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Modelling Carbon Dioxide Emission, Energy Consumption and Economic Growth in Nigeria: Environmental Kuznets Curve (EKC) Approach

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Abstract:- This paper attempts to model the relationship between CO2 emission, Energy consumption and economic growth in Nigeria using Environmental Kuznets curve (EKC) hypothesis. The aim is to make a useful contribution to the gap that exists in the literatures that studied the relationship between energy consumption, CO2 emission and economic growth in Nigeria. This study uses regression equations of linear, quadratic and cubic functions to econometrically modelCO2 emission, energy consumption and economic growth (GDP) data. It was discovered that a quadratic relationship exist between CO2 emission and economic growth represented by the GDP.The inverted U shaped relationship between CO2 per capita emission and income akin to developed countries is also evident in developing Nigerian economy. Though this is surprising, national internal policy inertia explains this behavior rather than international treaty on CO2 emission that has been used to explain this behavior for developed nations.

Employing Autoregressive Integrated Moving Average (ARIMA) method to forecast the dynamic CO2 behavior for Nigeria up to 2030 certeris paribus, our forecast shows that even though economic growth has historically been on the increase up to the end of period under study, (2010), CO2 emission per capita will continue to be on decrease to circa 400 (kg per capita) having crossed the turning point of the inverted U shaped EKC in about 2005. Government should continue to strengthen its policy on reduction of CO2 emitters in its economy with no consequence on economic growth as observed. We recommend further work to be done to include more explanatory variables to this work.

I. INTRODUCTION

Human activities and natural occurrences are contributing significantly to climate change with its attendant increase in global temperature. This is as a result of the increase in the emission of greenhouse gases such as Carbon Dioxide (CO2). Nigeria accounts for the largest volume of gas flaring in the world whichis 24.1 BCM(World Bank report, 2007). This volume could emit some 400 million tons of carbon dioxide into the atmosphere.

The negative impacts of Co2 emission such as high temperature, inconsistent rainfall, desertification and low agricultural yield are evident in Nigeria.This is having negative impact on the welfare of millions of Nigerians.The agricultural sector contributes some percentage of the Nigerian Gross National Product and majority of the rural populace are employed in this sector. The dominant role agriculture plays makes it obvious that even minor climate deteriorations can cause devastating socioeconomic consequences**.**

The increasing threat of global warming and climate change has led to a focused attention on the relationship among economic growth, energy consumption, and environmental pollution, Tiwari, A. K (2011).The increase of energy consumption showed that CO2 emissions in the atmosphere have increased dramatically, and these lead many scientists to push governments of the developing countries to take action for the formulation of environmental policies. Many studies have attempted to look for the direction of causality between energy consumption (EC), economic growth (GDP) and CO2 emissions mainly on developing countries, Chaido Dritsaki and Melina Dritsaki, (2014).Saibu, M O and Jaiyeola A O (2013) analyzed the relationship between Carbon Dioxide Emission, Energy Consumption and Economic Growth in Nigeria using the causal effect of oil production and carbon emission from gas flaring on the growth rate in Nigeria between 1970 and 2011. It was concluded that there is causal relationship between oil production and carbon emission.

Wan- Jiun Chen (2012) studied the relationship between carbon dioxide emission and income in a newly industrialized economy of Taiwan using the Environmental Kuznets Curve (EKC) hypothesis. To explain the pattern of Co2 emissions, along with the economic growth of Taiwan, Chen uses the regression equations of linear, squared and cubic income to fit data. The signs of the coefficients of the linear, the quadratic and the cubic income variables were expected to be positive, negative and positive. To verify the relationship, a three-step analysis with the relationship hypothesis test was conducted to ascertain whether the relationship is N-Shaped, U-Shaped or monotonic.

Environmental Kuznets curve (EKC) analysis is an econometric methodology that adopts the view that environmental pollutant emissions are correlated explicitly with economic growth, represented by the per capita gross domestic product (GDP). The EKC analysis commonly used in the literature is the specification of the polynomial function:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 X_{it}^2 + \beta_3 X_{it}^3 + \varepsilon_{it}$$

Where,
i=1, …..N, countries
t=1, ……T, years
Y_{it} = CO2 emissions per capita
β_0 = country specific intercept
X_{it} = real GDP per capita
ε_{it} = an error term

The squared term produces the inverted U behavior (Figure 6), and the cubic term accounts for increases that sometimes return at the highest income levels. The inverted Ushape has been interpreted to mean that pollution increases with national industrial and income growth, but once a specific income turning point is reached, environmental quality begins to improve as incomes grow further. This is what Simon Kuznets originally used in his studies of income inequality, and it has become a tool used by econometricians to model economic phenomena.

Though global warming depends on worldwide Greenhouse Gas (GHG) emissions, its consequences differ among countries, based on their social and natural characteristics, if no action is taken to reduce emissions, the concentration of greenhouse gases in the atmosphere could double as early as 2035 from its pre-industrial level, Tiwari, A. K (2011).

Nigeria uses much volume of petrol, diesel and gas to power generator, cars and for power generation. This has significant increase in environmental pollutants. With the increasing population of about 180 million, understanding the behavior of environmental pollutants with regard to economic growth and energy consumption has become imperative. There are however few studies to that effect, Yusuf, Yahaya and Nasiru (2012), Saibu and Jaiyeola (2013, Chindo (2014) but none considered the use of EKC hypothesis.

This paper therefore adopted the Environmental Kuznets curve (EKC) methodology in modelling the relationship between energy consumption, carbondioxide emission and economic growth in Nigeria.It used the Wan-Jiun Chen, (2011) approach to apply the regression equations of linear, squared and cubic income to data of Co2 emission, energy consumption and economic growth in Nigeria.This study is made up of five sections; 1. Introduction which gives background into the research 2. Literature review 3. Methodology 4. Data analysis and interpretation of results 5. Conclusion and recommendation for policy formulation.

II. LITERATURE REVIEW

The relationship between energy consumption, Co2 emission and economic growth has burdened developing countries for decades. Recently, the number of papers modeling the relationship between CO2 emissions, energy consumption and economic growth has significantly increased, using different techniques. Tiwari, A.K(2011a), examined the causality in both static and dynamic framework between energy consumption, CO_2 emission and economic growth in India, using Granger approach in Vector Autoregressive (VAR) framework. Mohammad, Ismat, Jeroen and Guido (2012) which investigated existence of dynamic causality between energy consumption, electricity consumption, carbon emissions and economic growth in Bangladesh using co-integration and dynamic causality analysis. The result indicates that uni-directional causality exists from energy consumption to economic growth both in the short and the long-run while a bi-directional long-run causality exists between electricity consumption and economic growth but no causal relationship exists in short-run.

Chaido and Melina (2014) analyzed the Causal Relationship between Energy Consumption, Economic Growth and CO2 Emissions using the panel unit root tests, panel co-integration methods and panel causality test to investigate the relationship between energy consumption (EC), economic growth (GDP) and CO2 emissions for three countries of Southern Europe (Greece, Spain, and Portugal) using the FMOLS and DOLS to estimate the long run relationship between the variables. The result shows that there is a short-run bilateral causal link between the examined variables.

Xing-Ping and Xiao-Mei (2009) examined the existence and direction of Granger causality between economic growth, energy consumption, and carbon emissions in China, applying a multivariate model of economic growth, energy use, carbon emissions, capital and urban population. Empirical results for China over the period 1960–2007 were used. The result suggests a unidirectional Granger causality running from GDP to energy consumption, and a unidirectional Granger causality running from energy consumption to carbon emissions in the long run.

Sahbi Jaleleddine (2012) analyzed Energy Consumption, Economic Growth and CO2 Emissions: evidence from Panel Data for Middle East and North African Region. The study explored the direction of causality between energy consumption (EC), economic growth (GDP) and CO2 emissions using the panel unit root tests, panel co-integration methods and panel causality test to investigate the relationship between EC, GDP and CO2 emissions for 15 MENA countries covering the annual period 1973-2008. The result reveals that there is no causal link between GDP and EC; and between CO2 emissions and EC in the short run. Christopher (2012) examined Energy Consumption, Economic Growth and CO2 Emissions in Middle East and North African Countries. The study applied bootstrap panel unit root tests and co-integration techniques to investigate the relationship between carbon dioxide emissions, energy consumption, and real GDP for 12 Middle East and North African Countries (MENA) over the period 1981–2005. The findings show that in the long-run energy consumption has a positive significant impact on CO2 emissions. It also shows that real GDP exhibits a quadratic relationship with CO2 emissions for the region as a whole. Although the estimated long-run coefficients of income and its square satisfy the EKC hypothesis in most studied countries, the turning points are very low in some cases and very high in other cases, hence providing poor evidence in support of the EKC hypothesis. Thus, overall findings suggest that not all MENA countries need to sacrifice economic growth to decrease their emission levels as they may achieve CO2 emissions reduction via energy conservation without negative long-run effects on economic growth.

Wan-Jiun (2012) examined the Environmental Kuznet Curve (EKC) pattern of CO_2 emissions in a small and newly industrialized economy of Taiwan from 1970 to 2000, as a comparison to the N-shaped relationship found in Austria, a developed economy. The EKC model and the inverted U-shaped hypothesis were considered. The single-country data is preferred to the cross-country data. This is because employing single country time series data in an empirical study provides methodological relevance and also includes the country's specific characteristics. It is more reliable for analyzing the relationship between environmental degradation and income increase overtime. The CO_2 patterns are also useful for individual countries to develop polices for implementing international agreements.

To explain the pattern of CO_2 emissions along with the economic development of Taiwan, the study uses regression of equations of linear, squared and cubic incomes to fit data. The estimated result shows a quadratic relationship between CO_2 emissions and income in Taiwan, rather than a linear or cubic relationship. This shows that the CO_2 relationship is not monotonically increasing with income, as often stated in the literature. Thus, the emission patterns in Taiwan did not follow the N-shaped trajectory of developed countries.

The impact of energy consumption on economic growth in Nigeria over the period 1980-2010 were carried out by Yusuf, Yahya and Nasiru (2012) using the new autoregressive distributed lag (ARDL) approach to co-integration analysis. Findings indicated a long-run relationship between economic growth and energy consumption variables. Chindo Sulaiman, (2014) investigated the causality between energy consumption, CO2 emission and economic growth in Nigeria, using modified version of granger causality suggested by Toda and Yamamoto. The result shows a unidirectional relationship from CO2 emission to economic growth, energy consumption to CO2 emission and bi-directional causality between energy consumption and economic growth in Nigeria. Godwin S.A and Usenobong F.A (2012) examined the long-run relationship of electricity consumption, CO2 emission and economic growth in Nigeria using multivariate vector error correction model (VECM) with time series data from 1970 to 2008. The finding shows that in the long-run, economic growth is associated with increase in CO2 emissions, while an increase in electricity consumption leads to an increase in CO2 emission.

Mohammed and Mutiuexamined the effect of energy consumption, CO2 emission on economic growth in Nigeria, Using the Gregory-Hansen cointegration test and the Toda Yamamoto causality test. This is to ignore the possible effects of structural breaks which may have an effect on energy consumption. The study found the existence of a long-run relationship between the variables considered. But did not find a causal relationship running from energy consumption and CO2 to economic growth. But there is a significant causal relationship running from growth expansion to CO2 and energy consumption.

Saibu and Jaiyeola (2013) investigated Energy Consumption, Carbon Emission and Economic Growth in Nigeria: Implications for Energy Policy and Climate Protection in Nigeria. The study examined the causal effect of oil production and carbon emission from gas flaring on the growth rate in Nigeria between 1970 and 2011. Empirical result shows that economic growth rate, change in crude oil production growth rate, crude oil production growth rate, crude oil consumption growth rate, consumption growth rate, change in growth rate of carbon monoxide emission from gas flaring, growth rate of carbon monoxide emission from gas flaring and change in investment growth rate, investment growth rate are significant factors influencing economic growth in Nigeria.

In the light of the above literature, the U shape and N shape relationship between Co2 emission and economic growth has not been studied in Nigeria. This paper therefore is a part of an extended study attempting to model the relationship between energy consumption, CO2 emission and economic growth in Nigeria using the EKC hypothesis. Findings from this study would contribute to policy formulation that the government could implement for the growth of Nigeria.

III. METHODOLOGY

The research methodology employed involve 3 stages executed using existing econometric framework, Figure 1. In stage 1preliminary analysis is carried out involving Graphical analysis Figure 2, Descriptive statistics, Unit Root Test and Cointegration test. In stage two Estimation/specification is carried out and lastly stage 3 where post estimation analysis are carried out viz: Normality test, Serial correlation and lastly

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Heteroscedasticity tests. These post estimation tests were done to check if the model used in estimation stage is well behaved in which case any of the ARIMA model form can be used to forecast long and short run relationship If a model is not well behaved after the post estimation testi.e., heteroscadisticity test is violated, ARCH or GARCH form of the specified model is required to forecast the time series.

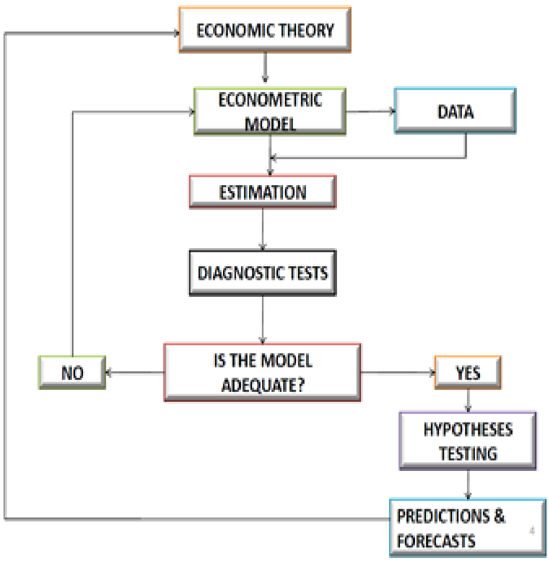

Fig 1

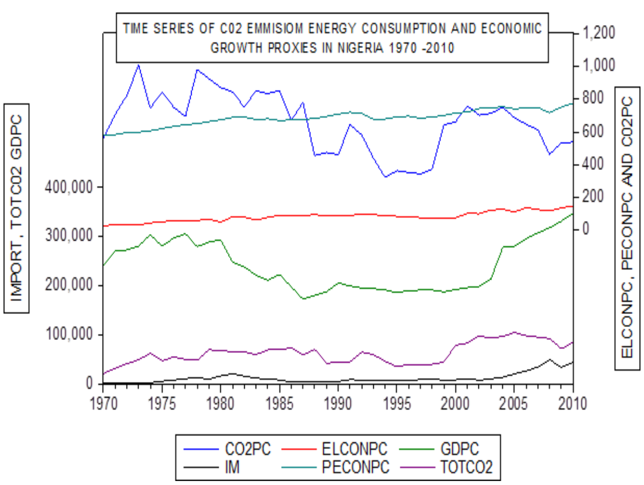

Fig 2:- Graphical analysis

IV. ANALYSIS AND INTERPRETATION OF RESULTS

The dependent variable in the study is carbon dioxide emission per capita (CO2PC) in Nigeria. Several data on possible endogenous variables were statistically screened to obtain best fit regressors for the estimation model. Among the explainers is electric power consumption per capita (ELCONPC), primary energy use per capital (PECONPC), and gross domestic product per capita (GDPC), import and total carbon dioxide emissions.

The adopted functional form and specification in this study was arrived after series of preliminary testing for multi collinearity and regressors relationships. The criteria used are: (1) conformity to stationarity of the data relevant to Nigeria; (2) testing for robustness of model specifications; (3) selection of affected variables by the expected signs and magnitudes of variable coefficients; (4) testing for statistical significance of the estimated coefficients; and (5) diagnostic analysis for serial correlation, homoscedasticity, and normality.

Data on carbon dioxide emissions stemming from the burning of fossil fuels and the manufacture of cement are used as proxy for carbon dioxide emission per capita (CO2PC). The proxy includes carbon dioxide produced during combustion of solid, liquid, and gas fuels and gas flaring. The data are from World Bank (2011) for 1970 to 2010. Definitions and descriptive data statistics of CO2PC and the finally chosen variables are presented in tables 1 and 2.

Generally, the classical linear regression model (CLRM) technique of ordinary least squares (OLS) method is valid when all variables are stationary. Consequently, test for stationarity of individual variables using Augmented Dickey-Fuller (ADF) unit root test (MacKinnon, 1991, 1996) is performed. At the level state, the variables are nonstationary. In OLS, if the variables are nonstationary, they are differenced to be stationary and restricted for time series analysis to be integrated of order one, I(1). Result for the test of stationarity is presented in Table 3.

Since the series are nonstationary and all variables are integrated of order one, test of co-integration between variables is conducted. Co-integration test is a joint test and it deals with the entire model. The Engle-Granger and Johansen co-integration tests are both conducted in this study as shown in Table 4. The Engle-Granger null hypothesis is series are no co-integrated. Since there is significance, the series are co-integrated and the null hypothesis is rejected.

To investigate and resolve the challenge of multi collinearity in CLRM in case of too many variables which may cause problems such as unneeded variables misspecification, or too few variables which may cause other problems such as omitted variables misspecification or incorrect functional form; variance inflation factors (VIF) and correlation matrix test are performed and reported in Tables 5 and 6. From the uncentered VIF result, there may be evidence of severe multi collinearity with the VIF > 10 implying severe relationship between the observed regressor and others when the expectation is that the regressors should be independent. Correlation matrix result reveals high relationship between PECONPC and ELCONPC (at 0.924298) and also between TOTCO2 and ELCONPC (at 0.714749). Consequently, the regressors cannot be used in the same regression. Thus, we suppress the regressors PECONPC and TOTCO2 in our regression. Alternatively, we estimate another regressor with the suppressed regressors.

Having suppressed PECONPC and TOTCO2 regressors, Johansen co-integration test (Johansen, 1991, 1995) is performed strictly between CO2 and income variables proxied by CO2PC and GDPC respectively. In the Johansen test reported in Table 7, the trace test indicates no integration at the 0.05 level. With the observed p-Values, it denotes rejection of the hypothesis at the 0.05 level. The Johansen test infers that CO2PC and GDPC variables are co-integrated and the OLS method could be used to estimate the coefficients of the regression equations for CO2PC emissions.

In establishing the causal relationship between CO2 emission and economic development in Nigeria, Chen (2011) three-step analysis is adopted to explain the pattern of CO2 emission for the regression equations of linear, quadratic and cubic income parameters.

The adapted regression models and three-step analysis with relationship hypothesis tests are (Chen, 2011):

$$CO2PC_t = \alpha + \beta_1 GDPC_t + \beta_2 GDPC_t^{\;2} + \beta_3 GDPC_t^{\;3} + \gamma_1 CO2PC_{t-1} + \gamma_2 ELCONPC_t + \gamma_3 IMPORT_t + \varepsilon_t \qquad \ldots 1$$

$$CO2PC_t = \alpha + \beta_1 GDPC_t + \beta_2 GDPC_t^{\;2} + \gamma_1 CO2PC_{t-1} + \gamma_2 ELCONPC_t + \gamma_3 IMPORT_t + \varepsilon_t \qquad \ldots 2$$

$$CO2PC_t = \alpha + \beta_1 GDPC_t + \gamma_1 CO2PC_{t-1} + \gamma_2 ELCONPC_t + \gamma_3 IMPORT_t + \varepsilon_t \qquad \ldots 3$$

Step 1: Start analysis with equation 1 to test for the significance of $H_0: \beta_3 = 0$. If the left-tail hypothesis test hypothesis of $H_0: \beta_3 = 0$ for equation 1 is rejected; an N-shaped relationship exists, as in the single country study of Friedl and Getzner (2003). Then, if β_3 is not significantly different from zero, equation 1 reduces to equation 2.

Step 2: Based on the hypothesis test for equation 2, the inverted U-shaped Environmental Kuznets Curve (EKC) hypothesis relationship exists if the right-tail hypothesis tests of $H_0: \beta_2 = 0$ is rejected. Instead, if β_2 of equation 2 are not significantly different from zero, equation 2 can be reduced to equation 1.

Step 3: In equation 1, if the null hypothesis of $H_0: \beta_1 = 0$ is rejected, a monotonic increasing emissions couple with income increases. Instead, if the β_1 of equation 1 is not significantly different from zero, there is no linear, square or cubic relationships.

The estimated result for the adopted step analysis is presented in Table 8. As reported in Chen (2011), the signs of the coefficient of the linear, the quadratic and the cubic income variables are expected to be positive, negative and positive respectively i.e. $\beta_1 > 0,\ \beta_2 < 0\ and\ \beta_3 > 0$ (Holtz-Eakin and Sedan, 1995; Agras and Chapman, 1999; Friedl and Getzner, 2003). As expected, the observed signs follow the pattern as seen in table 8. The null hypothesis for equation 1 $H_0: \beta_3 = 0$. The coefficient β_3 is not significantly different from zero as p-value suggests, thus, equation 1 reduces to equation 2. For equation 2, the null hypothesis is $H_0: \beta_2 = 0$. The estimated coefficient β_2 is significantly different from zero as p-value (t-Stats = 0.0711; significant at 10%) suggests, thus, equation 2 is valid.

Consequently, we infer from the estimated result that a quadratic relationship exist between CO2 emissions and income in Nigeria, similar to the newly industrialized nation of Taiwan as the studied by Chen (2011). The inverted U shape EKC model evidence from Nigerian empirical data are shown in figures 3 and 4. The result also reveals no cubic or linear relationship exist between CO2 emissions and income in Nigeria. Thus, the N-shaped relationship akin to developed nations (Friedl and Getzner, 2003) and the commonly reported monotonically increasing relationship of CO2 emission with income are evident in Nigeria.This trajectory for Nigeria is not attributable to signing of any international treaty on CO2 emission containment but rather explainable from internal CO2 control policy inertia in Nigeria. Similar analysis was done with ELCONPC suppressed while PECONPC took its place among the regressors in which case equations 1, 2 and 3 become:

$$CO2PC_t = \alpha + \beta_1 GDPC_t + \beta_2 GDPC_t^{\;2} + \beta_3 GDPC_t^{\;3} + \gamma_1 CO2PC_{t-1} + \gamma_2 PECONPC_t + \gamma_3 IMPORT_t + \varepsilon_t \qquad \ldots 1a$$

$$CO2PC_t = \alpha + \beta_1 GDPC_t + \beta_2 GDPC_t^{\;2} + \gamma_1 CO2PC_{t-1} + \gamma_2 PECONPC_t + \gamma_3 IMPORT_t + \varepsilon_t \qquad \ldots 2a$$

$$CO2PC_t = \alpha + \beta_1 GDPC_t + \gamma_1 CO2PC_{t-1} + \gamma_2 PECONPC_t + \gamma_3 IMPORT_t + \varepsilon_t \qquad \ldots 3$$

The outcome of the analysis is similar to the one with ELCONPC as expected.

The positive sign of coefficient of primary energy consumption implies that an increase in primary energy consumption leads to increase in CO2 emission in Nigeria. This may be due to importation of bad petrol, used cars and gas flaring which have high potential for CO2 emission Nigerian is a mono economy with crude oil and natural gas contributing to over 90% of its revenue. Gas flaring, a necessary evil in crude oil production constitute significant amount of CO2 emission in the atmosphere.

On the other hand there is inverse relation between CO2 emission per capita and electricity consumption in Nigeria as can be seen from the negative sign of coefficient of electricity consumption. This can be explained by the fact that when Nigerian electricity industry which is mainly by hydro-generation increases its output, people and industries abandon or reduce alternative sources of power generation and consumption such as petrol and diesel-engine gensets, kerosene lamps and firewoods, charcoal which are high emitters of CO2. Also people have embraced renewable energy sources such as solar, energy saving bulbs, rechargeable lamps in preference to these emitters.

Nigeria import a lot of industrial and consumer goods that contribute to total CO2 emission. For example used automobiles, refined petroleum products (petrol, diesel, kerosene etc.) electricity generator sets. These are proxied in the model with the variable import. The negative sign of this variable alongside with primary energy consumption variable implies importation to support economic activities in Nigeria is not causing CO2 emission per capita increase but rather decrease. This is because of recent policy on importation of major pollutant i.e. certain grade of used vehicles. This policy mantra means whereas importation of used cars of higher grade has increased Co2 emission has decreased (the so called inverse relationship).

Finally since our series exhibit unit root or non stationarity as well as homoscdasticity, we employed Autoregressive Integrated Moving Average method to forecast the dynamic CO2 behaviour for Nigeria up to 2030 certeris paribus. Our forecast shows that even though economic growth has historically been on the increase up to the end of period under study, (2010), CO2 emission per capita will continue to be on decrease to circa 400 (kg per capita)having crossed the turning point of the inverted U shaped EKC in about 2005.

Post Estimation Test for Multiple Regression Model

Our post estimation analysis was done based on both versions of our quadratic EKC model yielding similar results but in this paper we report on the outcome with ELCONPC for simplification.

Ramsey Reset Test

The NULL hypothesis for Ramsey RESET test says that the equation is correctly specified. Since we are testing for specification using Ramsey RESET, we observed that the p-value of the coefficients is not statistically significant thus we do NOT REJECT the null hypothesis. Non-linearity exists and there is no misspecification in the regression model. We could conclude that the model is non-linear are the specification is correct. Also, it is observed that none of the coefficients is statistically significant; which is evidence of no general misspecification.

Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.988041	Prob. F(5,34)	0.1055
Obs*R-squared	9.048847	Prob. Chi-Square(5)	0.1071
Scaled explained SS	5.084874	Prob. Chi-Square(5)	0.4056

Heteroskedasticity Test: ARCH

F-statistic	0.019216	Prob. F(1,37)	0.8905
Obs*R-squared	0.020244	Prob. Chi-Square(1)	0.8869

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.492946	Prob. F(2,32)	0.6154
Obs*R-squared	1.195532	Prob. Chi-Square(2)	0.5500

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.936968	Prob. F(1,33)	0.3401
Obs*R-squared	1.104362	Prob. Chi-Square(1)	0.2933

$$ARCH\ LM - F(1,37) = 0.019216(0.8905)$$

The null hypothesis for the ARCH states that there is no heteroscedasticity but, the result shows no statistical significance. So we do NOT REJECT the null hypothesis, meaning there is equal spread (homoscedasticity).

Serial Correlation Test

The heteroscedasticity test involving Ljung-Box (Q-stat and Q2-stat correlogram in EViews) specifies for higher order lags (>= 2 lag specifications). But, Durbin-Watson (D-W) allows for only first order lags. Consequently, the D-W is more suited for our analysis.

For display purpose only, the L-M result for low frequency data as ours is:

1 - Lag

$$Serial\ LM - F(1,33) = 0.936968(0.3401)$$

2 – lags

$$Serial\ LM - F(2,32) = 0.492946(0.6154)$$

With the results above, we are not able to reject the null hypothesis, meaning there is no evidence of severe auto correlation problem up to lag 2 in the regression model as p-values suggest.

Normality Test

The null hypothesis states that series is normally distributed. As p-value suggests we are not rejecting the null distribution as the residuals are normally distributed as expected of the linear regression model (Figure 5).

V. TABLES

Variable	Description
CO2PC	Carbon dioxide emission per capital (kg per capita)
ELCONPC	Electric power consumption per capita (kWh per capita)
PECONPC	Primary energy consumption per capita (kg of oil equivalent per capita)
GDPC	Gross domestic product per capita (current Nigeria naira, N)
TOTCO2	

Table 1

Minimum	21539.96	1059.100	172402.7	28.49249	322.0404	577.4985
Std. Dev.	21113.21	11119.59	50878.41	29.95994	182.4476	49.07583
Kurtosis	2.173610	6.215874	1.709108	2.572757	2.183160	2.700565
Jarque-Bera	1.669230	42.51086	3.735316	0.408387	1.392178	1.614853
Probability	0.434042	0.000000	0.154485	0.815304	0.498531	0.446004
Sum	2585836.	500082.9	9890033.	3450.199	27020.86	28108.57
Sum Sq. Dev.	1.78E+10	4.95E+09	1.04E+11	35903.92	1331485.	96337.46
Observations	41	41	41	41	41	41

Table2:- Descriptive statistics

Variable	Level			First Difference			Order
	None	Constant	Constant & trend	None	Constant	Constant & trend	I(d)
GDPC	0.883057	-0.101696	0.173652	-5.572078***	-5.556180***	-6.166110 ***	I(1)
CO2PC	-0.590734	-2.217108	-2.926788	-7.780752 ***	-7.683995 ***	-7.587097***	I(1)
ELCONPC	1.76569	-1.025384	-2.832130	-8.019457 ***	-8.625851 ***	-8.515424 ***	I(1)
PECONPC	2.273191	-1.359547	-2.544010	-5.063016 ***	-5.656879 ***	-5.584765 ***	I(1)
IMPORT	1.034120	-0.014221	-0.870565	-6.957125***	-7.275416***	-7.481199***	I(1)
TOTCO2	0.133703	-2.258712	-2.451087	-7.000477***	-7.016029***	-6.925450***	I(1)

Table 3: Results of the unit root test using ADF test for stationarity
Note: *** represents p<0.01; ** represents p<0.05; * represents p<0.1

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Option (CO2PC)	Tau Stats	Option (ELCONPC)	Tau Stats
None	-3.384350 (0.4261)	None	-5.945746 (0.0037)***
Constant	-3.352671 (0.5998)	Constant	-5.232607 (0.0419)**
Trend	-8.254516 (0.0001)***	Trend	-5.245265 (0.0794)*
Option (GDPC)	Tau Stats	Option (IMPORT)	Tau Stats
None	-3.314124 (0.4578)	None	-3.841077 (0.2398)
Constant	-4.087610 (0.2771)	Constant	-4.535105 (0.1445)
Trend	-3.979092 (0.4579)	Trend	-4.232283 (0.3493)
Option (PECONPC)	Tau Stats	Option (TOTCO2)	Tau Stats
None	-3.082021 (0.5712)	None	-6.212795 (0.0019)***
Constant	-4.269003 (0.2161)	Constant	-6.125417 (0.0064)***
Trend	-4.188896 (0.3670)	Trend	-7.363915 (0.0010)***

Table 4: Result of Engle-Granger co-integration test

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	4.54E+09	1473.648	NA
CO2PC	146.0631	22.14113	1.540304
ELCONPC	29928.45	77.33114	8.510516
GDPC	0.004267	84.13056	3.499591
IMPORT	0.123131	10.77152	4.823177
PECONPC	11557.58	1772.784	8.818441

Table 5: Results of Variance Inflation Factor

	CO2PC	ELCONPC	GDPC	IMPORT	PECONPC	TOTCO2
CO2PC	1.000000	-0.355729	0.356955	-0.118800	-0.315363	0.195627
ELCONPC	-0.355729	1.000000	0.062742	0.671310	0.924298	0.714749
GDPC	0.356955	0.062742	1.000000	0.592318	-0.055893	0.297114
IMPORT	-0.118800	0.671310	0.592318	1.000000	0.609569	0.582698
PECONPC	-0.315363	0.924298	-0.055893	0.609569	1.000000	0.686029
TOTCO2	0.195627	0.714749	0.297114	0.582698	0.686029	1.000000

Table 6: Correlation Matrix Result

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Co-integration between CO2PC and GDPC (assume linear deterministic trend and restricted constant)		
Hypotheses	Ho: r = 0	Ho: r = 1
	H1: r = 1	H1: r = 2
Trace statistic	12.40350	4.405758
5% critical value	25.87211	12.51798
p-Value	0.7833	0.6829
Maximum-eigen statistics	7.997739	4.405758
5% critical value	19.38704	12.51798
p-Value	0.8217	0.6829

Table 7: Results of Johansen Co-integration Test

	Dependent variable: CO2PC					
Variables	Cubic		Quadratic		Linear	
Constant	-2943.394	(-0.911678)	-1070.909	(-1.497914)	229.5026	(1.432181)
$CO_2PC(-1)$	0.566580	(4.546851)***	0.564274	(4.574193)***	0.654570	(576575***
GDPC	0.034426	(0.884345)	0.011538	(1.943869)*	0.000532	(0.884313)
$GDPC^2$	-1.13×10^{-7}	(-0.736810)	-2.20×10^{-8}	(-1.863168)*	-	-
$GDPC^3$	1.18×10^{-13}	(0.595040)	-	-	-	-
ELCONPC	-1.138028	(-1.117647)	-1.069233	(-1.067104)	-1.432851	(-1.409022)
IMPORT	-0.000159	(-0.046243)	0.000220	(0.065927)	-0.000578	(-0.168751)
R^2	0.69		0.68		0.65	
ADJ-R^2	0.63		0.64		0.61	
D-W Stat	2.31		2.21		2.25	
F-Stats	11.98632***		14.58995***		16.22399***	
Ramsey RESET			F = 0.475559 (p-value = 0.495)			

Table 8: Estimated results of the relationship of yearly CO_2PC emissions and Nigerian GDP with ELCONPC
Note: t-Statistics are given within parentheses
*** represents p<0.01; ** represents p<0.05; * represents p<0.1

	Dependent variable: CO2PC					
Variables	Cubic		Quadratic		Linear	
Constant	-2830.262	(-0.860860)	-1381.758	(-1.602025)	65.31423	(0.122638)
$CO_2PC(-1)$	0.554064	(4.381473)***	0.552684	(4.423575)***	0.652651	(5.409326***
GDPC	0.031155	(0.780390)	0.013116	(2.226128)**	0.000943	(1.414548)
$GDPC^2$	-9.60E-08	(-0.611522)	-2.45E-08	(-2.078200)**	-	-
$GDPC^3$	9.27E-14	(0.595040)	-	-	-	-
PECONPC	-0.000215	(-0.000327)	0.046363	(0.072212)	-0.016965	(-0.025282)
IMPORT	-0.002733	(-0.753722)	-0.002497	(-0.703923)	-0.004154	(-1.148489)
R^2	0.673563		0.67		0.66	
ADJ-R^2	0.614210		0.62		0.59	
D-W Stat	2.265523		2.19		2.25	
F-Stats	11.34856***		13.89996***		14.88384***	
Ramsey RESET			F = 0.155460 (p-value = 0.6959)			

Table 9:- Estimated results of the relationship of yearly CO_2PC emissions and Nigerian GDP with PECONP

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Ramsey RESET Test
Equation: UNTITLED
Specification: CO2PC C CO2PC(-1) GDPC GDPC^2 ELCONPC IMPORT
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.689608	33	0.4953
F-statistic	0.475559	(1, 33)	0.4953
Likelihood ratio	0.572322	1	0.4493

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	5969.565	1	5969.565
Restricted SSR	420209.5	34	12359.10
Unrestricted SSR	414239.9	33	12552.73
Unrestricted SSR	414239.9	33	12552.73

LR test summary:

	Value	df
Restricted LogL	-241.9501	34
Unrestricted LogL	-241.6640	33

Unrestricted Test Equation:
Dependent Variable: CO2PC
Method: Least Squares
Date: 02/17/16 Time: 11:02
Sample: 1971 2010
Included observations: 40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2182.057	1765.034	-1.236269	0.2251
CO2PC(-1)	1.093611	0.777594	1.406404	0.1690
GDPC	0.020999	0.014966	1.403084	0.1699
GDPC^2	-3.97E-08	2.83E-08	-1.401629	0.1704
ELCONPC	-2.386148	2.160211	-1.104590	0.2773
IMPORT	0.000441	0.003382	0.130402	0.8970
FITTED^2	-0.000725	0.001051	-0.689608	0.4953

R-squared	0.686610	Mean dependent var	661.4751
Adjusted R-squared	0.629630	S.D. dependent var	184.0988
S.E. of regression	112.0389	Akaike info criterion	12.43320
Sum squared resid	414239.9	Schwarz criterion	12.72875
Log likelihood	-241.6640	Hannan-Quinn criter.	12.54006
F-statistic	12.05001	Durbin-Watson stat	2.250858
Prob(F-statistic)	0.000000		

Table 10:- Post estimation: Ramsey RESET

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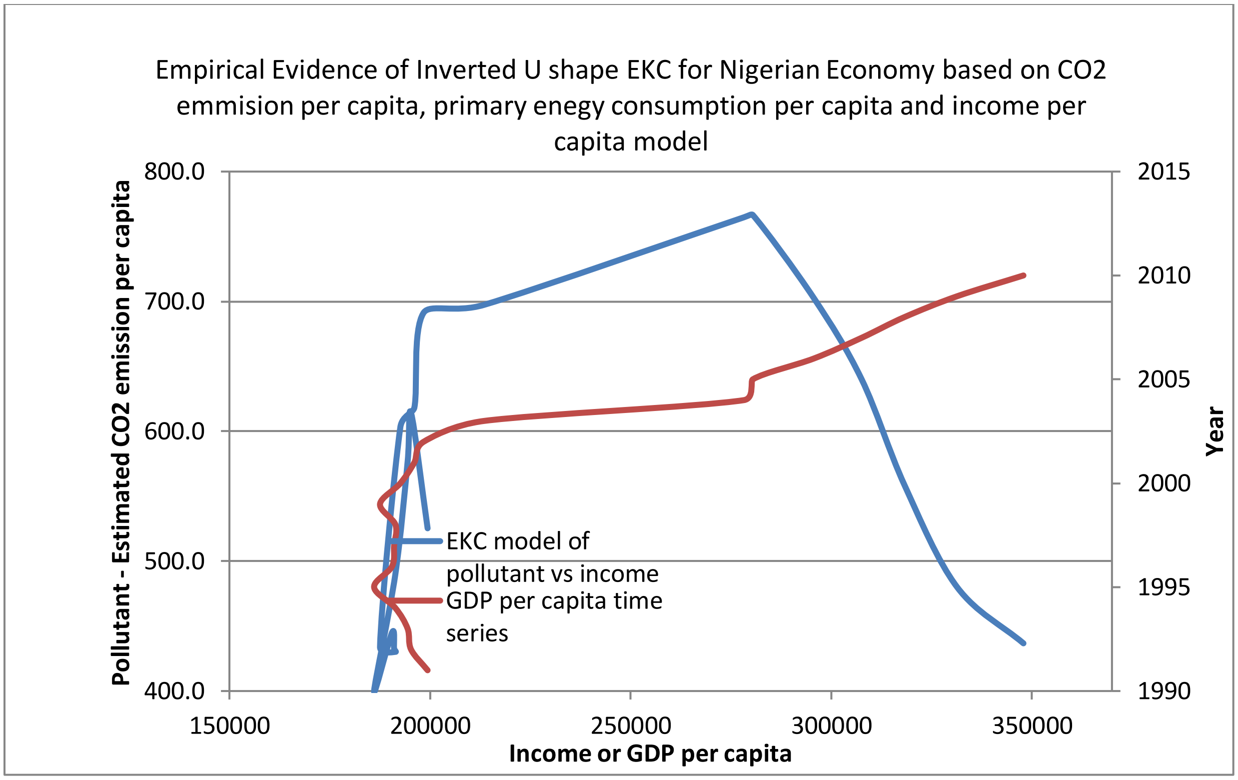

Fig 3:- Empirical Evidence of Inverted U shape EKC for Nigerian Economy based on CO2 emission per capita, primary enegy consumption per capita and income per capita model

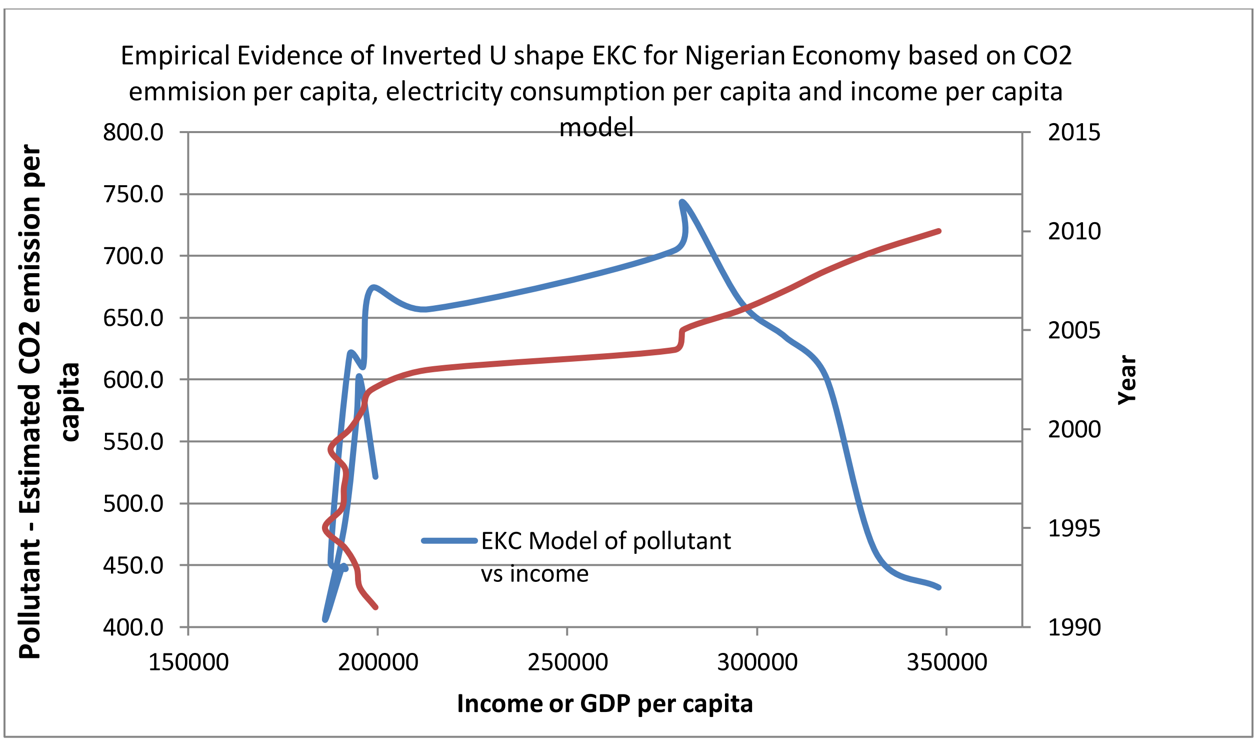

Fig 4:- Empirical Evidence of Inverted U shape EKC for Nigerian Economy based on CO2 emission per capita, electricity consumption per capita and income per capita model

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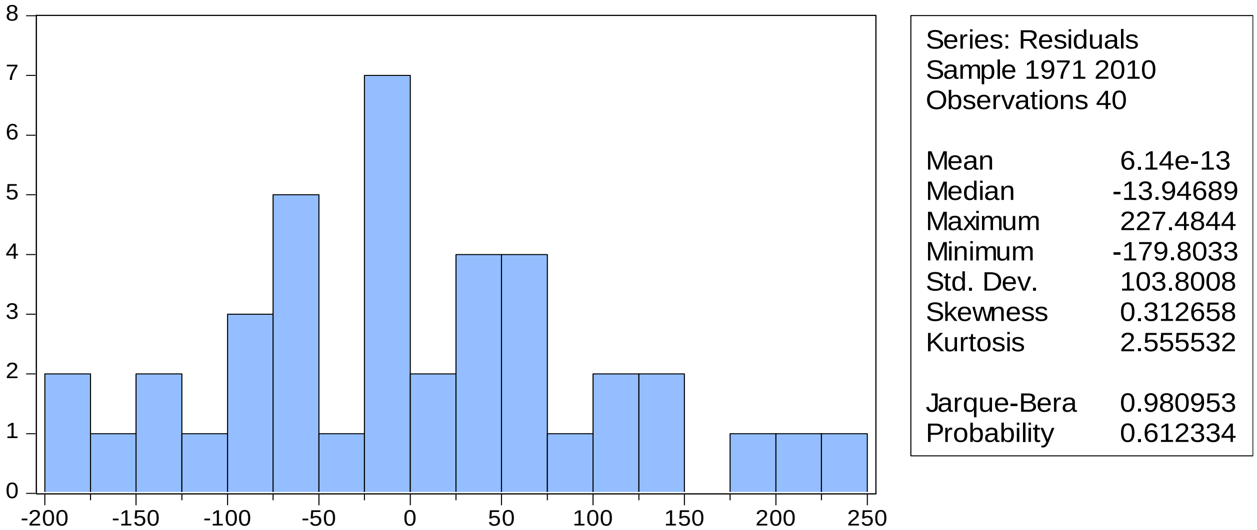

Fig 5:- Normality post estimation test

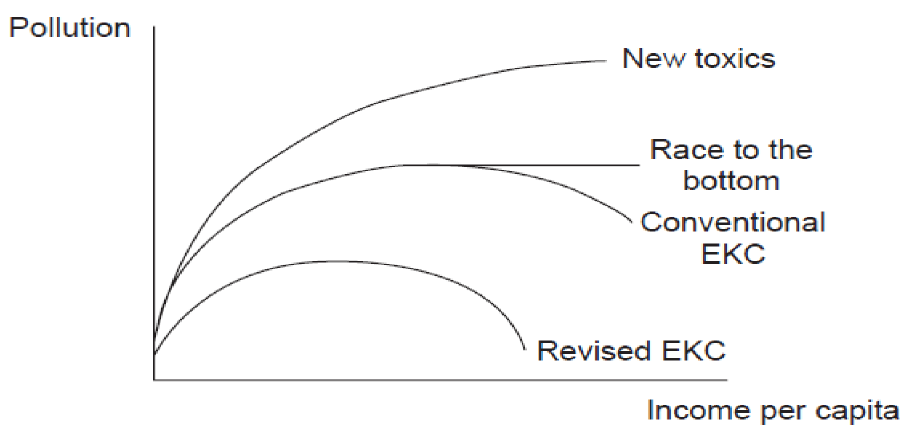

Fig 6:- Environmental Kuznets curve (EKC): differentscenarios. From Dasgupta et al. (2002)

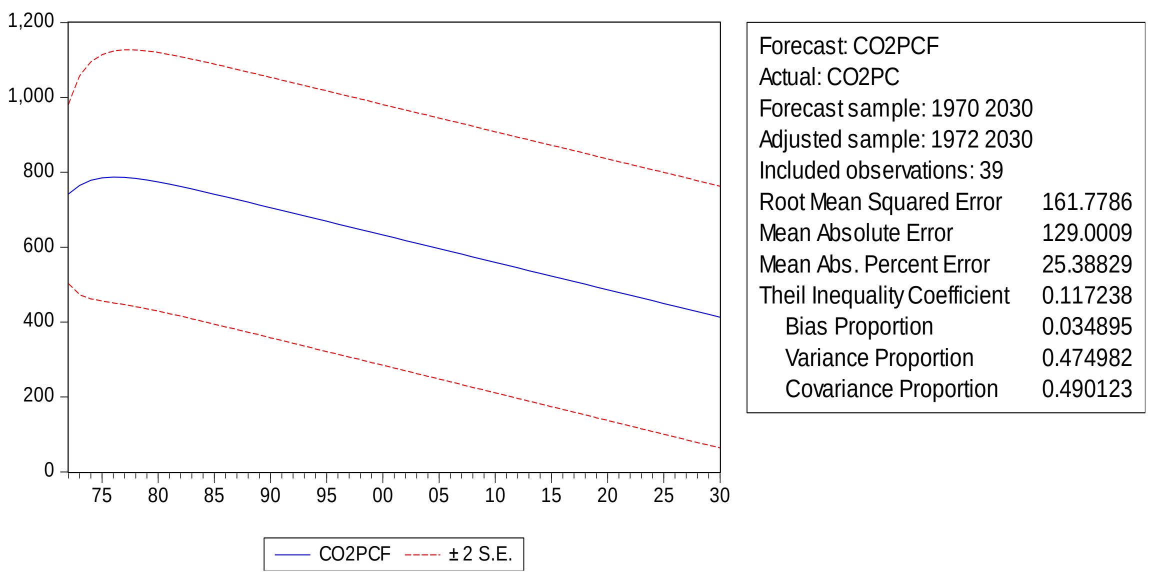

Fig 7:- Dynamic Forecast

VI. CONCLUSIONS AND POLICY RECOMMENDATIONS

The increasing amount of CO_2 emission which is the dominant variable contributing to greenhouse effect and its relationship to economic growth and energy consumption have burdened researchers and academics for years. The emission in a developing economy of Nigeria is explained largely by changes in (1) income,(2) primary energy consumption, (3) electricity consumption and (4) trade variable –import of economic goods.

The inverted U shaped relationship between CO_2 per capita emission and income akin to developed countries is also evident in developing Nigerian economy. Though this is surprising, national internal policy inertia explains this behavior rather than international treaty on CO_2 emission containment that has been used to explain this behavior for developed nations. Some of these policies include flare down policy aggressively implemented by International Oil companies operating in the country through establishment of associated gas gathering systems. Also the ban on importation of certain heavy emitters of CO_2 by the government of Nigeria e.g. certain grades of "tokunbo" cars. Also as Nigerian electricity industry which is mainly by hydro-generation increases its output, people and industries abandon or reduce alternative sources of power generation and consumption such as petrol and diesel-engine generator sets, kerosene lamps and fire woods, charcoal which are high emitters of CO_2. Also people have embraced renewable energy sources such as solar, energy saving bulbs, rechargeable lamps in preference to these CO_2 emitters.

Employing Autoregressive Integrated Moving Average (ARIMA) method to forecast the dynamic CO_2 behavior for Nigeria up to 2030 certeris paribus, our forecast shows that even though economic growth has historically been on the increase up to the end of period under study, (2010), CO_2 emission per capita will continue to be on decrease to circa 400 (kg per capita) having crossed the turning point of the inverted U shaped EKC in about 2005.

Government should continue to strengthen its policy on reduction of CO_2 emitters in its economy with no consequence on economic growth as observed. We recommend further work to be done to include more explanatory variables to this work.

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