

THE SHAPE OF ENVIRONMENTAL KUZNETS CURVE IN THE ANALYSIS OF ENVIRONMENTAL QUALITY

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Abstract

Studies on Environmental Kuznets Curve (EKC), which attempt to investigate the relationship between environmental degradation (pollutions/pollutants like CO₂ emissions) and income per capita employ CO₂ emissions as proxy for Environmental Quality (EQ). They, however, fail to capture the inverse relationship that exists between EQ and CO₂ emissions. The present paper examines the implications of using CO₂ emissions as a measure of EQ in the analysis of EKC shape. Theoretical expositions reveal that with EQ as regressand or EQ on the vertical axis of the growth-emission relationship, the hypothesised inverted-U EKC will transform into U-shaped Environmental Quality Kuznets Curve (EQKC) with similar pollution-income effects. Using CO₂ emission as a proxy for EQ in the quadratic model of dynamic Ordinary Least Square (OLS) technique and employing relevant dataset of Nigeria over the period 1971-2013, this study discovered a U-shaped EKC and the alternative inverted-U shaped EQKC, in contrast to the hypothesised shapes. These findings confirm the existence of lower EQ in Nigeria particularly in the 21st century. The study therefore recommends the formulation and implementation of economic and environmental policies capable of reducing pollution emissions, particularly in the transport, power, and oil and gas sectors of the country.

Keywords: Environmental Quality, Environmental Kuznets Curve, Environmental Quality Kuznets Curve, CO₂ emissions, Energy Consumption

INTRODUCTION

Environmental quality (EQ) is a measure of the conditions and characteristics of the environment relative to the well-being of human existence and the ecosystem in general. Environment is composed of the air, water, noise, space, vegetation, natural and physical structures, pollutions, and all residual wastes in the immediate and remote surroundings. Each of these components creates some effects on human beings, plants, animals, and economic performance at large. According to Jolivi (1981), pollution is the disruption in the natural equilibrium of the environment. Pollution is a measure of EQ with inverse relationship. EQ is a stronger term to describe the environment. Better EQ is characterised by lower pollution level while higher pollution level signals poor EQ.

The Environmental Kuznets Curve (EKC) explains how emissions or environmental degradation (ED) arising from economic activities initially increases, reaches a maximum, and thereafter nose-dives as the economy records growth over time. The growth-emission relationship as illustrated by the EKC is helpful in understanding whether or not a country, region, or a set of countries is on the path of sustainable development.

Following Grossman and Krueger (1991), and Panayotou (1993) among others, analyses of EKC shapes in the literature are based on the relationship existing between income and CO₂ emissions rather than between income and EQ. Positive relationship between the former implies negative relationship between the latter, and vice versa. Where the former results in the hypothesised inverted-U EKC, the latter does not. Grossman and Krueger (1991) analysed the relationship between two pollutants, sulfur dioxide (SO₂) and smoke, as the first reference to the original inverted-U shaped curve of Kuznets (1955) while Panayotou (1993) first coined EKC to describe the relationship between ED and income.

The literature is replete with studies on EKC after the original Kuznets curve was extended to growth-emission analysis. As works on EKC increase, the term *environmental quality* was introduced and used, freely and unconsciously, to explain the hypothesised EKC, but without any particular attention to the inverse relationship existing between EQ and all pollutants. Such studies include Dinda (2004); Mukherjee and Chakraborty (2009); Omisakin (2009); Ajide and Oyinlola (2010); Chakraborty and Mukherjee (2010); Constantini and Martini (2010); Dellachiesa (2010); Omojolaibi (2010), Alege and Ogundipe (2013); and Oshin and Ogundipe (2015). Dellachiesa (2010); Chakraborty and Mukherjee (2010); and Alege and Ogundipe (2013) depicted the EKC with EQ or Environmental Performance Index (EPI) on the vertical axis. Though EQ or EPI is inversely related to pollution, the authors still unconsciously analysed the growth-emission relationship in terms of the inverted-U EKC.

In the literature, pollutants are regarded as indicators or indices of EQ (Fare *et al.*, 2001; and Dinda, 2004). Alpay (2003), Constantini and Martini (2010), Chakraborty and Mukherjee (2010), Agliardi and Pinar (2012), and Strong (2013) frown at using a single pollutant as an indicator of EQ, and recommend the use of composite index. Strong (2013) displayed a better understanding of the inverse relationship between EQ and pollution by stating that growth-emission analysis could result in *U-shaped curve between income and EQ*, or the *inverted-U EKC between income and pollution*. Nevertheless, Strong (2013) found inverted-U shaped EKC for emissions, and emissions toxicity on income per capita without any reference to EQ.

The foregoing observations in the EKC literature, particularly in some of the recent studies, raise some mind-probing questions. For instance, what is the true shape of EKC? Can all the U-shaped or all the inverted-U shaped relationships between income and EQ be referred to as EKC? If ED translates to pollution, are EQ and CO₂ emissions equivalent measures of pollution? This study provides answers to these questions, and examines the shape of the

growth-emission nexus with a special focus on EQ, using Nigeria as a case study. Specifically, the analysis is extended to EQ, which some past studies failed to reveal.

Following this introduction, the next section provides a review of the existing relevant literature. The third and fourth sections of this study deal with methodology and discussion of empirical results, respectively, while the conclusion is presented at the end of the study.

LITERATURE REVIEW

Theoretical Dimensions

The EKC has been rationalised with reference to stages of growth hypothesis, the role of technical progress, and the consideration on EQ as a luxury good for individuals (Galeotti, 2002). According to Rostow (1960), the five stages of growth are the (i) traditional society, (ii) pre-conditions for take-off, (iii) take-off, (iv) drive to maturity, and (v) higher massive consumption. The first two stages represent a clean agrarian economy with no pressure on the environment. The rapid growth occurring at the take-off stage through the process of industrialisation results in greater use of natural resources, and pressurizes the environment. At the fourth stage, the rate of resource depletion begins to exceed the rate of natural resource replenishment, constituting greater environmental concern. Pasche (2002) notes that at the final stage of development, the structural change towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology, and higher environmental expenditures result in gradual decline in ED similar to EKC analysis.

The aggregate pollution effect of economic growth processes on the environment has been attributed to three transitional mechanisms (Grossman and Krueger, 1991). They are scale effects from production volume, composition effects resulting from output mix in different sectors, and technique effects from technological improvement. The economy tends to shift towards less polluting industries and technologies as economic growth occurs. Pollution intensity is not the same across all sectors; and unlike developed countries, developing countries tend to attract pollution-intensive industries in the effort to encourage more foreign direct investment (FDI). However, the shift towards service FDI generally has a positive effect on the environment. Technological improvement has effect on both output and the environment. Diverse techniques can be used to produce a given product, some cleaner than others. Porter and van der Linde (1995) observed that the technique effect results in net positive effect if environmental laws encourage innovation. These three effects yield the hypothesised EKC.

EKC and the Determinants of the Shape

While economic growth constitutes increase in emissions from economic activities, the use of green technology can yield lower pollution level, and thus improve EQ (Antel, 1993). The EKC captures the interaction of these two scenarios in economic growth process. The EKC is illustrated with income on the horizontal axis and ED or pollutants on the vertical axis. Moving up the vertical axis indicates increase in ED, which is undesirable for sustainable development. ED is a direct measure of pollution. Hence, EKC is specifically pollution/ED exposition rather than an EQ one. Pollution Kuznets Curve (PKC) or Environmental Degradation Kuznets Curve (EDKC) would have been an appropriate term for the EKC because the term *environmental* in the EKC has wider scope than it does in ED or pollution. Placing EQ on the vertical axis is rare, although the use of EQ as dependent variable with CO₂ emissions as proxy is common. Some of the studies, which fall within this category

placed CO₂ emissions on the vertical axis and interpreted it as EQ unconsciously, forgetting the inverse relationship between the two concepts. With EQ on the vertical axis, movement upward along the axis means improvement in EQ, or decrease in pollutions. Dellachiesa (2010), and Alege and Ogundipe (2013) placed EQ on the vertical axis to illustrate the inverted-U EKC in which increase in EQ translates to high pollution levels.

When EQ is depicted on the vertical axis, the analysis is reversed and the curve takes a U-shape, which is completely opposite of the hypothesised EKC. The growth-emission relationship resulting from EQ and income per capita has been termed Environmental Quality Kuznets Curve (EQKC) by Posu (2014). EQKC indicates that EQ first decreases, reaches a turning point at a minimum, and then begins to rise as income per capita increases across the entire period of economic growth process. Figures 1 and 2, respectively, show hypothetical illustrations of the bell-shaped EKC, and the emerging U-shaped EQKC. Inverted-U shaped EKC is equivalent to U-shaped EQKC.

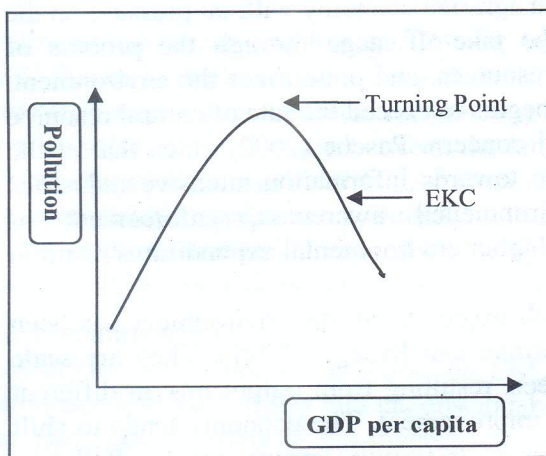


Figure 1: Hypothetical Environmental Kuznets Curve (EKC)

Source: Grossman and Krueger (1991)

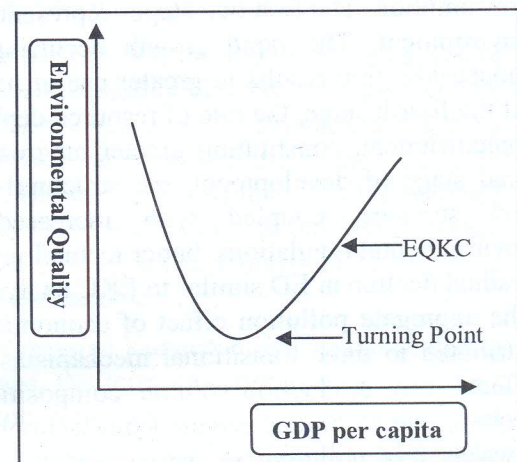


Figure 2: Hypothetical Environmental Quality Kuznets Curve (EQKC)

Source: Posu (2014)

Different studies have emerged with variants of the hypothesised inverted-U shaped curve. The bell shape of the EKC has been attributed in the literature to scale, composition, and technique effects in economic transformation processes. These effects and the resulting pollution intensities differ across countries, regions, and sectors. Pollution intensity also depends on the types of goods or services, production technique, and development stage of the economy among others. These factors are responsible for the mixed results on the validity of the EKC. The mixed results from the relationship between different indicators of pollution and income per capita include linear, inverted-U shaped (Tamazian *et al.*, 2009; Shahbaz *et al.*, 2011), U-shaped (Omisakin, 2009; Shahbaz, 2012), N-shaped (de Bruyn *et al.*, 1998; Mazzanti *et al.*, 2007), inverted-N (Akpan and Chuku, 2011), and even mirror-side S or lazy-S-shaped curves (Strong *et al.*, 2011).

Mazzanti *et al.*, (2007) observe that there is no single EKC dynamic. Some pollutants could produce inverted-U shaped curves while others could show monotonic or even N-shaped relationship arising from different specifications. The dynamics could be due to period of observation; location; sector; and emission types. The authors show that services tend to depict inverted-N shape while manufacturing, like all industries, shows a mix of inverted-U and inverted-N shapes, depending on the type of emissions. The shape can also be influenced by methodology and estimation techniques; heterogeneity across sectors and location as well as adequacy and quality of data.

Economic activities generate series of emissions. From the initial exposition on EKC, different emission types, in relation to income per capita, have been employed to investigate the concept. Grossman and Krueger (1991) explored changes in SO₂, smoke, and suspended particulate matters (SPM). Shafik and Bandyopadhyay (1992) examined total annual deforestation, lack of clean water, lack of urban sanitation, ambient levels of SPM, ambient sulfur oxides, change in forest area, dissolved oxygen in rivers, fecal coliforms in rivers, municipal waste per capita, and carbon emissions. Selden and Song (1994) considered SO₂, nitrous oxide (NO_x), SPM, and carbon monoxide (CO) while Cropper and Griffiths (1994) investigated the rate of deforestation. Lantz and Martínez-Espínheira (2008), and Strong *et al.*, (2011) used bird biodiversity to investigate the EKC hypothesis. Majority of the studies on EKC, actually, adopt CO₂ emissions per capita. The literature on growth-environment nexus classified CO₂ emissions as global air pollutant while SO₂, CO, and NO_x are three major local air pollutants (Selden and Song, 1994; and Wagner, 2008) but time series data on local pollutants are not readily available in most developing countries. Bernauer and Koubi (2006) observe that CO₂ as a measure of air quality is regarded as the most important indicator of EQ. It is the most concentrated gas in the atmosphere, and may take up to a century or more to dissipate (Cotton and Pielke, 2007; IPCC, 2007). IPCC (2007) shows that other greenhouse gases are measured in CO₂ equivalence.

Empirical Review

Review of empirical literature focuses on the shape of EKC, particularly when EQ is the regressand. A good number of studies use CO₂ emissions as proxy for EQ where EQ is the dependent variable and/or is included as keywords in the title of the study. Nevertheless, in the analysis, they fail to capture the inverse link between EQ and pollution. Such studies analysed EQ as having direct link with CO₂ emissions.

Lantz and Feng (2006) assessed the impacts of GDP, population, and technology on CO₂ emissions in five different regions within Canada. The dataset comprises CO₂ emissions, GDP per capita, and other covariates for Canada over 1970–2000. Using panel estimation, and Generalised Least Square (GLS) technique, the authors found that income per capita is not related to CO₂ emissions. Omisakin (2009) investigates the relationship between economic growth and CO₂ emissions in Nigeria, employing time series data of 1970–2005. The author estimates CO₂ emission per capita on GDP per capita, its squared term, and a set of covariates applying OLS estimator. The study establishes a U-shaped relationship and depicts the curve on CO₂ emission per capita and GDP. The author however, failed to explain the inverse relationship between EQ and CO₂ emissions after *specifying the model in terms of EQ*. The results of the model translate to inverted-U EQKC between EQ and GDP. Alege and Ogundipe (2013) also failed to spot the link between EQ and CO₂ emissions. The authors even define EKC as ‘an inverted-U shaped hypothesis existing between income and EQ’. Such a definition seems inconsistent because the hypothesised EKC establishes an inverted-U curve between pollution/pollutants/ED and GDP. Alege and Ogundipe (2013) added that as ‘pollution increases, EQ deteriorates’ but erroneously illustrated a ‘hypothetical inverted-U EKC’ with EQ on the vertical axis.

Other authors that are not fully conscious of the inverse relationship between EQ and CO₂ emissions include Dinda (2004), Constantini and Martini (2010), Chakraborty and Mukherjee (2010), Choi *et al.*, (2010), Dellachiesa (2010), and Strong (2013). Choi *et al.*, (2010) freely use the concept of EQ, and like Alege and Ogundipe, the authors took no cognisance of the relationship between CO₂ emissions and EQ. The authors employ CO₂ emissions as proxy for EQ with further explanation that ‘CO₂ emissions represent better EQ when CO₂ emission is

lower'. Though the model was specified in terms of EQ, the empirical findings were interpreted with respect to CO₂ emissions only. Strong (2013) consistently used EQ as an inverse of pollution but the empirical findings were interpreted in relation to CO₂ emissions only, without any reference to EQ. Constantini and Martini (2010) consistently adopt the term EQ but remain silent on its relationship with CO₂ emissions.

Dellachiesa (2010) used EQ to explain pollution level in reference to the hypothesised EKC. The author employed eight (8) different diagrams (labeled as Figures 1.14 through 1.21) to 'show an inverted-U shape between environmental quality and all measures of economic activity selected'. The author concluded that the diagrams 'are consistent with the inverted-U shaped relationship between per capita income and pollution emissions...' While the diagrams are true illustration of the hypothesised EKC, the author was wrong in describing the relationship as being between EQ and the economic activities. With EQ in the analysis, the curve will no longer be inverted-U EKC but U-shaped EQKC.

Chakraborty and Mukherjee (2010) is a study with a little difference and better understanding on the implication of using EQ in growth-emission relationship. The authors specify EPI as the dependent variable and note that ED is negative of EPI. Higher EPI implies better EQ. With EPI on the vertical axis, they obtained a regression curve that has inverted-U shape 'which is opposite to the EKC hypothesis prediction' with no specific name given to it. This implies that the inverted-U shape curve does not translate to inverted-U EKC. Since EPI and EQ are positively related, the curve is inverted-U EQKC.

METHODOLOGY

The methodology adopted for this study stems from the previous related studies by Mazzanti *et al.*, (2007); Choi *et al.*, (2010); and Shahbaz (2012) on growth-emissions nexus. The function is given as

$$EQ_t = f(GDPC_t, FDI_t, DMV_t, TRAD_t, EGYC_t, FDEVG_t) \quad (1)$$

EQ_t is environmental quality in the ambit of air quality. CO₂ emission in metric tons (mt) per capita is the measure of EQ. $GDPC_t$ represents real Gross Domestic Product per capita. FDI_t indicates the inflow of foreign direct investment. DMV_t implies the stock of domestic investment proxied with gross capital formation. $TRAD_t$ stands for trade intensity, which is the ratio of the sum of exports and imports to GDP. $Egyct$ is energy consumption per capita, and $FDEVG_t$ captures financial development with respect to access and the ease with which funds are available for economic activities. It is the domestic credit to private sector as a percentage of GDP. Subscript t represents time. Relevant data on the variables were obtained from World Development Indicator (WDI) of the World Bank (2014), and Statistical Bulletin of the Central Bank of Nigeria (2013).

Taking the natural logarithm of only the series stated in actual units of measurement, and introducing a one-year lag, equation (1) is transformed into a linear model of the type

$$\begin{aligned} \ln EQ_t = & \gamma_0 + \beta_1 \ln GDPC_{t-1} + \gamma_2 \ln GDPC_{t-1}^2 + \gamma_3 \ln FDI_{t-1} + \gamma_4 \ln DMV_{t-1} + \\ & \gamma_5 \ln TRAD_{t-1} + \gamma_6 \ln EGYC_{t-1} + \gamma_7 \ln FDEVG_{t-1} + \mu_t \end{aligned} \quad (2)$$

where μ_t is the stochastic error term, which is assumed normally distributed with zero mean and constant variance. The theoretical signs of the parameters are displayed in Table 1.

Table 1: *A Priori* Signs

Variable	GDPC	GDPC ²	FDI	DMV	TRAD	EGYC	FDEVG
Parameter	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	γ_7
Expected Sign	+	-	+	+	+	+	+

Source: Authors' Compilation

EMPIRICAL RESULTS AND DISCUSSIONS

Clemente-Montanes-Reyes (CMR, 1998) developed a composite test capable of capturing two structural break points endogenously, and testing unit root in the series. Perron (1989) observes that the presence of structural breaks in series renders ADF and PP unit root tests invalid. The results of CMR tests are reported in Tables 2 and 3. The series indicate one break point each possibly due to the relative small sample size of 43 years. The structural break in the dependent variable occurred in 1987, which is attributable to the Structural Adjustment Programme introduced in the preceding year. Trade intensity has structural break in the same year as EQ. Structural break occurred in EGYC, GDPC, DMV, and FDI in 1974, 1979, 1981, and 1984, respectively. Financial development is the only regressor having structural break in the 21st century (i.e. 2005), which may not be unconnected with the bank recapitalisation policy in the country some two years earlier. Accordingly, Structural Break Dummy (SBD) is introduced to capture the effect of the break in the regressand. The unit root tests show that the dependent variable and all explanatory variables, except log(GDPC), are stationary at first difference, while log(GDPC) is stable at level.

Table 2: Results of CMR Structural Break Tests

Variables	Level			
	Coefficient	t-statistics	5% critical value	Break Year
Log(envq)	-0.190	-2.529**	0.016	1987
Log(gdpc)	0.971	4.191***	0.000	1979
Log(fdi)	0.851	2.128**	0.041	1984
Log(egyc)	0.000	----	----	1974
Log(dmv)	-0.693	-2.861***	0.007	1981
Trad	31.343	3.736***	0.001	1987
Fdevg	11.105	5.538***	0.000	2005

Note: ***<0.01, and **<0.05

Source: Authors' Compilation

Table 3: Results of CMR Unit Root Tests

VARIABLES	LEVEL			FIRST DIFFERENCE			
	Coefficient	t-statistics	5% critical value	Coefficient	t-statistics	5% critical value	Order of Integration
Log(envq)	-0.420	-3.432	-4.270	-1.173	-8.096	-4.270	I (1)
Log(gdpc)	-0.430	-5.298	-4.270	-0.956	-11.156	-4.270	I (0)
Log(fdi)	-0.295	-2.462	-4.270	-1.018	-6.251	-4.270	I (1)
Log(egyc)	-0.363	-3.440	-4.270	-1.204	-6.745	-4.270	I (1)
Log(dmv)	-0.118	-2.863	-4.270	-2.226	-5.340	-4.270	I (1)
Trad	-0.888	-4.240	-4.270	-1.607	-5.344	-4.270	I (1)
Fdevg	-0.449	-3.459	-4.270	-2.306	-8.656	-4.270	I (1)

Source: Authors' Compilation

From the regression results in Table 4, R^2 shows that the explanatory variables account for about 77.1% variation in EQ. The F-statistic and its p-value, 12.623(0.000), reject the null hypothesis at all levels of significance that all the slope coefficients in the regression are zero.

All the parameter estimates except DMV have the right signs. The results show that GDPC, $(GDPC)^2$, $TRAD(-2)$, EGYC, and SBD are statistically significant. GDPC exhibits a negative sign while a positive relationship holds between GDPC squared and CO_2 emission.

The coefficient of GDPC is negative and statistically significant, implying that a decrease in GDPC will cause CO_2 emissions to rise, and thereby degrade the environment. In recognition of the inverse relationship between EQ and CO_2 emissions, a 10% increase in GDPC will improve EQ by 37.76%. The coefficient of GDPC squared is statistically significant and positively related to CO_2 emissions. This implies that GDPC squared is associated with poor EQ. CO_2 emission will increase by 2.59% given a 10% increase in GDPC squared, and accordingly degrade EQ by 2.59%. Thus, the quadratic estimation of the EKC model shows that EQ first improves, and deteriorates later with GDPC squared. This finding of this study is consistent with Ajide and Oyinlola (2010), Korves *et al.*, (2011), and Shahbaz (2012) only in terms of the U-shaped growth-emissions relationship but different in the analysis of EQ (with CO_2 emission as only a proxy) leading to inverted-U EQKC just emerging in the literature on growth-emissions.

Table 4: Regression Results

Dependent Variable: LOG(EQ)			
Variable	Coefficient	t-Statistic	Prob.
C	-24.9666**	-2.7452	0.0101
LOG(GDPC)	-3.7763***	-2.9526	0.0061
LOG(GDPC) ²	0.2594***	2.7868	0.0091
LOG(FDI)	-0.0287	-0.6242	0.5372
TRAD(-2)	-0.0089***	-3.6254	0.0011
FDEVG	-0.0035	-0.5602	0.5795
LOG(DMV(-3))	-0.0177	-0.5147	0.6106
LOG(EGYC)	6.0368***	4.1763	0.0002
SBD	-0.4060***	-2.8842	0.0072
R ² :	0.77097	F-statistic	12.6233
Adj R ² :	0.70989	DW stat	1.7634
Diagnostic Tests (p-value)			
Jarque - Bera	0.414 (0.813)		
LM	1.467 (0.248)		
BPG	1.706 (0.323)		
RESET	0.922 (0.364)		

***, and ** denote statistical significance at 1%, and 5%

Source: Authors' Compilation

Focus on the inverse relationship is quite important in any study that makes CO_2 emissions as a proxy for EQ. The findings of this study based on the quadratic model shows that Nigeria has (i) U-shaped EKC because of the positive relationship between GDPC and CO_2 emissions, but (ii) inverted-U shaped EQKC when the negative relationship between GDPC and EQ is the basis of analysis.

Trade intensity improves EQ; however, FDI is not significant. Energy use per capita leads to increase in CO_2 emissions and reduces EQ. A statistically significant negative relationship exists between the structural break dummy and CO_2 emission. The structural shift led to decrease in CO_2 emission and consequently improved EQ.

The results of the diagnostic tests are reported in the third segment of Table 4. The test on normal distribution of the residuals using the JB statistic is 0.414 with a p-value of 0.813. Therefore, the null hypothesis cannot be rejected since the test shows that residual errors in the quadratic EKC/EQKC model are normally distributed. The F-statistic from the LM test is 1.467(0.248). The p-value is above 5 percent, and therefore fails to reject the null hypothesis

of no serial correlation in the residuals. Similarly, the Breusch-Pagan-Godfrey Heteroskedasticity test statistic is 1.706(0.323). It indicates that constant variance exists in the residuals. The null hypothesis of homoskedasticity cannot be rejected. The RESET statistic is 0.922(0.364). It rejects the null hypothesis of all coefficients being zero.

Tables 5 and 6 present the Johansen cointegration tests on the quadratic model with deterministic and non-deterministic trends respectively. The cointegration rank test in each table is reported with the trace statistic and maximum-eigenvalue statistic. Considering the deterministic cointegration test at 5% level of significance, the trace statistic indicates at most 3 cointegrating equations while the maximum-eigenvalue statistic identifies at most 1 cointegrating equation. In the non-deterministic trend, at most 2 cointegrating equations exist when considering trace statistics, while at most 1 cointegrating equation exists when maximum-eigenvalue is used. Since one cointegrating relation is enough to prove that long-run relationship exists in the model, the results validate the interpretation and analysis on the quadratic EKC/EQKC model for Nigeria over the period 1971-2013.

Table 5: Deterministic Johansen Cointegration Test

Trace statistic					Maximum Eigen value				
No. of CE(s)	Eigen value	Trace	Critical Value	Prob†	No. of CE(s)	Eigen value	Max-Eigen	Critical Value	Prob†
None *	0.859	224.477	159.530	0.000	None *	0.859	78.226	52.363	0.000
At most 1 *	0.696	146.251	125.615	0.002	At most 1*	0.696	47.577	46.231	0.036
At most 2 *	0.504	98.674	95.754	0.031	At most 2	0.504	28.060	40.078	0.558
At most 3 *	0.478	70.613	69.819	0.043	At most 3	0.478	26.006	33.877	0.320
At most 4	0.364	44.607	47.856	0.098	At most 4	0.364	18.133	27.584	0.484
At most 5	0.277	26.474	29.797	0.115	At most 5	0.277	12.973	21.132	0.455
At most 6	0.232	13.501	15.495	0.098	At most 6	0.232	10.537	14.265	0.179
At most 7	0.071	2.964	3.841	0.085	At most 7	0.071	2.964	3.841	0.085

† Probability reported at 5% significance level

Source: Authors' Compilation

Table 6: Non-Deterministic Johansen Cointegration Test

Trace statistic					Maximum Eigen value				
No. of CE(s)	Eigen value	Trace	Critical Value	Prob†	No. of CE(s)	Eigen value	Max-Eigen	Critical Value	Prob†
None *	0.711	185.857	143.669	0.000	None *	0.711	49.628	48.877	0.042
At most 1 *	0.690	136.229	111.781	0.001	At most 1 *	0.690	46.864	42.772	0.017
At most 2 *	0.549	89.365	83.937	0.019	At most 2	0.549	31.867	36.630	0.162
At most 3	0.384	57.498	60.061	0.081	At most 3	0.384	19.369	30.440	0.588
At most 4	0.341	38.129	40.175	0.079	At most 4	0.341	16.683	24.159	0.367
At most 5	0.266	21.446	24.276	0.109	At most 5	0.266	12.392	17.797	0.270
At most 6	0.198	9.054	12.321	0.166	At most 6	0.198	8.848	11.225	0.127
At most 7	0.005	0.206	4.130	0.706	At most 7	0.005	0.206	4.130	0.706

† Probability reported at 5% significance level

Source: Authors' Compilation

CONCLUSION

Environmental degradation (ED) and environmental quality (EQ) are two terms normally employed in the EKC literature to describe the level of pollutions. Economic activities in the form of production, distribution, and consumption generate series of residual wastes into the environment. Degree of pollution intensities differ across countries, regions, and sectors. Pollution intensity depends on type of economic activity, goods produced or service rendered, production technique, and level of economic development among others. Various pollutants used in the EKC literature include CO₂ emissions, SO₂, smoke, SPM, deforestation, water

quality, urban sanitation, change in forest area, dissolved oxygen in rivers, fecal coliforms in rivers, municipal waste per capita, NOx, CO, and bird biodiversity.

In the effort to find support for the EKC, CO₂ emissions per capita has been the most commonly used indicator of pollution possibly because of data availability, and because it is the strongest global air pollutant. EQ or EPI is rarely employed. A few studies that use EQ as dependent variable fail to interpret their empirical findings in recognition of the inverse relationship between ED and EQ. The hypothesised EKC gives a direct exposition on pollution or ED but an indirect one on EQ. Pollution Kuznets Curve (PKC) or Environmental Degradation Kuznets Curve (EDKC) would have been a proper term for the EKC. Posu (2014) hypothetically illustrates Environmental Quality Kuznets Curve (EQKC) to capture the inverse relationship between EQ and other pollutants with a U-shaped curve.

Empirical investigations on the growth-emission relationship in Nigeria for the period 1971-2013 reveal a U-shaped EKC and the alternative inverted-U shaped EQKC. The quadratic model confirmed the existence of lower EQ particularly in the 21st century in Nigeria. Accordingly, the study failed to find support for the hypothesised EKC/EQKC to show that increase in national income per capita first improved EQ, and later degraded the environment. This study reveals that economic growth processes in Nigeria have not made the country to reach the turning point that will usher in improved EQ, possibly because enforcement of environmental stringency is still a mirage in the nation. The study therefore recommends formulation and implementation of economic and environmental policies capable of reducing pollution emissions in the country, particularly in the energy, transport, and oil and gas sectors of the economy.

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