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Abstract

The Environmental Kuznets Curve (EKC) hypothesis posits that ecological degradation as a result of different pollutants upsurges at the primary stages, but declines as the economy attains a particular level of economic growth, determined by considering the per capita income of that economy. This hypothesized association results in an inverted U-shaped curve. The hypothesis has become a critical area of concern amid scholars who study environmental guidelines hence drawing much enquiry attention for both established and developing economies. This study examines the environmental Kuznets curve (EKC) hypothesis in Kenya using the time period of 1970–2015 relying on data from Energy Information Administration database and World Bank's World Development Indicators database. The study utilized the Autoregressive Distributed Lag (ARDL) model to achieve the objective of this study. The study sought to address this challenge of climate change by examining the macroeconomic factors that are responsible in increasing environmental pollution and recommend appropriate policies for stable and sustainable economic growth and development in line with Kenya's vision 2030. With the application of bounds test, the findings of this study confirmed the presence of a long run equilibrium relationship between the variables under study. Applying the Narayan and Narayan 2010 approach, the study determined that the short run coefficient 0.035 ($p < 0.05$) is weaker than the long run coefficient 0.207 ($p < 0.05$) confirming the absence of EKC in Kenya. This implies that there is no evidence of positive effect of economic activities on emissions in Kenya. This therefore means that EKC hypothesis is not significant for formulating policy in Kenya given its stumpy level of economic development. In terms of policy implication of these findings, intensifying economic activities in the country may not extremely result into carbon emissions. However, it should be noted that there will be no environmental paybacks from ill-using the environment in the name of economic growth. The study therefore recommends that in order to ensure sustainable development, Kenyan policymakers should make significant investments on appropriate environmental policies alongside economic development policies in order to achieve positive results regarding environmental quality along with the economic growth.

1.0 Background Information

Economic growth and development is an important goal for all developing countries to catch up with developed economies. On the other hand, economic expansion generally causes environmental degradation mainly from CO_2 emissions due to industrial development. Consequently, implementation of appropriate policies in relation to ending of environmental degradation without impairing economic development in the country is fundamental for policy makers. The increase in economic growth significantly results to increased demand for energy levels to sustain industrial development. The increase in gross domestic product therefore demands for increased energy supply to meet the rapid demand especially in the major areas that are sustaining economic growth for instance infrastructural development, agricultural machinery and industrial developments. The energy mix in Kenya is skewed to developing renewable energy sources alongside increasing energy production. The government has implemented energy proposals targeting developing renewable energy and restoration of forests in Kenya. The policy implementations anchored on the Environment Management and Co-ordination Act (Amendment No. 5 of 2015) was enacted with the aim of entrenching the county governments in environment and natural resource management. The 21st session of the UN Climate Change Conference (COP 21) took place in France's capital in 2015. A major outcome of the conference was the consensus to edge global warming to less than 2° Celsius. The overall electricity connectedness rose by 6.3 percent to 2,333.6 MW in 2015, whereas aggregate electricity production stretched by 4.1 percent to 9,514.6 KWh in the matching period. Power demand rose to 7,826.4 million KWh in 2015 from 7,415.4 million KWh in 2014 (Kenya National Bureau of Statistics, 2016). The high demand for electricity attributed to the increased investments in the country coupled with increase in population with government implementing the last mile electricity program to bring more homesteads on the grid.

Total petroleum products' demand upsurge to 4,742.7 thousand tons in 2015, chiefly as a result of the growing of local demand for illuminating kerosene, motor gasoline and light diesel oil which upsurge by 29.9, 22.5 and 20.9 percent, respectively. Light diesel oil, the key kind of fuel sold in the country, measured up to 43.9 percent of the aggregate domestic demand in 2015. Consumption of fuel for power generation declined by more than 60.0 percent to stand at 32.3 thousand metric tons. The transportation segment (roads and aviation - excluding government) remain the leading user of petroleum products, conjointly measuring up to 85.5percent of the cumulative sales in 2015 up from 84.3 per cent in 2014 (Kenya National Bureau of Statistics, 2016). CO_2 releases from residential buildings and commercial and public services (percent of cumulative fuel ignition) have decreased over the last four decades from highs of 15percent in 1980 to 7.3percent representing over 100percent. The decline is attributed to adoption of more renewable sources of energy supported by government interventions and economic development that places such resources at the disposal of the general public. CO_2 emissions from electricity and heat fabrication (percent of aggregate fuel ignition) averaged 9.33percent for the period 1980 to 1990. The following decade experienced an increase of emissions to an average of 21.99percent which proclaims the ambitious plan to increase electricity production (The World Bank, 2016). The increasing threat of air pollution and global warming has also been widely discussed in various international reunions. As per the Intergovernmental Panel on Climate Change (IPCC), carbon dioxide emissions (CO_2) are the major source of global warming. IPCC (2007) projected a global temperature increment from 1.1° to 6.4° and 16.5 to 53.8 cm rise in sea level by 2100. CO_2 emission as a main source of greenhouse gases is mainly indorsed to energy consumption mostly, fossil fuels burning such as oil and gas. Unlike other gases such as SO_2 and NOx, CO_2 emission spreads beyond the borders to other countries and indirectly affect the health, thus a country is likely to be less incentive in CO_2 emission reducing especially during rapid economic expansion period.

However, the emissions of greenhouse gases are not falling yet the effects of climate change are worsening. The situation may worsen due to the recent United States withdrawal from the Paris climate agreement yet the US contributes about 15% of global emissions of carbon, but it is also a significant source of finance and technology for developing countries in their efforts to fight rising temperatures.

Much more still needs to be done to address this challenge proactively mainly in African countries where 70 percent of the population is dependent on rain-fed, smallholder agriculture. The study sought to address this challenge of climate change by examining the macroeconomic factors that are responsible in increasing environmental pollution and recommend appropriate policies for stable and sustainable economic growth and development in line with Kenya's vision 2030.

1.1 Statement of the Problem

Environmental pollution challenges are adverse stretching from famine, swamping, amplified insecurity as a result of insufficiency of basic resources such as water and food. Ensuring sustainable economic development is the primary goal of any economy in ensuring that the benefits resulting from agricultural modernization, increase in the production and use of different energy mix do not adversely impact the environment. Kenya's growth has been associated with structural changes such as the decline in agriculture, rapid population and urbanization of town centres, and environmental degradation including increase of CO_2 emissions over the years. Despite its gradual economic growth, the Kenyan economy faces the challenges in attaining balanced environmental development. Therefore, the appropriate utilization of resources is important for the environmental protection and also ensure economic growth. This therefore, indicates that Kenyan policymakers should make significant investments on appropriate policies in order to achieve positive results regarding environmental quality along with the economic growth. These developments therefore motivated this study with an aim to investigate the relationship between economic growth and environmental quality since environmental concerns are making their way into main public policy agenda. The analysis of environmental effects arising from different macroeconomic factors under the Environmental Kuznets model is yet to be explored hence the scanty literature on the subject.

1.2 Empirical Literature Review

Kang *et al*., (2016) examined the CO_2 EKC theory of China. Their outcomes revealed that the connection among economic growth and CO_2 emissions comes out as an inverted-N trajectory. Li, Wang, and Zhao (2016) applying a panel of 28 provinces of China from 1996 to 2012. They found out that the Environmental Kuznets Curve (EKC) theory is sufficiently supported for all the three chief pollutant emissions in China across diverse models and approximation techniques. Paramati, Alam, and Chen (2016) empirically confirmed evidence of the EKC proposition on the link amid tourism growth and CO_2 emissions. Javid and Sharif (2016) affirmed the presence of an EKC in Pakistan both in the short and long term. Al-Mulali *et al*., (2016) scrutinized the reality of EKC hypothesis in Kenya for the period, 1980-2012. Using ARDL and applying the Narayan and Narayan (2010) approach to regulate the multicollinearity, they confirmed that EKC exists in Kenya. Farhani and Ozturk (2015) inspected the causal association amid CO_2 emissions, real GDP, energy utilization, financial development, trade openness, and urbanization in Tunisia over the time of 1971–2012. Their outcomes did not bolster the legitimacy of EKC theory. Mistri and von Hauff (2015) assert that no EKC relationship exists with the measured indicators in the Indian setting. Yang *et al*., (2015) revisited the legitimacy of the EKC theory in light of information for seven polluting agents in 29 Chinese provinces from 1995 to 2010. Their test revealed that the EKC proposition cannot be viewed as legitimate for any of the seven emission indicators. Ozturk and Al-Mulali (2015) study did not confirm the presence of EKC in Cambodia. Applying autoregressive distributed lag bounds testing technique from 1971 to 2008, Shahbaz *et al*., (2015) affirmed the existence of EKC theory in both the short-run and long-run. Further, Shahbaz *et al*., (2015) used the Pedroni cointegration test and Johansen cointegration test to analyze the relationship between economic growth, energy intensity and CO_2 emissions in 12 African nations for the period, 1980–2012. The outcomes demonstrate that while EKC theory is available at panel level, it is available in just South Africa, Congo Republic, Ethiopia and Togo. Arouri *et al.*, (2014) investigated the presence of EKC in Thailand over the time of 1971-2010. Their results confirmed the reality of an EKC for Thailand. Lau *et al*., (2014) confirmed that the inverted U-shaped association amid economic growth and CO_2 discharge does not exist in both the short-and long-run for Malaysia. Saboori and Sulaiman (2013) investigated the cointegration and causal relationship between economic growth, CO_2 emissions and energy consumption in five ASEAN nations for the period 1971-2009. The EKC proposition was affirmed in Singapore and Thailand. Ozcan (2013) analyzed the presence of EKC hypothesis in 12 Middle East nations for the period, 1990–2008. Utilizing the Westerlund (2008) panel cointegration test and the FMOLS, the EKC theory was confirmed in three nations, including Egypt, Lebanon, and UAE. Utilizing Bayesian approach, Musolesi *et al*., (2010) explored the EKC theory utilizing the information of 109 nations of the globe. They found that EKC theory exists in developed nations, however, a positive connection is found between economic growth and CO_2 emissions in low income nations. Tamazian and Rao (2010) utilized the GMM strategy to investigate the presence of EKC hypothesis in 24 transition economies for the period, 1993-2004. The study supported the EKC impact. Mazzanti and Musolesi (2013) applied the GMM method to inspect the presence of EKC theory for North America and Oceania, South Europe and North Europe but discovered EKC hypothesis is legitimate in North European region. Aldy (2005) discovered evidence for an EKC for the US, which is consistent with (Carson *et al*., 1997). Romero-Avila (2008) analyzed the connection between economic growth and per capita pollution for 86 nations utilizing information from 1960 to 2000, however neglected to affirm an EKC relationship.

2 Methodology and Data

The study employed Dickey & Fuller (1979) and Philips & Perron (1988) to determine stationary. It was essential to determine the stationarity as it tells the selection of the model to determine the relationship of the variables. If all the variables under study are integrated of order one, the Johansen and Juselius (1990) method of Cointegration is applied. In the event that the variables end up having different levels of stationary both I (1) and I (0) then a dynamic model of analysis for instance the ARDL model is employed in Cointegration analysis (Nkoro & Uko, 2016). Two tests of stationarity are required to check for robustness (Enders, 2012). The ARDL model was utilized to estimate the long-run and short-run relationships among study variables. The bounds test was employed to determine the existence of a long run equilibrium among the variables under study. Further, Granger non-causality tests which are statistical tests of causality in the sense of determining whether lagged observations of another variable have incremental forecasting power when added to a univariate autoregressive representation of a variable was conducted.

The relevant equations that explains the relationship between CO_2 emissions to different variables under study are defined in equation 1 as per the objectives of the study.The study utilized the Al-Mulali *et al.*, (2016) model and made appropriate adjustment to include the specific features of Kenya. Therefore the general relationship amongst the variables under this study were expressed as:

$$CO_{2t} = f(IE_t + FO_t + RE_t + ANE_t + GDP_t + TRD_t + PPL_t) \dots\dots\dots\dots\dots\dots 1$$

CO_{2t} is CO2 emissions per capita, IE is imported energy estimated as energy use less production, both measured in oil equivalents, FO is electricity generated from fossil fuel sources (such as coal, oil, and natural gas) in kilowatt-hours per capita, RE is electricity generated from renewable sources (such as hydro-energy and solar energy) in kilowatt-hours per capita, ANE is alternative and nuclera energy which is clean energy that does not produce carbon dioxide when generated. It includes hydroenergy and nuclear, geothermal, wind and solar energy in percentage of total energy use, GDP is real gross domestic product per capita, TRD is trade openness which is the ratio of trade to GDP [imports of goods and services plus exports of goods and services devided by GDP, PPL is annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage.

The equivalent explicit long-run equations in this study were expressed as:

$$\ln CO_{2t} = \alpha_0 + \alpha_1 \ln IE_t + \alpha_2 \ln FO_t + \alpha_3 \ln RE_t + \alpha_4 \ln ANE_t + \varepsilon_t \dots\dots\dots\dots\dots\dots 2$$

$$\ln CO_{2t} = \mu_0 + \mu_1 \ln GDP_t + \mu_2 \ln TRD_t + \mu_3 \ln PPL_t + \varepsilon_t \dots\dots\dots\dots\dots\dots 3$$

Where α_i and μ_i are coefficients and ε_t is residual term assumed to be normally distributed in time period t. The longrun equations 2 and 3 were estimated to scrutinize the effect of energy mix variables under study and other other selected economic indicators; imported energy, renewable energy sources, fosil fuel, alternative, nuclear energy use, economic growth, trade openess and population growth on CO_2 emissions. The results of longrun equation 3 were further used to examine the EKC hypothesis. For EKC to be confirmed, the short-run coefficient of GDP must be greater than the long-run coefficient. To remove the non-normality in subsequent analysis, it was essential to transform the data by the use of natural logs since they are monotonic transformation and always reduce the values of the coeficient.

To confirm the model structural stability, the Cusum tests were estimated. The cusum test is based on a plot of the sum of the recursive residuals. If this sum goes outside a critical bound, it implies that there was a structural break at the point at which the sum began its movement toward the bound. The cusum-of-squares test plots the cumulative sum of squared recursive residuals, expressed as a fraction of these squared residuals summed over all observations. The cusum tests were estimated to test for the structural stability of the model.

3.0 Empirical Results and Discussions

Table 1: Unit Root Test at Level and First Difference

	Level					Differenced				
Variable	ADF	P-values	PP	P-values	Remarks	ADF	P-values	PP	P-value	Remarks
LGDP	-5.211	0.000	-6.946	0.000	No Unit root	-9.903	0.000	-5.207	0.00	No Unit root
LCO2	-2.599	0.2805	-1.235	0.6584	Unit root	-6.945	0.000	-6.946	0.00	No Unit root
LPPL	1.530	0.9976	1.345	0.9968	Unit root	-7.661	0.000	-7.625	0.00	No Unit root
LANE	-1.940	0.3134	-2.059	0.2612	Unit root	-7.076	0.000	-7.137	0.00	No Unit root
LIE	-2.127	0.2339	-2.133	0.2316	Unit root	-6.350	0.000	-6.348	0.00	No Unit root
LRE	-1.273	0.6412	-1.300	0.6290	Unit root	-6.205	0.000	-6.148	0.00	No Unit root
LFO	-1.357	0.2598	-1.178	0.6831	Unit root	-6.807	0.000	-6.978	0.00	No Unit root

Source: Authors' Computation

From the results in table 1, the critical values for Augmented Dickey Fuller are -3.621. -2.947 and -2.607 for 1%, 5% and 10% respectively for difference data. The critical values for Augmented Phillip Perron are -3.614, -2.944 and -2.606 for 1%, 5% and 10% respectively for difference data. Gross domestic product is stationary at level given that its calculated value of -5.211 is larger than the critical value. All other variables such as carbon IV oxide, renewable energy fossil energy, alternative and nuclear energy, population growth and imported energy were observed to be stationary at first difference since their coefficients are not more than the critical values in ADF and Phillip Perron tests.

The test for structural breaks sought to determine sudden changes to the data emanating from changes in various factors. Identification of structural breaks and their significance assist determine the extent of influence on determination of the long run equilibrium.

Table 2: Zivot Andrews Test for Structural Breaks

Variable	ZA	Year
LCO2	-4.236	2004
LGDP	-6.219*	2004
LIE	-3.669	2005
LTRD	-4.296	1993
LFO	-4.660	1994
LRE	-4.128	2001
LANE	-5.312*	1986
LPPL	-2.786	1979

Legend: * indicates the coefficient is statistically significant at 5%
Source: Authors' Computation

The critical values for the Zivot Andrews are -5.57 , -5.08 and -4.82 at 1%, 5% and 10% respectively. The structural break for carbon (IV) oxide in the year 2004 is not significant. The year 1982 experienced a sharp decline in the carbon (IV) oxide emissions that may be attributed to changes in climatic conditions and less use of fossil fuels. The structural break in gross domestic product in 2004 is significant. The break is attributed to sharp decline in economic growth resulting from political factors during this year and adverse climatic conditions resulting to low incomes from agricultural sector. Trade openness sufffered a break in 1993 although not significant. Imported energy had a structural break in 2005 although not significant.

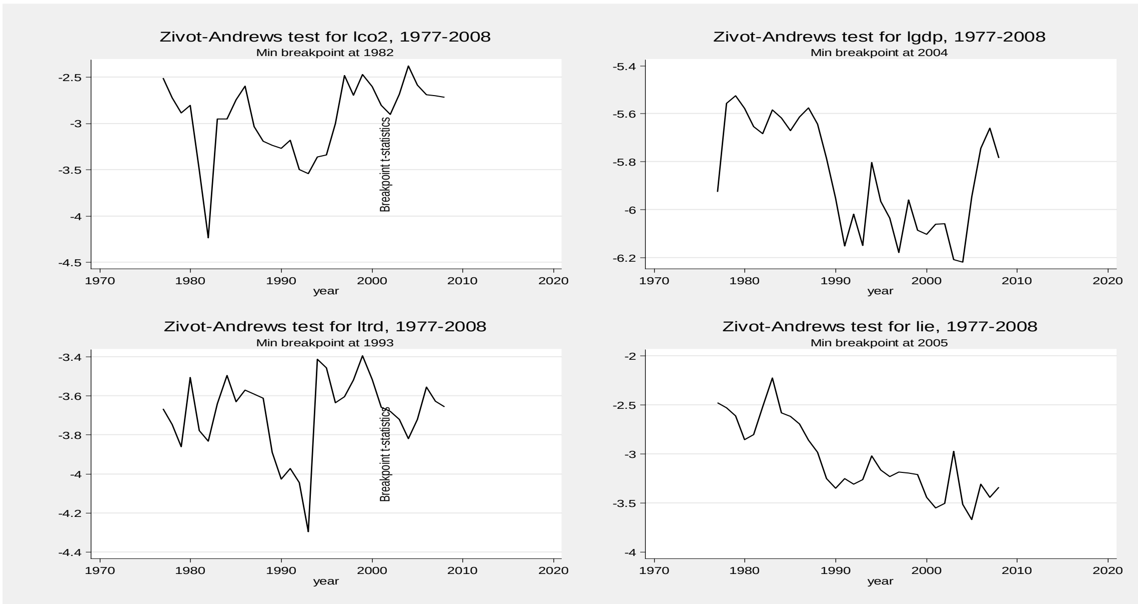

Figure 1: Zivot Andrews Test for LCO2 LGDP LTRD and LIE
Source: Authors' Computation

From visual introspection, trade openness has structural breaks with and extreme in the year 1994. The break may result from trade policy. The structural break in carbon (IV) oxide in the year 1982 may arise to changes in consumption of fossil fuels due to a decline in their importation to the country.

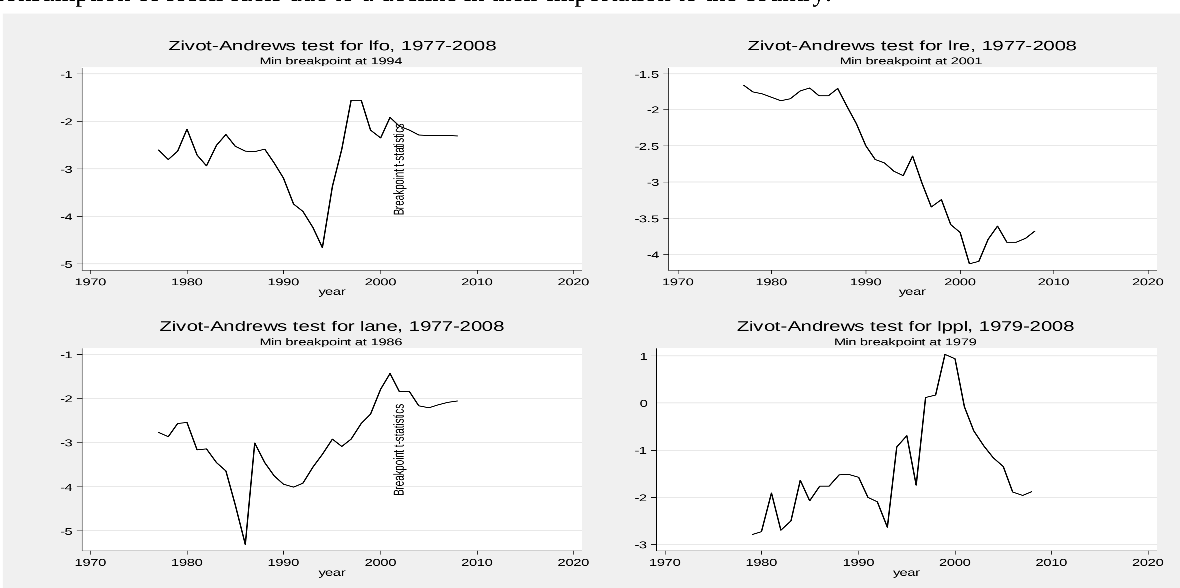

Figure 2: Zivot Andrews for LFO, LRE, LANE and LPPL
Source: Authors' Computation

Alternative and nuclear energy has a structural break in 1986 that is significant. The decline in the use of alternative and nuclear energy may be attributed to high use of hydroelectric power. The structural breaks for population growth, use of fossil energy and renewable energy have structural breaks but are insignificant.

Cointegration test was meant to determine how time series data, which nevertheless might be independently non-stationary and drift widely past the equilibrium can be combined such that the workings of equilibrium forces will guarantee they cannot drift too far apart. Cointegration imitates the presence of long run relationship in time series that converges over time. The evaluation of cointegration follows the determination of the lag length and cointegrating rank of the models in study. Cointegration determination is essential in model specification to evade misspecification which can later end up with biased coefficients. The variables under study are integrated of order one and at level. This then means that a model of dynamic analysis is required to test for the long run and short run relationships. The ARDL models of cointegration permits for analysis for variables that are integrated at level and at order one. The error correction model estimates the short run and long run coefficients using the lags that are determined by the ARDL model specification (Pesaran , Shin, & Smith , 2001).

The lag length permits determination of time break in which the dependent variable is affected by changes in the model variables. The effects of the independent variables on the dependent variables may not essentially display an immediate effect but in its place encompass of both immediate and lagged effect that is spread over a period of time. This determination therefore gives the background to establishment of the rank of Cointegration of the model.

Table 3: Determination of Lag Length Equation 3

Sample: 1974 - 2015 Number of obs = 42

Lag	LL	LR	DF	P	FPE	AIC	HQIC	SBIC
0	26.6014				4.00E-06	-1.07626	-1.0156	-0.91077
1	180.466	307.73	16	0	5.70E-09	-7.64125	-7.33795*	-6.8379*
2	190.248	19.564	16	0.241	7.80E-09	-7.34514	-6.79921	-5.85571
3	213.262	46.028	16	0	5.90E-09	-7.67914	-6.89056	-5.52774
4	234.119	41.714*	16	0	5.2e-09*	-7.91042*	-6.8792	-5.09705

Source: Authors' Computation

Table 3 above gives the lag as established by FPE, AIC, HQIC and SBIC. AIC results determines that there are four lags while HQBIC and BIC defines it to be one lag. Therefore the model with the smallest lag length between AIC and SBIC is selected to provide the lag length. This explains why the selection of one lag length in determining the cointegrating rank.

The ARDL analysis that was done with the variables at their level found the presence of long run relationship. The analysis selects the best model with the smallest standard errors and a high R^2.

Table 4: ARDL Analysis of Long Run Relationship for Equation 3

Sample: 1974 - 2015
Number of obs = 42
R-squared = .97986153
Adj R-squared = .96410098

	Coef.	Std. Err.	T	P>t	[95% Conf. Interval]	
LCO2						
L1.	0.58342*	0.133863	4.36	0.000	0.306504	0.860336
L2.	-0.10816	0.160695	-0.67	0.508	-0.44058	0.224267
L3.	0.131753	0.159074	0.83	0.416	-0.19732	0.460822
L4.	-0.23184	0.125776	-1.84	0.078	-0.49203	0.028348
LGDP	0.034934*	0.015161	2.3	0.031	0.003572	0.066297
L1.	0.029387	0.016275	1.81	0.084	-0.00428	0.063054
L2.	0.015578	0.017204	0.91	0.375	-0.02001	0.051168
L3.	0.021207	0.014894	1.42	0.168	-0.0096	0.052018
L4.	0.028273	0.013847	2.04	0.053	-0.00037	0.056919
LPPL	-1.17751	2.578595	-0.46	0.652	-6.51174	4.156723
L1.	1.830199	3.18515	0.57	0.571	-4.75879	8.419184
L2.	13.92078*	3.678876	3.78	0.001	6.310448	21.53112
L3.	-6.21885	3.461254	-1.8	0.086	-13.379	0.941305
L4.	-6.61314*	3.032269	-2.18	0.04	-12.8859	-0.34041
LTRD	0.019172	0.14617	0.13	0.897	-0.2832	0.321547
L1.	0.226206	0.185393	1.22	0.235	-0.15731	0.609721
L2.	-0.32724	0.176413	-1.85	0.076	-0.69218	0.037696
L3.	0.513302*	0.140753	3.65	0.001	0.222132	0.804472
Cons	-0.24233	0.880183	-0.28	0.786	-2.06312	1.578471

Legend: * indicates the coefficient is statistically significant at 5%
Source: Authors' Computation

The results above for estimated equation 3, R-squared of 97 percent and adjusted R squared of 96 percent which indicates of the model's applicability in explaining the changes in levels of carbon emissions. The first lag of CO_2 is significant with p –value 0.000 < 0.05 with coefficient of 0.58342 suggesting a unit change of t-1 results into an increase in the current levels of CO_2 emissions by 58.342%. Gross domestic product has a coefficient of 0.034 with a probability of 0.031 < 0.05.The positive coefficient shows the direct relationship in influencing CO_2 levels in the long run. The third lag of trade is also significant with a probability of 0.001and a coefficient of 0.5913 suggesting that it directly influences levels of CO_2. Further, the second and fourth lag of population growth with p -values 0.001 and 0.04 which are less than 0.05 are significant suggesting that the second lag of population change has a positive effect towards CO_2 emissions by 13.92078 units while the fourth lag of population change has a negative effect towards CO_2 emissions by -6.61314 units. This coefficients are significant at 5% level of significance (p – values 0.001& 0.04 < 0.05).

Table

5: Bounds Test

H0: No levels relationship F = 12.676 t = -5.60

Critical Values	0.1		0.05		0.025		0.01	
	[I_0] L_1	[I_1] L_1	[I_0] L_05	[I_1] L_05	[I_0] L_025	[I_1] L_025	[I_0] L_01	[I_1] L_01
k_3	2.72	3.77	3.23	4.35	3.69	4.89	4.29	5.61

accept if F < critical value for I(0) regressors
reject if F > critical value for I(1) regressors

Critical Values	0.1		0.05		0.025		0.01	
	[I_0] L_1	[I_1] L_1	[I_0] L_05	[I_1] L_05	[I_0] L_025	[I_1] L_025	[I_0] L_01	[I_1] L_01
k_3	-2.57	-3.46	-2.86	-3.78	-3.13	-4.05	-3.43	-4.37

accept if t > critical value for I(0) regressors
reject if t < critical value for I(1) regressors
k: # of non-deterministic regressors in long-run relationship

Critical values from Pesaran/Shin/Smith (2001)
Source: Authors' Computation

The F statistic from the bounds is 12.676 and the upper bounds at 10%, 5%, 2.5% and 1% significance levels is 3.77, 4.35, 4.89 and 5.61 respectively. Given that the F statistic is higher than the higher bounds in all significance levels, the null hypothesis is rejected that there is no level relationship amongst the study variables. The presence of a level relationship among variables confirms a long run equilibrium among the variables analyzed (Enders, 2015). The error correction term determination estimates both the long run and the short run coefficients. The determination of the ECT is depends on the optimal lags identified from the ARDL model. The optimal lags were identified as [4 4 4 3] for the variables; [LCO2 LGDP LPPL LTRD] as per the order of presentation. Using the optimal lags identified from the model the estimated ECT model is presented in table 6.

Table 6: ECM Estimation

Sample: 1974 -2015
Number of obs = 42
R-squared = 0.809076
Adj R-squared = 0.659658

	D.LCO2	Coef.	Std. Err.	T	P>t	[95% Conf. Interval]	
ECT		-0.62482*	0.111574	-5.6	0.000	-0.85563	-0.39401
LR	LGDP						
	L1.	0.207065*	0.081443	2.54	0.018	0.038588	0.375542
	LPPL						
	L1.	2.787178*	0.19684	14.16	0.000	2.379983	3.194373
	LTRD						
	L1.	0.690498*	0.286683	2.41	0.024	0.09745	1.283546
SR	LCO2						
	LD.	0.208242	0.143803	1.45	0.161	-0.08924	0.505721
	L2D.	0.100086	0.131495	0.76	0.454	-0.17193	0.372104
	L3D.	0.231839	0.125776	1.84	0.078	-0.02835	0.492027
	LGDP						
	D1.	0.034934*	0.015161	2.3	0.031	0.003572	0.066297
	LD.	-0.06506*	0.028894	-2.25	0.034	-0.12483	-0.00528
	L2D.	-0.04948*	0.020354	-2.43	0.023	-0.09158	-0.00738
	LPPL						
	D1.	-1.17751	2.578595	-0.46	0.652	-6.51174	4.156723
	LD.	-1.0888	2.864429	-0.38	0.707	-7.01432	4.836726
	L2D.	12.8319*	2.779453	4.62	0.000	7.08225	18.58172
	LTRD						
	D1.	0.019172	0.14617	0.13	0.897	-0.2832	0.321547
	LD.	-0.18606	0.15537	-1.2	0.243	-0.50747	0.135347
	L2D.	-0.5133*	0.140753	-3.65	0.001	-0.80447	-0.22213
	Cons	-0.24233	0.880183	-0.28	0.786	-2.06312	1.578471

Legend: * indicates the coefficient is statistically significant at 5%
Source: Authors' Computation

From the estimated model in equation 3, the value of R squared is 80 and adjusted R is 65 indicating that the coefficients are reliable. ECT is the adjustment or the error correction term. The coefficient of the error correction term is negative -0.62482 and significant at P value 0.0 < 0.05. With the negative sign, it indicates a long run convergence (adjustment). The existence of the error correction term is a confirmation of a long run equilibrium.
Consequently, this is an indication for the tendency in the model for carbon dioxide emissions per capita to go back to its long-run equilibrium path whenever it shifts away. To be precise, almost 62% of the disequilibrium between actual rate of carbon dioxide emissions per capita at previous year and the long-run rate of carbon dioxide emissions per capita would adjust back in the current year.
From the results, it was also observed that in the long run, gross domestic product, population changes and changes in trade significantly influence level of carbon (IV) oxide. Population growth directly impacts changes to CO_2 by 2.787 in the long run. The coefficient of population growth is significant at 5% level of significance with a probability of 0.000 < 0.05 level of significance. Trade also affects changes in CO_2 by 0.69 in the long run. The coefficient of trade openness is significant with a probability of 0.024 < 0.05 level of significance. The coefficient of gross

domestic product is also statistically significant with probability 0.018 < 0.05 level of significance in the long run and has a positive direct influence at changes in CO_2 emissions by 0.2071 units.

The short run analysis under the ECT present similar results as the ARDL analysis. In the short run past levels of carbon IV oxide is not significant in influencing current levels. The coefficients of carbon IV oxide are insignificant in the short run. Changes in the first difference of gross domestic product affects carbon (IV) oxide by 0.034. The coefficient is significant since the probability of 0.031 is less than the threshold of 0.05 level of significance. Though the first and second lagged difference of GDP have a negative impact to CO_2 emissions with coefficients -0.06506 and -0.04948 with p – values 0.034 and 0.023 both significant at 5% level of significance. The second lagged difference of population growth significantly impacts changes in the level of CO_2 at the level of 12.8319 units. This therefore indicates that population growth changes affect carbon (IV) oxide emission over a period of two years. The second lagged difference of trade openness is significant with a coefficient of -0.5133 implying that in the short run trade openness does result to lower carbon emissions. From the results therefore, the hypothesis of absence of EKC in Kenya is not rejected. After performing co-integration, short-run and long-run relationship was estimated. Using the Narayan and Narayan, 2010 approach, who suggested an alternative method to investigate EKC hypothesis in order to eliminate multicollinearity problem, this hypothesis was tested. In this study, multicollinearity arose between GDP per capita and GDP per capita square. This alternative approach suggests a comparison between short-run and long-run elasticity. If the long-run income elasticity is smaller than the short run income elasticity, then we can conclude that, over time, income leads to less CO_2 emission. The results of this study indicated that the long-run coefficient of GDP which is 0.207065 significant at 5% level of significance (p – value 0.018< 0.05) is greater than the short-run coefficient of GDP which is 0.034934 significant at 5% level of significance (p – value 0.031< 0.05). Therefore, the results confirms that EKC hypothesis does not exist in Kenya hence the hypothesis was not rejected.

Table 7: Granger Causality Wald Tests Equation 2

Equation	Excluded	chi2	df	Prob> Chi
LCO2	LANE	4.4438	4	0.349
LCO2	LRE	4.788	4	0.31
LCO2	LIE	20.686	4	0.000*
LCO2	LFO	7.4547	4	0.114
LCO2	ALL	63.336	16	0.000*
LANE	LCO2	24.881	4	0.000*
LANE	LRE	6.7711	4	0.148
LANE	LIE	1.5019	4	0.826
LANE	LFO	18.923	4	0.001*
LANE	ALL	66.721	16	0.000*
LRE	LCO2	31.685	4	0.000*
LRE	LANE	21.275	4	0.000*
LRE	LIE	50.916	4	0.000*
LRE	LFO	11.256	4	0.024*
LRE	ALL	95.932	16	0.000*
LIE	LCO2	2.0513	4	0.726
LIE	LANE	11.34	4	0.023*
LIE	LRE	11.01	4	0.026*
LIE	LFO	5.3154	4	0.256
LIE	ALL	26.833	16	0.043*
LFO	LCO2	2.6662	4	0.615
LFO	LANE	1.7564	4	0.78
LFO	LRE	3.0696	4	0.546
LFO	LIE	2.3014	4	0.681
LFO	ALL	16.385	16	0.426

Legend: * indicates the coefficient is statistically significant at 5% level of significance

Source: Authors' Computation

The results in table 7 indicate that carbon IV oxide and imported energy have a bi-directional relationship. The results also indicate that carbon IV oxide and alternative energy, renewable energy, fossil fuels have a unidirectional relationship. The results also indicate a bidirectional relationship in all the variables. These results are significant at 5% level of significance.

Table 8: Granger Causality Wald Tests Equation 3

Equation	Excluded	chi2	Df	Prob
LCO2	LGDP	10.646	4	0.031*
LCO2	LPPL	93.649	4	0.000*
LCO2	LTRD	26.274	4	0.000*
LCO2	ALL	116.81	12	0.000*
LGDP	LCO2	4.1827	4	0.382
LGDP	LPPL	11.604	4	0.021*
LGDP	LTRD	2.2018	4	0.699
LPPL	LCO2	10.398	4	0.034*
LPPL	LGDP	4.3794	4	0.357
LPPL	LTRD	5.1283	4	0.274
LPPL	ALL	12.804	12	0.383
LTRD	LCO2	8.3863	4	0.078
LTRD	LGDP	5.4663	4	0.243
LTRD	LPPL	16.401	4	0.003*
LTRD	ALL	32.718	12	0.001*

Legend: * indicates the coefficient is statistically significant at 5% level of significance
Source: Authors' Computation

The results indicate that there was a bidirectional relationship between carbon IV oxide and changes in population, trade openness and gross domestic product. It also shows that there is a bidirectional relationship between carbon IV oxide and all other variables. The results also indicate that trade has a bi-directional relationship with all the variables while population changes have a unidirectional relationship with all the variables. These statistics are significant at 5% level of significance.The cusum and cusum squared test result for estimated equation 3 are given in figure 3 and figure 4. It is deduced that the model is stable given that the stability line lies between the set limits. Hence both the cusum and the cusum squared test confirm the structural stability of the model.

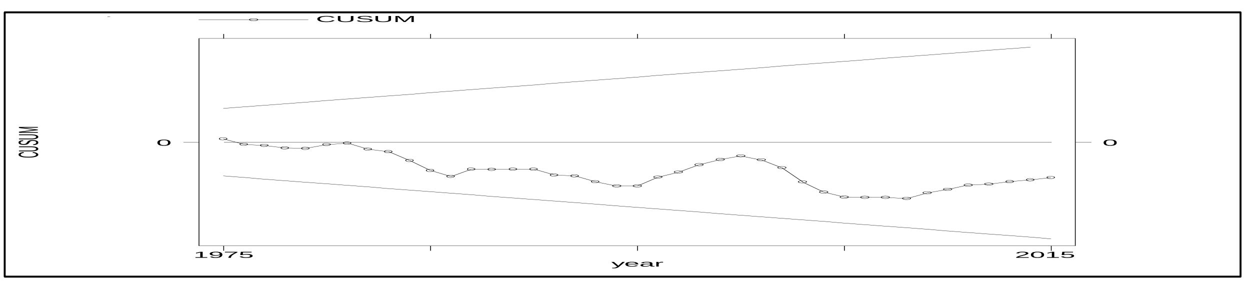

Figure 3: Cusum Test
Source: Authors' Computation

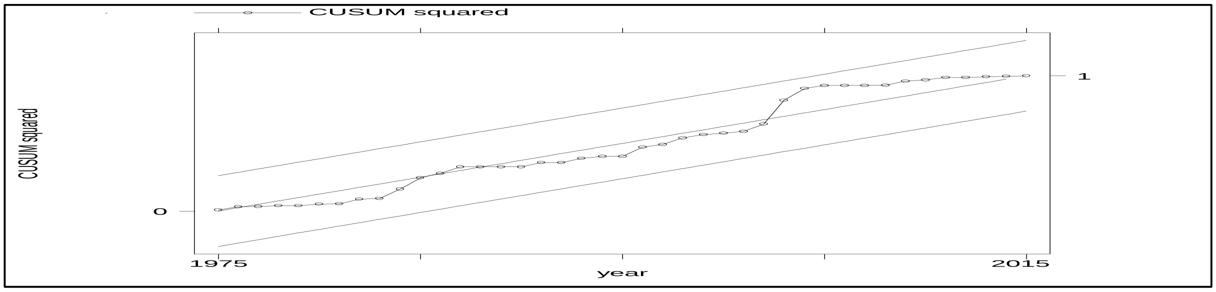

Figure 4: Cusum Squared Test
Source: Authors' Computation

4 Conclusion and policy implications

The main purpose of this study was to investigate the presence of EKC in Kenya. The study established that gross domestic product had a positive effect on CO_2 levels both in the short and long run. Population growth had a positive effect on changes on carbon IV oxide both in the short run and log run. Trade openness had a significant positive effect on carbon IV oxide both in the short run and in the long run. The study therefore further determined that the short run coefficient is weaker than the long run coefficient confirming the absence of EKC hypothesis in Kenya. The estimated results of the absence of EKC are in line with other studies such as, Yang *et al*., (2015) Ozturk and Al-Mulali (2015), Lau *et al*., (2014), Mistri and von Hauff (2015). The determination on the absence of EKC hypothesis in Kenya anchors disputed evidence to this hypothesis. The findings therefore means that Kenya should not be expected to drop its ambitious growth plans as outlined in its vision 2030 by sacrificing economic growth in the name of reducing carbon dioxide emissions. The absence of EKC in Kenya provides ground for analysis of this theory using other variables and different econometrics analysis models. The findings indicate that selected macroeconomic variables and energy mix are crucial for the economic growth of the Kenyan economy and that policy interventions are useful in addressing or containing the adverse effects to the economy from these variables in order to have a sustainable economic growth that is environmental friendly.

References

Al-Mulali, U., & Ozturk, I. (2016). The investigation of environmental Kuznets curve hypothesis in the advanced economies: The role of energy prices. *Renewable and Sustainable Energy Reviews, 54*, 1622-1631.

Al-Mulali, U., Solarin, S. A., & Ozturk, I. (2016). Investigating the presence of the environmental Kuznets curve (EKC) hypothesis in Kenya: an autoregressive distributed lag (ARDL) approach. *Natural Hazards, 80*(3), 1729-1747.

Aldy, J. E. (2005). An environmental Kuznets curve analysis of US state-level carbon dioxide emissions. *The Journal of Environment & Development, 14*(1), 48-72.

Arouri, M., Shahbaz, M., Onchang, R., Islam, F., & Teulon, F. (2014). Environmental Kuznets curve in Thailand: cointegration and causality analysis. *J Energy Dev, 39*, 149-170.

Dickey, D. and W. Fuller, (1979): Distribution of the estimators for autoregressive time series with a Unit Root. *J. The American Statistical Association,* 74(366): 427-431.

Enders, W. (2015). *Applied Econometric Time Series*. Hoboken: NJ: John Wiley & Sons.

Farhani, S., & Ozturk, I. (2015). Causal relationship between CO2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia. *Environmental Science and Pollution Research, 22*(20), 15663-15676.

Greene, W. H. (2017). *Econometric Analysis*: Pearson Education.

Hamilton, J. (2002). D.(1994), Time Series Analysis: Princeton: Princeton University Press.

Javid, M., & Sharif, F. (2016). Environmental Kuznets curve and financial development in Pakistan. *Renewable and Sustainable Energy Reviews, 54*, 406-414.

Jarque, C. M., & Bera, A. K. (1987). A test for normality of observations and regression residuals. *International Statistical Review/Revue Internationale de Statistique*, 163-172.

Kang, Y.-Q., Zhao, T., & Yang, Y.-Y. (2016). Environmental Kuznets curve for CO 2 emissions in China: A spatial panel data approach. *Ecological Indicators, 63*, 231-239.

Kenya National Bureau of Statistics. (2016). *Economic Survey 2016.* Nairobi: Kenya National Bureau of Statistics.

Kongo, O. Y. (2018). Macroeconomic Determinants of Carbon Emissions in Kenya: An ARDL Approach. *Researchjournali's Journal of Economics, 6*(53).

Lau, L.-S., Choong, C.-K., & Eng, Y.-K. (2014). Investigation of the environmental Kuznets curve for carbon emissions in Malaysia: Do foreign direct investment and trade matter? *Energy Policy, 68*, 490-497.

Li, T., Wang, Y., & Zhao, D. (2016). Environmental Kuznets Curve in China: New evidence from dynamic panel analysis. *Energy Policy, 91*, 138-147.

Mazzanti, M., & Musolesi, A. (2013). Nonlinearity, Heterogeneity and Unobserved Effects in the CO2-income Relation for Advanced Countries: Nota di Lavoro, Fondazione Eni Enrico Mattei.

Mistri, A., & von Hauff, M. (2015). Environmental Kuznets Curve (EKC): Implications on Economic Growth, Access to Safe Drinking Water and Ground Water Utilisation in India. *Global Journal of Human-Social Science Research, 15*(1).

Musolesi, A., Mazzanti, M., & Zoboli, R. (2010). A panel data heterogeneous Bayesian estimation of environmental Kuznets curves for CO2 emissions. *Applied Economics, 42*(18), 2275-2287.

Narayan, P. K., & Narayan, S. (2010). Carbon dioxide emissions and economic growth: panel data evidence from developing countries. *Energy Policy, 38*(1), 661-666.

Ozcan, B. (2013). The nexus between carbon emissions, energy consumption and economic growth in Middle East countries: A panel data analysis. *Energy Policy, 62*, 1138-1147.

Ozturk, I., & Al-Mulali, U. (2015). Investigating the validity of the environmental Kuznets curve hypothesis in Cambodia. *Ecological Indicators, 57*, 324-330.

Paramati, S. R., Alam, M. S., & Chen, C.-F. (2016). The Effects of Tourism on Economic Growth and CO2 Emissions A Comparison between Developed and Developing Economies. *Journal of Travel Research*, 0047287516667848.

Romero-Avila, D. (2008). Questioning the empirical basis of the environmental Kuznets curve for CO 2: new evidence from a panel stationarity test robust to multiple breaks and cross-dependence. *Ecological economics, 64*(3), 559-574.

Saboori, B., & Sulaiman, J. (2013). CO 2 emissions, energy consumption and economic growth in Association of Southeast Asian Nations (ASEAN) countries: a cointegration approach. *Energy, 55*, 813-822.

Shahbaz, M., Dube, S., Ozturk, I., & Jalil, A. (2015). Testing the environmental Kuznets curve hypothesis in Portugal. *International Journal of Energy Economics and Policy, 5*(2).

Shahbaz, M., Solarin, S. A., Sbia, R., & Bibi, S. (2015). Does energy intensity contribute to CO 2 emissions? A trivariate analysis in selected African countries. *Ecological Indicators, 50*, 215-224.

Tamazian, A., & Rao, B. B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy Economics, 32*(1), 137-145.

The World Bank. (2016). *World development indicators*. Retrieved 10 15, 2016, from The World Bank: http://data.worldbank.org/datacatalog/

Yang, H., He, J., & Chen, S. (2015). The fragility of the Environmental Kuznets Curve: Revisiting the hypothesis with Chinese data via an "Extreme Bound Analysis". *Ecological economics, 109*, 41-58.