ENVIRONMENTAL EMISSIONS AND LIFE EXPECTANCY NEXUS: FURTHER EVIDENCE FROM NIGERIA

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ABSTRACT: *The paper examined the nexus between environmental emissions and life expectancy using Johansen co-integration and error correction modeling in Nigeria, applying time series data spanning 1990-2016. The finding reveals that environmental emission (proxied by per capita carbon dioxide) is a significant determinant of life expectancy at birth in Nigeria. Also, results reveal that both improved sanitation facilities and public expenditure on health positively and significantly impact on longevity level in Nigeria. Arising from the findings, the study recommends, amongst others, that relevant government policies that could significantly curtail environmental emissions should be strictly enforced and accorded priority in development policy measures. Such efforts should be complemented by embarking on mass sensitization of the Nigerian populace on the strategies to help keep their environment clean in order to reduce mortality relating to unkempt environment and to improve the health status of the citizens.*

KEY WORDS: *Air Pollution, Longevity, Environment, Carbon dioxide, Nigeria.*

JEL Classification: *Q53, Q56, I118, O13.*

1. INTRODUCTION

For the past three and half decades, global concern over the negative impact of environmental pollution on public health has been on the increase. This is partly so because the negative consequences of environmental pollution do not consist only in terms of loss of quality of life, but also the quantum of healthcare expenditure by the government as well as private individuals. On the part of the public and individuals, environmental contamination of any sort tends to put increased strain on their respective budgets. In terms of health, environmental pollution is commonly linked with such human health risks as respiratory and cardiovascular diseases. Interestingly, the major source of environmental pollution is air pollution. Thus, while pollution

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promotes environmental damage, which is wholly borne by the society, air pollution adversely affects human health and has severe consequences on labour productivity and life expectancy. This, in turn, directly or indirectly impinges on the outputs of the firms, industries and the economic growth and development of such nations.

In Nigeria, the quest for accelerated growth of the domestic economy has encouraged increase in production and consumption activities, a development that has brought in its wake increase in pollution of all kinds, and the attendant threat to human health and the environment. Nowhere else is this environmental hazard more prevalent than in our densely populated urban centres/cities with low standard of living. Given the high level of economic activities in those urban centres, pollution associated with industrial and automobile emissions not only help to shorten the life span of people exposed to them, but also promote the depletion of ozone layer.

Given the deleterious effects of environmental emissions on both human and the ecosystem and in a bid to curb further increase in carbon dioxide (CO_2), both the developed and developing countries are intensifying efforts aimed at developing and utilizing other sources of fuel for their energy sector including transport. Recent studies have confirmed that transportation contributes significantly to the emission of the major greenhouse gas, CO_2, whose rising level of concentration has been identified as the main cause of global warming (Marjanovic, et al., 2016; Armeanu, et al., 2018).

Evidence from the Federal Republic of Nigeria (2006), indicated that CO_2 emissions in Nigeria rose significantly by about 54 percent, that is, from 68.5 million metric tons to 105.2 million metric tons from 1980 to 2005. It however declined to about 82.6 metric tons in 2016, representing about 21.5percent decrease. This reduction, notwithstanding, the quantum of CO_2 emission is still considered deleterious to human health. This relatively high emission level has been partly attributed to the increasing utilization of fossil fuel in the transport sector, mostly because of the continuous smuggling in of old and fairly used vehicles as well as the increasing use of motorcycles and tricycles for public transportation.

Despite the hazards associated with environmental emissions, especially as it relates to the possibility of shortening the life span of people exposed to it, and the depletion of the ozone layer, empirical studies on this observation are few within the Nigerian context. For instance, while some studies such as Faboya (1997), Iyoha (2000), and Magbagbeola (2001) emphasized oil industry pollution, others, such as Alege and Ogundipe (2013), Nwodo, Ozor, Okekpa and Agu (2018), andGambo, Ishak, Ismail and Idris (2018) examined the nexus between environmental emissions and economic growth. Still, even the few other ones that focused on transportation emission were carried out in some selected states, for instance, studies like Abam and Unachukwu (2009), Osuntogun and Koku (2007), Jerome (2000) and Usman, Abdulhamid, Gwadabe, Usman, Isah and Mallam (2017). Replicating the policy prescription(s) from such state- centred studies for the Nigerian economy as a whole may be quite misleading. Further, the latest period examined by the authors was 2007. And considering the fact that the Nigerian economy has undergone series of environmental legislations and fiscal incentives in the last one decade, the relevance of such policy recommendations becomes doubtful.

Thus, the present study extends the current literature on environmental emissions and health outcomes in at least three (3) important ways. First, it examines the nexus between environmental emissions (proxied by carbon dioxide) and health outcome (proxied by life expectancy at birth) with a view to ascertaining the effect of such emissions on longevity of those exposed to it. Second, this study utilized a longer period than any of the previous studies within this area, thereby taking into consideration changes that may have transpired for the past one decade or so. Third, the study employed cointegration and error correction procedure aimed at providing estimates for both the long-run structure and short-run dynamics.

2. REVIEW OF RELATED LITERATURE

A number of empirical studies, based on cross-country or time-series data, have aimed at investigating the nexus between environmental emissions and the economy or a sector thereof while others have attempted to examine the impact of such emissions on a range of health system indicators. In what follows, we briefly review some of such related studies. The Environmental Kuznet Curve (EKC) introduced by Kuznets in 1960 hypothesizes an inverted U-shaped relationship between income and carbon dioxide. Specifically, the theory reveals that, at the early stage of development, as economic growth increases, pollution of the environment increases correspondingly, but at a certain level, increases in economic development will bring about a decline in the level of carbon dioxide emission (Grossman and Helpman, 1991; Shafik and Bandyopadhyay, 1992).

The avalanche of empirical studies on the EKC hypothesis has so far produced inconclusive results. For instance, Shafik and Bandyopadhyay (1992), Shafik (1994), Agras and Chapman (1999), Lucena (2005), and Azomahou, Laisney and Van (2006) observed a linear relationship between carbon dioxide emission and income from their studies. On the other hand, Fodha and Zaghdoud (2010), Ozturk and Acaravci (2010), Esteve and Tamarit (2012), Hamit-Haggar (2012), Saboori, Sulaiman and Mohammed (2012), Lau, Choong and Eng (2014), and Osabuohien, Efobi and Gitau (2014) recorded a non-linear relationship between the two variables.

On the nexus between carbon dioxide emission and life expectancy, results of several empirical studies tend to be mixed. For instance, studies such as Cialani (2007), Deschenes and Greenstone (2007), Narayan and Narayan (2010), Pascal, Corso, Ung, Declercq and Medina (2011), Ali and Ahmad (2014), Jerumeh, Ogunnubi and Yusuf (2015) and Balan (2016) lend credence to the fact that life expectancy tend to be higher in those countries with low carbon emissions, an indication that carbon emission is detrimental to longevity. Balan (2016) investigated the nexus (causality) between environment and health in a sample of 25 EU member countries.

The result suggests that $C0_2$ emission has a negative and significant impact on life expectancy; however, CO_2 emission from petroleum is positively related to life expectancy. This result is in consonant with the finding by Ali and Ahmad (2014) which revealed that, in the short-run, CO_2 emissions have inverse and significant relationship with life expectancy at birth. Conversely, there are studies which tend to support a positive relationship between CO_2 and longevity. Such studies include Shafik (1994), Saidi and Hammani (2015), MonsefandMehrjardi (2015) and Raza and Shah (2018). In a panel study of 58 countries, Saidi and Hammani (2015), reported that a positive and statistically significant relationship exist between CO_2 and energy consumption in the four panels considered. This outcome is similar to that of Delavari, Zandiyan, Razaei, Miradinazar, Delavari, Sabor, and Fallah (2018) for Iran, and Amuka, Asogwa, Ugwuanyti, Omeje and Onyechi (2016) for Nigeria, with both studies confirming that CO_2 emission tend to have a positive but insignificant association with life expectancy at birth in Nigeria.

3. DATA AND METHODOLOGY

The data utilized for this study consists of time series spanning 1990-2016. This period was chosen owing to data unavailability for some of the variables before 1990. The variables under consideration are life expectancy (LEXP), carbon dioxide emissions (CDE), improved sanitation facilities (IMS), total government expenditure on health (TGHE), and mortality rate (MRATE). The data for all the variables are sourced from diverse sources, including Central Bank of Nigeria Statistical Bulletin, National Bureau of Statistics (NBS), World Health Organization (WHO) and World Bank Development Indictors (WDI), and other sundry sources. Drawing on the reviewed literature, we hypothesize a simple model where life expectancy (LEXP) is specified as a function of a number of health inputs, namely, carbon dioxide emissions, improved sanitation facilities, total government expenditure on health and mortality rate as follows:

$$LEXP = \alpha_0+\alpha_1 CDE+\alpha_2 IMS+\alpha_3+TGHE+\alpha_4 MRATE+\varepsilon \qquad (1)$$

Where: $\alpha_{1,}\alpha_4$ <0,while $\alpha_{2,}\alpha_3$ >0, LEXP = Life expectancy at birth, CDE = Per capita dioxide emissions, a proxy for environmental pollution (see Davidson, 2003), IMS = Improved sanitation facilities, TGHE = Total government expenditure on health, MRATE= Mortality rate, ℓ = Error term (Gaussian white noise)

Basically, the methodology for this paper draws on regression analysis. Specifically, the study utilized the method of cointegration and error-correction modeling for the investigation. This approach encompasses testing the variables for unit root (in this wise, we utilized the Augmented Dickey-Fuller and Phillip – Person tests), the cointegration test (using Johansen cointegration test) and, if the variables are found to have a long-run relationship, we then estimate an error-correction model to capture the short-run dynamic relationship, using the Engle and Granger (1987) two – step procedure. The error-correction term in the short-run model indicates the speed of convergence to equilibrium path when the equation is disturbed. In addition, taking into cognizance the relatively small size of this study (1990-2016) and in order to avoid producing spurious parameter estimates, which may be detrimental to policy making, we construct the structural stability test using the Cumulative Sum of Recursive Residual (CUSUM) and the Cumulative Sum of Squared Recursive Residual (CUSUMSq).

4. ANALYSIS OF RESULTS AND DISCUSSION OF FINDINGS

Table 1 (Panel A) shows the description of the variables used. From the table, total government expenditure (TGHE), improved sanitation facilities and life expectancy at birth were positively skewed, while carbon dioxide emissions and mortality rate were found to exhibit negative skewness. Also, all the variables employed in this study (except life expectancy at birth) followed normal distribution as revealed by the Jarque-Bera statistic and the corresponding probability. Similarly, CDE, TGHE, IMS and MRATE were platykurtic in their distributions, while LEXP was found to have excess kurtosis value, suggestive of leptokurtic distribution.

Table 1. Descriptive Statistics (Panel A)

	CDE	THE	IMS	LEXP	MRATE
Mean	74.63	71.84	33.09	244.49	388.62
Median	91.52	34.20	32.90	47.63	389.69
Maximum	106.07	257.72	38.10	5343.00	411.60
Minimum	35.20	0.15	28.64	46.07	356.21
Std.Dev.	27.59	82.76	2.87	1018.94	15.01
Skewness	-0.40	0.99	0.14	4.90	-0.51
Kurtosis	1.33	2.55	1.81	25.03	2.46
Jarque-Bera	3.84	4.64	1.66	654.56	1.49
Prob.	0.14	0.09	0.43	0.00	0.47
Observ.	28	28	28	28	28

Source: Author's Computation Using E-view 9.

From the correlation matrix (Panel B), life expectancy at birth (LEXP) shows a positive correlation with CDE (21 percent) and TGHE (26 percent), and a negative correlation with IMS (-37 percent) and MRATE (14 percent).

Correlation Matrix (Panel B)

	LnCDE	LnTGHE	LnIMS	LnLEXP	LnMRATE
LnCDE	1.0000				
LnTGHE	0.8478	1.0000			
LnIMS	-0.8366	-0.9545	1.0000		
LnLEXP	0.2081	0.2602	-0.3709	1.0000	
LnMRATE	-0.3007	-0.4423	0.6004	-0.1423	1.0000

Source: Author's Computation

4.1. Stationarity test

It has been observed in the literature that time series variables always trend in non-stationary forms (Nelson and Plosser, 1982) and, as such, are prone to spurious regression. To avoid this pitfall, we investigated the stationarity status of the series using the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests. The unit root test outcomes are presented in table 2. The ADF test is premised on minimizing the Akaike information criterion (AIC), while the PP test, the spatial estimation is based on the Barttelt- Kernel method while the band with is obtained based on the Newey-West approach.

Table 2. ADF and PP Unit Root Tests

Variables	ADF Test	ADF		Phillips-PerronTest	PP	
	Level	Critical Values	Remark		Critical Values	Remark
LnCDE	*** -4.2365	-3.7241	I (1)	*** 4.2097	-3.7240	I (1)
LnTGHE	*** -6.1882	-3.7279	I (1)	*** -10.6921	-3.7240	I (1)
LnIMS	*** -7.5737	-37241	I (1)	*** -7.4697	-3.7240	I (1)
LnLEXP	*** -9.2965	-37241	I (1)	*** -142.0653	-3.7240	I (1)
LnMRATE	*** -4.2015	-3.7241	I (1)	*** -4.4014	-3.7240	I (1)

*Source: Author's Computation; Note: *** denote significance at 1 percent*

From the unit root tests results (that is, ADF and PP tests), all the variables became stationary at first difference, and they were all significant at 1 percent level of significance.

4.2. Cointegration test

Basically, cointegration tests are carried out to ascertain the presence (or otherwise) of a long-run relationship among the variables in a regression relation. This study therefore utilizes the methodology advanced by Johansen-Fisher (1990).

Table 3. Johansen-Fisher Cointegration Test Results

Hypothesis		**Test Statistic**	**Critical**	
Null hypothesis	**Alternative**	**P =10**	**5 percent**	**Prob.**
Panel E. λtrace-statistic				
H_o: ϒ = 0	H_1: ϒ≥ 1	193.0714 **	87.31	96.58
H_o: ϒ≤ 1	H_1: ϒ≥ 2	110.1380 **	62.99	70.05
H_o: ϒ≤ 2	H_1: ϒ≥ 3	43.9511 *	42.44	48.45
H_o: ϒ≤ 3	H_1: ϒ≥ 4	21.6745	25.32	30.45
H_o: ϒ≤ 4	H_1: ϒ≥ 4	8.4316	12.25	16.26
Panel F. λmax-statistic				
H_o: ϒ = 0	H_1: ϒ = 1	82.9334*	37.52	42.36
H_o: ϒ≤ 1	H_1: ϒ = 2	66.1868**	31.46	36.65
H_o: ϒ≤ 2	H_1: ϒ = 3	22.2765	25.54	30.34
H_o: ϒ≤ 3	H_1: ϒ = 4	13.2429	18.96	23.65
H_o: ϒ≤ 4	H_1: ϒ = 5	8.4316	12.25	16.26
Notes: Trend assumption: Linear deterministic trend *(**) denotes rejection of the hypothesis at the 5 percent (1 percent) level				

Source: Author's computation.

The procedure provided by the Max-Eigen (λmas) and the Trace (λtrace) tests are for evaluating the number of possible cointegrating equations. However, in the event that the two produce different results, the λmas test is preferred as it has been observed to be more dependable especially in small samples (Dulta and Ahmed, 1997: Odhiambo, 2005). Table 3 presents the results for the Johansen cointegration tests. The test statistic that suggests absence of cointegration among the variables can be rejected. The trace test results show that there are three cointegrating equations, two at the 5 percent level and one at the 1 percent level respectively, while max-eigen value test suggests 2 cointegration equations at the 5 percent and 1 percent level respectively. In all, the results validate the possibilities of advancing with the analytical techniques employed by the study.

4.3. The error-correction model

Having established that the variables are stationary and cointegrated, we specify a parsimonious error correction model with a view to capturing the short-run dynamics that might have ensued in estimating the long-run estimates. The parsimonious error-correction model accomplishes this by incorporating an error-correction factor. In this connection, the error-correction variable enables us to measure the rate of adjustment of life expectancy at birth to its long-run convergence in the event of any shock. Equation 2 presents the error-correction model.

$$\Delta LEXP_t = \alpha_0 + \alpha_{1i} \sum_{i=0}^{1} \Delta LEXP_{t=1} + \alpha_{2i} \sum_{i=0}^{1} \Delta CDE_{t-1} + \alpha_{3i} \sum_{i\ =0}^{1} \Delta TGHE_{t-1} + \alpha_{4i} \Delta IMS_{t-1} + \alpha_{5i} \sum_{i\ -0}^{1} \Delta MRATE_{t-1} + \alpha_{6i} \varepsilon ct_{t-1} \quad (2)$$

Where: εct is the error-correction term, and "Δ" represents the difference of a series, α_1, ……$\alpha_6$are parameters of the model to be estimated. The "i" represents the number of lags included for the first difference of both the dependent and independent variables, while t represents the time period.

Since all the variables in the equation are stationary, estimating the equation by ordinary least squares (OLS) gives consistent estimates (Enders, 1995). Accordingly, we utilize the OLS method, and the model is then tested for stability. However, we had to transform equation (2) by introducing logarithms as that helps to provide stability to the variance of the time series data, just as differencing helps to provide stability to the mean by simply removing seasonality and trend that may occur owing to extreme variations in the data set (Asterious and Hall, 2007; Hyndman and Athanasopoulos, 2013).

Thus, the estimated parsimonious ECM model in a dynamic form utilized in the work is given in equation (3).

$$\Delta \ln LEXP_t = \alpha_0 + \alpha_{1i} \sum\nolimits_{i=0}^{1} \Delta \ln LEXP_{t-1} + \alpha_{2i} \sum\nolimits_{i-0}^{1} \Delta \ln CDE_{t-1} + \alpha_{3i} \sum\nolimits_{i-0}^{1} \Delta \ln TGHE_{t-1} + \alpha_{4i} \sum\nolimits_{i=0}^{1} \Delta \ln IMS_{t-1} + \alpha_{5i} \sum\nolimits_{i-0}^{1} \Delta \ln MRATE_{t-1} + \alpha_{6i} \varepsilon ct_{t-1} \quad (3)$$

Table 4: Parsimonious Error Correction Estimates Dependent Variable: D(LNLEXP) Sample (adjusted): 1991-2017 (Included, observations: 27 after adjustment)

Variable	Coefficient	Std. Error	t-statistic	Prob.
C	1.470	0.421	3.491	0.002**
D(LnCDE)	-0.968	0.426	-2.273	0.034*
D(LnIMS)	3.279	1.229	2.669	0.015*
D(LnHEXP)	0.328	0.107	3.073	0.006**
D(LnMRATE)	52.286	9.778	5.348	0.000**
ECM (-1)	-0.468	0.205	-2.277	0.034*
R-Squared	0.855	Prob. (F.Stat)		0.000
Adj.R-Squared	0.819	Akaike info criterion		1.140
Durbin-Watson. Stat	1.955	Schwarz criterion		1.430
F-Statistic	23.693	Hannan Quinn criterion		1.224

Note: (**) significant at 5 percent and 1 percent, respectively*
Source: Author's computation.

Table 4 contains the parsimonious error correction results for life expectancy (LEXP). From the table, the parameter of carbon dioxide emissions has a statistically significant negative relationship (5percent) with life expectancy at birth in Nigeria. Specifically, the result reveals that 1 percent rise in carbon dioxide emission rate will translate to about 0.97 percent reduction in life span. This result is consistent with such empirical findings like (Deschenes and Greenstone, 2007; Ali and Ahmad 2014; Jerumeh, Ogunnubi and Yusuf, 2015 and Balan, 2016), but in contrast with those of (Delavari, Zandian, Rezaei, Morandinazar, Delavari, Saber and Fallah, 2008, and Monsef and Mehrjardi, 2015). Expectedly, carbon monoxide causes blood clothing, especially when it reacts with haemoglobin, which tends to cut the supply of oxygen in the respiratory system after long exposure. Given the severe implications of these carbon dioxide emissions on the health of a country's citizens, there is the urgent need for the relevant organizations to put in place tighter/stringent control measures aimed at minimizing such likely effects.

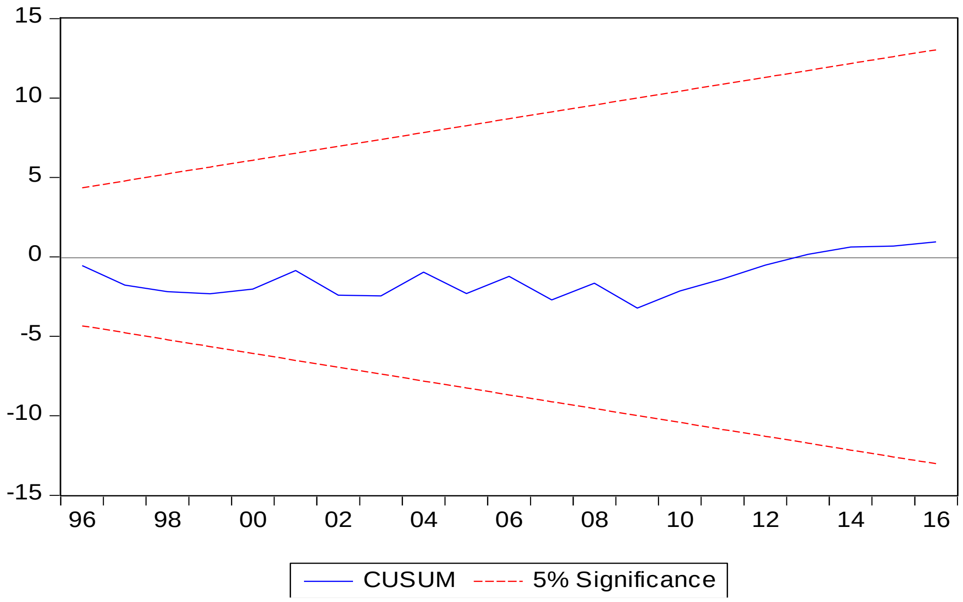
The coefficient of improved sanitation facilities (IMS) was positive and statistically significant at 5 percent level of significance in its impact on life expectancy in Nigeria. Specifically, an improvement in sanitation facilities by 1 percent will bring about 3.28 percent rise in life expectancy in Nigeria. This result is in conformity with those of Keita (2013), Selck and Deckarm (2015) and Popoola (2018) which posit that improvement in sanitation facilities tend to promote life expectancy at birth. This is no surprise because close to 20 percent of the burden of diseases in developing nations (Nigeria inclusive) is traceable to poor sanitation measures (Ene, 2014). Similarly, public expenditure on health was found to be positively associated with life expectancy at birth at 1 percent level of significance during the period under consideration. Thus, a 1 percent rise in public expenditure on health leads to about 0.33 percent rise in life expectancy. This result is consistent with those of Jaba, Balan and Robu (2014), Bein, Unlucan, Olowu and Khalifa (2017) and Ranabhat, Atkinson, Park and Jakovljevic (2018). In contast, the studies by Heuvel and Olarolu (2017) and Rahman, Khanam and Rahman (2018) did not find public health expenditure to be a major determinant of life expectancy at birth in their studies.

Mortality was found to be significantly and positively related to life expectancy. This finding however contradicts our theoretical apriori expectation. Also, the coefficient of one-period lagged error correction term (ECM-1) is appropriately signed. It suggests that about 46 percent of the previous year's shock in like expectancy is offset by periodic adjustment (annually), and this is significant at 5 percent level as shown by the corresponding t-ratio.

4.4. Stability test

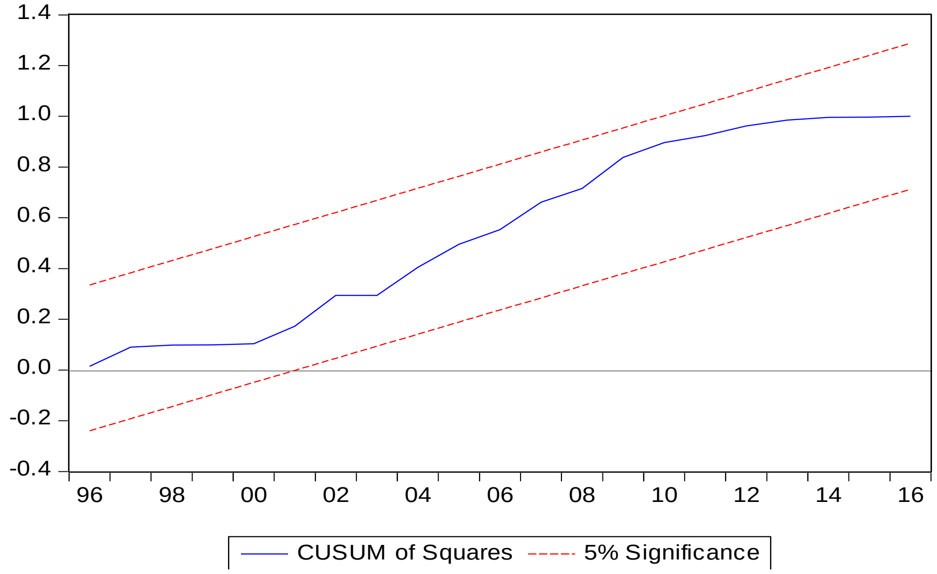
Following the procedure provided by Brown, Durbin and Evans (1975), we examine the stability properties of the life expectancy at birth model using the plots of Cumulative Sum of Recursive Residual (CUSUM) and Cumulative Sum of Squares of Recursive Residual (CUSUMSq). The results are presented in figures 1 and 2.

The rule demands that if CUSUM and CUSUMsq go outside the borders given by the two critical lines, then the parameters are said to be unstable. On the other hand, when they stay within the borders, parameter stability is confirmed. They are both estimated 5 percent critical level. From the figures, both CUSUM and CUSUMsq stay within the 5 percent critical lines, implyingstability of parameters all through the sample period. This suggests, in part, that this finding is relatively robust for policy formulation and analysis purposes.



Source: Author's Computation

Figure 1. CUSUM Test Result



Source: Author's Computation

Figure 2. CUSUM of Squares Test Result

5. CONCLUSION

This study has investigated the nexus between environmental emissions (carbon dioxide) and health outcomes, using life expectancy at birth as a proxy for the latter in Nigeria for the period 1990 to 2016. The estimated results from the parsimonious error correction model suggest that carbon dioxide emissions have statistically significant impact on life expectancy at birth.

The critical role of both improved sanitation facilities and public expenditure on health on life expectancy at birth were clearly confirmed, as increase in both variables was positively associated with the rise in life expectancy. However, mortality rate exhibited a positive relationship with life expectancy at birth, a development that tend to contradict our a priori expectation.

Arising from the foregoing finding, we make the following policy recommendations.

First, there is the pressing need for the government and other relevant agencies to formulate and enforce policies aimed at curbing the emission of carbon into the environment, given its deleterious consequences on human health status and the environment. In this regard, policies aimed at curbing gas flaring for instance, ns should be enforced and modern technology introduced in line with international best practices to help convert such gas being flared into more productive uses.

Second, the importation and use of "Second –hand" products, especially automobiles, should be utterly banned. Though policies are currently in place in this regard but our borders are somewhat porous. To this end, there should effective surveillance of all such entry points of our borders.

Third, the government and other relevant agencies should embark on the sensitization of the Nigerian populace on the need for a clean environment, especially as it affects their health and, by extension, life expectancy. The Nigerian government should ensure that modern sanitation facilities are provided at highly subsidized rates throughout the country, and ensure that they are used for the desired purpose.

Lastly, the present public expenditure on health as a percentage of the GDP is far below international standards. Thus, there is need for the government to significantly raise its expenditure on health with a view to raising the quality of healthcare of the citizenry. In this regard, the government should make healthcare of its citizens a top priority in its policy formulation and execution.

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