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IMPACT OF ELECTRICITY CONSUMPTION, FINANCIAL DEVELOPMENT, TRADE OPENNESS ON CO_2 EMISSIONS: EVIDENCE FROM NIGERIA

This paper has explored the role of electricity consumption financial development and trade openness on the CO_2 emissions. The study utilizes annual data from 1972 to 2014 and employs various robust econometric techniques. Our analysis reveals that there is no long-term relationship financial development, trade openness and CO_2 emission. However, the short-run analysis indicates significant relationship among the variables. The results also reveal that the bidirectional relationship between electricity consumption and CO_2 emissions, and a unidirectional causality from financial development to CO_2 emissions. Our results imply that policies that will promote renewable energy consumption and financial development can be pursued concurrently.
JEL: C32; G0; O44; Q43

1. Introduction

Carbon dioxide (CO_2) emissions contribute 76% of the world's greenhouse gas emissions, of which, 68% comes from energy-related sources (IPCC, 2014). Over the next 25 years energy consumption and energy-related CO_2 emissions are projected to rise by 56% and 46%, respectively (EIA, 2013). As a result, Nigeria has announced climate change commitments by initiating GHG inventory system, CDM projects, and the largest gas gathering in Africa (LNG). The main aim of CDM projects is mandatory reduction of emissions by 20% of JVs (Awojuola, 2015). The project will use clean energy technologies to meet up with the target.

Therefore, the country is focusing on increasing the share of renewable energy in total energy consumption. This can be seen in the recently established Renewable Energy Association of Nigeria (REAN), which intends to be a strong voice to advocate favorable conditions for the growth of renewable energy in Nigeria. Among others, $300 million loans have been secured to implement solar projects that will generate up to 1.15 gigawatts (GW) of electricity. Further, government has shown commitment, with ratification of

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Intended Nationally Determined Contributions (INDCs) declaration, which commits companies to reducing greenhouse gas (GHG) by 20 percent unconditionally and by 45 percent conditionally by 2030. Also, the issuing of sub-Saharan African's first Sovereign Green Bonds in 2017 will be used to raise additional capital to fund "low emission" energy projects and facilitate implementation of the INDCs. Lastly, Central Bank of Nigeria (CBN) issued the Nigerian Sustainable Baking Principles (NSBP), which mandate all commercial, merchant and development banks in the country to incorporate environmental and social principle in their operations (Atuluku, 2017).

The administration of Dr. Goodluck Jonathan presented a Roadmap on the Power Sector Reform to the stakeholder in the industry on 26 August 2010. The reform aimed to address the problem of inadequate electric power supply in Nigeria (VETIVA, 2010). In the light of this, Clean Technology Fund (CTF) Investment Plan (IP) was endorsed by the CCTF Trust Fund Committee (TFC) on 12 November, 2010 with a wonderful offer of US$ 250 million in CTF funding. CTF IP basically focused on three projects in the Transport, Renewable Energy, and Energy Efficiency sectors, with a total of US$135 million of CTF funding released. As of May 2014, US$26 million CTF funding has been approved by the CTF Trust Fund Committee for two AfDB's projects, including US$1 million project preparation grant for Nigeria Urban Transport Project – Abuja Mass Transit and US$25 million for project proposal titled Nigeria: Line of Credit for Renewable Energy and Energy Efficiency Projects (Clean technology fund investment plan for Nigeria, 2014).

These government policies demonstrate that financial development and CO_2 emissions growth have become more pronounced in recent years. In addition to other vital factors, the long-term environmental health is correlated with the degree of financial development. There are different indicators to measure financial development such as size, depth, access, efficiency and stability of a financial system. The financial systems include markets, intermediaries, range of assets, institutions and regulations. A strong financial system guarantees the high capital accumulation (the rate of investment), trading, hedging, insurance services, diversified saving and portfolio choices etc. which facilitate and encourage the inflow of foreign capital and technological innovation such as renewable energy devices. The greater financial development leads to reduction of pollution, through the purchase of none – emission energy sources. Thus, in this paper financial development refers to the domestic credits provided by the banks to the private sector in the economy.

Electricity consumption is essentials for a healthy environment and economic development. Hence, we used electric power consumption to explain the total amount of fossil fuel and other none – renewable energy consumed in a given period of time. Most electricity today is generated by burning fossil fuels which drive a stream turbine that, in turn, drives an electrical generator. More serious are concerns about the emissions that result from fossil fuel burning. Switching to renewable technologies can have significant environmental benefits, by generating electricity and fuel without releasing significant quantities of CO_2 emissions and other forms greenhouse gases that contribute to climate change.

Trade openness is the sum of exports and imports (both on goods and services) as a share of GDP. Trade openness can improve environmental qualities in two ways. Firstly, an increase in trade can lead economic growth, development, and social welfare, contribute to a greater capacity to manage the environment more effectively. More importantly, open markets can

improve access to new technologies that make local production processes more efficient by diminishing the use of inputs such as energy, water, and other environmentally harmful substances. Secondly, trade and investment liberalization can provide firms with incentives to adopt more stringent environmental standards. As a country becomes more integrated within the world economy, its export sector becomes more exposed to environmental requirements imposed by the leading importers. Changes needed to meet these requirements, in turn, flow backwards along the supply chain, stimulating the use of cleaner production processes and technologies

Given the significance of energy use, prior studies have investigated the determinants of CO_2 emissions in Nigeria. In this context, there are three categories studies; first, the nexus between energy consumption and CO_2 emission in Nigeria. Notably, Chindo et al. (2015) concluded that there is no correlation between energy consumption and CO_2 emissions using autoregressive distributed lag (ARDL) approach. On the contrary, Akpan and Akpan (2012) found an increase in electricity consumption led to an increase in carbon emissions in Nigeria. Second, on the nexus between financial development and CO_2 emissions; Ali et al. (2018) used ARDL approach and report that financial developments have a positive impact on carbon dioxide emissions. However, Abdulrashid (2016) reported financial development stimulates energy demand, but lower CO_2 emissions. Third, the nexus between trade openness and CO_2 emissions; Ali et al. (2016) found that trade openness negatively affects CO_2 emissions. Abdulrashid (2016) reported similar results whereas financial development stimulates energy demand, but lower CO_2 emissions.

It appears there have been considerable literature on determinants of CO_2 emission in Nigeria, however there are still some limitations on these studies which create gap for our current study. For instance, Akpan and Akpan (2012) argued that electricity consumption impact on CO_2 emissions in Nigeria, however, they failed to consider the interaction of trade openness in their model. We argued that trade openness is crucial to Nigeria as both developing and an oil-producing country. As a developing country, Nigeria imports most of its consumable from other countries invariably making it less industrial pollutant. As an oil-producing country, Nigeria is on high side of $C0_2$ emission. Second, Chindo et al. (2015) reported that energy consumption does not affect CO_2 emission. This result steered controversy as it failed to consider the source of energy (non-renewable energy) in Nigeria. Thirdly, Ali et al. (2018) and Abdulrashid (2016) reported on the impact of trade openness, energy consumption, financial development on CO_2 emissions, however, they failed to use more robust econometric model, they all use autoregressive distributed lag approach. Autoregressive distributed lag (ARDL) often uses non-stationary which is unpredictable and cannot be modeled or forecasted. The results obtained by using non-stationary time series may be spurious in that they may indicate a relationship between two variables even if there is no relationship. Also, their studies are challenged by the period covered. It neglected the period of implementation of the Roadmap for Power Sector of August 2010. The implementation that led to the privatizations of the power sector on November 1, 2013, with the formal handover of the successor companies to private investors as six generation companies (GENCOS) and 11 distribution companies (DISCOS) and establishment of the Transmission Company of Nigeria (TCN), (Adeniji and Osisiogu, 2014).

Against this background, the present study considered trade indicator (i.e., trade, which refers to the sum of exports and imports (both on goods and services) as a share of GDP) in the model to reflect the export and import in Nigeria. Further, the study uses Vector Autoregressive (VAR) model in order to show clearly the relationship in the variable either is in long or short term. Also, VAR model is designed for stationary variables and allows the use of unknown cointegration structure. More so, VAR model is natural tools for forecasting; their setup is such that current values of variables of a set of variables are partly explained by the past values of the variables involved. Lastly, our study is different from the previous studies as it expands period cover by prior studies from 1972-2014. This ensures our study captured the significant reforms that occurred between the 2010-2014 (Roadmap for Power Sector of August 2010 implementation). Our approach is of importance for policy and decision-makers to better apprehend the determinants of carbon emissions to develop effective energy policies that will palliate the impacts of human activities, and thereby contribute to the curbing of carbon emissions.

Using the VAR and Granger causality models on data from 1972 to 2014, our analysis demonstrates a significant short-run negative relationship between CO_2 emissions and electricity consumption, but positive relationship in the case of financial development and trade. The Granger causality test indicates a weak significant bidirectional causality running from CO_2 emissions to electricity consumption and in turn, from electricity consumption to CO_2 emissions at 10% level. However, the findings from financial development and trade openness indicate unidirectional causality running from financial development to CO_2 emissions and financial development to trade openness and no feedback relationship. These findings suggest the promotion of renewable energy technologies through development of financial system and trading with rest of the world should be favored in policymaking.

The present study makes following contributions to the existing body of knowledge. As our findings reveal that both trade openness and financial development play an important role for the promotion of renewable energy, policymakers should initiate effective policies that will encourage financial institutions to provide funding for the purpose of obtaining renewable energy projects. This will increase the renewable energy share in the total electricity consumption and ensures sustainable economic development in African countries including Nigeria. Our study also adds value to the literature in terms of identifying the role of trade openness on CO_2 emissions. These findings will assist the policymakers to take additional initiatives to promote the renewable energy consumption and financial sector development to mitigate the CO_2 emissions.

The paper is set as follows. Section 2 presents an overview of the literature. Section 3 introduces empirical methodologies, data and preliminary statistics of our variables. Section 4 reports the empirical findings in detail. Final section summarizes our findings with policy suggestions.

2. Literature Review

We review the literature under three subsections, viz. electricity consumption and CO_2 emission; financial development and CO_2 emissions; and trade openness.

2.1 Electricity consumption and CO_2 emission

The existing literature offers a wide range of perspectives and insights into the issue of the energy consumption – CO_2 emission nexus, which, however, report contradicting results. For instance, Alam et al. (2012) document a unidirectional causality from energy consumption to CO_2 emission for the short-run but feedback causality in the long-run in Bangladesh. Yang and Zhao (2014) examine the linkages among economic growth, energy consumption, and carbon emissions for India during the period 1970-2008. Their results reveal energy consumption unidirectional Granger causes carbon emissions. However, Shahbaz et al. (2014a) found electricity consumption to reduce the incidence of CO_2 emissions in United Arab Emirates (UAE), from 1975 to 2011. The authors also found bi-directional causality between electricity consumption and CO_2 emissions. Similar results were reported by Farhani and Shahbaz (2014) in the case of 10 Middle East and North Africa (MENA) from 1980 to 2009.

On the contrary, Shahbaz et al. (2014b), found that electricity consumption contributes to CO_2 emissions in Bangladesh. The authors also found unidirectional causality running from electricity consumption to CO_2 emissions. Similarly, Lean and Smyth (2010) found a unidirectional causality from emissions to electricity consumption in the short-run. Cowan et al. (2014) explored the causal link between electricity consumption, economic growth and CO_2 emissions in the BRICS countries (i.e., Brazil, Russia, India, China, and South Africa) for the period 1990– 2010. Their results indicate that causality runs from electricity consumption to CO_2 emissions in India, while there is no causality between electricity consumption and CO_2 emissions in Brazil, Russia, China, and South Africa. Another study by Chang (2010), reported that coal consumption and CO_2 emissions bidirectional affect one another.

Omir (2013) adopted simultaneous-equations models for 14 MENA countries spanning the period 1990–2011. The author found unidirectional causality from energy consumption to CO_2 emissions without any feedback effects. Using Johansen method of cointegration, Nasir and Rehman (2011) found energy consumption to have positive effects on emissions in Pakistan. For a panel of BRIC countries; Pao and Tsai (2010) investigated the dynamic causal relationships between pollutant emissions, energy consumption, and economic growth. They found the long-run relationship between the series. Energy consumption has positive impact on energy emissions, and the EKC hypothesis also exists in BRIC region. The panel causality analysis revealed the feedback effect between energy consumption and CO_2 emissions and same is true for economic growth and energy consumption. They suggested that in order to reduce CO_2 emissions and not to affect economic growth, increasing both energy supply investment and energy efficiency and speeding up energy conservation policies to reduce wastage of energy can be initiated for energy-dependent BRIC countries.

In Nigeria, Chindo et al. (2015) employed autoregressive distributed lag approach and find in both short and long- run, an increase in CO_2 emissions facilitates GDP growth. On the other hand, energy consumption negatively impact on GDP in the short run and found no correlation between energy consumption and CO_2 emissions. On the contrary, Akpan and Akpan (2012) found that in the long run, economic growth correlate with increasing carbon emissions, while an increase in electricity consumption leads to an increase in carbon

emissions. Similarly, Alege et al. (2016) adopted the maximum likelihood Johansen cointegration technique; normalized long-run estimates show that fossil fuel consumption enhances the level of environmental degradation in Nigeria by increasing more than proportionately the concentration of CO_2 emissions. Contrary, electric power consumption varies inversely with carbon emissions and the causality test shows a unidirectional causal relation exists from electric power consumption and indicator of human capital GDP per capita and CO_2 emissions, respectively.

2.3 Financial development and CO_2 emissions

The branch of literature which emphasizes the relationship between carbon emission and financial development (domestic credit to private sector by banks) considers the fact that pollution is generated in the production of goods, and consumption, which in turn lead to higher pollution, when such production relies heavily on non-renewable energy or heavily emitted process. For instance, Ozturk and Acaravci (2013) examined the causal relationship between financial development, trade, economic growth, energy consumption and carbon emissions in Turkey for the 1960–2007 periods. The results confirm that financial development does not relate to per capita carbon emissions in the long- run. The authors also found a unidirectional causality from financial development to per capita carbon emissions. On the contrary, Boutabba (2014) found financial development to have long-run positive impact on carbon emissions in India, implying that financial development improves environmental degradation. Moreover, Granger causality test indicates a long-run unidirectional causality running from financial development to carbon emissions.

Shahbaz et al. (2013) explore the linkages among economic growth, energy consumption, financial development, trade openness and CO_2 emissions throughout 1975-2011. Results indicate that financial development compact carbon dioxide emissions. As for the Granger causality, the study confirms financial development to granger causes CO_2 emissions. Similarly, Shahbaz et al. (2013) studied the effects of financial development, economic growth, coal consumption and trade openness on environmental performance using time series data over the period 1965-2008 in case of South Africa. The results show that financial development improves environmental quality by reducing the growth of energy pollutants. In the case of 19 countries, Al-Mulali and Binti Che Sab (2012) found causality running from financial development to emissions in the countries under investigation based on the long-run causal relationship and the positive short-run causal relationship. In Nigeria, Bello and Abimbola (2010) found that stock value traded have significant positive impact on carbon emissions.

Tamazian and Rao (2010) investigate the linkage between not only economic development and environmental quality but also financial development and institutional quality for 24 transition economies and panel data for 1993-2004. The author's findings support the EKC hypothesis while indicating the importance of both institutional quality and financial development for environmental performance. Also, they found that financial liberalization may be harmful for environmental quality if it is not accomplished in a strong institutional framework. On the contrary, Haseeb et al. (2018) confirmed financial development contribute to the carbon dioxide emissions but supported the EKC hypothesis in BRICS

economies. Further, the study reveals bi-directional causality exists between financial development and CO_2 emissions. Based on panel data for 29 Chinse provinces from 1995 to 2012, Hao et al. (2016) found that the direct effects of financial depth and financial efficiency on environmental quality are positive and negative, respectively. This suggests that the influences of the financial development on environment depend on the level of economic development. Specifically, at the early stage of economic growth, financial development is friendlier to the environment, but when the economy is highly developed; financial development is harmful to the environmental quality.

In Nigeria, Ali et al. (2018) uses an autoregressive distributed lag bound testing technique for the period 1971-2010 to examined the dynamic impact of financial development, energy consumption, trade openness, and economic growth. The authors found that in the long run, economic growth, financial development, and energy consumption have a positive impact on carbon dioxide emissions, whereas trade openness has negative impact on carbon dioxide emissions. Using similar method, Abdulrashid (2016) reported financial development stimulates energy demand, but lower CO_2 emissions. Economic growth lowers energy demand but increases CO_2 emissions. Further, the study revealed that trade openness increases energy consumption but improves environmental quality by lowering CO_2 emissions. On the other hand, energy consumption increases CO_2 emissions. The result from Granger causality shows a bidirectional causal relationship between financial development and CO_2 emissions. However, Maji et al. (2016) also employed similar method but found financial development and national income negatively related to CO_2 emissions in agricultural sector.

2.3 Trade openness and CO_2 emissions

Economists have been analyzing for decades on how trade intensity affects environmental quality. However, both the theoretical and the empirical literature on trade, economic development, and the environment are largely inconclusive about the overall impact of trade on the environment. Openness to international trade is expected to have both positive and negative effects; Managi et al. (2013), found that both in the short and long run, trade reduces emissions in OECD countries. On the other hand, the study also found that trade has a beneficial effect on BOD emissions all over the world in both the short and long terms. Similarly, Gul et al. (2013) report that foreign trade and the use of foreign investment to cause CO_2 emissions to increase rapidly in the long run. Authors also found a unidirectional causality from foreign trade dependency to carbon dioxide emissions, while the causality between FDI dependency and carbon dioxide emissions is bidirectional.

Sharif Hossain (2011) reported no evidence of a long-run causal relationship, but there is unidirectional short-run causal relationship from trade openness to carbon dioxide emissions. In supportive, Hohler (2013) found that South Africa trade liberalization has not contributed to a long-run growth in pollution-intensive activities nor higher emission levels. On the contrary, Yang and Zhao (2014) reported that trade openness is one of the important determinants of energy consumption and carbon emissions in India from 1971 to 2004. While, Omri (2013) modeled CO_2 emissions and its drivers by applying Gaussian Mixture Modelling (GMM) to data of 14 MENA countries over the period of 1990-2011. The paper

calculated a negative and statistically insignificant impact of trade openness on CO_2 emissions for individual countries (13 out of 14) and the entire panel. More recently, Hasanov et al. (2018) uses PDOLS, PFMOLS and PMG methods and found that exports and imports have impacts of opposite signs on Consumption-based CO_2 emissions in both the long- and short-run and that the effects of changes in the trade-CO_2 emissions relationship will fully be absorbed around three years. However, exports and imports are statistically insignificant for Territory-based CO_2 emissions.

Al Mamun et al. (2014) studied CO_2 emissions by utilizing data of 136 countries over 1980-2009 and used Mean Group (MG) and Pooled MG (PMG) methods. They divided countries into different samples based on income level. The study concluded that the impact of income on emissions is higher in high-income countries than in low-income countries. Based on the estimation results, Al Mamun et al. (2014) concluded that trade openness generally exhibits negative impact on emissions in most of the country groups, but these results are statistically significant only for low-income and high-income OECD countries. On the contrary, Mrabet, and Alsamara (2019) studied the validity of the EKC hypothesis by applying the Autoregressive Distributed Lags Bound Testing approach to Qatari data over 1991-2000. They estimated an effect of trade openness on emissions that was statistically significant in the long-run (the elasticity is 1.2), but insignificant in the short-run. Sohag et al. (2017) studied the impacts of trade openness, economic growth, population growth, and energy use on CO_2 emissions for 82 middle-income countries over 1980-2012, by employing the MG, Cross-Correlated MG, Augmented MG methods. The authors estimated that a one-unit increase in openness led to a 0.003-unit reduction of CO_2 emissions in the case of upper-middle-income countries. The results for the impact of trade openness were inconclusive for the full sample countries and lower-middle-income countries.

In Nigeria, Ali et al. (2016) used autoregressive distributed lag bound testing technique (ARDL) approach and found that trade openness negatively affects CO_2 emissions and consumption of energy is among the main determinant of CO_2 emissions which is directly linked to the level of income. Ali et al. (2018) also used autoregressive distributed lag bound testing technique for the period 1971 -2010 to examines the dynamic impact of financial development, energy consumption, trade openness, and economic growth. The authors find that in the long run, economic growth, financial development, and energy consumption have a positive impact on carbon dioxide emissions, whereas trade openness has negative impact on carbon dioxide emissions. Using similar method, Abdulrashid (2016) reported financial development stimulates energy demand, but lower CO_2 emissions. Economic growth lowers energy demand but increases CO_2 emissions. Further, the study reveals that trade openness increases energy consumption but improves environmental quality by lowering CO_2 emissions. On the other hand, energy consumption increases CO_2 emissions. The result from Granger causality shows a bidirectional causal relationship between financial development and CO_2 emissions.

It is clear from existing literature that the findings are inconclusive regarding the relationship between energy consumption, financial development, and pollution and this could be as a result of the stages of economic development and environmental regulations are different in different countries. Research methods and designs also differed. Further,

literatures on Nigeria are very scanty; these show little has been done in this area concerning Nigeria. These studies employed similar methodology that is autoregressive distributed lag (ARDL) approach. The results may be biased due to varying regional regulations causing unobserved heterogeneity and behaviors affecting CO_2 emissions.

3. Data and methodology

3.1 Data and sources

We used annual data from 1972 to 2014 of the Nigeria economy. Data was sourced from the World Development Indicators (WDI, 2015). Before starting the empirical analysis, we transformed all the variables into natural logarithms which assist to avoid the problems associated with the data measurement (Kutan et al. 2017; Paramati et al. 2016; Paramati et al. 2017).

3.2 Model Specification

The focus of this research is to explore the role of electricity consumption, financial development and trade openness on CO_2 emissions. To achieve these research objectives, we framed the following models using the existing theoretical and empirical approaches:

$$CO2_t = f(EC_t, FD_t, TP_t, \upsilon_t) \qquad (1)$$

The variables of the study are described as follows: CO_2 emissions (CO_2) in thousand kilotons (kt), Electric power consumption (kWh per capita) (EC), Domestic credit to private sector (% of GDP) (FD), and Trade (% of GDP) (TP).

The model in equation (1) provides a general specification, which aims to examine the role of electricity consumption, financial development and trade openness on CO_2 emissions. Where, CO_2 emission is treated as a dependent variable while electricity consumption, financial development, and trade openness are treated as explanatory variables in the model. υ_t represent error term and, period are indicated by the subscripts *t*.

As the first step of the empirical analysis, we employ Augmented Dickey-Fuller unit root tests to investigate the stationarity and order of integration of the variables as this determines selection of econometric models for the analysis. If all the variables are integrated in the same order, i.e. I (1), then this indicates that all the variables are non-stationary at levels and stationary at their first order differentials. This finding may suggest that these variables, as a group, may have a cointegration relationship in the long-run, then VECM model will be adopted. However, if the residuals are not cointegrated, meaning no relationship in the long-run, then unrestricted VAR model will be adopted. Finally, we aim to identify the direction of short-run dynamic; Granger causality will be used to estimate the variables in the model.

3.3 Descriptive statistics

We presented the descriptive statistics of variables in Table 1. The CO_2 emission growth rate is very low, at 0.65%. Among others, electricity consumption growth rates are significantly higher at 88.82%. However, the growth rates in the financial development are drastically low, as its speed is at 13.48 annually. While, trading in the country has recorded significant growth, with average growth rates at 48.92. Overall, the results suggest that electricity consumption growth rates are very high.

Table 1

Descriptive statistics

Variable	Obs	Mean	Slt.dev	Min	Max
CO2 emissions	44	44.648	0.190	0.325	0.10
Energy Consumption	44	88.823	33.320	28.571	156.7333
Financial development	44	13.479	6.378	4.700	38.387
Trade openness	44	48.924	15.710	22.764	81.813

Note:The growth rates were calculated using original data

4. Empirical findings and discussion

4.1 Unit root test

The ADF unit root test works under the assumption that null hypothesis of a unit root (non-stationary) is tested against the alternative hypothesis of no unit root (stationary).

The ADF unit root tests' results are presented in Table 2. The results show that the null hypothesis of a unit root cannot be rejected for all of the variables at levels. However, when these tests are applied on the first difference data series, then the null hypothesis is rejected for all of the variables at the 1% significance level. This implies that the variables are stationary at the first-order difference. The findings confirm that the order of integration for all of the variables is I (1). Since all the variables are integrated of same order, then there may be a long-run association among these variables, which is explored in the following section.

Table 2

Result of ADF Unit Root Test

Variable	Level Value	Difference Value
CO2 emission	-2.487(0)	-7.607(0)***
Energy consumption	-3.048(0)	-8.728(0)***
Financial development	-2.966(0)	-5.812(0)***
Trade openness	-2.382(0)	-9.084(0)***

*Note: *** indicate the rejection of the null hypothesis of a unit root at 1% significance levels.*

4.2 Long-run equilibrium relationship

Given the findings of ADF unit root tests, we explore the long-run equilibrium relationship among the variables of equation (1), using the Fisher-Johansen (1991) cointegration test. The appropriate lag length for the analysis has been selected using the (FPE, AIC, HQIC, SBIC) criterion. The results of the cointegration test are reported in Table 3. The findings confirm no long-run equilibrium relationship among the variables of equation (1).

Table 3

Results of the Test for Optimal Lags

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	17.173				.0303	-.659	-.598	-.490
1	34.896	35.446*	1	0.000s	.0132*	-1.495*	-1.419*	-1.284*
2	35.403	1.014	1	0.314	.0135	-1.470	-1.379	-1.217
3	35.496	.186	1	0.667	.0141	-1.425	-1.318	-1.129
4	35.719	.447	1	0.504	.0147	-1.386	-1.264	-1.048

*Note: * Indicates the corresponding optimal Lags to be Selected*

Table 4

Results of Johansen Tests for the Number of Cointegrating Ranks

Variables	CO2 emission	Energy consumption	Financial development	Trade openness
CO2 emission	.7319227 (7.59)***	-.0011141 (-1.85)*	.0010259 (0.35)	-.0008046 (-0.68)
Energy consumption	17.72669 (1.77)*	.9056174 (14.48)***	.2276881 (0.76)	.2118062 (1.73)*
Financial development	8.024791 (2.13)*	.0347502 (1.48)	.5771913 (5.12)***	.0899299 (1.96)*
Trade openness	-8.255527 (-0.88)	.0150136 (0.26)	-.3018082 (-1.08)	.7007912 (6.15)***

Note: Both Trace Statistic and Max suggests no cointegrating rank.

4.3 The short-run elasticities of emissions, electricity consumption, financial development, and trade openness

The results of the VAR model in Table 5 explain the short-run relationship between dependent variable, CO_2 emissions and independent variables comprising electricity consumption, financial development, and trade openness. The finding confirms the relationship between CO_2 emissions and energy consumption at 10% significance level. On other hand, financial development and trade openness have no relationship with CO_2 emissions. These results show that the growing consumption in electricity negatively contributes to CO_2 emissions. The results also show that development of financial sector and inflows of goods and services do not increase the CO_2 emissions. Therefore, fossil fuel electricity consumption is the cause of rising CO_2 emissions in Nigeria. This implies that renewable energy source of electricity consumption will favor Nigeria.

Table 5

Vector Autoregression model

Variables	CO2 emission	Energy consumption	Financial development	Trade openness
CO2 emission	.7319227 (7.59)***	-.0011141 (-1.85)*	.0010259 (0.35)	-.0008046 (-0.68)
Energy consumption	17.72669 (1.77)*	.9056174 (14.48)***	.2276881 (0.76)	.2118062 (1.73)*
Financial development	8.024791 (2.13)*	.0347502 (1.48)	.5771913 (5.12)***	.0899299 (1.96)*
Trade openness	-8.255527 (-0.88)	.0150136 (0.26)	-.3018082 (-1.08)	.7007912 (6.15)***

Notes: Figures in parentheses are Z calculated values, significant at 1% (***); 10% (*)

4.4 The direction of causality

In the final step, we explore the direction of causality among CO_2 emissions, electricity consumption, financial development, and trade openness. For this purpose, we make use of Granger causality test. This test can only be applied on the series, which is stationary; hence we converted the data series into first-order difference. The results of causality test are reported in Table 6. The findings show bidirectional causality between CO_2 emissions and electricity consumption while we also found unidirectional causality that runs from financial development to CO_2 emissions. We also found a unidirectional causality that runs from financial development to trade openness. However, we could not establish any causal relationship between trade openness and CO_2 emissions and on electricity consumption. Overall, our short-run causality test results imply that the financial development affects CO_2 emissions and trade openness.

Table 6

Granger Causality Tests

Dependent Variable	Independent Variable	Chi Square test Statistics
CO2 emission	Energy consumption	4.0393 (0.044)*
	Financial development	.79904 (0.371)
	Trade openness	.09724 (0.755)
Energy consumption	CO2 emission	2.8119 (0.094)*
	Financial development	.81856 (0.366)
	Trade openness	2.4281 (0.119)
Financial development	CO2 emission	5.0707 (0.024)*
	Energy consumption	1.1867 (0.276)
	Trade openness	4.5128 (0.034)*
Trade openness	CO2 emission	.49485 (0.482)
	Energy consumption	.22435 (0.636)
	Financial development	.93289 (0.605)

Note: indicate the rejection of the null hypothesis at 1% significance level.

5. Conclusion and policy suggestions

This study has investigated the long run and causal relationships between CO_2 emissions and electricity consumption in Nigeria. The study used annual time series data set for a sample of 44 years from 1972 to 2014 on the basis of the data availability. To achieve the objective of this study, VAR model, and Granger causality test have been applied.

While, it is clear that there is a significant negative relationship between CO_2 emissions and electricity consumption in Nigeria in the short run, with no evidence of long-run relationship. Similarly, from the results, it is concluded that there is no significant short-term relationship between CO_2 emissions, financial development and trade openness in Nigeria. We conclude that electricity consumption contributed greatly to the environmental degradation in Nigeria. However, we also argued that financial development and trade openness plays no role in promoting clean environment in Nigeria.

The results of Granger causality test indicate a weak significant bidirectional causality running from CO_2 emissions to electricity consumption and in turn, from electricity consumption to CO_2 emissions at 10% level. This implies that policies that will reduce CO_2 emissions such as hydro fuel electricity consumption may be pursued in Nigeria. The government can spend more money for the provision of renewable energy technologies and welfare and ensure steady use of renewable energy technologies by utilizing the abundantly solar and wind resources in Nigeria. Our analysis also highlights unidirectional causality running from financial development to CO_2 emissions and financial development to trade openness. Since the pursuit for clean electricity consumption is influenced by the renewable energy technologies, government should ensure the development of financial system; such development will provide more funds for individuals and firms to obtain renewable energy devices and also transact in the area of renewable energy technologies with the rest of the world.

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