ENVIRONMENTAL QUALITY, CORRUPTION AND ECONOMIC GROWTH IN NIGERIA: Evidence from a Nonlinear Autoregressive Distributed Lag (NARDL) Approach

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ABSTRACT

With the increase in corrupt practices in the Nigerian economy in recent years coupled with exploitation and degradation of the environment, this study investigated the impact of corruption and environmental quality on economic growth in Nigeria, as well as the possibility of a long-run relationship among the variables. Utilizing economic data ranging from 1996 to 2021 and employing the Nonlinear Autoregressive Distributed Lag (NARDL) method, the study found that environmental degradation adversely impacts economic growth. The study also established that while a positive change in corruption leads to an increase in economic growth, a negative change results in a decline in economic growth. The study further established a steady, long-run relationship between the variables. The study thus recommends that both institutional and environmental measures be employed to check corrupt trends and improve the environment for economic growth.

Keywords: corruption, environment, growth, nonlinear
JEL classification: Q56, Q58

1. Introduction

The quest to acquire, sustain, and retain a cleaner environment has been in the fore in both developed and developing economies through the years.

Governments the world over have expended billions of dollars to maintain the environment in the face of perceived environmental chaos such as global warming and its accompanying effects. Several definitions of what the environment represents have been given over time, but that of Adeyemo (2008) is of particular interest. Adeyemo (2008) defined the environment as "*the surrounding conditions that affect people and other organisms*" (p. 7). In order to sustain the surrounding conditions, environmental policies have been formulated and implemented explicitly.

However, a major bottleneck to the implementation of environmental policies is corruption and its attendant effects. Corruption can be defined as:

> . . . behaviour which deviates from the formal duties of a public role because of private-regarding (personal, close family, private clique) pecuniary or status gains; or violates rules against the exercise of certain types of private regarding influence. This includes such behaviour as bribery (use of a reward to pervert the judgment of a person in a position of trust); nepotism (bestowal of patronage by reason of ascriptive relationship rather than merit); and misappropriation (illegal appropriation of public resources for private-regarding uses). (Nye, 1967; p. 419)

This definition was corroborated by the World Bank (1997), which sees corruption as "*the illegal diversion of state revenues as well as patronage or nepotism by government officials or theft of state assets*" (p. 8). Corruption can negatively impact the environment through the indiscriminate extraction and distribution of natural resources and the mismanagement of wildlife amidst government environmental policies. Corruption on the part of the government can lead to the adoption of environmental policies that will further harm the environment due to bribery and embezzlement on the part of those in authority. Such sharp practices can result in the diverting of funds meant for environmental enhancement programmes to other or personal uses. Corruption has also prevented environmental regulations from being effectively enforced. For instance, vehicles emitting fumes that are hazardous for the environment are still seen moving freely on the roads even in the presence of environmental officers. Smoke from generators and factories is

emitted without regard to environmental policies because millions of dollars have been paid in bribes to regulatory bodies. Structures are approved to be built on waterways without consideration for environmental implications. Even remediation plans are not carried out due to embezzlement on both the part of contractors and certain oil-producing communities (Ewharieme & Cocodia, 2011; Olele & Efayena, 2014), leading to environmental degradation on a large scale.

In Nigeria, growth in oil revenue has been achieved at the expense of the environment. With the increase in such revenues, the environment continues to deteriorate due to exploitative activities. One of the environmental issues facing Nigeria is air pollution due to increased emissions from industrial activities. Figure 1 shows the trend in CO2 emissions between 1990 and 2020.

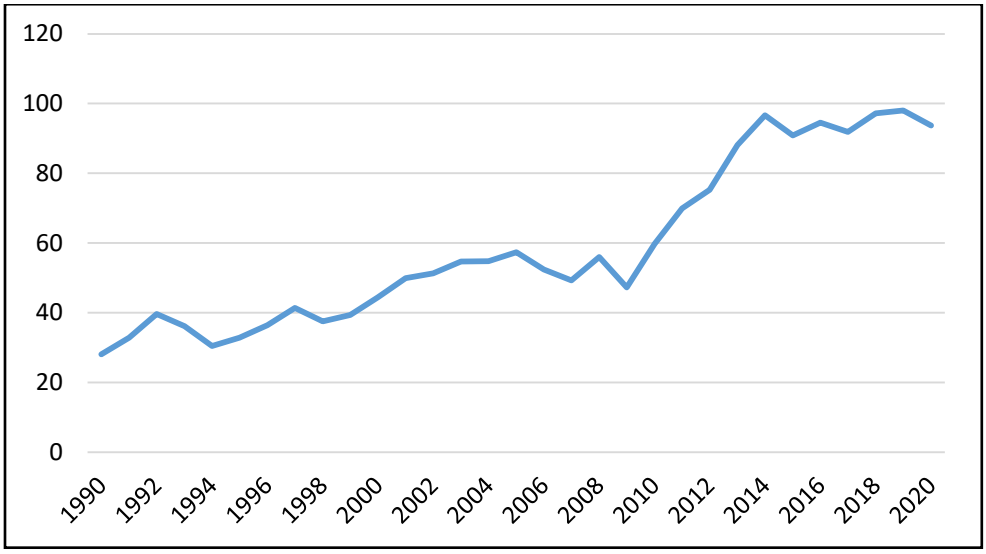

Figure 1. Nigeria CO2 emissions (metric tons), 1990-2020

Source: Authors' compilation from the International Energy Agency (2023).

Figure 1 shows a steady increase in CO2 emissions from 28.06 metric tons in 1990 to 44.44 metric tons in 2000. As depicted in the figure, there has

been a marked increase in recent years. As at 2020, CO2 emissions stood at a staggering 93.74 metric tons. This trend is expected to negatively impact the environment.

However, any attempt to curb the rise in this environmentally-threatening situation will be unfruitful owing to the woeful corruption level in Nigeria. According to Transparency International, Nigeria occupied the 144th position of 180 countries in 2018 in an assessment of public sector corruption. The corruption syndrome has enveloped environmental authorities in Nigeria. Reports show that about ₦28.4 billion allocated for natural resource development was diverted without proper accountability. The reports clearly show that about ₦48.6 billion was received into the Ecological Fund for the year (Usim, 2018).

In Nigeria, despite the existence of the federal and state ministries of environment, the Federal Disaster Relief and Protection Agency was created to address natural disasters and the effects of their occurrences. A corruption trend observed in this was the establishment of the Ecological Fund despite the presence of the Ministry of Environment at all levels of government. The Ecological Fund, as a unit operating outside the sphere of the Ministry of Environment, seems like a hub for embezzlement and corrupt practices. The Nigerian Senate revealed that in a period of fifteen years, the government (federal and state) has been diverting ecological funds allocated to cater for environmental issues to the sum of about ₦500 billion (Ayado & Isah, 2018). Billions of unaccounted funds are diverted by the Ministry of Environment while environmental menaces plague the citizenry.

Various empirical studies have been carried out to critically investigate the impact corruption exerts on the environment as well as the impact of energy consumption on economic growth (see Leitao, 2010; Woods, 2008; He, Makdissi & Wodon, 2007; Cole, 2007; Welsch, 2004; Efayena, Olele & Buzugbe, 2022; Damania, Fredriksson & List, 2003; Fredriksson, List & Millmet, 2003; Fredriksson & Svensson, 2003; Lopez & Mitra, 2000; Efayena, Olele & Buzugbe, 2023; among others). However, there is a severe dearth of such studies in Nigeria. This study is a needed addition to studies on the impact of corruption and environmental quality on economic growth.

It should be noted that while the broad consensus is that corruption adversely impacts economic growth, some studies argue that corruption may

be necessary for growth given that it bypasses bureaucratic processes, government failures, and inefficient regulations in both the private and public sectors (Trabelsi, 2023; Bardhan, 1997; Beck & Maher, 1986; Lien, 1986). The argument in these studies is based on the "grease the wheels" hypothesis proposed by Huntington (1968), Leys (1965), and Leff (1964). The hypothesis argues that corruption tends to correct the distortions present in inefficient systems. Thus, this paper investigates the effect of corruption and environmental quality on economic growth in Nigeria. Specifically, the study examines the symmetric or asymmetric effects of corruption on economic growth. The study contributes to existing studies in two ways. First, the study investigates the economic growth-corruption-environmental quality nexus using a nonlinear model. This is highly essential, given the fact that the variables of interest in this study are hardly linear in nature. Secondly, the study disaggregates the corruption variable into positive and negative shocks (changes) and examines the effect of these components on economic growth.

Following this background, the rest of the paper is organized as follows: section 2 examines related literature; section 3 outlines the empirical model to be estimated as well as the procedure of analysis; section 4 discusses the findings of the estimated model, while section 5 concludes the study by offering a policy mix to ensure sustainable environmental quality.

2. Review of Related Literature

There is a plethora of empirical studies on the economic growth-corruption-environmental quality nexus (see Wang et al., 2015; Zhang & Da, 2015; Seldadyo & De Haan, 2011; Leitao, 2010; Cole, 2007; Fredriksson, Vollebergh & Dijkgraaf, 2004; Fredriksson et al., 2003; Damania, 2002). Such studies range from developed countries to developing countries and adopt varying methods for analysing the extent of the impact. For instance, Afonsoand de Sá Fortes Leitão Rodrigues (2022) utilized the generalized method of moments (GMM) in 48 countries between 2012 and 2019. The study found that corruption adversely impacts economic growth. A similar conclusion was previously reached in the study by Gründler and Potrafke (2019), which employed a dataset of 175 countries over the period 2012-

2018. Makar et al. (2023) carried out a country-specific study using the Johansen cointegration and vector error correction techniques. The study found that corruption hindered economic growth in Nigeria between 1986 and 2019.

On the other hand, Trabelsi (2023), utilizing a panel of 65 countries between 1987 and 2021, found that corruption within an optimal threshold spured economic growth. Allan and Roland (2013) employed linear and nonlinear techniques in 42 developing economies between 1998 and 2009. The study found that corruption enhanced economic growth. Similar conclusions were found in Kata and Sato (2015), Mushfiq (2011), and Méon and Weill (2010). The study by Spyromitros and Panagiotidis (2022) resulted in mixed findings. Employing a panel of 83 developing economies between 2012 and 2018, the study found that different levels of corruption resulted in differing impacts (positive and negative) on economic growth, especially in Latin American economies.

There is also a plethora of studies that examine the effect of environmental quality on economic growth. For instance, Daly and Abdouli (2023) explored the nexus between CO2 emissions and growth in Saudi Arabia between 1990 and 2017, utilizing the simultaneous equation technique. The study found that environmental quality impeded growth. Kahia, Omri and Jarraya (2021) also investigated the environmental quality-growth nexus in Saudi Arabia between 1990 and 2016. The study found a bidirectional nexus between the variables. Ojo and Amassoma (2021), utilizing the cointegration method on a Nigerian dataset between 1990 and 2019, found that improved environmental quality spurred economic growth during the period under consideration. Adejumo (2020) carried out a country-specific study, using Nigeria as a case study. Employing a dataset between 1970 and 2014, environmental degradation depleted economic growth as measured by GDP per capita. Rifa'i and Dewi (2018) investigated the environmental quality-economic growth nexus among 10 ASEAN economies between 1994 and 2015. The study found that environmental quality had an adverse effect on economic growth.

Utilizing data from Indonesia, Malaysia, and the Philippines between 1970 and 2017, Ridzuan et al. (2019) found that corruption and environmental quality negatively impacted economic growth. Iheanachor,

Ogbechie and Ozegbe (2023), utilizing the ARDL method on a Nigerian dataset between 1981 and 2020, revealed that corruption adversely impacted environmental quality (CO2 emissions) and economic growth by raising the levels of CO2 emissions validating the environmental Kuznets Curve (EKC) hypothesis.

Conversely, the study by Mobosi, Madueme and Osuntuyi (2017) resulted in a different conclusion. Mobosi et al. (2017) investigated the nexus relationship in Nigeria from 1970 to 2014. The study discovered the presence of an N-shaped link between environmental pollution and income growth in Nigeria, which deviated from the expected U-shaped or inverted U-shaped relationship. The study suggests that income and economic growth policies in Nigeria should not be developed separately. Instead, policies concerning economic growth and environmental quality should be combined. The same conclusion was reached by Oyeranti and Taiwo (2022). who investigated the relationship between economic growth and environmental quality (deforestation) in Nigeria, specifically focusing on whether the environmental Kuznets curve (EKC) exists. The study utilized the Autoregressive Distributed Lag (ARDL) model and the Nonlinear Autoregressive Distributed Lag (NARDL) model and found that the inverted U-shaped environmental Kuznets curve (EKC) was not supported, both in the short-term and long-term estimations. Nevertheless, when the investigation was conducted using the NARDL model, the findings revealed a curvilinear EKC pattern, indicating the need to recognize a non-linear association between environmental quality and economic growth in Nigeria.

Hwang, Kim and Yu (2023) applied the two-stage least squares to a dataset of the Commonwealth of Independent States (CIS) between 2003 and 2013. The study found that corruption depleted economic growth by increasing the level of environmental degradation (CO2 emissions). Utilizing the ARDL technique on an Indonesian dataset between 1984 and 2020, Pujiati et al. (2023) found that corruption worsened environmental degradation in the short run, but positively impacted environmental degradation in the long run. The impact on economic growth was found to be mixed. Similar findings were observed in the study by Habib, Abdelmonen

and Khaled (2020) which employed the GMM technique among African economies.

Maduka, Ogwu and Ekesiobi (2022) investigated the moderating effect of institutional quality on the growth-environmental quality relationship in Nigeria between 1990 and 2020. By employing the dynamic ARDL technique, the study found that the proxies for institutional quality showed varying effects on environmental quality (CO2 emissions). For instance, control of corruption spurred CO2 emissions in the long run. However, when the variable interacts with level of income, it significantly reduces CO2 emissions. The study also established an N-shaped relationship rather than a U-shaped nexus among the variables.

Alege, Adediran, & Ogundipe (2016) examined the causality among economic growth, energy consumption, and emissions in Nigeria between 1970 and 2013, employing both the Wald exogeneity Granger causality test and the Johansen cointegration technique. The results show that while fossil fuel resulted in increased CO2 emissions, there was a unidirectional nexus from fossil fuel to growth and emissions.

Sekrafi, Abdelmonen and Khaled (2018) used panel quantile regression as well as the generalized method of moments (GMM) in analysing the links between environmental quality (captured by CO2 emissions) and corruption in African countries. In addition to showing that the level of corruption in African countries is extremely high, the empirical results of this study also show that corruption in these countries negatively affects environmental quality, thus causing serious ecological problems.

For their part, the study by Sekrafi and Sghaier (2018) evaluated the direct and indirect impact of corruption on the quality of the environment in Tunisia, employing autoregressive distributed lag (ARDL) and cointegration techniques. The results show that with an increase in corruption in Tunisia, environmental quality decreased, with a corresponding negative effect on economic growth. The study also observed a negative and significant relationship between energy consumption and corruption controls.

Liao, Eyup and Baek (2017) investigated the relationship between SO2 emissions, energy, and income. The study also incorporated a corruption variable into the empirical model. Using data spanning 1999 to 2012 for 29

Chinese provinces, the study applied a panel cointegration technique. Results from the empirical model indicate that environmental degradation decreased and economic growth increased with the application of increased anti-corruption policies.

Using thirteen MENA countries, Sekrafi and Sghaier (2016) analysed the relationship between environmental degradation, corruption, energy consumption, and economic growth between 1984 and 2012. The study employed the dynamic panel approach (Sys-GMM and Diff-GMM), and the empirical results show that an increase in the level of corruption impacted economic growth and energy consumption directly, while it impacted environmental quality indirectly.

Maurizio and Migliardo (2016), using a panel data analysis, validated the presence of the EKC hypothesis. The study also confirmed that corruption has a negative impact on the quality of the environment. The study thus recommended the adoption of improved anti-corruption policies in order to improve environmental quality. The study by Ozturk and Al-Mulali (2015) was focused on analysing the impact of corruption on CO2 emissions in Cambodia between 1996 and 2012. With the aid of the two-stage least squares (2SLS) and generalized method of moments techniques, the study clearly showed that corruption negatively affected the environment and, thus, called for increased corruption controls.

Ogbeide and Mustapha (2013) examined the factors that influence corruption and its effects on the economic growth of 39 nations in sub-Saharan Africa between 1996 and 2011. Dynamic panel regressions were performed in a Barro-style economic growth model to analyse both the factors that determine corruption and the models that link growth and corruption. The empirical findings of the model indicate that corruption had a significant role in explaining The GDP per capita. Consequently, corruption was found to distort the long-term dynamics of economic growth. Thus, it is necessary to enhance the institutional frameworks that promote a continuous cycle of economic growth among nations in sub-Saharan Africa.

Ewharieme and Cocodia (2011) carried out an extensive study on how corruption affects environmental quality (degradation) in Nigeria, in

particular the Niger Delta region. The study confirms that the ecological menaces affecting Nigeria have remained unsolved due to corrupt practices on the part of the government and its officials. Ebiede (2011) investigated the roles of corruption and environmental degradation in the re-occurring conflicts in the Niger Delta region of Nigeria. The study found that corruption aggravated the environmental menace and thus concluded that peace efforts in the region will be ineffective if the twin issues of environmental degradation and corruption are left unchecked.

Woods (2008) reported that in the United States, environmental intervention programmes have suffered several setbacks in terms of performance due to political corruption, while He et al. (2007) employed cross-country data and confirmed that corruption negatively affects environmental controls.

The study by Cole (2007) investigated the direct and indirect effects of corruption on environmental quality in 94 countries between 1987 and 2000. The study showed that, except for high-income countries, corruption negatively affected environmental quality.

For their part, Pellegrini and Gerlagh (2006) adopted the ordinary least squares (OLS) estimation when investigating the impact of corruption on environmental policies. The study alluded to corruption levels as a major factor in the variation in the efficiency of environmental policies among European countries.

The study by Fredriksson et al. (2004) on the impact of corruption on environmental policy shows that corruption reduces the effectiveness of environmental policies. This result was a confirmation of the study by Damania et al. (2003), which arrived at the conclusion that corruption reduces the stringency of environmental regulatory policies. In other words, the study asserted that corruption severely affects the efficiency of environmental policies, thus negatively affecting environmental quality.

An overview of the review literature shows that the analysis of the economic growth-corruption-environmental quality nexus resulted in varying conclusions, ranging from positive to negative, and neutral. Most of the previous studies assumed a linear relationship between the variables. It should be noted that the nexus between corruption, environmental quality, and

economic growth is likely nonlinear due to the dynamic nature of the individual variables, although some previous empirical studies viewed the nexus as linear (Maduka et al., 2022; Alege et al., 2016). Moreover, there is a dearth of empirical studies investigating the environmental quality-corruption-economic growth nexus in Nigeria, employing a nonlinear approach. This study is structured to fill these knowledge gaps.

3. Methodology

3.1 Theoretical framework

In order to assess the direct and indirect effects of corruption on the environment, the study incorporated corruption into the typical Environmental Kuznets Curve (EKC), which links economic growth and the environment. The environmental Kuznets curve (EKC) is a hypothesized relationship between various indicators of environmental degradation and per capita income. In the early stages of economic growth, pollution emissions increase and environmental quality declines, but beyond some level of per capita income (which will vary for different indicators), the trend reverses, so that at high income levels, economic growth leads to environmental improvement (Panayotou, 1993; Stern, Common & Barbier, 1996). It can be argued that corruption affects economic growth indirectly while directly affecting the environment through reduced or non-implementation of environmental policies (Lopez & Mitra, 2000).

3.2 Empirical model: Nonlinearity ARDL (NARDL) approach

The ARDL approach allows testing of short- and long-term asymmetries between variables. Nonlinear models can be examined by NARDL analysis. Shin, Yu & Greenwood-Nimmo (2014) introduced the NARDL approach to examine the explanatory variables' positive and negative shocks. The NARDL approach, based on the linear ARDL model, can be applied regardless of whether the series examines I(0) or I(1). However, if the unit root test results are I(2), the NARDL approach cannot be applied (Ibrahim, 2015; Bahmani-Oskooee & Saha, 2018). The NARDL model is estimated

with the ordinary least squares (OLS) approach (Bildirici & Türkmen, 2015; Yacouba & Altintas, 2019). The asymmetric long-run regression is formed as follows in order to examine the effects of negative and positive changes in foreign direct investments on carbon emissions.

$$LRGDPG_t = \alpha + \beta_1 LCORR_t^- + \beta_2 LCORR_t^+ \quad + \varepsilon_t \tag{1}$$

where: β_1 and β_2 are the long-run parameters, and $LCORR_t^-$ and $LCORR_t^+$ denote shocks (negative and positive respectively). The asymmetric cointegration model, which has all variables, is shown below.

$$LRGDP_t = \gamma_0 + \gamma_1 LCORR_t^- + \gamma_2 LCORR_t^+ + \gamma_3 LCO2_t + \gamma_4 LFDI_t + \epsilon_t \tag{2}$$

ϵ_t and γ_0 denote the error and constant terms respectively. The variables $LCORR_t^-$ and $LCORR_t^+$ are included in the model to capture the negative and positive shocks of corruption. $LCORR_t^-$ and $LCORR_t^+$ can be derived by taking partial sums (negative and positive) as shown below.

$$LCORR_t^- = \sum_{j=1}^{t} \Delta LCORR_t^- = \sum_{j=1}^{t} min\left(\Delta LCORR_j^-, 0\right) \tag{3}$$

$$LCORR_t^+ = \sum_{j=1}^{t} \Delta LCORR_t^+ = \sum_{j=1}^{t} max\left(\Delta LCORR_j^+, 0\right) \tag{4}$$

Utilizing the information in Equation (2), the study specified the NARDL model below. Specifically, the NARDL model examined the effect of environmental quality and corruption (symmetric and asymmetric) on economic growth.

$$\begin{aligned}\Delta LRGDP_t = {} & \delta_0 + \sum_{i=1}^{q} \beta_i \Delta LRGDP_{t-i} + \sum_{i=0}^{q} \partial_i \Delta LCO2_{t-i} + \sum_{i=0}^{q} \mu_i \Delta\, LFDI_{t-i} \\ & + \sum_{i=0}^{q} (\theta_i^- \Delta LCORR_{t-i}^- + \theta_i^+ \Delta LCORR_{t-i}^+) + \omega_1 LRGDP_{t-1} \\ & + \omega_2 LCORR_{t-1}^- + \omega_3 LCORR_{t-1}^+ + \omega_4 LCO2_{t-1} + \omega_5 LFDI_{t-1} \\ & + e_t \end{aligned} \tag{5}$$

β_i, ∂_i, and μ_i represent short-run coefficients, while ω_1, ω_2, ω_3, ω_4, and ω_5 are long-run coefficients.

It should be noted that the F-test is designed to examine the cointegration nexus between the variables. This has long-run implications for the findings of the study. Furthermore, the short-run dynamics of the error correction model (ECM) are given as follows:

$$\Delta LRGDP_t = \pi_0 + \sum_{i=1}^{q} \beta_i \Delta LRGDP_{t-i} + \sum_{i=0}^{q} \partial_i \Delta LCO2_{t-i} + \sum_{i=0}^{q} \mu_i \Delta\, LFDI_{t-i} + \sum_{i=0}^{q} (\theta_i^- \Delta LCORR_{t-i}^- + \theta_i^+ \Delta LCORR_{t-i}^+) \quad + \Omega_t \tag{6}$$

In addition, the asymmetric effects of corruption on economic growth are tested utilizing the Wald test in both the short run and long run.

3.3 Test of nonlinearity

The study employed the BDS test proposed by Brock et al. (1978) to test for nonlinearity in the models. This test was adopted because it does not impose any distributional assumptions in its estimation. The null hypothesis of linearity is rejected if the test statistics exceed the significance level, which implies that the series is nonlinear (Weng, Chang & Lee, 2008).

3.4 Data and sources

The annual data employed covers the period 1996-2021. Table 1 shows the variables employed and their sources.

Table 1. Variables, Measurements, and Sources

Variable	Measurement	Source
FDI	Foreign Direct Investment, inflows (% GDP)	World Bank Indicators (WDI)
CORR	Perception of Corruption Index (CPI)	Transparency International (TI)
RGDPG	Real Gross Domestic Product	World Bank Indicators (WDI)
CO2	Carbon dioxide emissions (metric tons per capita)	International Energy Agency (IEA)

Source: Authors' compilation.

4. Results and Discussion

4.1 Unit root and nonlinearity tests

It is essential to ascertain the dataset properties before any formal empirical analysis. The study utilized the unit root of the dataset via the Augmented Dickey Fuller (ADF), the Kwiatkowski-Phillips-Schmidt-Shin (KPSS), and the Phillips-Perron (PP) tests. The results are presented in Table 2. The results show that at levels, the variables exhibit a unit root in both the ADF and PP tests. Thus, the null hypothesis cannot be rejected. Under the KPSS test, the null hypothesis that there is no unit root is rejected at the 5% and 10% levels of significance.

Table 2. Unit Root Test

	Level			First Difference		
Variable	ADF	PP	KPSS	ADF	PP	KPSS
LCO2	-0.711	-0.942	0.763***	-6.564***	-6.837***	0.113
LCORR	-1.583	-1.066	0.614***	-9.851***	-11.343***	0.071
LFDI	-0.671	-0.313	0.195**	-4.734***	-5.037***	0.220
LRGDP	-1.754	-1.637	0.431**	-7.283***	-7.276***	0.093

Source: Authors' compilation

Note: *, **, and *** denote significance at 1%, 5%, and 10% levels respectively.

Under the first difference, all variables are stationary under the ADF and PP tests at the 1% level of significance. Thus, the series are taken at their first differences, as authenticated by the ADF, PP, and KPSS tests.

The results of the BDS nonlinearity test are presented in Table 3. The estimation was carried out to ensure that the model was appropriately specified as nonlinear.

Table 3. Nonlinearity Test

Variable	LCO2	LCORR	LFDI	LRGDP
m = 2	21.364***	19.076***	11.921***	33.769***
m = 3	23.517***	19.951***	12.351***	33.804***
m = 4	26.085***	21.368***	15.719***	35.063***
m = 5	29.308***	21.614***	16.041***	37.521***
m = 6	33.857***	21.947***	17.288***	38.671***

Source: Authors' compilation

Note: *, **, and *** denote significance at 1%, 5%, and 10% levels respectively.

From the results in Table 3, the variables are found to be nonlinear at the 1% level of significance. Thus, the utilization of the NARDL is fully justified.

4.2 Cointegration and symmetric tests

The study also carried out a cointegration analysis as well as a Wald test to ascertain a symmetric or otherwise relationship among the variables in both the short run and the long run. The results are presented in Table 4.

Table 4. Short-run and Long-run Asymmetric Results

Test	F-Statistics	Prob.
F	831.052***	0.0000
Wald tests		
Short-run asymmetry (W_S)	11.695**	0.0112
Long-run asymmetry (W_L)	5.427**	0.0142

Source: Authors' compilation
Note: *, **, and *** denote significance at 1%, 5%, and 10% levels respectively.

The results show that the null hypothesis of no cointegration among RGDP, CO2, CORR, and FDI is rejected at the 1% level of significance. The results also show that there is an asymmetric nexus among the variables at the 5% level of significance, as seen in the statistical values of W_S and W_L. Thus, there are cointegration and asymmetric relationships among the variables. The results are in tandem with those of previous studies such as Ojo and Amassoma (2021) and Kahia et al. (2021).

4.3 NARDL analysis

After justifying the utilization of the NARDL model, the short-run and long-run coefficients of the NARDL are presented in Table 5.

Table 5. NARDL Estimates

Variable	Coefficient	p-value
LCO2(-1)	-0.421***	0.000
$LCORR^{-}(-1)$	0.567**	0.028
$LCORR^{+}(-1)$	-0.217***	0.000
LFDI(-1)	0.193**	0.019
LRGDP(-1)	0.062*	0.082
ΔLCO2	-0.381**	0.018
ΔLCO2(-1)	-0.208**	0.034
ΔLCO2(-2)	-0.401	0.803
$\Delta LCORR^{-}$	0.676*	0.052
$\Delta LCORR^{-}(-1)$	0.311**	0.021
$\Delta LCORR^{+}$	-0.588*	0.076
$\Delta LCORR^{+}(-1)$	-0.269*	0.051
ΔLFDI	0.117***	0.000
ΔLFDI(-1)	0.276*	0.067
Con_	9.599***	0.000
R^2	0.527	
F-stat.	374.259	0.000

Source: Authors' compilation.
Note: *, **, and *** denote significance at 1%, 5%, and 10% levels respectively.

The long-run results show that a 1% increase in CO2 emissions decreases RGDP by 0.42%. This outcome is in tandem with the studies of Daly and Abdouli (2023) and Ridzuan et al. (2019).

The results also show a similar trend. In other words, the short-run results show that CO2(-1) and CO2(-2) negatively impact RGDP, though the coefficient of CO2 is statistically insignificant. A 1% increase in FDI increases RGDP by 0.19% in the long run. In the short run, a 1% increase in FDI results in a 0.28% **increase** in GDPG. These results corroborate those of Makar et al. (2023) and Hwang et al. (2023), but contrast the findings of Trabelsi (2023) and Bardhan (1997).

The results also show that increasing corruption levels have a dampening effect on RGDP in the short run and the long run. Specifically, the results show that a positive change in corruption at lag 1 ($CORR^{+}(-1)$) leads to an increase in RGDP. Whereas, a negative change in corruption at lag 1 ($CORR^{-}$

(-1)) results in a decrease in RGDP. Thus, the "*grease the wheels*" hypothesis was not validated in the Nigerian economy, thus contrasting the conclusion reached by Trabelsi (2023), Kato and Sato (2015), and Bardhan (1997). At all levels, increasing corruption adversely impacted economic growth. This calls for urgent institutional intervention.

4.4 Diagnostic tests

The robustness of the specified model was established with several tests. These included the Jarque Bera normality test, the Breusch-Pagan (heteroskedasticity) test, ARCH tests, and the Breusch-Godfrey LM autocorrelation test. As Table 6 clearly indicates, the specified model has desirable econometric properties. The results show no presence of serial correlation; the residuals are normally distributed, and there is the absence of heteroskedasticity. Thus, the results emanating from the model are highly viable for policy recommendations.

Table 6. Diagnostic Tests

Test	Statistics	p-value
Breusch-Pagan	13.6871	0.5170
Jarque Bera	0.8271	0.5321
ARCH(1)	2.1925	0.1485
ARCH(6)	6.2861	0.3518
LM(1)	1.8752	0.1683
LM(6)	7.6014	0.2072

Source: Authors' compilation.

5. Conclusion

This paper empirically investigated the economic growth-corruption-environmental quality nexus in Nigeria using a nonlinear model. In the face of increased environmental issues such as air pollution, climate change, flooding, and others, the study clearly showed that weak anti-corruption institutions as well as ill-structured policies have negatively affected economic growth in Nigeria. The study also showed that the quality of the

environment has also adversely impacted economic growth. Thus, there is an urgent need to address this menace due to the importance of the environment for both human lives and economic activities. The government should strengthen its anti-corruption institutions and empower them to extend their power to environmental issues since it seems the modus operandi revolves around weak public governance and administration, high levels of bribery and corruption, a lack of public transparency, as well as non-existing or inadequate environmental standards. Environmental policies should be proposed and implemented rigorously to ensure compliance. This can only be achieved if governments at all levels embrace the challenge of ensuring that the environment is well maintained.

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