARDL bounds test and VECM for its analysis. The study found a long run cointegration association amongst variables of interest. Trade and economic growth reduce environmental quality. Validating the impacts of trade and economic growth on carbon emissions in Nigeria's scenario is the thrust of this present study.

Nasreen, Tiwari, Nisa and Ishtiaq (2023) studied the effect of Per capita Income (PCI), air pollution, and health care services on health expenditure in Asian region. GMM and instrument variable quartile panel regression was employed in the study. The result showed that environmental pollution and urbanization increase health expenditure at both lower and upper quartiles. The policy implication for this study is to enhance environmental quality as way of reducing health expenditure. Identifying the variables that spur carbon emissions will help in its mitigation. This current study aims to achieve that.

3. Methodology

3.1 Data and Sources

The study utilizes the annual time series data from 1990 – 2022 obtained from the World Bank Development Indicator (WDI) to test the effect of trade openness, foreign direct investment, energy consumption, and GDP on carbon emissions. The variables used and their sources are presented in Table 1 below.

Table 1: Variable Descriptions

S/N	Variable Name	Descriptions	Sources
1	Co_2	Carbon emission in metric tons per capital (Used as proxy for environmental quality)	WDI
2	GDP	Gross Domestic Product per capita measured at constant in Naira (Used as proxy for economic growth)	WDI
3	TRO	Trade Openness measured as ratio of total trade to GDP	WDI
4	FDI	Foreign Direct Investment Net Inflow measured as percentage of GDP	WDI
5	REN	Total Renewable Energy Consumption measured as percentage of total energy consumption	WDI
6	NREN	Total fossil fuel energy consumption measured as percentage of total energy consumption (used as proxy for non-renewable energy consumption)	WDI

Source (WDI, 2023)

3.2 Method of Data Analysis

The EKC model assumes a quadratic relationship between environmental pollution and economic growth. The relationship is represented thus:

$$Co_2 = \beta_0 + \beta_1 GDP + \beta_2 GDP^2 + \beta_3 GDP^3 + e_t \quad (1)$$

The study however factored in other variables such as trade openness, foreign direct investment, energy consumption (decomposed into renewable and non-renewable energy consumption), and gross domestic product. All these variables are believed to have some level of impacts on environmental quality. The relationships in this model will take the form;

$$Co_2 = \beta_0 + \beta_1 GDPt + \beta_2 TRO_t + \beta_3 FDI_t + \beta_4 REN_t + \beta_5 NREN_t + e_t \quad (2)$$

Where: β_0 – β_5 denotes the estimates of variables of interest,

t stands for time while e denotes the error term.

By apriori expectation, $\beta_1 > 0$ for EKC hypothesis to be valid. The signs of β_2 and β_3 are uncertain because the net effect of trade openness and foreign direct investment on environmental quality is uncertain, it depends largely on institutional control. The sign of renewable energy (REN) is expected to be negative while that of Non-renewable energy (NREN) is expected to be positive.

Unit Root Test

The first procedure is to test for stationarity of the time series variable using a unit root test. It is assumed that linear combinations of non-stationary series can become stationary when differenced (Engle & Granger, 1987; Chontonawat, 2019). When such stationarity exists at the same order of integration especially, I(1), then the series is believed to be cointegrated. The stationarity model is specified thus:

$$\Delta X_t = \alpha_1 + \alpha_2 T + \delta X_{t-i} + \varepsilon_t \qquad X_t = 1 - n \quad (3)$$

Where X_t represents any variable of interest in the model, T is the time trend, Δ stands for difference operator and δ represents the coefficient of interest.

The null and alternative hypothesis is presented below:

H_0: $\delta = 0$ (i.e. X_t is non-stationary)

H_1: $\delta \neq 0$ (i.e. X_t is stationary)

Cointegration Test

Once the variables are confirmed to be stationary at first differenced or integrated of order one i.e. I(1), then the Johansen and Juselius cointegration test can be applied by using unrestricted vector auto-regressive (VAR) model such that a vector of variable (X × 1) at time t is related to the vector of past variables. The VAR specification is presented thus:

$$\Delta X_t = \alpha_1 + \alpha_2 T + \pi x_{t-1} + \ldots + \phi D_{t+Wt} \quad (4)$$

Where $\pi =$ and $\Gamma_i =$ -

X_t = (X × 1) dimension vector in which all the variables are I(1)

The π, Γ, and ϕ estimates of parameters.

Dt = vector with deterministic elements (i.e. constant and trend) and W_t = matrix of random error that follows the Gaussian white noise process with zero mean and constant variances. The rank of matrix π contains long-run information and the speed of adjustment.

If $\pi = 1$ i.e. there is one cointegrating vector or one linear combination that is stationary such that the cointegrating rank matrix π is decomposed into $\pi = \alpha\beta^1$ where α is the vector of long run equilibrium. This way, X_t is I(1) but the combination of $\beta^1 X_{t-1}$ is I(0). The Johansen procedure estimates the π matrix from an unrestricted VAR and test whether the restriction implied by the reduced rank π can be rejected. The two methods of testing for the reduced rank π are:

(i) The trace method i.e. $\lambda_{trace} = -T \ln (I-\lambda^2 i)$

(ii) The max Eigenvalue i.e. $\lambda_{max(r,r+1)} = -T \ln (I-\lambda_{r+1})$

Where λ_i = estimated ordered eigenvalue gotten from the estimated matrix and

T = numbers of observations after lag adjustment.

The trace statistics test the null hypothesis that the number of distinct cointegration vector is less than or equal to r against the general alternative. The maximal eigenvalue tests the null hypothesis that the number of cointegrating vector is r against the alternative of r+1 cointegrating vector

Vector Error Correction Model (VECM) Specification

When the variables in the model are cointegrated, an error correction term (ECT) must be factored into the model to allow for both short-run and long run relationships (Engle & Granger, 1987). A VECM can therefore be expressed thus:

$$\Delta CO_{2t} = \alpha_1 + \sum_{i=1}^{k-1} a_1 \Delta C0_{2t-1} + \sum_{ij=1}^{k-1} b_1 \ \Delta TRO_{t-j} + \sum_{m=1}^{k-1} c_1 \Delta FDI_{t-m} + \sum_{n=1}^{k-1} D_1 \Delta REN_{t-n} + \sum_{o=1}^{k-1} E_1 \Delta GDP_{t-o} + \sum_{p=1}^{k-1} F \Delta NREN_{t-p} + \Phi_1 ECT_{t-1} + \varepsilon_{1t} \quad (5)$$

$$\Delta TRO_t = \alpha_2 + \sum_{i=1}^{k-1} a_2 \Delta C0_{2t-1} + \sum_{ij=1}^{k-1} b_2 \ \Delta TRO_{t-j} + \sum_{m=1}^{k-1} c_2 \Delta FDI_{t-m} + \sum_{n=1}^{k-1} D_2 \Delta REN_{t-n} + \sum_{o=1}^{k-1} E_2 \Delta GDP_{t-o} + \sum_{p=1}^{k-1} F_2 \Delta NREN_{t-p} + \Phi_2 ECT_{t-1} + \varepsilon_{2t} \quad (6)$$

$$\Delta FDI_t = \alpha_3 + \sum_{i=1}^{k-1} a_3 \Delta C0_{2t-1} + \sum_{ij=1}^{k-1} b_3 \ \Delta TRO_{t-j} + \sum_{m=1}^{k-1} c_3 \Delta FDI_{t-m} + \sum_{n=1}^{k-1} D_3 \Delta REN_{t-n} + \sum_{o=1}^{k-1} E_3 \Delta GDP_{t-o} + \sum_{p=1}^{k-1} F_3 \Delta NREN_{t-p} + \Phi_3 ECT_{t-1} + \varepsilon_{3t} \quad (7)$$

$$\Delta REN_t = \alpha_4 + \sum_{i=1}^{k-1} a_4 \Delta C0_{2t-1} + \sum_{ij=1}^{k-1} b_4 \ \Delta TRO_{t-j} + \sum_{m=1}^{k-1} c_4 \Delta FDI_{t-m} + \sum_{n=1}^{k-1} D_4 \Delta REN_{t-n} + \sum_{o=1}^{k-1} E_4 \Delta GDP_{t-o} + \sum_{p=1}^{k-1} F_4 \Delta NREN_{t-p} + \Phi_4 ECT_{t-1} + \varepsilon_{4t} \quad (8)$$

$$\Delta NREN_t = \alpha_5 + \sum_{i=1}^{k-1} a_5 \Delta C0_{2t-1} + \sum_{ij=1}^{k-1} b_5 \ \Delta TRO_{t-j} + \sum_{m=1}^{k-1} c_5 \Delta FDI_{t-m} + \sum_{n=1}^{k-1} D_5 \Delta REN_{t-n} + \sum_{o=1}^{k-1} E_5 \Delta GDP_{t-o} + \sum_{p=1}^{k-1} F_5 \Delta NREN_{t-p} + \Phi_5 ECT_{t-1} + \varepsilon_{5t} \quad (9)$$

$$\Delta GDP_t = \alpha_6 + \sum_{i=1}^{k-1} a_6 \Delta C0_{2t-1} + \sum_{ij=1}^{k-1} b_6 \ \Delta TRO_{t-j} + \sum_{m=1}^{k-1} c_6 \Delta FDI_{t-m} + \sum_{n=1}^{k-1} D_6 \Delta REN_{t-n} + \sum_{o=1}^{k-1} E_6 \Delta GDP_{t-o} + \sum_{p=1}^{k-1} F_6 \Delta NREN_{t-p} + \Phi_6 ECT_{t-1} + \varepsilon_{6t} \quad (10)$$

Where ECT_{t-1} is the error correction term. It contains long run information derived from the long run cointegration relationship. The coefficient of ECT (Φ) represents an error term mechanism or speed of adjustment that derives the variables back to long term equilibrium. The lagged coefficients show the short run relationship. K- 1 is the lag length reduced one.

4. Results and Discussion

4.1 Unit Root Test Results

The unit root test in table 2 indicates that all the variables for this study failed stationarity test at level but the variables however became stationary at first difference. According to Engle & Granger, (1987), a linear combination of the non-stationary series can become stationary. If all the variables are integrated at order one I(1) then we can conclude that the series are cointegrated suggesting the possibility of a long run relationship. This way, a cointegration test will be necessary to ascertain the nature of cointegrating relationships in this case the Johansen and Juselius cointegration test will be applied.

Table 2: Unit Root Test estimation

Test		ADF			PP		Order of
Variables	I(0)	I(1)	I(2)	I(0)	I(1)	I(2)	Integration
Co_2	-	-3.66***	-	-	-3.66***	-	I(1)
		(0.0002)			(0.0000)		
FDI	-	-3.66***	-	-	-3.66***	-	I(1)
		(0.0000)			(0.0002)		
GDP	-	-3.56**	-	-	-3.50**	-	I(1)
		(0.01)			(0.02)		
NREN	-	-3.66***	-	-	-3.66***	-	I(1)
		(0.0001)			(0.0001)		
REN	-	-3.66***	-	-	-3.66***	-	I(1)

		(0.0003)			(0.0003)		
TRO	-	-3.67***	-	-	-3.66***	-	I(1)
		(0.0001)			(0.000)		

Source: (Eviews 2013)

4.2 Cointegration Test Results

Table 3 contains the details of Johansen cointegration test. The Johansen technique is to estimate the parameter matrix from an unrestricted VAR and to test whether we can reject the restriction implied by the reduced rank using the trace test and maximum Eigen value. The result of Johansen estimates indicates that cointegration relationship is established not only at atmost3 but atmost4 and atmost5 of the variables. This is because the trace and maximal Eingen statistical estimate is less than the critical values at 5% level. The results fail to reject the null hypothesis of no cointegration relationship at none and at almost 1 level.

Table 3: Johansen Cointegration Result

Hypothesized No of Cointegration	Trace Statistics	0.05 critical value	Prob	Max-Eigen Statistic	0.05 Critical value	Prob	Eigen Value
None*	124.17	95.75	0.0002	52.74	40.07	0.0011	0.81
Atmost 1*	71.43	69.81	0.03	34.78	33.87	0.03	0.67
Atmost2	36.65	47.85	0.3	19.54	27.58	0.3	0.46
Atmost3	17.10	29.79	0.6	9.34	21.13	0.8	0.26
Atmost4	7,75	15.49	0.49	7.01	14.26	0.4	0.20
Atmost 5	0.64	3.84	0.42	0.64	3.84	0.4	0.02

Source (Eview 2013)

Table 4: VECM Estimates (LR)

Cointegration Eq	Co2(-1)	FDI (-1)	GDP (-1)	NREN (-1)	REN (-1)	TRO (-1)	C
Estimates	1	0.07	4.29E-06	0.14	-0.11	0.11	0.69
		(0.09)	(7.8E-07)	(0.06)	(0.06)	(0.01)	
		{0.85}	{5.4}	{2.1}	{-1.6}	{9.3}	

Source:(Eview, 2023)

Normalized cointegrating equation is represented below:

ECT_{t-1}= 1.00 $Co2_t$ + 0.7FDI +4.29E-06GDP + 0.14NREN + (-0.11) REN + 0.11TRO + 0.69

By implication FDI, GDP, Non-renewable energy consumption and trade openness has negative and significant impact on environmental quality at 10% level of significance in the long run. An increase in each of these variables will worsen the quality of the environment by way of increasing carbon emission which is a primary component of environmental pollution. The effect of FDI, GDP and NREN on Co2 in the long run is asymmetric. The finding agrees with some existing research work (Usman, Kousar, Makhdum, Yaseen, & Nadeem, 2022; ul Hasan, Hussain, & Ali, 2021; Onuonga, 2020; Alam, 2022; Maduka, Ogwu & Ekesiobi, 2022). Renewable energy on the other hand has positive and significant impact on environmental quality at 10% level of significance in the long run. This confirms the findings of (Cao, Khan, Rehman, Dagar, Oryani, & Tanveer, 2022; Khan, Weili, Khan, & Khamphengxay, 2021; Wang, & Dong, 2019). Increasing the rate of utilization of renewable energy in the economy will boost the quality of the environment by reducing the rate of carbon emission.

4.3 Vector Error Correction Estimates

Table 5 VECM Estimate (SR)

Error Correction	CointEQ1	D{Co2(-1)}	D{FDI (-1)}	D{GDP (-1)}	D{NREN (-1)}	D{REN (-1)}	D{TRO (-1)}	C
Estimates	-0.02 (0.01) {-1.3}	0.17 (0.3) {0.5}	-0.01 (0.009) {-1.9}	4.298E-07 (6.5E-07) {0.76}	-0.01 (0.01) {-0.87}	-0.003 (0.01) {-0.27}	-0.0003 (0.001) {-0.3}	-0.02 (0.02) {-.2}

Source:(Eview, 2023)

$= -0.02 + 0.17 - 0.01 + 4.298E-07 - 0.1 - 0.003 - 0.0003 - 0.02ECT_{t-1}$

Table 5 presents the short run dynamics of error correction. The error correction coefficient gives the speed of adjustment within which the equilibrium model can restore back its equilibrium given any situation of disequilibrium or disturbance. The adjustment term is significant at 1% indicating that deviation from long term equilibrium is corrected for at the convergent speed of 2% within the current year. The coefficient of FDI, NREN, REN and TRO are negative and significant at 1% level suggesting a convergence from short run equilibrium towards long run equilibrium at 1%, 1%, 0.3% and 0.03% respectively. The coefficient of GDP is however positive and not significant, suggesting a lack of significant adjustment towards long run equilibrium in case of any disturbance. The table also reveals the short run effect of the different variables on environmental quality.

5. Conclusion and Recommendations

The study has so far considered both the short run and long run impact of Foreign Direct Investment, Gross Domestic Product, Renewable Energy Consumption, Non-Renewable Energy Consumption and Trade Openness on $C0_2$. The findings validate the Environmental Kuznets Curve hypothesis that economic growth worsen environmental pollution at the initial stage of growth. There was however not enough evidence to establish U-shape curve of the EKC hypothesis. The study also established that trade openness, foreign direct investment, gross domestic product and consumption of non-renewable energy worsen the environmental condition only in the long run but not in the short run. This finding agrees with the work of (Wang, & Dong, 2019; Chontanawat, 2020; Maduka, Ogwu, & Ekesiobi, 2022). The study again established that renewable energy use improves the environmental quality not only in the short run but also in the long run.

The policy implication therefore is first, to use the instrument of legislation to curtail the use of non-renewable energy while reinforcing increasing use of renewable energy. Budget allocation towards transition to renewable energy should be increase. Tax holiday should be considered for businesses or industries whose stock in trade is in renewable energy. Laws relating to environmental pollution should be articulated and enforced strictly. Institutions should be empowered and strengthened to enforce strict environmental laws and policies. Trade and foreign investment policies should be well articulated in ways that do not jeopardize the environment. Nigeria government should comply with international protocol and agreement relating to climate change. Education and awareness for a cleaner and quality environment should be taking seriously. Importation of pollution enhancing gadgets and equipment should be discouraged using the custom duty and high tariff.

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