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JOINT IMPACT OF STOCK MARKET DEVELOPMENT AND ENERGY CONSUMPTION ON CARBON DIOXIDE EMISSIONS IN NIGERIA: 1990 TO 2021

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Abstract

Environmental degradation and global warming are two of the most pressing concerns facing the world today. This study examines the joint effects of stock market development and energy consumption on environmental degradation in Nigeria from 1990 to 2021. Utilizing the ARDL cointegration framework, the analysis reveals a long-run cointegration relationship among the variables at the speed of 124% towards long-run equilibrium. Carbon dioxide emission is positively and significantly influenced by stock market growth and energy consumption but negatively and insignificantly by the interaction of stock market and energy use. The control variables of foreign direct investment and trade openness have a negative impact on emissions while economic growth has positive impact on emission. The findings suggest that the adverse impacts of stock market growth and energy consumption on the environment require effective regulations, sustainable practices, and environmental protection with the use of renewable energy prioritized through the stock market and energy consumption agencies and policy makers. In the same vein, the Nigerian government should also prioritize policies aimed at reducing carbon dioxide emissions through the expansion of the trade sector and foreign direct investment because they play a crucial role in mitigating environmental degradation while it should promote sustainable economic growth that will encourage reduced carbon emission.

JEL classification: Q50, Q53, G10, O55

Keywords: Environmental Degradation, Stock Market Development, Energy Consumption, Carbon Dioxide Emissions, Nigeria, ARDL Cointegration

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Introduction

The rapid industrialization of Nigeria has led to a significant increase in carbon emissions, primarily driven by the reliance on fossil fuels for energy (Ansari, 2022). This surge in emissions poses serious threats to environmental quality and public health, contributing to global warming and climate change (Meinshausen et al., 2022). While many nations are actively pursuing strategies to mitigate carbon emissions, the unique context of Nigeria requires a focused examination of the interplay between economic growth, stock market development, and energy consumption.

In Nigeria, the stock market plays a crucial role in shaping economic activity, influencing consumer and business confidence. This heightened confidence can lead to increased energy consumption, further exacerbating environmental degradation (Sadorsky, 2010 & 2011; Coban & Topcu, 2013). Previous studies have highlighted the positive correlation between financial development and environmental degradation, yet there is limited research specifically addressing how stock market dynamics impact carbon emissions within the Nigerian context.

Recent research has emphasized the importance of renewable energy in reducing carbon emissions. However, Nigeria's transition to renewable energy sources remains slow, with fossil fuels dominating the energy landscape (Adebayo, 2022a; Kartal et al., 2022b). The challenge lies not only in promoting renewable energy consumption but also in understanding how stock market growth can facilitate investments in cleaner technologies. Existing literature has primarily focused on developed economies, leaving a gap in understanding the implications for emerging markets like Nigeria.

This paper aims to explore the roles of stock market development and energy consumption on carbon dioxide emissions in Nigeria from 1990 to 2021. Specifically, it seeks to investigate how the growth of the stock market and the consumption of renewable energy influence environmental degradation, as well as the effects of trade openness and foreign direct investment on these relationships.

The structure of the paper is as follows: the next section provides a review of relevant literature, focusing on theoretical frameworks and empirical findings related to the research topic. Following this, the methodology section outlines the data sources and analytical techniques employed in the study. The results section presents the findings from the data analysis, while the discussion interprets these results in the context of existing research. Finally, the conclusion summarizes the key findings and offers policy recommendations aimed at promoting sustainable development in Nigeria.

Literature review

The stock market has been increasingly used as a tool for expanding and financing operations for companies that are listed (Ayoub, 2023). The improvement of the effectiveness, scope, and calibre of stock market offerings is referred to as the development of the stock market. The ultimate purpose of the stock market comes from optimizing the allocation of savings from investors and using the funds to invest in the country's capital (Ayoub, 2023). This creates a capital-intensive economy that provides goods and services in a way that is sustainable for a nation's growth. Most measures of stock market development have focused on market capitalization, market liquidity or market size. In this study, stocks traded per capita as a ratio of GDP is used as the measurement for stock market development.

According to Jówik et al. (2022), energy consumption is the amount of energy used directly, or before it is converted into other final consumer fuels. It is equivalent to domestic output plus imports and stock changes, less exports and fuels needed for global transportation. Prior to being converted into various end-use fuels, primary energy is used, which is referred to as energy consumption (Hassan et al., 2021). A common phrase used to describe energy use is 'the lifeblood of an economy'. In today's society, energy is a necessary component for all production, construction, and consumption. A country's economy requires energy in a variety of ways for its citizens, enterprises, and long-term growth. The quantity of energy utilised by people, businesses, countries, and various other units is referred to as energy consumption (Nadeem et al., 2022). In this study, energy use is measured in kilogrammes of oil equivalent per person.

The decline in the quality of the environment and depletion of resources are both closely related to ecological degradation. The unrestrained use of resources that are natural, such as the uncontrolled burning of fossil fuels, the contamination of water and soil, and the emission of harmful gases, has led to this crisis, which is currently the most pressing issue facing the planet. It has posed numerous challenges to people, plants, animals, wildlife, and the environments in which they live. Numerous issues, such as emissions, the environment, climate change, waste management, deforestation, desertification, and population growth, may contribute to environmental deterioration. Policies that will help to slow down environmental deterioration are required.

The term 'environmental degradation' refers to the deterioration of the environment's quality, which is mostly demonstrated by the contamination of the air, water, food supply, resources, and ecosystems. Accord-

ing to Serener et al. (2002), the term 'environmental degradation' is frequently used to describe a number of global problems, including pollution and the disappearance of biodiversity. In the present investigation, the degradation of the environment is quantified in terms of carbon dioxide emissions, which is characterised as emissions from the production of manufacturing plants and the burning of fossil fuels. Additionally, they comprise CO_2 emissions from burning petrol fuels, flaring gas and the use of liquid and solid fuels.

On the theoretical front, according to the market's trajectory of expansion, stock market indicators may have a substantial beneficial or detrimental effect on carbon emissions. This strengthens the case for the Kuznets curve for the environment (EKC) hypothesis, which holds that stronger markets for stocks are essential to reducing carbon emissions. A second source of funding for companies aiming to grow can come from stock markets. Increased demand for energy and CO_2 emissions could result from this expansion. The manufacturing and use of products and services are encouraged by a healthy stock market, which can also be a sign of a strong economy, increasing emissions. In addition, a robust market for stocks is anticipated to be strictly controlled, which may result in severe regulations requiring publicly traded corporations to use eco-friendly technologies (Paramati et al., 2018). The phenomenon can have several causes, one of which is that industrialised markets for stocks have created strong regulations against environmental deterioration and carbon emissions for listed companies, whereas emerging stock markets have not caught up.

Trade can affect the EKC and is a significant factor in determining pollution. According to Mahmood et al. (2019), exports are an intrinsic part of GDP, boosting economic size and consumption of energy. As a result, pollution emissions will increase due to the scale effect. The structure of commerce and the type of foreign direct investment (FDI) show how an economy uses energy (Agras & Chapman, 1999). According to Suri and Chapman (1998), countries exporting more manufactured goods typically use greater amounts of energy. Trade specialisation may therefore account for the EKC phenomenon and replace businesses that produce large amounts of emissions in nations that are developing. Foreign investment and trade could boost employment as well as revenue levels in nations that are developing, therefore it would be beneficial for adopting strict environmental laws if those economies reach an appropriate stage of progress (Antweiler et al., 2001).

The relationship between stock market development and environmental quality is often framed within the Environmental Kuznets Curve (EKC) hypothesis. This theory posits that as an economy grows, environmental degradation initially increases before eventually declining after a certain income level is reached (Suri & Chapman, 1998). The role of stock markets is pivotal, as they can mobilize capital for environmentally sustainable projects. However, the literature presents mixed findings; some studies indicate that stock market growth can lead to increased emissions due to enhanced industrial activity, while others suggest that robust financial markets can facilitate the transition to cleaner technologies (Paramati et al., 2018).

Energy consumption is a primary driver of carbon emissions, especially in developing economies reliant on fossil fuels (Adebayo, 2022a). The literature suggests that higher energy consumption correlates with increased CO_2 emissions, reinforcing the need for a shift towards renewable energy sources (Li, 2022a). Trade openness has been shown to impact energy consumption patterns, allowing countries to adopt cleaner technologies from more developed nations (Mahmood et al., 2019).

Empirically, in a study of a global sample comprising both industrialised and developing nations, Paramati et al. (2018) investigated the effect of stock markets on CO_2 emissions. The findings demonstrated that stock market indicators, in advanced and developing economies, have a significant direct and indirect impact on carbon emissions, respectively. Additionally, increased stock markets result in an additional reduction in emissions of carbon dioxide.

Autoregressive distributed lag-bound testing approach was used by Ali et al. (2019) to examine the relationship between financial-development and carbon dioxide emissions in Nigeria during the periods of 1971 to 2010. It shows that there exists a long-run cointegration association, indicating that openness to trade adversely impacts carbon-dioxide emissions, while economic growth, financial sector expansion, and energy consumption have positive impact and significant effects on carbon dioxide emissions.

Zafar et al. (2019) looked at the influence of financial development and energy efficiency on carbon-dioxide emissions in order to assess the validity of the EKC hypothesis. Utilising data from the G-7 (Canada, France, Germany, Italy, Japan, United Kingdom and United State of America) and N-11 nations (Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, Turkey, South Korea and Vietnam) from 1990 to 2016, the study additionally assessed the validity of the EKC hypothesis. The outcome of the Lagrange Multiplier (LM) bootstrap cointegration panel methodology showed long-run elasticity outcomes. Additionally, the use of renewable energy improved the standard of the environment by lowering the intensity of carbon emissions for both categories of panel countries. Although the N-11 countries see a drop in carbon emissions, the G-7 countries see an increase due to the expansion of the stock market index.

Iorember et al. (2020) evaluated the relationship between the use of renewable energy and the quality of the environment in Nigeria, placing particular emphasis on the contribution of the financial sector over the years 1990 to 2016. The environmental Kuznet curve (EKC) theory's applicability to Nigeria was also investigated. Granger causality analyses using the Autoregressive Distributed Lag (ARDL) and Vector Error Correction Model (VECM) revealed that using energy from renewable sources improves environmental quality while using money harms it. The VECM Granger causality findings showed that the independent factors had a long-term effect on CO_2 emission, however, the short -run causality shows a mix of uni-directional and bi-directional causation between the variables involved.

Kirikkaleli and Adebayo (2020) used the completely modified OLS (FMOLS), dynamic OLS (DOLS), canonical cointegrating regression (CCR), Bayer and Hanck cointegration, and frequency-domain causality tests to examine the long-run and causal effects of financial development and renewable energy consumption on environmental sustainability in a global framework. The findings revealed that financial development and worldwide renewable energy usage had a considerable long-run positive effect on environmental sustainability.

In 184 nations between 1990 and 2017, Khan et al. (2021) looked into how financial development and energy use impacted CO_2 emissions. The findings of data estimated using the two-step difference, system GMM, and seemingly unrelated regression (SUR) models showed that energy consumption has a positive impact on CO2 emissions, whereas financial development has a negative impact. The research supported the environmental Kuznets curve for the nations examined.

The generalised method of moment (GMM) estimation was used by Younis et al. (2021) to analyse the effects of stock markets, the consumption of renewable energy, as well as urbanisation on the degradation of the environment in the BRICS nations (Brazil, Russia, India, China, and South Africa) from 1993 to 2018. The study found that urbanisation has an important positive correlation with environmental degradation, the MSCI (stock market index price) exhibits a negative association with CO_2 emissions, and the impact of the rise of stock markets on the degradation of the environment varies between BRICS countries.

Using panel econometric methods, Habiba et al. (2021) investigated the impact of the stock market and financial sector development on greenhouse gas emissions by factoring in the utilisation of foreign direct investment and renewable energy in the function of carbon emissions on G20 member countries from 1981 to 2017. The results showed that while the growth of the stock market index decreases carbon emissions across the board and in industrialised nations, it raises emissions in developing nations. However, the whole sample and wealthy countries see a rise in carbon emissions due to the index of financial institution development, while developing economies see little to no change. The amount of environmental damage across the panels is decreased by the use of renewable energy.

The Autoregressive Distributed Lag (ARDL) cointegration framework was used by Gopakumar et al. (2022) to analyse the Environmental Kuznets Curve, or EKC, in the Indian context for the years 1991 to 2018 taking into account the importance of economic growth, renewable energy, foreign direct investment, stock market size, energy intensity, and private investment. The findings demonstrated that while economic expansion and stock market size have an adverse effect on the natural world, long-term environmental benefits are brought about by renewable energy.

Azeem et al. (2022) used data from 40 major carbon-producing nations between 1996 and 2018 for evaluating the effect of the capitalization of stocks on carbon emissions. Using the Driscoll-Kraay method, the study demonstrated an inverted U connection between the capitalization of the stock market (SMC) and environmental damage.

The Environmental Kuznets Curve hypothesis was re-examined in South Asian nations by Jówik et al. (2022), who took into consideration openness to trade and energy usage. The NARDL approach was used in the study to determine the long- and short-term correlations between degradation of the environment, economic growth, energy use, and openness to trade in the South Asian region from 1971 to 2014. According to the study, there is an ongoing equilibrium among trade openness, GDP growth, and environmental degradation. Only for India and Pakistan were the results consistent with the inverted U-shaped EKC theory. Only across Pakistan, nevertheless, were the long-term energy consumption coefficients of statistical significance.

Using a yearly data spanning from 1990 to 2018, Wei et al. (2023) evaluated the impact of renewable energy, financial development, and technological advancement on the environmental footprint in Brazil. The study discovered that the use of renewable energy, trade globalisation, and advancements in technology reduce the ecological footprint. It did this by utilising the dynamic autoregressive distributed lag, Bayern and Hank cointegration framework, and frequency domain causality. Furthermore, there was no apparent link between Brazil's financial progress and ecological footprint.

By taking into account the significance of financial growth and development, Kartal et al. (2023) assessed the impact of nuclear and renewable energy consumption on ecological quality in the United States. A set of

data from 1965/Q_1 to 2018/Q_4 was used. The finding of the Bootstrap Fourier Granger Causality in Quantile method showed that the use of renewable energy and economic growth slow down damage to the environment.

In 23 nations that are developing, Tinoco-Zermeo (2023) used panel pair wise Granger causality and GMM estimations of panel VAR-Granger causality with fixed effects to examine the relationship between consumption of energy, emissions of carbon dioxide, financial development, and growth in the economy. The findings support a bidirectional causal connection between financial development and carbon dioxide (CO_2), financial development and gross domestic product (GDP), and primary energy consumption and carbon dioxide (CO_2), as well as a direct relationship between energy usage and financial development and CO_2 production. According to the study, there is no proof that GDP and energy use or CO_2 emissions are related.

There is not much investigation in the scientific literature currently available on how energy use and stock market growth affect emissions of carbon dioxide. Extant research has shown that sources of clean energy and financial development can both slow down environmental deterioration (Kim & Park, 2016; Brunnschweiler, 2010). According to studies (Paramati et al., 2018; Guo et al., 2019), stock volume of trade and financial growth efficiency have a positive incremental effect on carbon emissions for developed countries but have a negative impact on emissions for emerging economies and underdeveloped nations. Some research claimed that by lowering carbon dioxide emissions, financial development enhances environmental quality. Time series or panel data analysis has been used in prior research to examine how financial growth and consumption of energy affect CO_2 emissions. Additionally, very few studies have examined the specific effects of stock market growth and the use of energy consumption together on CO_2 emissions. The combined influence of energy consumed and the capital market on CO_2 emissions in Nigerian literature have not yet been examined.

Therefore, based on the literature review, the following hypotheses were tested in this study:

H_1: There is no statistical significant relationship between stock market development and carbon emissions in Nigeria.

H_2: Energy consumption has no statistically significant effect on carbon emissions, supporting the EKC hypothesis in Nigeria.

Methodology

This section consists of subsections such as model specification showing the model adapted and used in this study, the methods of analysis and the measurement of variables used.

Model specification

The model used in this investigation depends on an adaptation of Topcu et al. (2020) research on how environmental deterioration affects the development of stock markets in developing nations.

$$CO_2 = \beta_0 + \beta_1 SMD_t + X_t \quad (1)$$

Where X stands for additional control variables that influence degradation of the environment and CO_2 stands for carbon emissions. The usage of energy consumed, which is a vital component in reaching this study's goal, is not included in the criteria. Consequently, the following functional paradigm is defined for this study:

$$CO_2 = f(EC, SMD, EC * SMD, OPEN, FDI, GDPG) \quad (2)$$

Where CO_2, EC, SMD, OPEN, FDI and GDPG stand for carbon dioxide emissions, consumption of energy, development of the stock market, trade openness, foreign direct investment and percentage GDP growth respectively where OPEN and FDI are included as control variables and GDP is included in order to capture the important variable of the Environmental Kuznets Curve (EKC) hypothesis.

The econometric model for the study is shown as:

$$CO_2 = \beta_0 + \beta_1 EC_t + \beta_2 SMD_t + \beta_3 EC * SMD_t + \beta_4 OPEN_t + \beta_5 FDI_t + \beta_6 GDPG_t + \mu_t \quad (3)$$

The World Development Indicator (WDI) web database, which was published by the World Bank, provided the time series data for consideration regarding the relevant variables.

Method of data analysis

The Augmented Dickey Fuller Unit Root Test is used in this study to determine whether the variables are stationary, and the ARDL limits testing method of cointegration introduced by Pesaran et al. (2001) is used to test for a cointegration relationship This method has the important benefit of handling tiny data samples, which is true for the current investigation.

The potential for endogeneity among the explanatory variables is also covered. The models' long-run and short-run estimates are also useful to know. This research displays the short-run model's error correction term (ECT) and the long-run model's long-run model. The ARDL limits testing method also has the intrinsic benefit of not requiring any particular order of integration for the variables, as long as they have the value I(0) or I(1). The ECT value, which is predicted to be significant but negative, is computed using the short-run model. When there is a shock to the equilibrium, ECT

calculates how quickly things will adjust in the long run. It then goes through a series of model diagnostics and stability tests, including ones for serial correlation, heteroskedasticity, and the recursive estimates CUSUM and CUSUMQ.

Measurement and sources of data

This study employs annual-time series data on environmental degradation (CO_2 emission), renewable energy consumption, and stock market development over the period 1990 to 2021.

Table 1: Measurement of variables

Variable	Symbol	Measurement	Source	Supporting Literature
1st Environmental degradation (CO_2 Emission)	CO_2	Metric tons per capital	World Development Indicators (World	Iorember et al. (2020)
Energy Consumption	EC	Gigawatt hours (equivalent of one million kilowatt hours)	International Energy Agency	Iorember et al. (2020)
Stock Market Development	SMD	Stocks traded per capita	World Development Indicators (World	Iorember et al. (2020)
Interaction of Energy Consumption and Stock Market Development	EC*SMD	Energy Consumption multiplied by Stock Market Development	Authors' Calculations	Novelty
Trade Openness	OPEN	Trade openness was measured as the percentage of exports and imports to GDP	World Development Indicators (World Bank, 2022)	Khan et al. (2020)
Foreign Direct Investment	FDI	FDI net inflows as a ratio of GDP	World Development Indicators (World Bank, 2022)	Iorember et al. (2020)
Gross Domestic Product Growth	GDPG	Annual percentage GDP growth	World Development Indicators (World Bank, 2022)	Suri and Chapman (1998)

Source: Authors' construction from literature review.

Results and discussion

The data estimation, outcomes, and discussion of results are all covered in great length in this area of the study. Table 2 provides descriptive data regarding the study's variables.

Summary statistics

The sample's mean, standard deviation, and lowest and maximum values are all provided. Since all of the observed series match the normality condition for running a regression result, they are all normally distributed as a result.

Table 2: Summary statistics

Variable	Mean	Standard	Min.	Max	Jarque-Bera	Prob.
CO_2	0.682790	0.121399	0.491393	0.916432	2.414940	0.298953
EC	84.919140	2.279607	80.640000	88.680000	1.792100	0.408179
SMD	0.958498	1.300284	0.108820	6.238708	2.735200	0.351742
EC*SMD	81.887400	1.131657	9.394672	544.514500	1.622980	0.186687
OPEN	36.160160	9.393959	16.352190	53.277960	3.177311	0.154856
FDI	1.628123	1.198091	0.183822	5.790847	4.643222	0.253515
GDPG	4.320114	4.017196	-2.035119	15.329160	1.120671	0.571017

Source: Authors' own work.

The stationary status of time series data must be confirmed before creating a regression model. Based on ongoing mean and variance observations, stationarity is assumed. The variables in the model are tested for stationarity (stationary qualities) using the unit root method. The test determines the regression model to employ for the estimate in addition to validating the integration order-I(d) for each variable. The augmented Dickey-Fuller Test of Unit Root confirms that the variables are stationary as a result. Table 3 displays the results of the unit root test.

Table 3: Augmented Dickey-Fuller-Unit root test results

Variable	ADF Statistics Value	Stationarity	Conclusion
CO_2	-5.415913**	First Difference	I (I)
EC	-5.392265**	First Difference	I (0)
SMD	-5.460350**	First Difference	I (1)
EC*SMD	-5.409775**	First Difference	I (1)
OPEN	-5.422172**	First Difference	I (1)
FDI	-3.039983**	Level	I (0)
GDPG	-3.625627**	Level	I (0)

Note: ** denote the null hypothesis being rejected at the 5% significance level

Source: Authors' own work.

The ADF unit-root test demonstrates that variables are stationary at I(0) or I(1), respectively; nevertheless, foreign direct investment and GDP growth are level-stationary. These data challenge the competing explanation that the variables are not stable. The ARDL framework, which ensures the development of long-term associations between variables, is provided with an estimation method by this discovery. The bound testing approach to cointegration makes the assumption that all variables are I(0) and I(1), which also implies that all variables are integrated with respect to each other.

ARDL bounds testing approach for co-integrating relationship

To determine if the variables are linked in a long-run equilibrium, this study employs the ARDL paradigm that Pesaran and Shin (1999) first suggested, and which was later supported by Pesaran et al. (2001). The potential for a long-term relationship between the variables is examined using the lower and upper bound critical values of the ARDL bounds test. The null hypothesis of no cointegration is rejected when the estimated F-statistic exceeds the upper bound critical values, and vice versa.

Table 4: ARDL Bounds test cointegration results

F-statistics	Asymptotic critical values							
	10%		5%		2.5%		1%	
F-stat. value =	I (0)	I(1)	I(0)	I (1)	I (0)	I (1)	I (0)	I (1)
10.37240***	2.12	3.23	2.45	3.61	2.75	3.99	3.15	4.43

*Notes: *** denotes null hypothesis is rejected at a 1% significance level. I (0) and I (1) signify lower bound and upper bound, respectively*

Source: Authors' own work.

In Table 4, the results of the ARDL bounds test, an F-test value of 10.37240 is displayed. Value exceeds the I(1) asymptotic critical value upper bound at all levels of significance. The study findings strongly reject the null hypothesis, confirming a cointegrating relationship between the variables, which can be used to construct a dynamic model that accounts for both long- and short -term changes.

Results of the ARDL Regressions

The study generates model coefficients for both the long and short runs. Results from the estimation can be used to test the study's hypotheses. Table 5 provides an overview of the outcomes.

Table 5: Results of ARDL Model. Dependent variable = CO_2

	Variables	Coefficient
ADJ	ECM_{t-1}	-1.249329** (0.028200)
Long-Run	EC	0.145282* (0.077000)
	SMD	1.264636 (0.506900)
	EC*SMD	-0.016142 (0.475500)
	OPEN	-0.029029* (0.096000)
	FDI	-0.088152* (0.075300)
	GDPG	0.040909* (0.085700)
	Constant	-13.124010 (0.177700)
Short-Run	EC	-0.032736** (0.042600)
	EC_{t-1}	-0.086236** (0.035100)
	EC_{t-2}	-0.020677* (0.073200)
	SMD	1.196500* (0.058000)
	SMD_{t-1}	0.338373 (0.174600)
	SMD_{t-2}	0.396382 (0.142100)
	EC*SMD	-0.013783* (0.057700)
	$EC*SMD_{t-1}$	-0.002459 (0.266000)
	$EC*SMD_{t-2}$	-0.003454 (0.185700)
	OPEN	-0.012995** (0.031200)
	$OPEN_{t-1}$	0.014078** (0.030500)
	$OPEN_{t-2}$	0.002326* (0.078400)
	FDI	-0.004749 (0.167700)
	FDI_{t-1}	0.091428** (0.032900)
	FDI_{t-2}	0.046885** (0.036800)
	GDP	0.005771* (0.067500)
	GDP_{t-1}	-0.019362** (0.035600)
	GDP_{t-2}	-0.002184 (0.119400)

	Variables	Coefficient
	Constant	-13.124010 (0.177700)
F-statistics		10.372400***
LM Serial Correlation Test (Breusch-Godfrey)		Chi^2 = 5.384324* (0.067700)
Heteroskedasticity Test (ARCH Effect)		Chi^2 =0.111918 (0.738000)
Heteroscedasticity Test (Breusch-Pagan-Godfrey)		Chi^2 =11.25849 (0.337700)
Jarque-Bera Model Residual Normality Test		1.305109 (0.520714)

Notes: ***, **, and * indicate at 1%, 5%, and 10% levels of significance, respectively, indicate that the null hypothesis is rejected. The p-values are represented by brackets.

Source: Authors' own work.

This study presents the ARDL regression estimates for the long-run model in Table 5, illustrating how the consumption of energy and growth in Nigeria's stock market contributes to environmental degradation proxy with carbon emission. The long-run estimates reveal a positive and significant relationship between the use of energy and environmental degradation at 10% significance level. Specifically, the coefficient for energy consumption (EC) is 0.145282. This means that, ceteris paribus, a 1 percentage point increase in energy consumption, measured in gigawatt-hours (GWh), is associated with an increase in environmental degradation by 0.145282 units, as such, hypothesis one is hereby rejected. It is important to note that the linear nature of the model implies that this relationship holds true without the influence of other variables. At a significance level of $p < 0.10$, the impact of energy consumption on environmental degradation is substantial.

Additionally, stock market development shows a positive but insignificant impact on environmental degradation, with a coefficient value of 1.264636. This indicates that a unit increase in stock market growth leads to an insignificant increase in environmental degradation by 1.264636 units, holding all else constant, as such, hypothesis two is also rejected. Consequently, the interaction of energy consumption and stock market development shows a negative value of -0.016142 with an insignificant impact on environmental degradation. This means that increased interaction of energy consumption and stock market development will reduce environmental degradation in the long run.

In contrast, all the control variables have significant impact on environmental degradation at 10% level of significance. Trade openness and foreign direct investment have negative impacts with coefficients of -0.029029 and -0.088152 respectively ($p < 0.10$). This suggests that a unit increase in trade openness and foreign direct investment is associated with a reduction in environmental degradation in the long run. On the other hand, Gross domestic growth shows a positive impact with a coefficient of 0.040909 with $p < 0.10$ which does not agree with the EKC hypothesis.

The ARDL model also displays an adjustment (ADJ) coefficient that is negative and significant at the 5% level, indicating that short-run disequilibrium is adjusted at a speed of 124% in order to return to a long-term equilibrium and the existence of long-run association within the variables.

In the short-run regression estimates, consumption of energy has significant negative impact on environmental quality for the lag periods with $p < 0.10$ for lag 2 and insignificant positive impacts of stock market development on environmental degradation. The interaction of energy consumption and development of the stock market shows negative and insignificant impact on environmental degradation. However, these are inconsistent with the long-run coefficient for energy consumption which indicates that increasing energy consumption correlates with a rise in CO_2 emissions, not a reduction. This highlights a potential misalignment in the investment strategies within the Nigerian stock market, which appears not to prioritize environmentally beneficial projects, thus limiting the short-run impact of energy consumption and the long-run and short-run impact of the interaction of stock market and energy consumption on carbon emission.

The short-run estimates demonstrate that the control variable has mixed positive and negative coefficients with openness showing significance at both $P < 0.05$ and $p < 0.10$ for the lag periods. Foreign direct investment is positive at $p < 0.05$ for the lag periods while growth in gross domestic products is negative for the lag periods with $p < 0.05$ in lag 1 period. The constant coefficient has negative impact on carbon emission with the same estimate for both the long-run and short-run with the value of -13.12401 but significant with $p < 0.05$ in the short-run and insignificant in the long-run.

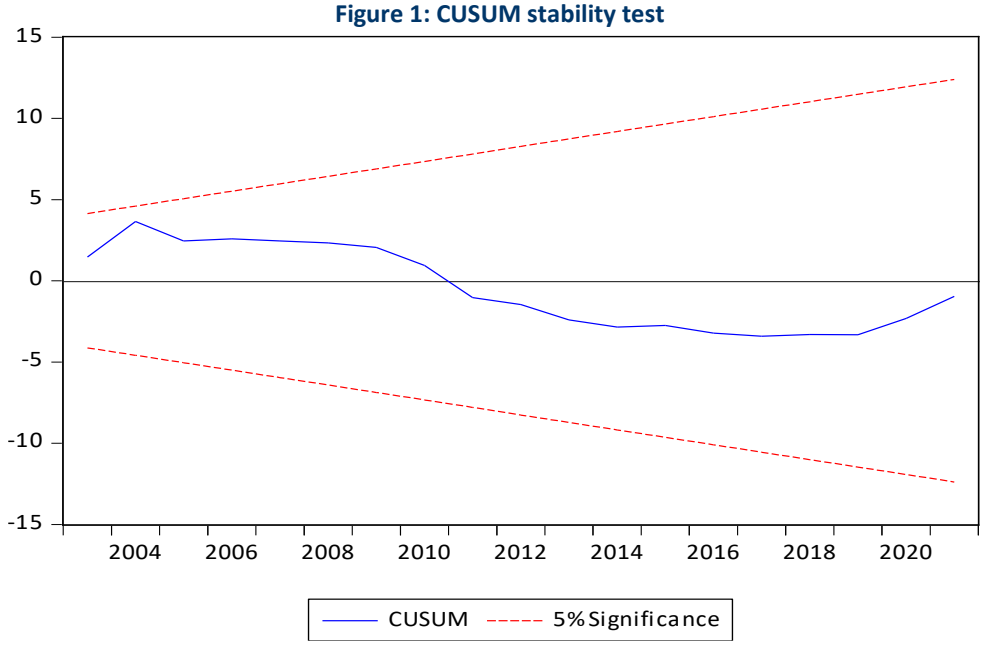
Results of model diagnostics tests

The model diagnostic and stability tests validate the study's regression findings. The investigation of serial correlation and homoscedasticity assumptions as shown in Table 5 indicates that there was no proof of

higher-order serial correlation in the error term using the Breusch-Godfrey LM Serial Correlation test at 5% significant level. The White Heteroscedasticity test using the Breusch-Pagan-Godfrey test statistics indicates homoskedasticity in the errors term of the model (p-value = 0.3377 > 0.1) and in the same vein, the ARCH effect result shows the p-value is 0.7380 > 0.1. Therefore, the null hypothesis of no serial correction is accepted in these diagnostic tests.

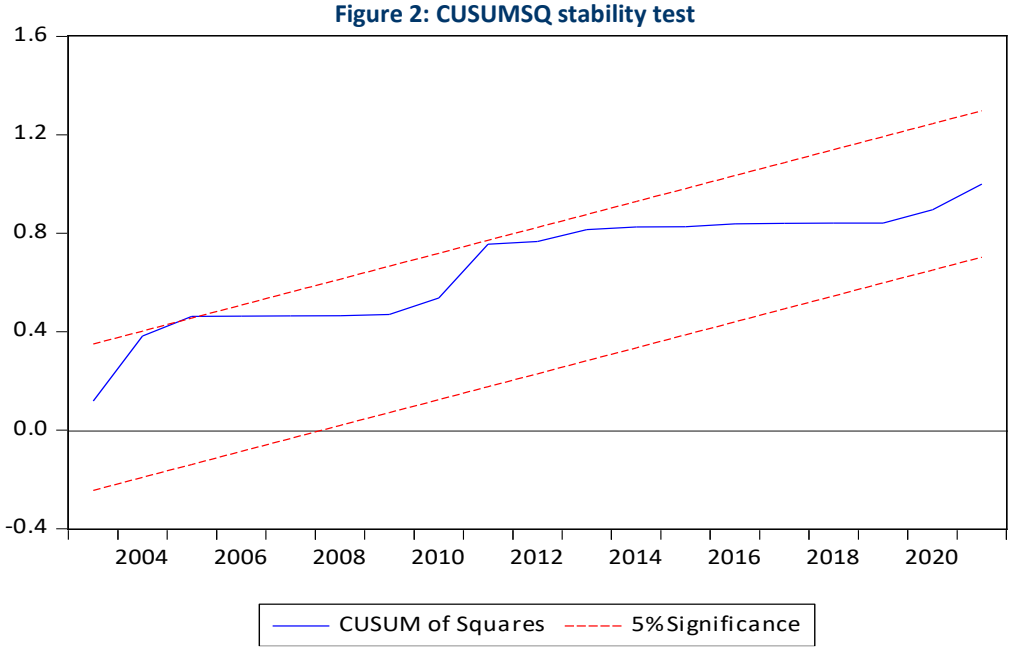
The CUSUM and CUSUMSQ tests to assess the long-run estimations' structural stability of the statistical numbers are within acceptable bounds because the plots of the CUSUMSQ and CUSUM statistics sit within the critical value limit at a significance level of 5%. This indicates that the null hypothesis is rejected, which states that the regression coefficients are unstable as shown in Figures 1 and 2. Also the Jarque-Bera normality test result is 1.305109 with the p-value of 0.520714 greater that 5% significant level, which shows that the residuals are normally distributed as shown in Figure 3. Consequently, the serial correlation, stability and normality test of diagnostic examinations show that the results of the regression are valid.

Figure 1: CUSUM stability test



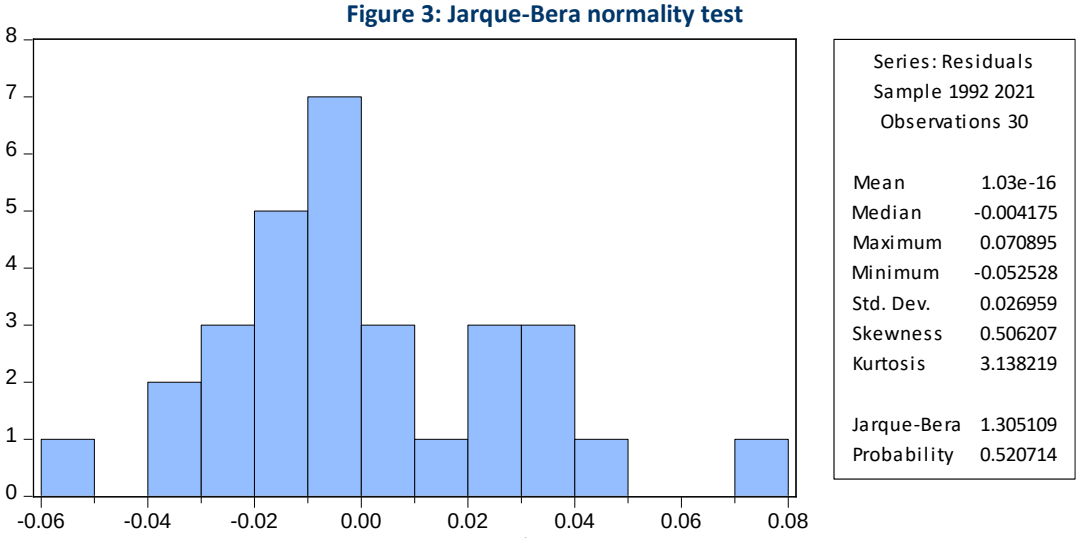
Source: Authors' own work using Eviews.

Figure 2: CUSUMSQ stability test



Source: Authors' own work using Eviews.

Figure 3: Jarque-Bera normality test



Source: Authors' own work using Eviews.

Discussion of findings

The findings of this study emphasize the complex relationships among energy consumption, stock market growth, and carbon emission in Nigeria, particularly emphasizing the long-term effects observed through the ARDL model.

The study establishes a significant long-term relationship between the stock market, the use of energy and environmental degradation. While one might expect energy consumption to improve environmental quality, this research indicates that the current conventional energy use can lead to adverse environmental impacts thus the need for renewable energy use. Specifically, the extraction of raw materials, such as copper, necessary for renewable energy technologies, can result in soil erosion and water contamination. This broader life-cycle perspective highlights the need to consider not only the end-use benefits of renewable energy but also the environmental costs associated with its production. This observation aligns with research by Ali (2021) and Gopakumar et al. (2022), which similarly points to the environmental challenges posed by resource extraction. Conversely, it tests the assertion that the utilization of renewable energy has a beneficial impact on environmental degradation.

The findings also indicate that growth in Nigeria's stock market intensifies environmental degradation. This is consistent with the long-term conclusions drawn by Topcu et al. (2020). The study posits that increased investment in manufacturing and energy production, driven by stock market growth, can lead to higher pollution levels and resource depletion, particularly in the absence of robust environmental regulations. Contrastingly, some studies, including those by Habiba et al. (2021) and Younis et al. (2021), have reported a negative association between stock market growth and environmental degradation, suggesting that the context and regulatory environment significantly influence these relationships. Thus, it is more accurate to state that while renewable energy is intended to mitigate environmental harm, its implementation in Nigeria requires the need of the interaction with the stock market as indicated in both the short-run and long-run interaction estimate of this study.

Regarding control the variables of trade openness and foreign direct investment, the study's results support findings from Wei et al. (2023) and Muhammad et al. (2021) respectively, indicating that trade can slow environmental degradation and that FDI can help reduce environmental degradation. Trade openness facilitates the transfer of environmentally beneficial technologies and practices from developed nations to developing countries like Nigeria. This transfer allows for the adoption of cleaner industrial processes, thereby enhancing environmental quality in the long-run. The growth in gross domestic product estimate is in contrast with the EKC hypothesis in the long-run.

The short-run estimates indicate that increase in energy consumption has negative and significant impact on environmental quality, while the short-run analysis reveals a positive and non-significant relationship between stock market growth and CO2 emissions. The interactions of energy consumption and stock market is negative and insignificant on carbon emission. This suggests that, in the short term, the stock market is effective in channeling investments into environmentally beneficial projects, highlighting a potential connection between financial growth and sustainable development.

These findings have significant implications for policy-making in Nigeria. To mitigate the adverse effects of carbon emission, the stock market plays an important

role if it interacts with energy consumption. This is possible if the stock market attracts renewable energy investment instead of the conventional energy sources. In the same vein, gross domestic product growth in Nigeria needs critical policy attention in order to mitigate environmental degradation in the long-run which is not visible in the short-run as revealed in this study.

Policymakers should prioritize the development of comprehensive frameworks that not only encourage renewable energy sources but also address the environmental impacts of conventional energy consumption for extraction and industrial activities. Additionally, fostering an investment climate that emphasizes environmental protection alongside economic growth will be essential for achieving sustainable development goals.

Conclusion and recommendations

This study investigates the effects of Nigeria's developing stock market and the use of energy sources on environmental degradation from 1990 to 2021, employing the ARDL bound testing technique. The results of the F-test indicate that these variables are cointegrated, suggesting a long-term relationship among them. The short run disequilibrium is adjusted at a speed of 124% towards the long run association.

The long-run coefficient estimates reveal that both the use of renewable energy and the stock market have a positive and significant impact on carbon dioxide emissions (CO2) with energy consumption being significant at 10% significant level while stock market development is not significant. The interaction of stock market and energy consumption negatively affects carbon emission but not significantly. This finding suggests that, there exist potential benefits of renewable energy if integrated into Nigeria's energy use mix, while the conventional energy use presently contributes to environmental degradation not significantly reducing carbon emission with its interaction with the stock market. This could be due to inefficiencies in energy production through investment and consumption or a lack of regulatory frameworks that promote sustainable practices.

Furthermore, the control variables of trade openness and foreign direct investment (FDI) have significant effects on environmental degradation at a 10% level, with both negative impacts observed. Trade openness can lead to increased industrial activity and energy consumption via renewable energy sources, resulting in reduced CO2 emissions while FDI can bring in capital and technology for sustainable development, it may also result in reduced carbon emissions if investments are directed toward environmentally friendly resource-intensive industries. Conversely, economic growth also shows positive contribution to carbon emission which is in contrast to the EKC indicating requirement for policy makers' attention to the long run effect of economic development in reducing environmental degradation. Long-run policies to support the use of cleaner technologies and practices that can mitigate environmental harm should be encouraged.

Recommendations

Based on these findings, this study recommends that Nigeria prioritize environmental conservation by implementing effective regulatory frameworks and promoting sustainable practices. Specifically:

1. Enhance Regulatory Frameworks: The government should establish stricter regulations that encourage the adoption of environmentally friendly technologies and practices within and through the stock market and the energy sector.
2. Promote Sustainable Practices: Programs aimed at increasing awareness of sustainable energy practices should be developed, targeting both consumers and industries to reduce their environmental footprints.
3. Policy Initiatives for Economic Growth: Given that economic growth has an impact on environmental degradation, policies should be designed to maximize the benefits of growth while minimizing the environmental consequences. This could include incentives for industries that adopt cleaner technologies and practices.

Limitations

This study acknowledges certain limitations. The analysis is based on aggregate data, which may obscure specific sectoral dynamics and local variations within Nigeria. Additionally, the research does not explore the political dimensions of environmental policy, which could influence the effectiveness of regulations and practices. Future studies should consider these aspects to provide a more comprehensive understanding of the relationships among stock market development, energy consumption, and environmental degradation.

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