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ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS IN SUB-SAHARAN AFRICAN COUNTRIES- EVIDENCE FROM PANEL DATA ANALYSIS.

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ABSTRACT: *The paper investigates the validity of Environmental Kuznets Curve (EKC) hypothesis in Sub-Saharan African countries, using panel data analysis for the period 1980 to 2012. It seeks to examine the effects of economic growth on the environmental quality of the countries in the sub-region. The paper used annual secondary time series data obtained from World Bank Development Indicators (WDI) for the period under review. The validity of EKC hypothesis was examined through panel data fixed and random effects analysis. Panel unit root test and panel cointegration test were conducted to determine the degree of stationarity of the variables and long–run relationship among our variables of interest respectively. The paper considers a variety of pollutants in estimating the EKC pattern with observation that the responses of EKC depend largely on the nature of pollutants. The results of the empirical analysis support the validity of the EKC hypothesis for solid emission (CSF) and composite factor of emission (CFE) but maintain non-existence of EKC hypothesis for other pollutants: carbon emission (CO_2), industrial emission (CIN) and liquid emission (CLQ). The paper confirms that not all the selected environmental pollutants follow the same EKC process in the selected countries of Sub-Saharan African (SSA). The paper recommends that the impression of "polluting the economy now as it clears itself later" does not hold for many of the pollutants and should not be adopted in the region so as to ensure better environmental quality as there is no proof of better quality if it is not regulated. The findings show that SSA countries need to harmonise a well – coordinated environmental and economic policy mix that would ensure greater output but at the same time protect their environment from degradation and pollution.*

KEYWORDS: *Environmental Kuznets Curve (EKC), Panel Data Analysis, Cointegration, Fixed and Random Effects.*

INTRODUCTION

For some social and physical scientists, growing economic activities [production and consumption] requires larger inputs of energy and material and generates larger quantities of waste by-products. Increased extraction of natural resources, accumulation of waste and concentration of pollutants will therefore overwhelm the carrying capacity of the biosphere and result in the degradation of environmental quality and a decline in human welfare, despite rising income. It is also argued that degradation of the resources base will eventually put economic activity itself at risk. To save the environment and even economy from itself, economic growth must cease and the world must make a transition to a steady-state economy. At the other extreme are those who argue

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that the fastest road to environmental improvement is along the path of economic growth. That with higher income comes increased demand for goods and services that are less material intensive, as well as demand for improved environmental quality that leads to the adoption of environmental protection measures (Ajide and Oyinlola, 2010).

The ultimate goal of any economy regardless of its political system inclinations and arrangement is to achieve a desirable and sustainable level of economic growth and development. The growth of this complex interdependent relationship which engendered growth trajectory has a direct bearing on the environment. The quality of this environment therefore is often believed to vary with the different stages, pattern and structure of development. There is a clear evidence that although economic growth usually leads to environmental deterioration in the early stages of the process, in the end the best and probably the only way to attain a decent environment in most countries is to become rich (Beckerman, 1992). The central issue is the proof of existence and applicability of Environmental Kuznets Curve (EKC) which hypothesizes that at low level of income, an increase in national income corresponds to an increased environmental pressure, in later stages of development the de-linking between economic growth and environmental degradation leads to a better environmental quality. The inverted U-shaped resulting from this relationship is usually known as Environmental Kuznets Curve (EKC).

Some empirical studies have supported an inverted U-shaped relationship between environmental degradation and economic growth (Grossman and Krueger, 1991; Seldom and Song, 1994; Rothman, 1998). Several studies such as Azomahon and VanPlus, (2006); Stern (2004), Kemade (2010), Yi, *et al* (2008), etc discover the existence of a bell-shaped relation between the levels of environmental quality and per capita income. While Ayide and Oyinlola (2010) find that growth rate of GDP plays no significant role in the dynamics of environmental quality.

Evidences have also shown from various research works, both at country-specific and cross-country levels, that there is no consensus on the validity of EKC hypotheses. Most of the available cross-country analyses are for developed countries (Yu, 2012). There may be larger deviations from these hypotheses in developing countries than in developed countries. The limited cross-country analyses for developing countries in this regard are non-African studies, and the evidences are mixed (Ajide and Oyinlola, 2010). Hence, a thorough understanding of validity of this hypothesis particularly in Sub-Saharan Africa is a gap to be filled in the literature.

Moreover, many of the previous studies used a single environmental variable, particularly Carbon dioxide emission, as a proxy for environmental quality. But not all environmental pollutants follow the same EKC process, the impact of FDI and economic growth on each environmental variable in a particular country may vary. Studies that have examined a variety of pollutants in estimating the EKC pattern are very scanty, and none, to the best of our knowledge, for the SSA. This reinforces the need for this study. Various environmental factors shall be assessed using factor analysis to determine principal environmental variables for this study. Panel data approach is adopted enable a more detailed study of the EKC hypothesis in the case of Sub-Saharan Africa countries for the period 1980 to 2012.

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The remainder of the paper is organized as follows: Section 2 provides review of literature. Section 3 describes the analytical framework and methodology adopted for the paper. Section 4 presents the empirical results and section 5 concludes the paper.

REVIEW OF LITERATURE

Theoretical studies on deriving the path between environmental quality and economic growth have considered basically the EKC Hypothesis. The Environmental Kuznets Curve Hypothesis states that as an economy's per capita income increases, the total amount of environmental impact of economic activities initially grows, reaches a maximum and then falls. The original Kuznets curve (1955) suggested an inverted U-shaped relationship between environment and national income, saying that environmental degradation increases at lower income levels, reaches a maximum, and then declines thereafter. While this ultimately did not hold up to empirical scrutiny, it served as a backdrop for policy makers to advise governments to 'grow now, worry equally later' (Gallagher, 1999).

The hypothesis as put by Grossman and Krueger (1991) explains that the improvement in environmental quality at higher levels of per capita income due to factors such as changes in the composition of output, the introduction of cleaner production technology, and the greater demand for improved environmental quality, leading to more stringent environmental regulations. The functional specification is usually quadratic, log quadratic or cubic in income. Another possible explanation for the downward sloping part of the EKC: as countries develop, they stop producing the pollution-intensive goods and instead import them from developing countries with weaker environmental standards. However, they argue that it does not mean the differences in environmental stringency are an important determinant of the pattern of international trade, because "the volume of such trade is probably too small to account for the reduced pollution that has been observed to accompany different levels of economic growth".

In 1993, Panayotou points out that EKC is an inevitable result of structural change accompanying economic growth. Later on, Panayotou *et al.* (2000) demonstrate that pollution emissions rise at the process of one country's industrialization and decrease in the post-industrial stage. Cole (2000) finds that EKC could be the result of a falling share of manufacturing and the shifting of the manufacturing to "clean" sectors away from "dirty" sectors. But he also points out that a falling income elasticity of demand for pollution intensive products is associated with rising income level.

A great number of empirical studies have been devoted to the relationship between economic growth and the environment; these studies have been conducted to test the EKC hypothesis. There are two main purposes for those studies, one is to see whether the EKC exists or not, and the other one is to find the turning point if the EKC does exist and the empirical findings were incompatible. **S**ome of the empirical studies focused on individual countries. For example, Vincent *et al.* (1997) find that SPM and chemical oxygen demand (COD) are increasing with income, while biochemical oxygen demand (BOD) is decreasing with income in Malaysia; Carson *et al.* (1997) find all major air pollutants decline with increasing levels of income across 50 US states. In terms of the empirical studies in China, Shen (2006) uses a simultaneous equations model to examine the existence of the EKC relationship between per capita income and per capita pollution emissions.

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He uses two air pollutants (SO_2 and Dust Fall) and three water pollutants (COD, Arsenic and Cadmium) from 1993 to 2002 in 31 Chinese provinces and municipalities. The results suggest an EKC relationship for all water pollutants. Meanwhile, SO_2 shows a U-shaped relationship with income levels and Dust Fall has no significant relationship with income levels. The study reveals that both environmental policy and industrial structure play important roles in determining the water and air pollution levels in China.

Giles and Mosk (2003) exhibit that relations between CH4 emission and income per capita in New Zealand is inverted-U shaped curve. Huang and Shaw (2002) also show that EKC exists for N_2O and CO in Taiwan during the period between 1988 and 1997. But Rica *et al.* (2001) analyze six atmospheric pollutants in Spain and find that there doesn't exist EKC hypothesis, except for SO_2. Alege and Ogundipe (2013) investigate the relationship between environmental quality and economic growth in Nigeria using a fractional cointegration analysis over the period 1970 to 2011. The study finds that early stages of development in Nigeria accentuate the level of environmental degradation and fails to attain a reasonable turning point, hence, a non-existence of EKC in Nigeria.

Considering cross-section analysis, they are estimated econometrically using panel data methodology. Some test for country and time-fixed-effects and some test for random-effects. The results of studies by Selden and Song (1994) and Grossman and Krueger, 1995) confirm the basic EKC pattern for certain pollutants. However, the turning points for the emissions of SO_2, NOx, SPM, and CO in Selden and Song (1994) are much higher than those found by Grossman and Krueger (1993). The difference is explained as the reduction of emissions lagging behind the reduction in ambient concentrations. Additionally, the results from Shafik (1994) are ambiguous, suggesting that the EKC does not hold at all times and for all pollutants.

Chen, (2007) confirms that environmental pollution is an important issue in the process of economic growth by testing the availability of the Environmental Kuznets Curve in China using reduced form model based on provincial panel data. Analyzing the relationship between GDP per capita and the emissions of five kinds of industrial pollutants (solid wastes, waste water, SO_2, soot and smoke), he concludes that the relationship varies on the types of pollutants and regions. In order to make the harmonized development, environmental regulation needs to be strengthened. From the empirical results, it was found that the EKC hypothesis is not clear in China, since the relationship between environmental quality and income varies on the types of pollutants and regions. The inverted U-shaped curve cannot be generalized for all emissions. The relationship between economic growth and environment in China is complicated.

Perman and Stern (2003) tries to validate the Environmental Kuznets Curve (EKC) by using panel data approach to cointegrate and confirm the long run equilibrium stable relation between sulfur emissions and economic growth but failed to support the existence of the EKC. Also, Asics and Atil (2011) investigate causal relationships between economic growth and environmental degradation for the low, middle and high income counties. They conclude that positive effect of income on environmental degradation is stronger in middle income countries as compared to low and high income economies. Moreover, in high income countries, the effect is not only negative but also statistically insignificant. Thus, the results do not provide support for EKC hypothesis.

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Harbaugh, *et al*. (2002) use the updated and revised panel data on ambient air pollution in cities worldwide to re-examine the robustness of the evidence for the existence of the EKC studied by Grossman and Krueger (1995). They test the sensitivity of the pollution-income relationship to function forms and econometric specification used, including additional covariates and changes in the nations, cities and years sampled. They conclude that there is little evidence to support an inverted-U shaped relationship between several important air pollutants and national income in these data.

De Bruyn *et al.* (1998) adopt a dynamic model and estimate for three types of emissions (CO_2, N_2O and SO_2) in four separate developed countries (Netherlands, UK, US and Western Germany). It is found that these emissions correlate positively with economic growth and that emissions may decline over time probably due to structural and technological changes. Schmalensee *et al.* (1998), Galeotti and Lanze (1999) have studied the interactions between CO_2 and GDP per capita. Their findings show that inverted U-shaped curve exists for CO_2. Although the above research results show that EKC does exist for some pollutants, there are some other studies that do not support the EKC hypothesis. According to Kaufmann *et al.* (1998), the relationship between SO_2 and income is U-shaped curve. Meyer, *et al.* (2003) conducted a survey on deforestation based on the data of 117 countries and the time span from 1990 to 2000. The finding is a U-shaped curve.

From the foregoing, the empirical findings are inconsistent. Conflicting results exist even for the same pollutant among various studies. Also, not all environmental pollutants follow the same EKC process. There is widespread perception that the region of Sub-Saharan Africa is structurally different from the rest of the world, and the lessons from East Asia or Latin America do not apply to them because their situation is different. But African leaders can learn from one another, hence, the validity of EKC hypothesis needs to be confirmed in the SSA region, particularly for variant pollutants.

ANALYTICAL FRAMEWORK AND METHODOLOGY

Background

This study adopts Trade and Investment theory formalized by Copeland and Taylor (1994) that was based on the theory of comparative advantage, which states that 'in order to allocate resources efficiently and hence maximise global output and income, countries should specialise in the production and export of products that use in their production a relatively large amount of the resources that the country has in relative abundance'. Therefore, countries should produce and export products for which they have a comparative advantage, and they should import products in which they have a comparative disadvantage. Countries where assimilative capacity is exhausted and; incremental residual discharge has a high cost would have a comparative disadvantage in dirty production and a comparative advantage in clean production. Thus, specialization through comparative advantage and international trade (investment) efficiently allocates resources, increases production and improves world welfare. Therefore, the supply and demand for environmental services can be treated as an additional factor of production, and that an efficient pattern of world production will reflect that factor. In 2001, Copeland and Taylor updated their

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book titled "Trade and the environment". where a general analysis model was established to show that trade can affect environment through economic scale, industrial structure and the technology regulated by the government. The three mechanisms are given as scale effects (expansion of economic activity), composition effects (change in industrial structure) and technique effects. It has since been one of the standard approaches to analyse environmental kuznets curve hypothesis.

Following up from economic scale effect of FDI in the theory of trade and investment, Wei (2002) uses standard Cobb- Douglas production function as the starting point to show relationship between Growth and environmental quality. This gives production function as:

$$Y= A\, K^{\alpha}\ H^{b} \quad \cdots\cdots 1$$

Where *Y*= Output, *H*=Labour force, *K*=Capital and *A*= The total factor productivity, which explains the output growth that is not accounted for by the growth in factors of production specified. While α and b denote the elasticity of output with respect to K and H respectively.

Taking the logarithms form and differentiating equation 1 with respect to time and in panel form, we obtain

$$y= a_{it} + \alpha k_{it} + bh_{it} + ei \quad \cdots\cdots 2$$

The quality of the environment is assumed to be a determinant of economic growth. Therefore, environment is modelled as an input in the production process; the depletion of this input may or may not have feedback effects on the stock of productive resources. This changes equation 2 to give

$$y= a_{it} + \alpha kd_{it} + bh_{it} + \lambda env_{it} + e_{i} \quad \cdots\cdots 3$$

Note: *env* stands for environmental variables.

Model Specification

Scale effect as explained in trade theory, emphasizes that economic activities impact on the environmental quality. According to Jing (2008), following up from the production function as expressed in equation 3, the relationship between environmental quality and output can be expressed as:

$$Env = f\,(Y) \quad \cdots\cdots 4$$

$$Env = \alpha + \beta Y \quad \cdots\cdots 5$$

Where: Env and Y represents environmental quality and output respectively.

For a situation where different countries and years are considered, time and country specifics are to be considered. The year specific effects are included to pick up any effects that are common to all countries but which change over time; and the country specific effects pick up the effects specific to each country which do not change over time. This changes equation 5 to

$$Env = \alpha + y_i + \theta_t + \beta Y \text{ ....6}$$

The EKC Hypothesis shows that different stages of economic scales must be taken into consideration as FDI, through economic activities, influences environmental quality. Therefore, second function of output is included in the model to give the expression below.

$$Env = \alpha + y_i + \theta_t + \beta_i Y + \beta_2 Y^2 \text{ ....7}$$

Since we are using panel data, the year specific effects are included to pick up any effects that are common to all countries but which change over time; and the country specific effects to pick up the effects that are specific to each country which do not change over time. The equation changes to

$$Env_{it} = \alpha + y_i + \theta_t + \beta_i Y_{it} + \beta_2 Y_{it}^2 + \varepsilon_{it} \text{ ....8}$$

Apriori expectations for a standard EKC relationship (inverted-U) between income and pollution are $\beta_1 > 0$ and $\beta_2 < 0$.

Since not all environmental pollutants follow the same EKC process, the impact of economic growth on each environmental variable may vary; hence, various environmental factors were assessed using factor analysis to select four principal environmental variables.

$$CO_{2it} = \alpha + y_i + \theta_t + \beta_i Y_{it} + \beta_2 Y_{it}^2 + \varepsilon_{it} \text{ .... 9}$$

$$CIN_{it} = \alpha + y_i + \theta_t + \beta_i Y_{it} + \beta_2 Y_{it}^2 + \varepsilon_{it} \text{ ....10}$$

$$CLQ_{it} = \alpha + y_i + \theta_t + \beta_i Y_{it} + \beta_2 Y_{it}^2 + \varepsilon_{it} \text{ .... 11}$$

$$CSF_{it} = \alpha + y_i + \theta_t + \beta_i Y_{it} + \beta_2 Y_{it}^2 + \varepsilon_{it} \text{ ....12}$$

Also, the selected environmental variables were interacted as a single variable through component analysis to have a composite variable as an environmental variable. The model is then expressed as:

$$CFE_{it} = \alpha + y_i + \theta_t + \beta_i Y_{it} + \beta_2 Y_{it}^2 + \varepsilon_{it} \text{ -------------------------------- 13}$$

Where: CO_2 = Carbon Dioxide Emissions; CIN = Industrial Emissions; CLQ = Liquid Emissions
CSF = Solid Emissions; CFE = Composite Factor of Emissions.

Sources of Data / Measurement of Variables This study makes use of secondary data sourced from World Development Indicators (WDI). The study is interested in the relationship between

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environmental quality and economic growth in the thirty-three selected countries of Sub-Saharan Africa region. Annual data spanning 1980 to 2012 shall therefore be used. The study will make use of econometric analysis with broad panel data of 33 selected countries in the sub-region based on the availability of data over the period of 1980 to 2012 for an in-depth analysis. This wide coverage is essential in order to enhance the reliability of the data used for estimation as well as reliability and consistency of the results. An advantage of using a dataset spans a large set of countries over a longer period is that it increases the degrees of freedom and therefore enhances the credibility of our results. The selected countries are:

1) Angola	12) Ghana	23) Nigeria
2) Benin	13) Guinea	24) Senegal
3) Botswana	14) Kenya	25)Sierra Leone
4) Cameroon	15) Liberia	26) South Africa
5) Chad	16)Madagascar	27) Sudan
6) Congo Republic	17) Malawi	28)Swaziland
7)D. R. Congo	18) Mauritania	29) Tanzania
8) Cote d'Ivoire	19) Mauritius	30) Togo
9) Equatorial Guinea	20)Mozambique	31) Uganda
10) Ethiopia	21) Namibia	32) Zambia
11) Gabon	22) Niger	33) Zimbabwe

For the purpose of estimation, the variables of interest are defined as follows:
GDP: The real per capita growth rate was used. This is real gross domestic product in (US Dollars) divided by midyear population.
Carbon Dioxide Emissions (CO_2): These are carbon dioxide emissions stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. This is measured in kilogram per 2005 US$ of GDP.
Liquid Carbon Dioxide Emissions (CLQ): These are emissions from liquid fuel consumption. It refers mainly to emissions from use of petroleum-derived fuels as an energy source. This is measured in kilogram per 2005 US$ of GDP.
Solid Carbon Dioxide Emissions (CSF): These are emissions from solid fuel consumption which are mainly emissions from use of coal as an energy source. This is measured in kilogram per 2005 US$ of GDP.
Industrial Carbon Dioxide Emissions (CIN): This considers the CO_2 emissions from manufacturing industries and construction which contains the emissions from combustion of fuels in industry. It also includes emissions from industry autoproducers that generate electricity and/or heat. This is measured in kilogram per 2005 US$ of GDP.

EMPIRICAL RESULTS AND DISCUSSION

To achieve the objective of this paper which intends to verify the validity of EKC hypothesis in the selected countries of Sub-Saharan Africa, panel analysis of fixed and random effects estimators were used to analyse the already given models. The series were firstly subjected to panel unit root

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test to determine the degree of stationarity of the variables of concern. Kao cointegration test was also conducted to ascertain if long run relationship exists among the variables in the specified models.

Panel Unit Root Test

This section considers the panel unit root test for all the variables in the study. The results of the stationarity tests obtained using Levin, Lin and Chu, Im, Pesaran and Shin, P.P. Fisher and ADF Fisher panel unit root test were presented in Table 1 below:

Table 1: Panel Unit Root Test Results

Variable	Levin, Lin and Chu (t-stat)	Im, Pesaran & Shin(W-sta)	ADF Fisher (Chi-sq)	P.P. Fisher (Chi-sq)	Level of Stationarity
GDP*	-17.9437	-18.7501	479.082	545.139	1
GDP**	-19.3889	-20.3712	487.189	736.901	1
CO2 *	-28.5274	-28.8380	786.925	872.749	1
CO2**	-28.1323	-29.9246	802.112	1490.75	1
CIN*	-25.2586	-25.4515	515.250	541.492	1
CIN **	-22.8744	-24.3618	496.830	742.760	1
CLQ*	-29.4134	-29.5117	791.141	909.098	1
CLQ**	-29.8928	-31.8024	820.856	1622.35	1
CSF*	61.0899	-2.25315	196.322	186.333	1
CSF**	-5.37688	-4.27726	209.435	225.037	1
CFE*	-1.08873	-2.22856	106.072	102.985	1
CFE**	-2.81654	-2.21959	95.4254	78.6199	1

** Intercept; ** Linear Deterministic Trend; 1- Stationary at first difference.*
Source: Author's Computation

The results showed that all the variables tested were non-stationary at their levels. This indicates that the incorporated time series variables are unstable and non-mean reverting and this might render the model estimations structurally unstable at levels. Stationarity was only induced to many of the variables after first difference. This implies that those panel series are integrated of order one. It could therefore be seen that the series in the selected Sub-Saharan Africa countries could

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adequately be regarded as a random walk when they are in their levels but revert to their mean level after first differencing. Since the results suggested that the variables of interest were only stationary in first difference, it becomes econometrically reasonable to conduct the panel cointegration test thereafter.

Panel Cointegration Test

Following the findings in Table 1 that stationarity was induced to all the variables of interest after first difference, hence the cointegration test statistics to ascertain if long run relationship exists among the variables of concern in the specified models. To achieve this, a Kao Residual Cointegration test was employed. The summaries of results of the Cointegration test for the selected SSA countries are shown in Table 2 below:

Table 2: Kao Residual Cointegration Test Results for EKC

EKC MODEL	t-stat	Prob
1	-1.002837**	0.0680
2	-0.573122**	0.0533
3	-12.11700***	0.0000
4	2.300001***	0.0107
5	0.560552**	0.0376

***, *** indicate 5% and 1% level of significance.*
Source: Author's Computation

Evidence from Kao cointegration tests results in Table 2 indicates rejection of null hypothesis of no cointegration among the variables for all the model specifications at 1% and 5% levels of significance. The result indicated that at least one co-integrating vector exists among the variables in each model. This implies that the variables are cointegrated, suggesting that there is presence of long run feedback effects on the short run dynamism of the specified models in the selected countries of SSA for the period under review.

Panel Random and Fixed Effect Estimations

To test for the validity of Environmental Kuznets Curve Hypothesis in Sub-Saharan Africa, we estimated equations 9, 10, 11, 12 and 13 as given in the earlier section through Panel Random and Fixed Effect methods. The Hausman test was then applied to find out whether the random effects

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model is appropriate or not. The results suggest that, in all cases, the individual effects and time effects could not be adequately modeled by random effects models (χ^2=0, P≠1), and revealed that the fixed effects specification is consistent and efficient in each case. The Redundant Fixed Effect Diagnostic Test was also conducted for the specified models and the results reject the null hypothesis that the fixed effect components are redundant at 1 percent level of significance for all the specified models. This implies that the fixed effect components are relevant in achieving the objective. The summary of the fixed effect estimations results is given in the table below:

Table 3: Results of Panel Fixed Effect Estimations

Dep. Var	CO_2	CIN	CLQ	CSF	CFE
Models	1	2	3	4	5
C	13.53536 (7.369106)	21.95066 (4.654377)	14.74528 (6.895670)	-19.31073 (-2.049205)	-7.652209 (-1.604400)
Gdp	-3.902418* (-4.120417)	-12.09953* (-5.399667)	-5.097848* (-4.820366)	14.03758* (2.990841)	6.510301* (2.835241)
Gdp_2	0.592628* (3.817396)	1.940857* (5.635780)	0.870111* (5.125530)	-2.550133* (-3.437678)	-1.030912* (-2.886785)
R^2	0.974814	0.982164	0.954652	0.902652	0.972775
AdjR^2	0.973886	0.981468	0.952931	0.897966	0.971382
F.Stat	1050.563	1410.208	554.5632	192.6137	698.3799

*Note: * implies 1% level of significance*
Source: Author's Computation

The results in table above reveal that the two components of real per capita income are consistently significant in contributing to environmental quality as proxied by CO_2 emission inthe region. But Gdp has negative sign while Gdp_2 has positive relationship with CO_2 emission.This invalidates the existence of EKC in the region. This result tallies with the findings of Alege and Ogundipe (2013), Yu (2012), Omisakin (2009), Azomahou, *et al* (2006), Bertinelli and Strobi (2005), which indicates that there is a U-shaped relationship between economic growth and environmental degradation. This relationship implies that environmental quality depreciates with an increase in per capita income after certain level of income has been reached in developing economies of the world. This shows that the relationship between growth and environmental quality is U-shaped and not inverted U-shaped in the case of sub-Saharan African countries for the period under review.

Considering the case of industrial emission (CIN) and liquid emission (CLQ) independently, the same results were obtained. Growth of real per capita income was shown to be significant to the volume of industrial emissions and liquid emissions in SSA. The normal Gdp has negative impact

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while the squared function of Gdp was shown to be positively related to both CIN and CLQ. The results also show that there is a U-shaped relationship between economic growth and environmental degradation, and reflect the opinion that carbon dioxide emission is the best measure of pollution indicator hinged on the fact that CO_2 emission is the main component of the green house gas emission (Carvallo and Eduardo, 2008; Galeoth *et al*, 2006).

In the case of composite factor of emission (CFE) and solid emission (CSF), different results were obtained. The real per capita income was shown to be significantly related as obtained in previous cases, and Gdp was shown to be positive while Gdp_2 was negative. The results validate the EKC hypothesis; there is an inverted U-shaped in the case of CFE and CSF for the selected countries of SSA. These results support the views of Chen (2007) and Yu (2012), that different pollution emissions may produce different EKC positions. We were able to observe that the responses depend largely on the nature of pollutants; the condition of a single environmental variable (CO_2) cannot be generalized for other pollutants.

CONCLUSION AND RECOMMENDATIONS

The paper attempts to investigate the relationship between environmental quality and economic growth in SSA countries using a panel analysis over the period of 1980 to 2012.The study considers other pollutants along with carbon dioxide emission which makes the study unique from previous studies for the countries of the region. The EKC relation is shown in this study to be variant in relation to the particular pollutants considered. This study reveals that it may be wrong to generalize the reaction of a single environmental variable to EKC hypothesis as it is found that different pollution emissions may produce different EKC positions. We are able to observe that the responses to EKC hypothesis depend largely on the nature of pollutants. The results reveal that Environmental Kuznets Curve is invalid for the selected countries of SSA for some pollutants but valid for others. Following the findings from this study, the impression of "polluting the economy now as it clears itself later" does not hold in all cases and should not be adopted in the region so as to ensure better environmental quality as there is no proof of better quality if pollution emission is not regulated.

The following recommendations are hereby made:

(i) Policy reforms that are growth – oriented and environmental preserving are necessary in the SSA region.
(ii) Policies that restrict importation of carbon-intensive products and highly polluting Trans-National Corporations must be embarked upon in the sub-region.
(iii) Governments in the various countries of SSA should make greater efforts to reducing the discharge of industrial emissions, carbon dioxide emission, and liquid emissions.
(iv) Environmental-related institutions are to be strengthened to ensure appropriate sanctions on derailing companies and adoption of cleaner technologies. It was found that the EKC hypothesis is not clear in SSA, since
(v) The EKC relationship for each pollutant is necessary to be indentified and differentiated environmental policies be adopted to ensure better environmental quality in the various countries of SSA.

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(vi) Leaders in SSA should make greater efforts to reducing the discharge of industrial emissions, carbon dioxide emission, and liquid emissions in the region.

REFERENCES

Ajide, K.B. and Oyinlola, M.A. (2010). Does the level of Economic Growth influence Environmental Quality in Nigeria: A Test of Environmental Kuznets Curve (EKC) Hypothesis? *Pakistan Journal of Social Sciences*, l7(4): 325-329.

Alege, P.O. and Ogundipe, A.A. (2013). Environmental Quality and Economic Growth in Nigeria: A Fractional Co-integration Analysis. *International Journal of Development and Sustainability, 2:2.*

Asici and Atil A. (2011). Economic Growth and its Impact on Environment: A Panel Data Analysis. *MPRA Paper No*. 30238.

Beckerman, W., (1992). Economic Growth and the Environment: Whose Growth? Whose Environment? *World Development,* 20(4): 481- 492.

Caves, R. E., (1982). *Multinational Enterprise and Economic Analysis*, Cambridge: Cambridge University Press.

Carson, R., Jeon, Y., and D., McCubbin. (1997). The Relationship between Air Pollution Emissions and Incomes: US Data. *Environment and Development Economics*, 2(4).

Chen, L. K. and Y. K. Kwan, 2007. What Are the Determinants of the Location of Foreign Direct Investment? The Chinese Experience, *Journal of International Economics,* 51: 379-400.

Cole, M.A., (2000a). Air Pollution and 'Dirty Industries': How and Why does the Composition of Manufacturing Output Change with Economic Development? *Environmental and Resource Economics*, 17(1): 102-123.

…………. (2000b). Development and the Environment: Are the Criticisms of the Environmental Kuznets Curve Justified? University of Birmingham, Department of Economics. *Discussion Paper* 00-08.

………….. (2003). Development, Trade, and the Environment: How Robust is the Environmental Kuznets Curve? *Environment and Development Economics,* 8:557-580

Copeland, B and Taylor, M. S. (1994). North-South Trade and the Environment, *Quarterly Journal of Economics*, 109: 755-787.

Copeland, B. and Taylor, M.S. (2001). International Trade and the Environment: A Framework for Analysis. *NBER Working Paper* No.8540. http://www.nber.org/papers/w8540

Copeland, B.and Taylor, M .S. (2004). Trade, Growth and the Environment. *Journal of Economic Literature*, 42(1):7- 71.

De Bruyn, S. M., Van Den Bergh, J. C. J. M., and J. B., Opschoor, (1998). Economic Growth and Emissions: Reconsidering the Empirical Basis of Environmental Kuznets Curve. *Ecological Economics,* 25(2).

Jing, Z. (2008) Foreign Direct Investment, Governance, and the Environment in China: Regional Dimensions. *An Unpublished Ph.D. Thesis Submitted to Department of Economics, School of Social Sciences*, The University of Birmingham.

Grossman, G.M. and A.B.Krueger. (1991). Environmental Impacts of a North American Free Trade Agreement. *NBER Working Paper No*. 3914.

Grossman, G. M. and Krueger, A. B. (1995). Economic Growth and the Environment. *Quarterly Journal of Economics*, 110: 353–377.

Hoffmann, R., Lee, C-G., Ramasamy, B and Yeung, M., (2005). FDI and Pollution: A Granger Causality Test Using Panel Data. *Journal of International Development* 17: 311-327.

Kaufmann, R. K., Davidsdottir, B., Garnham, S., and P. Pauly, 1998, 'The Determinants of Atmospheric SO_2 Concentrations: Reconsidering the Environmental Kuznets Curve' *Ecological Economics*, 25(2):. 209-220.

Kuznets, S. (1955). Economic Growth and Income Inequality. *American Economic Review*. 45(1).

Olusegun, O. (2009). Economic Growth and Environmental Quality in Nigeria: Does Environmental Kuznets Curve Hypothesis Hold? *Environmental Research Journal, 3(1).*

ISSN 2056-7537(print), ISSN 2056-7545(online)

Panayotou, T. (1993). Empirical Tests and Policy Analysis of Development. *ILO Technology and Employment Programme Working Paper*, WP238.

,, (2003). Economic Growth and the Environment. *Economic Survey of Europe*, No.2.

Perman, R. and Stern, D. I. (2003). Evidence from panel unit root and cointegration test: that the environmental Kuznets curve does not exist. *Australian Journal of Agricultural and Resource Economics*, 47: 325-327.

Rothman, D. S. (1998). Environmental Kuznets Curve-Real Progress or Passing the Buck: A case for consumption-base approaches. *Ecological Economics*, 25: 177-194.

Selden, T. M. and Song, D. Q. (1994). Environmental Quality and Development: Is there a Kuznets Curve for Air Pollution Emission. *Journal of Environmental Economics and Management*. 27: 147-162.

Shabbir T., And Mahmood A., (1992). The Effects of Foreign Private Investment on Economic Growth in Pakistan. *The Pakistan Development Review*, 31(4): 831-841.

Shafik, N., (1994). 'Economic Development and Environmental Quality: An Econometric Analysis. *Oxford Economic Papers*, Vol. 46, Supplement: 757-773.

Shafik, N. and Bandyopadhyay, S., (1992). Economic Growth and Environmental Quality: Time Series and Cross-country Evidence. *World Bank Policy Research Working Paper*, No.WPS904.

Shen, J., (2006). A Simultaneous Estimation of Environmental Kuznets Curve: Evidence from China. *China Economic Review*, 17(4): 383-94.

Stern, D. I., (2004). The Rise and Fall of the Environmental Kuznets Curve. *World Development*, 32: 1419-1439.

Vincent, J. R., Ali, R. M., and Associates, (1997). Environment and Development in A Resource-Rich Economy: Malaysia Under the New Economic Policy, Cambridge, MA: Harvard University Press.

World Bank (2012). World Development Indicators, http://publications.worldbank.org/WDI/.

Yu, X. (2012). Pollution, Foreign Direct Investment and Economic Growth: Some New Evidences from Urban China.

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