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Article

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Fossil Fuel Energy Consumption and CO_2 Emissions in Nigeria

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Abstract

This study examined the influence of fossils fuel energy consumption, economic growth, financial development, and FDI in Nigeria. The study applies the ARDL technique over the period from 1981-2014. Result of the bound test indicates that the variables are cointegrated. The estimates of the short-run result reveal that all the variable are positive and significant in explaining Carbon dioxide emissions. The long-run analysis shows that FFC, GDP, and FD increased CO_2 emissions. The study suggests that the policymakers in Nigeria should embark policies on efficient energy use that simultaneously promotes economic growth and environmental quality through the use of other forms of renewable energy like solar, and wind.

Key words

CO_2 emissions, Fossil fuel consumption, financial development, GDP, ARDL

JEL Codes: Q52, Q54

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1. Introduction

The deterioration of the global ecosystem has been attributed to the excessive expulsion of carbon dioxide emissions (CO_2) emissions (Boutabba 2014; Lau *et al.*, 2014). Increase in CO_2 emissions deflects ozone layer that resulted in climate change and consequently caused lower access to water, food, and the outbreak of diseases (Danlami *et al.*, 2018). According to IPCC (2007), the global CO_2 emissions has been on growing trend with 1.9 percent annual increment. It has been acknowledged that fossil fuels consumption like coal, oil, petroleum, and natural gas are the main determinants of CO_2 emissions (Adeel-farooq *et al.,* 2018; Saimanul and Abdul-Rahim 2017; Bloch *et al.,* 2015). International Energy Agency (IEA) documented that fossil fuels constitute about 82% of the global total primary energy, and it increased CO_2 emissions by 16% from 1990 to 2014. In this regard, various studies have established that high fossil fuels consumption is linked to more CO_2 emissions in the atmosphere (Boutabba 2014; Kang *et al.,* 2016). Similarly, the urgent need for both industrialized and emerging countries to realize a higher level of production and growth had increased the amount of energy consumption that emits more CO_2 emissions. Hence, necessary measures need to be considered to mitigate CO_2 emissions without jeopardizing the ability of these countries achieves economic growth and development. Environmental Kuznets curve (EKC) hypothesis proposed by Kuznets (1955) explain how economic progress influence environmental pollution. Therefore, other factors like energy use, FDI, trade, and financial resources could accelerate the performance of economic growth and consequently increased the level of CO_2 emissions.

In the past decade, it is evident that developing countries, like Nigeria, contributes to the growth of global CO_2 emissions. For instance, 13,190.20 kt was recorded in 2000, 21,635.30 kt in 2006, and the trend of CO_2 emissions rose to 33, 131.4 kt in 20014 (World Bank 2016). In the same regard, Nigeria is placed as the 3rd largest producer of bioenergy worldwide. This has led to the improvement in fossil fuel energy consumption with about 3.0% increase from 2009 to 2014 (IEA 2016). The trend of the above situation is disturbing if continuous, it could generate instability in the natural ecosystem. Hence, it necessary to explore the factors influencing the growth of CO_2 emissions. Based on the above view, this study analyzes the influence of fossil fuel energy consumption, GDP, financial development, trade openness, and FDI on CO_2 emissions in Nigeria.

2. Literature review

In economic literature, several studies have explored the relationship among energy consumption, economic progress, financial development, and FDI. Hence, the empirical review of the present study is presented in three stages. The first stage includes a review of studies on energy use and CO_2 emissions, while the second group consists of studies on economic progress, financial development, and EKC hypothesis. The last stage concerns studies on FDI and CO_2

emissions. For instance, study by Azlina, Law, and Mustapha (2014) analyze the link between energy use and CO_2 emissions in Malaysia by utilizing time series analysis from 1975 to 2011. The study finds energy consumption influenced CO_2 emissions positively. This finding is consistent with the result obtained by Bölük and Mert (2014) that fossil fuel consumption accelerates the level of CO_2 emissions in 16 EU countries. Similarly, Farhani and Ozturk (2015) used the ARDL technique to explore the linkage between energy use and emissions in Tunisia from 1971 to 2012. The finding reveals that energy use has a significant and positive effect to CO_2 emissions. A study by Bloch *et al.* (2015) confirms that coal consumption promotes the level of CO_2 emissions in China. Dogan and Turkekul (2016) investigate the effects of energy use on CO_2 emissions in the USA by applying the bounds testing approach from 1960 to 2010. The result indicates that use of energy promotes the level of CO_2 emissions. In contrast, a study by Mert and Bölük (2016) reported that the use renewable energy condensed CO_2 emissions in 21 Kyoto countries.

Furthermore, Acheampong (2018) employ PVAR and System GMM to examine the connection between use of energy, GDP, and CO_2 emissions in 116 nations. The study reveals that energy consumption improved the level of CO_2 emissions. Bekun *et al.* (2019) documented that in 16 EU countries, energy consumption influence CO_2 emissions positively. This outcome is similar with the result obtained by Hanif *et al.* (2019) that fossil fuel consumption increase CO_2 emissions in 15 Asian states. However, a study by Nguyen and Kakinaka (2019) reported a negative effect of renewable energy consumption on CO_2 emissions in 107 countries. Moreover, the second part of the review involves studies on the link between GDP, financial expansion, and CO_2 emissions. For example, Shahbaz et al. (2014) examine the role of economic progress on CO_2 emissions in UAE using ARDL approach from 1975 to 2011. The study documents that economic expansion promotes CO_2 emissions. Lau *et al.* (2014) apply bounds testing technique to analyze the influence of GDP on CO_2 emissions in Malaysia from 1970 to 2008. The result reveals that economic growth positively impacts on CO_2 emissions. Similarly, a study by Mrabet and AlSamara (2016) investigate the effect of GDP and financial progress on CO_2 emissions in Qatar from 1980 to 2011. The finding indicates positive and significant effects of GDP, financial progress, and CO_2 emissions. Saidi and Mbarek (2017) documented that economic growth and financial progress have positive influence on CO_2 emissions. This finding is similar to that reported by Zakaria and Bibi (2019) that GDP and financial enhancement accelerates the level of CO_2 emissions in South Asia. In the same regard, many studies have confirmed the applicability and validity of EKC hypothesis in both industrialized and emerging countries (Sarkodie and Adams 2018; Zakaria and Bibi 2019; Zafar *et al.*, 2019). Nevertheless, the study by Bölük and Mert (2014) reported that the EKC hypothesis do not occur in 16 EU nations.

In addition, the third segment of the review is on the studies related to FDI and CO_2 emissions. Hakimi and Hamdi (2016) analyze the impact of FDI on CO_2 emissions in Turkey and Morocco. The finding reveals that FDI accelerates CO_2 emissions in the studied countries. A study by Abdouli and Hammami (2017) studied the influence of FDI carbon dioxide emissions in 17 MENA countries from 1990 to 2012. The finding reveals that FDI influence CO_2 emissions positively. Salahuddin *et al.* (2018) reported that FDI contributes positively to emissions in Kuwait. The above literature review observed that the connection between use of energy and carbon dioxide emissions exist mostly in advanced countries. Nevertheless, very few studies linked fossil fuel consumption and CO_2 emissions in developing nations, particularly Nigeria. In addition, there is a paucity of studies on environmental-energy relationship. Hence, this study analyzes the influence of fossil fuel energy consumption, GDP, financial expansion, and FDI on CO_2 emissions in Nigeria.

3. Methodology of research

3.1 Data

This study applies time series data from 1981-2014, and the source of is the WDI. The variables include CO_2 emissions (metric tons per capita) fossil fuel consumption (kg of oil equivalence) GDP per capita (current USD), financial development (private sector credit/ GDP), and FDI inflow (percentage of GDP). All variables are converted to log for easy analysis. The nature of the data used in this study is shown in table 1. LFFC has the highest mean value among the variables. The mean value of LFFC is larger than the mean value of FDI by 17.22, signifying that LFFC has the highest variation among the independent variables.

Table 1. Statistical nature of the variables

Variables	Min	Max	Mean	SD
LCO2	10.5	11.6	11.1	0.4
LFFC	15.9	22.8	19.6	1.7
LEG	2.18	3.50	2.73	0.5
LFD	2.16	3.65	3.64	0.3
LFDI	2.16	2.38	2.38	0.6

Source: Author estimation, 2019

3.2. Method of analysis

3.2.1. Unit root

For the purpose of analyzing the aim this study Augmented Dickey-Fuller (ADF) unit root test was used to identify the stationarity and the integration order of the variables. Moreover, Phillip Perron (PP) unit root tests were also utilized to further certain the unit root results. The ADF test is illustrated below:

$$\Delta Z_t = \beta + \theta_{yt-1} + \beta T + \sum_{j-1}^{k} \vartheta_j \Delta Z_{t-j-1} + \varepsilon_t \tag{1}$$

Z signifies the sequences at period t, the coefficient is denoted by β, k indicates the number of lags, while the error term is represented by ε_t. Thus, unit root said to be exist if value of the ADF is lesser of the critical value, hence the null hypothesis cannot be rejected. However, the absence of unit root on the variables is confirm if value of ADF is greater than the critical and in this regard, the null hypothesis will be rejected. In addition, with clarity and purpose of other advantages in terms autocorrelation and heteroscedasticity issues, Phillip Perron (PP) test was also conducted. The PP test is presented as below:

$$\delta^2 = T^{-1}\sum_1^T \bar{e}_r^2 + 2T^{-1}\sum_{t-1}^{l} w(t,l) \sum_{r=t+1}^{l} \bar{e}_t \bar{e}_{t-1} \tag{2}$$

In equation 2: w(r, l) = 1[t/ (1+l)] and the lags is represented by 1. This test follows the same hypothesis criteria with ADF test.

3.2.2. Analytical Model

In this study an amended model from Salahuddin *et al.* (2018) is utilizes for the relationship between dependents and independent variables in the following equation:

CO_2 = f (FFC, GDP, FD, FDI) (3)

Where: CO_2 emissions, FFC, GDP, FD, FDI, denote Carbon dioxide Emissions, fossil fuel, GDP per capita, financial expansion, and foreign capital inflow. Therefore, to estimate the long run relationship of these variables, this study utilizes autoregressive distributed lag bounds (ARDL) technique by Pesaran *et al.*, (2001). This technique is applied irrespective of the order of integration or even if the variables are in mixed order. The ARDL model is expressed as:

$$\Delta LCO_{2t} = \beta_0 + \sum_{j=1}^{n} \beta_1 \Delta LCO_{2t-j} + \sum_{j=0}^{n} \beta_2 \Delta LFFC_{t-j} + \sum_{j=0}^{n} \beta_3 \Delta LGDP_{t-j} + \sum_{j=0}^{n} \beta_4 \Delta LFD_{t-j} + \sum_{j=0}^{n} \beta_5 \Delta LFDI_{t-j} + \alpha_1 LCO_{2t-1} + \alpha_2 LFFC_{t-1} + \alpha_3 LGDP_{t-1} + \alpha_4 LFD_{t-j} + \alpha_5 LFDI_{t-1} + \varepsilon_t \tag{4}$$

Where ε indicates the disturbance error, time is denoted by t while Δ shows the change in the first operator. Akaike information criteria (AIC) are the basis of lag selection criteria. The rule for making a decision on the long-run is built on the F statistic. Therefore, Pesaran *et al*., (2001) argued long run relationship occur among the variables if F-statistics is larger than the value of the upper bound. However, if the value of F-statistics is lower than the value of lower bound found it means no cointegration between the variables.

4. Results and discussions

This study applies ADF and PP unit root tests for the purpose of ascertain integration order and the level of stationarity in the data. ADF test was calculated on SIC standard while the PP test was based on Newey westbound standard. In Table 2 the results of unit root tests was reported. The result shows that all the variables are stationary at first difference except FDI that is found stationary at a level.

Table 2. Unit Root tests result

Variable	ADF LEVEL		PP LEVEL		ADF First Diff		PP First Diff	
LCO_2	-1.135316	(0.689)	-1.163269	(0.678)	-5.556751 *	(0.0001)	-5.556751	(0.0001)
LFFC	-2.597135	(0.103)	-2.642409	(0.095)	-5.860788 *	(0.0000)	-6.689935	(0.0000)
LGDP	0.429072	(0.981)	0.416682	(0.980)	-5.302426 *	(0.0001)	-5.296661	(0.0001)
LFD	-2.507462	(0.122)	-2.283787	(0.182)	-5.016924 *	(0.0003)	-7.882510	(0.0000)
LFD1	-3.081582**	(0.037)	-3.081582**	(0.037)	-	-	-	-

Notes: * and ** represents statistical significance at 1 and 5 % level. Figures in brackets indicate probability.
Source: Author estimation, 2019

Table 3 shows the bound test result. The result shows that there is the existence of a long-run characteristic since F-statistic is higher than the superior critical values at both 1 and 5 % level.

Table 3. Bounding test result

	1%		5%	
F-statistics	I(0)	I(1)	I(0)	I(1)
11.04	3.74	5.06	2.86	4.01

Source: Authors estimation, 2019

Table 4. ARDL estimated results

S.R Regressors	Coeff.	S.E	t-Statistics	Prob
∆LFFC	0.092390	0.030468	3.032334	0.0126
∆LGDP	3.133195	0.473563	6.616221	0.0001
∆LFD	0.976915	0.148448	6.580869	0.0001
∆LFDI	0.229524	0.077198	2.973185	0.0140
ECT(-1)	-0.892748	0.412553	-2.163960	0.0025
L.R Regressors				
LFFC	0.013444*	0.039431	3.333548	0.0076
LGDP	0.432193**	0.137900	3.134103	0.0106
LFD	0.798660**	0.186425	4.284076	0.0016
C	5.31610	1.634249	3.252968	0.0087

Source: Authors' estimation, 2019; Notes: * and ** represents significant at 1 and 5 percent level

Table 4 presents the results of a short run and a long run. In the short-run analysis, it is indicated that all the variables are positive and significant in determining the variation of CO_2 emissions in Nigeria. The adjustment towards long-run equilibrium is about 89.27 percent and is significant at one percent. The long-run estimates show that FFC, GDP, FD coefficient are significant, while FDI does not influence CO_2. The result elaborated that a 1 percent rise in FFC caused carbon dioxide emission to increase by 0.092 percent. The positive effect of fossil fuel consumption on CO_2 emissions in this study is not surprising as the recent diversification policy took the direction towards both export and import-oriented production strategies that demand high energy use. This outcome is consistent with findings reported by (Hanif *et al.*, 2019). Furthermore, a 1 percent increase in GDP results to 0.432 percent rise in CO_2 emissions. This shows that the growth in GDP may influence higher demand for energy that accelerates the level of CO_2 emissions. Moreover, a 1 percent increase in FD leads CO_2 emissions to increase by 0.798 percent. However, FDI do not influence CO_2 emissions in Nigeria.

Table 5 depicts the diagnostic checks of the model. The results show that the model is free from issues on Heteroskedasticity, no serial correlation, and the normality in errors occurs.

Table 5. Diagnostic Checks

Test Type	F-statistics	Probability	Result
Breusch-Pagan Test.	0.369897	0.9702	No Heteroskedasticity
Breusch-Godfrey Test	6.001145	0.1256	No Serial Correlation
Jarque-Bera	1.180607	0.5541	Normally Distributed

5. Conclusions

This study examined the influence of fossils fuel consumption, GDP, financial development, and FDI in Nigeria. The study applies the ARDL technique over the period from 1981-2014. Result of the bound test indicates that the variables are cointegrated. The estimates of the short-run result reveal that all the variable are positive and significant in explaining Carbon dioxide emissions. The long-run analysis shows that FFC, GDP, and FD increased CO_2 emissions. The positive association exists between FFC and CO_2 emissions in Nigeria was due to the recent implementation of the diversification policy toward higher production that causes more demand for energy consumption. The result is similar to the conclusion of previous studies (Salahuddin *et a*l., 2018; Bolük and Mert, 2014; Hanif *et al*., 2019). Based on the result obtained in this study FFC is positively linked to Carbon dioxide emissions, there arises a need for the policymakers to design advanced policies on efficient energy use that simultaneously promote economic growth and environmental quality through energy regulations laws and to encourage the use other forms renewable energy like, solar, wind biomass energy in Nigeria. Although the present study has a broader scope of the period, however, the limation is that the data used for the analysis ends in 2014. This is due to the fact the data on CO_2 emissions was available only to 2014. Lastly, future studies should explore other determinants that can stimulate environmental quality.

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