Financial Development and the Quality of the Environment in Nigeria: An Application of Non-Linear ARLD Approach

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Abstract

The present study examines the asymmetric effect of financial development on the quality of environment in Nigeria from 1970 to 2018. The study employed the techniques of non-linear ARDL approach as well as Diks and Panchenko (2006) non-linear test of causality. A comprehensive index of financial development is constructed using PCA. The empirical outcomes of the study reveal that financial development in Nigeria impedes the quality of the environment. The government should encourage lenders to ease the funding for the energy sector and allocate financial resources for environment-friendly businesses rather than wasting them in consumer financing. Moreover, economic growth and FDI are positively and significantly related to carbon emissions. On this basis, the government should introduce environmentally friendly technologies that will help improve the quality of the environment, increase long-term sustainability, and save resources for generations to come. A key policy consequence of this study is also that the FDI inflow to pollution-intensive industries should be closely monitored.

Keywords: financial development, quality of environment, Non-Linear ARDL

1. Introduction

Currently, the major global issues are environmental degradation and global warming that emanates as a result of GHGs (Green-House Gas Emissions). Countries have been making efforts to achieve the maximum possible economic growth since the beginning of the industrial revolution. This trend has resulted to an enormous increase in GHGs in general and in particular carbon dioxide emissions, resulting in global warming and loss of ozone layers. The consequences of climate change, global warming, and degradation of the environment are already visible in the escalation of extreme weather events, increased storm intensity, changing the patterns of rainfall, and increasing the sea level. Such alterations have an adequate effect on the proper functioning of ecosystems, forest sustainability, and human well-being (Boutabba, 2014; Dar & Asif, 2017).

Therefore, the efforts of international organizations to mitigate the adverse effects of global warming have focused on policies of reducing the amount of carbon emissions (Acheampong & Boateng, 2019; Tamazian, Chousa, & Vadlamannati, 2009). Despite the concerted efforts to reduce the concentration of the amount of carbon emissions on earth, global carbon emissions have been increasing. According to the report by the International Energy Agency (IEA) (2019), in 2018 global energy-related carbon emissions rise by 1.7%, this reflects an absolute rise of 560 million tons (Mt) to a long-time high of 33.1 gigatons (Gt) after remaining flat for the past four years. This unprecedented rise in carbon emissions stands in contrast to the Paris climate change agreement to reduce carbon emissions. The report of the IEA (2019) indicates that the increase in global carbon emissions stems from rapid global economic growth, slower energy efficiency measures, and lower prices of fossil-fuel.

Climate change is no longer being considered just as an issue of environment by looking at its potential effect on economic activities, it has become a developmental issue. It poses an existential threat to many developing countries, especially Nigeria, in terms of sustainable development. For example, climate change is projected to manifest in a loss of 6% to 30% of Nigeria's GDP by 2050, translating into US$ 100 billion to US$ 460 billion if no mitigation measures are taken (Department for International Development, 2009).

International agencies such as the UNDP (United Nations Development Program), the World Bank, and the Global Environment Facility (GEF) are currently working in Nigeria to support low-carbon projects through their in-country programs. For example, UNDP funded the Nigerian Master Plan for Renewable Energy, while the World Bank is implementing a project under its Clean Technology Fund (Eleri, Onuvae, & Ugwu, 2013). Despite this effort, the country is ranked 44th in the list of carbon dioxide emitters of more than 200 countries in the world (Sulaiman & Abdul-Rahim, 2018), Nigeria's GHG emissions rose in the same way in year 1980 to 2017 from 68.04 million tons to 107.30 million tons (IEA, 2019).

Financing for investment is one of the needs of any economy for sustainable economic growth. The provision of finance to different sectors of the economy will encourage the growth of the economy holistically, and this will lead to faster development and improvement of welfare (Acheampong, 2019). In light of this, the Nigeria Development Finance Initiatives of the Central Bank of Nigeria engage in formulating and implementing various policies, innovating appropriate products, and creating an enabling atmosphere for financial institutions to deliver services in a secure, competitive and sustainable manner. The main focus of the initiatives is on agriculture, rural development, and micro, small, and medium-sized enterprises (CBN, 2019).

Henceforth, higher consumption of energy, particularly from fossil fuels, leads to an excessive increase in carbon dioxide emissions (Yeh & Liao, 2017). According to Ali et al. (2018), 75% of the energy consumed in Nigeria comes from fossil fuels, which means higher energy consumption leads to higher CO2 emissions in the country. Since firms require large amounts of capital to start or broaden their existing businesses if the equipment used in the firms pollutes the environment and decreases its quality, the expansion of existing or new businesses could be related to higher carbon dioxide emissions.

Nonlinearity (asymmetries) can be observed in macroeconomic variables because of a country-wide interest rate differentials, economic cycles (booms or depressions, recessions or recovery periods), the international oil price mechanism, international trade, and domestic product supply and demand on local and international markets. The disbursement of credit to the private sector to enhance low, medium, and high levels of business is also dependent on the local market interest rate. Finally, specific unseen forces in time series data may cause asymmetries (Shahbaz, Shahzad, Ahmad, & Alam, 2016).

Finally, little has been known in Nigeria about the effect of financial development on carbon emissions. In Consideration of the inconsistency coupled with the knowledge gap in the literature. This research examines the asymmetric impact of financial development on the quality of the environment in Nigeria from 1970 to 2018. As such, it is essential to know the ultimate forces that are the reasons for the escalation of carbon emissions in Nigeria in order to design policies that will address it before it becomes worse.

Given the motivation of the study, this paper contributes in several respects to the literature. First, the literature also shows that ignoring asymmetries or nonlinearity in macroeconomic variables will result in biased empirical outcomes. This research provides a comprehensive effort to fill this void in existing environmental literature in the context of Nigeria by using the Nonlinear Autoregressive Distributed Lag (NARDL) cointegration method developed by (Pesaran, Shin, & Smith, 2001) to investigate the long-run asymmetric relationship between the variables of study. Second, to establish the causal link between the variables, the asymmetric causality method (Diks & Panchenko, 2006) is applied. Third, the study will construct an index of financial development using PCA (Principal Components Analysis), taking into account three measures from the banking sector (M2, M3 and domestic credit to the private sector) as well as three measures from the stock market (stock market capitalization, stock market traded value and stock market turnover).

The section of the "Literature review" of the paper presents related literature on financial development and the quality of the environment. The section on "Methodology" explained the methodological structure of the paper. The section for “Results and discussions” explained the outcomes as well as major findings, while the section for "Conclusion and Policy Implication" provides a detailed explanation concerning the conclusion and policy implication.

2. Literature Review

A review from the previews literature reveals that the relationships between CO2 emissions, financial development, economic growth, and FDI can be divided into three research clusters. First, the empirical research that focuses on the relationship between emissions of carbon and financial development. Secondly, studies that focus on the nexus of FDI-carbon emissions, and thirdly, analyzes that focus on CO2 emissions and economic growth test the validity of the ECK hypothesis, and. However, a limited number of studies are available for Nigeria:

Several researchers have concentrated on factors that influence carbon emissions, such as openness to trade, urbanization, and population growth. In recent years, studies have reported that financial development is also another important variable that could greatly affect carbon emissions, and the absence of financial development in the model of carbon emissions results in a biased and misleading empirical results (Hao, Zhang, Liao, Wei, & Wang, 2016; Shahbaz, Shahzad, Ahmad, & Alam, 2016a; Tamazian & Bhaskara Rao, 2010).

Henceforth, researchers have gained attention in the recent years in investigating the relationship between financial sector development and environmental degradation. Several studies indicate clear evidence of the development of financial sector causing increased emissions of carbon dioxide (Ali et al., 2018; Cetin, Ecevit, & Yucel, 2018a; Charfeddine & Khediri, 2015; Dar & Asif, 2017; Javid & Sharif, 2016; Paramati, Alam, & Apergis, 2018; Xing, Jiang, & Ma, 2017). The studies found explanations for a positive effect on CO2 emissions from the financial sector. First, stock market development can help the listed companies improve their channels of finance, minimize the cost of finance, reduce the risk of operation, make new investments, and thus increase the use of energy and CO2 emissions. Second, through increased levels of foreign direct investment inflows, financial development can increase environmental pollution. Eventually, an established financial system in a country may make it much easier for customers to purchase durables consumer goods and may result in higher carbon emission rates (Raza & Shah, 2018).

However, some researchers have found that financial development improves industry's energy performance and efficiency, thereby helping to reduce energy consumption and carbon dioxide emissions (Al-mulali, Tang, & Ozturk, 2015; Dogan & Seker, 2016; Ghorashi & Rad, 2018; Salahuddin, Gow, & Ozturk, 2015; Saud, Chen, Haseeb, Khan, & Imran, 2019). Besides, (Katircioğlu & Taşpinar, 2017) found a unidirectional causality between financial development and CO2 emissions in the case of OECD (organization for economic cooperation and development) countries. The findings of (Zaidi, Zafar, Shahbaz, & Hou, 2019) confirmed bidirectional causality between financial development and CO2 emissions in Asia Pacific of Cooperation Countries. In the same vein, (Farhani & Ozturk, 2015) found a unidirectional relationship moving from financial development to carbon emissions for Tunisia as well as (Zafar, Saud, & Hou, 2019) found a unidirectional form of relationship running from carbon emissions to financial development for OECD countries.

Theoretically, depending on which channel or dimension is dominant, FDI can have both positive and negative effects on the quality of environment, For example, while examining the FDI effect on CO2 emissions in China (Abdouli, Kamoun, & Hamdi, 2018) reported that FDI contributes to CO2 emissions. They also negate the argument put forward by (Zhu, Duan, Guo, & Yu, 2016) investigation of the countries of ASEAN-5, which advocates that FDI spread greener technology to the host country and lead to the improvement of environment in the developing countries. Nevertheless, later studies by (Zhang & Zhou, 2016), using Chinese regional data, and (Liu, Wang, Zhang, Zhan, & Li, 2018) and (Hao & Liu, 2015), using Chinese city-level data, report adverse effects of FDI on CO2 emissions. It indicates that even in a single country (China), we have diverse evidence. In confirmation from other developing countries, such as studies on Malaysia by (Hitam & Borhan, 2012) and (Lau, Choong, & Eng, 2014) report that even though FDI supports higher economic growth, it also leads to higher degradation of environment.

In a similar vein, (Tang & Tan, 2015) documents that; the key determinants of rising CO2 emissions in Vietnam are income and FDI. For the ASEAN-5 countries (Chandran & Tang, 2013) indicate that FDI leads to a substantial increase in energy consumption and CO2 emissions, although the relationship has some country-level heterogeneities. Similarly, a study by (Zhu et al., 2016) on the ASEAN-5 countries using the Quantile Regression Panel indicates that FDI has a detrimental effect on carbon emissions, except at the 5th quantile, and it is becoming significant at higher quantiles. Contrary to this, (Baek, 2016) uses the dynamic panel's pooled mean group (PMG) estimator for the ASEAN-5 countries, showing that FDI generally increases CO2 emissions. Likewise, the relationship between FDI inflows and carbon emissions (Paramati, Ummalla, & Apergis, 2016) is examined using data from developing economies. They show the positive and significant impact of economic FDI inflows on clean energy consumption and CO2 emissions. This means that it is essential to take into account the heterogeneity of the country level to see which channel is influential in the nexus between FDI and carbon emissions.

Among the studies of abundant natural resources, countries of the Middle East (Sbia, Shahbaz, & Hamdi, 2014) show that FDI leads to an increase in green energy use, but a rise in CO2 emissions in the UAE. Similarly, when investigating GCC countries by (Al-mulali & Foon Tang, 2013), it is stated that while FDI does not have a significant short-run causal relationship with CO2 emissions, FDI inflows have a long-run negative impact on CO2 emissions. Contrary to this, (Abdouli & Hammami, 2018) suggest the existence of unidirectional causality in MENA countries from FDI inflow to CO2 emissions, although there were variations at the country level. Nonetheless, (Kivyiro & Arminen, 2014) show mixed empirical findings in six sub-Saharan countries, but in Ghana's case (Solarin, Al-Mulali, Musah, & Ozturk, 2017) shows that FDI has a positive effect on CO2 emissions. (Shahbaz, Nasreen, Abbas, & Anis, 2015) Illustrate that FDI raises environmental degradation and supports the haven hypothesis of pollution (PHH). Their factual evidence also indicates that there is a feedback effect between CO2 emissions and FDI, while the results are sensitive to different income groups and regional effects. Analysis of OECD countries at a sectoral level (fishing and agriculture) (Pazienza, 2015) shows that FDI has a negative impact on CO2 emissions. On the contrary, a comprehensive analysis involving data from 54 countries (Omri, Nguyen, & Rault, 2017) highlights the presence of a feedback effect between emissions of FDI and CO2, except in Europe and North Asia.

Another strand of literature claimed that there is an association between CO2 emissions and economic growth. They argued that CO2 emissions rise as the country experiences economic growth in the early stages of economic development, but decline after hitting a certain level of economic growth (Al-Mulali, Tang, & Ozturk, 2015); (Ahmad et al., 2017); (Charfeddine & Mrabet, 2017). Nonetheless, previous studies describe the relationship between economic growth and environmental quality as contradictory for instance a study by Yeh & Liao (2017) for Taiwan, Boufateh (2019) for USA, Ma & Jiang (2019) for China, Aye & Edoja (2017) for 31 developing countries and Acheampong (2018) for 116 sample of countries across the globe showed that CO2 emissions decline with a rise in economic growth. Likewise, (Ozcan, 2013) also establish a little support that CO2 emissions decline with an upsurge in real GDP per capita. But Omri, Daly, Rault, & Chaibi (2015) for MENA countries, Begum, Sohag, Abdullah, & Jaafar (2015) for Malaysia, Ahmad et al., (2017) for Croatia, Charfeddine & Mrabet (2017) for MENA countries and Dong, Sun, & Dong (2018) for China and (Al-mulali, Saboori, & Ozturk, 2015) for Vietnam delivered empirical evidence to indicate that an upsurge in economic growth has the capability to rise consumption of energy and eventually exacerbates CO2 emissions. Henceforth, from the perspective of causal relationship between economic growth and carbon emissions by (Abdulrashid, 2016; Charfeddine & Mrabet, 2017) is bidirectional while for (Chandia, Gul, Aziz, Sarwar, & Zulfiqar, 2018; Uddin, Salahuddin, Alam, & Gow, 2017) is unidirectional moving from carbon emissions to economic growth for (Dong et al., 2018; Ssali, Du, Mensah, & Hongo, 2019) is also unidirectional but move from economic growth to carbon emissions.

3. Research Methodology

3.1 Data Description

The data on CO2 emissions (metric tons per capita), total FDI inflow (US$ million), real GDP (per capita), for index of financial development the indicators of both financial market and stock market were used such as money and quasi money (M2), liquid liabilities (M3), domestic credit to the private sector, stock market capitalization, stock market traded value and stock market turnover have been sourced from the World Development Indicators (2019). The study is based on data of time series that covered the period of 1970 to 2018. The data for all the concern variables have been sourced from the world development indicator (2019).

3.2 Methodology and Model Specification

In earlier studies, the financial development – CO2 emission relationship is usually studied using the auto-distributive lag model (ARDL) cointegration analysis of ordinary time series approaches, accompanied by modeling error correction (EC) and causality of Granger. Econometric methods, however, allow the assessment of the existence of long-run relationships followed by short-run associations while taking as symmetric the connection between financial development and CO2 emissions. Because of this, they are not sufficient to achieve conceivable variables asymmetries. This research then explores the short-term as well as the long-term asymmetric connection between financial development and the environmental quality through the use of the NARDL method established by (Shin, Yu, & Greenwood-Nimmo, 2014), with positive and negative partial sum decompositions of the explanatory variables. This method has the advantage of differentiating the explanatory variables under consideration between short-run and long-run asymmetric responses to changes in CO2 emissions. The change in the variable being analyzed is represented as the first difference in this variable's logarithmic transformation. The asymmetric cointegration relationship can be expressed as follows:

$$CO_{2t} = F\ (FD_t, EG_t, FDI_t) \tag{1}$$

All the variables are transformed into logarithmic form. The log-linear functional form of the empirical equation is as follows:

$$lnCO_{2t} = \beta_1 + \beta_2 lnFDI_t + \beta_3 lnEG_t + ln\beta_4^+ lnFD_t^+ + \beta_5^- lnFD_t^- + \mu_t \tag{2}$$

Where CO2 is carbon emissions representing the quality of environment, FDI specifies foreign direct investment, EG denotes economic growth, FD illustrates financial development, and $\beta = (\beta_1, \beta_2, \beta_3, \beta_4^+, \beta_5^-)$ is a vector of unknown parameters. Also, $FD_t = FD_0 + FD_t^+ + FD_t^-$, where FD_t^+ and FD_t^- are partial sum processes of positive and negative variation inFD_t:

$$FD_t^+ = \sum_{j=1}^{t} \Delta FD_j^+ = \sum_{j=1}^{t} max\emptyset\left(\Delta FD_j, 0\right), FD_t^- = \sum_{j=1}^{t} \Delta FD_j^- = \sum_{j=1}^{t} max\emptyset(\Delta FD_j, 0) \quad (3)$$

As part of the non-linear relationship between financial development and carbon emissions, the above equations based on a partial decomposition to model asymmetric cointegration were use, Equation (1) can be fitted in an ARDL setting under the context of (Pesaran, Shin, & Smith, 2001) (Pesaran, Pesaran, Shin, & Smith, 1999) as:

$$\Delta CO_{2t} = \rho_0 + \omega_1 CO_{2t-i} + \Pi_2 EG_{t-1} + \tau_3 FDI_{t-1} + \emptyset_4^+ FD_{t-i}^+ + \cap_5^- FD_{t-i}^- + \sum_{i=1}^{a} \cap \Delta CO_{2t-i} + \sum_{i=1}^{b} \theta_i \Delta EG_{t-i} + \sum_{i=1}^{c} \in_i \Delta FDI_{t-i} + \sum_{i=0}^{d} (\vartheta_i^+ \Delta FD_{t-i}^+ + \gamma_i^- \Delta FD_{t-i}^-) + \emptyset_t \quad (4)$$

Where a, b, c, and d, are lag orders. The unknown cointegration problem may ascend in the estimated Equation (1), so that it is incapable to deliver the true interpretation of the estimated asymmetric coefficients; hence, a constraint is enforced on the coefficients of Equation (1) such as:

$$\beta_4^+ = -\frac{\emptyset_4^+}{\omega_1} \text{ and } \beta_5^- = \frac{\cap_5^-}{\omega_1}$$

The $\sum_{i=0}^{d} \vartheta_i^+$ estimates the probable short-run effect of financial development increase on CO2 emissions while $\sum_{i=0}^{d} \gamma_i^-$ measures the short-run effect of financial development reduction on CO2 emissions. Therefore, the asymmetric short-run effect of variations in financial development on CO2 emissions is also captured in this setup together with asymmetric long-term association. The error correction model (ECM) of the previous equation is depicted as:

$$\Delta CO_{2t} = \sum_{i=1}^{a} \sigma_i \Delta CO_{2t-i} + \sum_{i=1}^{b} p_i \Delta EG_{t-i} + \sum_{i=1}^{c} z_i \Delta FDI_{t-i} + \sum_{i=1}^{d} (n_i^+ \Delta FD_{t-i}^+ + n_i^- \Delta FD_{t-i}^-) + \aleph_i ECT_{t-i} + \emptyset_t \quad (5)$$

Where, σ_i, p_i, and z_i represent short-run coefficients and n_i^+, n_i^- are for short-run adjustment symmetry, while $\aleph_i$ indicates the coefficient of the error correction term. The NARDL technique of estimation includes the following steps: First, the ARDL method is applicable irrespective of whether all the variables are combined with order zero or one or show mixed results. It is very important to use the unit root test to ensure that no variable of order two is incorporated, since the presence of an I (2) variable makes the estimated F-statistics null and void for measuring cointegration. To eliminate this problem, the commonly employed Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are used to find the order of integration. Next, using the standard Ordinary Least Squares (OLS) procedure, equation (3) is computed. The general-to-specific approach was implemented to enhance the NARDL model's final condition by lowering the insignificant lags. Next, upon estimating NARDL, a test is performed for the existence of a long-run relationship of variables included in the model using a bound test technique (Pesaran et al., 2001). This comprises the Wald F-test of the null hypothesis, H_0: $\omega_1 = \Pi_2 = \tau_3 = \emptyset_4^+ = \cap_5^- = 0$ against the null hypothesis, H1: $\omega_1 \neq \Pi_2 \neq \tau_3 \neq \emptyset_4^+ \neq \cap_5^- \neq 0$. Ultimately, with the existence of cointegration, in the relationships between financial development and CO2 emissions, a study of long-run and short-run asymmetries is carried out and inferences are made. In addition to this, asymmetric cumulative dynamic multiplier effects of 1% variation in ΔFD_{t-i}^+ and ΔFD_{t-i}^- respectively were computed as:

$$G_h^+ = \sum_{j=0}^{h} \frac{\partial CO_{2t+j}}{\partial FD_{t-1}^+}, G_h^- = \sum_{j=0}^{h} \frac{\partial CO_{2t+j}}{\partial FD_{t-1}^-}, \text{ h = 1,2,3…….. ……..}$$

It should be noted that as h$\emptyset\infty$ $G_h^+ \emptyset\, \beta_4^+$ and $G_h^- \emptyset\, \beta_5^-$.

We use the asymmetric causality test proposed by (Diks & Panchenko, 2006) to determine the direction of causation between the variables examined because the linear Granger causality test is inadequate to detect the presence of a potential nonlinear causal relationship between two variables. The null hypothesis is stated as follows:

$$q = E\left[f_{XYS}(X, Y, S) f_y(Y) - f_{X,Y}(X, Y) f_{Y,S}(Y, S)\right] = 0 \quad (6)$$

Where $N_t = Y_{t+1}$. by ingoring the index of the time and assume that lag x and y is equal to 1. The distribution of *S*- given that (*X*, *Y*) = (*x*, *y*) - is the same as that of *S* - given *Y* = *y*. The joint probability density function $f_{X,Y,s}$(*x*,*y*,*s*) and its marginal should satisfy the following relationship:

$$\frac{f_{X,Y,S}(x,y,s)}{f_Y(y)} = \frac{f_{X,Y}(x,y)}{f_Y(y)} \cdot \frac{f_{X,N}(y,s)}{f_Y(y)} \quad (7)$$

In other words, equation (4) states that X and S are independent, when $Y = y$ for each fixed value of y. Suppose $\hat{f}_W(W_i)$ is a local density estimator of a dW-variate random vector **W** at Wi, defined by $\hat{f}_W(W_i) = 2 \in_n{}^{-d}$ W$(n-1)^{-1} \sum_{j,j\neq i} I_{ij}^{W}$, where I_{ij}^{W} = I $(//W\_i - W\_j//<\in \_n), I(.)$ the indicator function and $\in_n$ the bandwidth, which depends on the sample size n^3. Then, the test statistic is a scaled sample version of q in equation (6):

$$L_n\epsilon_n = \frac{n-1}{n(n-2)} \cdot \sum_i \left(\hat{f}_{X,S,Y}(X_i, S_i, Y_i)\hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i, Y_i)\, \hat{f}_{Y,S,}(Y_i, S_i)\right) \tag{8}$$

For $l_x = l_y = 1$ and if $\in_n = Cn^{-\rho}$ $\left(C > 0, \frac{1}{4} < \rho < \frac{1}{3}\right)$, (Diks & Panchenko, 2006) prove that the test statistic in equation (8) satisfies the following:

$$\sqrt{n}\frac{(T_n(\in_n)-q)}{Z_n} \xrightarrow{d} N(0,1) \tag{9}$$

Where $\xrightarrow{d}$ signifies convergence in distribution and Sn is an estimator of the asymptotic variance of Tn (·) ((Diks & Panchenko, 2006); (Bekiros & Diks, 2008). Henceforth, the study will follow the suggestion of Diks and Panchenko by implementing a one-tailed version of the test.

4. Results and Discussions

The descriptive statistics and pair-wise correlation matrix are provided in Table 1. The results show that FDI more highly volatile than GDP, and carbon dioxide emissions are less volatile than financial development and GDP. Further, the standard deviation is higher for FDI than for CO2 emissions. Skewness and kurtosis show potential asymmetry in the data distribution. Hence, we rely on asymmetric rather than symmetric empirical analyses.

The correlation analysis indicates a negative correlation between CO2 emissions and financial development, CO2 emissions and GDP, as well as carbon emissions and FDI. Contrarily, financial development and FDI, financial development and GDP, as well as FDI and GDP, are positively correlated with each other.

Table 1. Descriptive statistics and correlation matrices

	LCO2	LFD	LFDI	LGDP
Mean	0.452047	5.95E-16	92.05495	12.65941
Median	-0.482964	-0.247327	92.02341	12.73897
Maximum	-0.190103	4.175905	99.46507	14.11097
Minimum	-0.671872	-1.756185	82.76840	10.70131
Std. Dev.	0.145742	1.443625	4.668428	1.057741
Skewness	0.240541	1.132786	-0.106828	-0.215213
Kurtosis	1.719220	3.980124	2.080886	1.650916
Jarque-Bera	3.041735	9.901865	1.446933	3.258602
Probability	0.218522	0.007077	0.485068	0.196067
Sum	-17.62984	2.85E-14	3590.143	493.7168
Sum Sq. Dev.	0.807144	79.19398	828.1804	42.51501
LCO_2	1.000000			

FD	- 0.432020**	1.000000		
	0.0060	-----		
LFDI	-0.538262*	0.449581*	1.000000	
	0.0000	0.0000	-----	
LGDP	-0.529549*	0.678707*	0.581109*	1.000000
	0.0005	0.0000	0.0000	-----

** indicate significance at 5% level. * indicate significance at 1% level.

Before deciding the dynamic relationship between financial development economic growth, FDI, and carbon dioxide emissions, we tested the stationarity of the variables. ARDL model is referred to as a dynamic econometric co-integrating approach because it can be applied when all the variables are stationary at 1(0) or 1(1) or 1(0) and 1(1) mixtures. The limitation of this technique, however, if any one of the varibales happened to be integrated of order two I(2), it is impossible to be applied (Ibrahim, 2015). For this reason, ADF and PP unit root tests are used to detect the stationarity of the variables under investigation in order to avoid the inclusion of I (2) variables. Table 2 summarizes the results of unit root checks. The results indicated that none of the variables that are I (2), we can, therefore, move to an asymmetric approach to ARDL.

Table 2. Unit root tests

In level			In first difference		
Series	ADF	PP	ADF	PP	Decision
LCO_2	-1.404678 (0.8435)	-1.729077 (0.7185)	-5.189701 (0.0008)	-5.183038 (0.0008)	I(1)
LFD	-3.292650 (0.0832)	-2.909886 (0.1709)	-4.486758 (0.0055)	-4.669888 (0.0032)	I(1)
LFDI	-1.247772 (0.8852)	-3.094728 (0.1220)	-10.91768 (0.0000)	-10.74858 (0.0000)	I(1)
LGDP	-1.262842 (0.8820)	-1.578972 (0.7826)	-7.872339 (0.0000)	-7.014444 (0.0000)	I(1)

Accordingly, we estimate Equation 2 by selecting the appropriate ARDL specification using a general-to-specific approach. Several studies (see Bahmani-Oskooee & Mohammadian, 2016; Ibrahim, 2015; Shin et al., 2014) have followed the general-to-specific procedure for the final ARDL specification. Furthermore, the Schwarz Information Criterion (SC) is used to select the appropriate lag order. Table 3 presents the bound test F-statistics values of asymmetric ARDL, and the findings of asymmetric ARDL are included in Table 4.

Table 3. Bounds test for nonlinear cointegration

	F.Statistics	Lower Bound (95%)	Upper Bound (95%)	Decision
Asymmetric ARDL K = 3	5.555581	2.56	3.49	Contegration Exist

The asymmetric ARDL, bound test result, however, indicates that there is evidence of co-integration between financial developments GDP, FDI, and carbon emissions as the measured asymmetric ARDL F-statistic value (5.55) exceeds the upper and lower bound tabulated value at the 5 percent significance level.

Table 4. Asymmetric ARDL estimation results

Variable	Coefficient	Std.Error	t-Statistics
ΔFD^{+}	0.133160*	0.012781	10.41859
ΔFD^{-}	-0.179621*	0.020503	-8.760718
$\Delta FD^{+}(-1)$	0.285080*	0.049622	5.745032
$\Delta FD^{-}(-1)$	-0.334834**	0.085159	-3.931868
ΔGDP(-1)	0.567208*	0.069506	8.160562
ΔFDI(-1)	-0.321207**	0.096196	-3.339231
F-statistic	214.43[0.0081]		

R-squared	0.554287
Adjusted R-squared	0.408574
X^2_{Norm}	4.423211[0.109525]
X^2_{sc}	1.264102[0.3044]
X^2_{Het}	0.758334[0.5598]

Note: The superscript "+" and "-" signify positive and negative collective sums, separately. X^2_{Norm} , X^2_{sc} and, X^2_{Het} signify LM tests for normality, serial correlation, and heteroscedasticity, respectively. Value in [ ] denotes p-values. *Significance at 1% level and **Significance at 5% level.

Before looking at the short-term and long-term relationship of positive and negative variations in financial growth on carbon emissions, we checked the diagnostic statistics such as serial correlation, heteroscedasticity, and normality to know the accuracy of dynamic forecasting and decision-making parameters. Table 4 shows the results of these diagnostic tests. The table shows that the approximate model met these diagnostic tests because there was no heteroscedasticity, autocorrelation, and non-normality at the significance level of 5 percent. However, the table also shows the short-run effect on the dependent variable of the independent variables. The long-run impact on the dependent variable of the explanatory variables is shown in Table 5.

Table 5. Results of Long run Non-linear ARDL

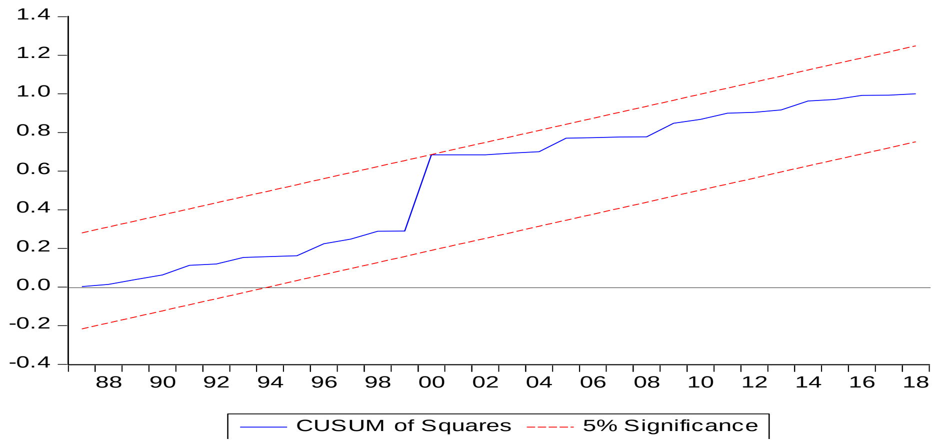
Variable	Coefficient	Std.Error	t-Statistics
LFD^+	0.60227*	0.05444	-11.0618
LFD^-	-0.13403*	0.01916	-6.99384
LFDI	0.89654*	0.07638	-11.7374
LGDP	0.18137**	0.04826	3.75774

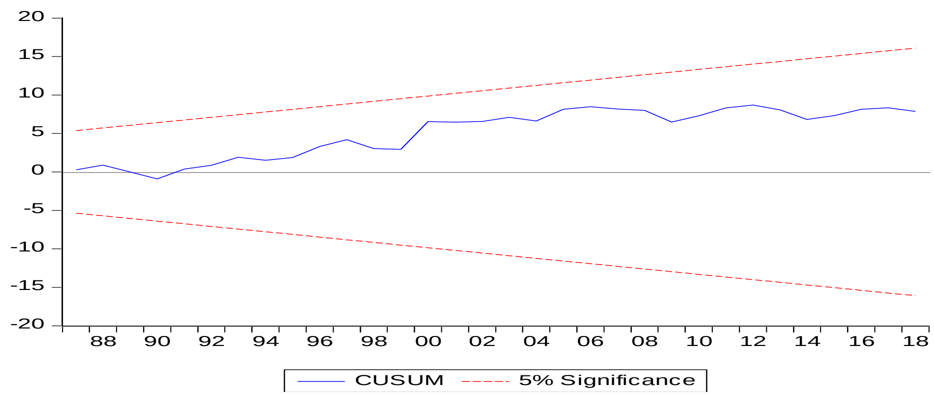
*Significance at 1% level and **Significance at 5% level.

Table 5 shows that the positive (LFD+) and negative (LFD-) changes in financial development have a positive and negative significant effect on carbon emissions at a 5% level of significance. These findings are in line with the findings of (Ahmad, Khan, Rahman, & Khan, 2018; Shahbaz, Shahzad, Ahmad, & Alam, 2016). Changes in financial development have an impact on the quality of environment because a 1% increase in the positive financial development, as such it would lead to 0.60% increase in the amount of carbon emissions, at the same time, a 1% decrease in the negative development of financial sector would lead to 0.13% increase in the amount of carbon emissions, meaning that a positive increase in financial development deteriorate the quality of environment and at the same time a negative decrease in financial development would deteriorate the quality of environment in the long run.

Moreover, the empirical results of the study show that there is an asymmetric effect of financial development on the quality of the environment. Henceforth, in the long run, LGDP is related positively with CO2. This result is in line with the outcome of (Dong, Sun, & Dong, 2018; Omri, Daly, Rault, & Chaibi, 2015). Meaning that, a 1% increase in economic growth would lead a 0.18% increase in carbon emissions. In Nigeria, an increase in economic growth deteriorate the quality of the environment. The positive coefficient of FDI specifies that FDI increases CO2 emissions in Nigeria as a 1% increase in the inflow of FDI causes CO2 emissions to increase by 0.89%, apparently supporting the pollution haven hypothesis (which suggests that FDI harms the home country environment). These results are corroborated by the findings of other researchers (Shahbaz, Nasreen, Abbas, & Anis, 2015; Solarin, Al-Mulali, Musah, & Ozturk, 2017).

Figures 1 & 2 also demonstrates the graphical analysis of an asymmetric relationship between predicted variables. Table 5 demonstrates the results of the long-term asymmetric relationship.





The stability of the NARDL model parameters is tested using Brown, Durbin, & Evans (1975)'s CUSUM and CUSUMSQ stability method. If the blue lines cross the upper or lower boundaries, the parameters in the model are not stable. Because the blue lines in both graphs are within lower and upper boundaries, we can deduce that the approximate model parameters are stable (see Figures 1 & 2). The model is, therefore, accurate for decision-making and forecasting.

To prevent the estimation bias that could occur when the relationship between environmental quality and financial growth is nonlinear (Chiou-Wei, Chen, & Zhu, 2008), We are applying Diks and Panchenko's nonlinear causality check. The nonparametric analysis of Diks and Panchenko was applied in both directions for lag=2 and for bandwidth πn=0.5, which was set according to the length of time series n4. Table 3 shows the resulting Diks-Panchenko research T-statistics and p-values.

Table 6. Non-Linear Causality Result

Variables	CO2	FD	FDI	GDP
CO2	-	3.436(0.000) [a]	0.327(0.059)	0.038(0.973)
FD	3.563(0.000) [a]	-	3.583(0.000)	3.299(0.000)
FDI	4.424(0.000) [a]	4.857(0.000) [a]	-	1.814(0.034) [b]
GDP	4.500(0.000) [a]	4.159(0.000) [a]	3.771(0.000)[a]	-

*Significance at 1% level and **Significance at 5% level.

The results obtained from the above test indicate evidence of a bidirectional non-linear causal relationship between financial development and carbon emissions, meaning that both financial development and carbon emissions cause each in Nigeria. This result is consistent with the findings of (Katircioğlu & Taşpinar, 2017). A unidirectional non-linear causal relationship runs from carbon emissions to FDI, and this result supports the findings of(Abdouli & Hammami, 2016). A one-way non-linear causal relationship exists from carbon emissions to GDP, and the outcome supports the findings of (Uddin, Salahuddin, Alam, & Gow, 2017).

5. Conclusion and Policy Implication

This study examines the relationship between financial development and CO2 emissions by integrating FDI and economic growth as additional factors in the functional form of CO2 emissions. The study uses the annual time series data between 1970 and 2018. We use the ADF and PP tests for empirical purposes to check the level of integration of the variables in the data of the time series. Besides, the asymmetric ARDL cointegration method is used to check the effect of positive and negative shocks in financial development, FDI and economic growth on CO2 emissions, and the relation of asymmetric causality between variables is tested using the asymmetric Granger causality study. based on the empirical findings of this study, we conclude that among the variables examined, i.e. financial development, FDI, economic growth, and CO2 emissions, there is strong asymmetric cointegration. The study found positive links between economic growth and CO2 emissions, as well as FDI and carbon emissions. Financial development is also responsible for adding both positive and negative shocks to CO2 emissions. The analysis of asymmetric causality explores the two-way symmetric causality between financial development and CO2 emissions, and the results show that there is unidirectional causality from economic growth and FDI to carbon emissions.

Financial development will help fund the purchase of new and energy-efficient technology as it is possible to obtain financial resources at a lower cost. However, our empirical evidence suggests that through positive and negative shocks occurring in the development of the financial sector, financial development impedes environmental quality. The financial system can also be established with new instruments and regulations in this regard because it correlates with economic growth. The government should, for instance, order Nigeria's central bank to control the financial resource allocation process of the financial sector, and financial institutions should track companies after allocating financial resources to ensure that credit is not provided at the expense of environmental quality. If any company is involved in increasing environmental degradation, it should be punished through tax holiday reductions or increases in interest-rate loans. The government should also encourage the banking sector to invest in the energy sector in general, but with specific effort in renewable energy sector . In this regard, financial institutions can allocate financial resources to R&D for energy-efficient technologies and acquire patents for these technologies to produce a guaranteed lifetime of income rather than waste financial resources on product financing that is car leases or household item loans.

Economic growth is related positively with CO2 emissions, reflecting the negative environmental degradation impact of economic growth. Such degradation of the environment can affect human health, which in the long run reduces productivity and thus affects the pace of economic growth. Energy-efficient engineering should, therefore, be implemented not only at the level of production but also at the level of transport and households. The introduction of environmentally friendly technologies will help improve the quality of the environment, increase long-term sustainability, and save resources for generations to come. In addition, attempts must be made to plant trees instead of deforestation for long-term economic growth, and sustainable sources of energy such as wind, hydropower, and solar power can be used to reduce pollution. Clear regulations to impose a carbon tax and minimum standards for fuel efficiency on cars should also be introduced.

An obvious consequence of different results is that FDI and financial development are widely assessed as the driver of growth in developing nations, both contributing positively to a nation's development, but also degrading the climate, as our analyzes show. Therefore, our study further indicates that by enforcing environmental regulations to regulate CO2 emissions, the Nigerian government will consider the attractiveness of FDI. Nonetheless, stringency in environmental regulation could potentially lead to a reduction in FDI, which is a key determinant of growth; it should, therefore, be encouraged to attract more FDI to service sectors, labor-intensive industries, or renewable energy sectors, as well as investment in green technology. In addition, FDI should be geared towards research and development (R&D), and sustainable technology for reducing CO2 emissions should be increased in R&D. Considering that Nigeria is one of Africa's largest CO2 emitters, there should be serious attention to environmental hazards. The country must enforce strict rules and regulations on the environment and also promote the use of environmentally friendly technology to increase domestic production. A key policy consequence of this study is also that the FDI inflow to pollution-intensive industries should be closely monitored. Since Nigeria can be considered a model for other developing and neighboring nations in this report, our results will benefit them as well.

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