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Econometric Analysis of Influences of Trade Openness, Economic Growth and Urbanization on Greenhouse Gas Emission in Africa (1960-2010)

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Abstract

This study investigated the influences of economic growth, increased urbanization and trade openness on carbon dioxide (CO_2) emissions in Africa. The study used time series data accessed from World Bank Data Base and Environmental Information Association (EIA) covering 51 years (1960-2010). The data were subjected to various econometric tests including Unit root tests before applying the bound test for cointegration using Autoregressive Distributed Lag (ARDL). It was found that GDP growth rate ($p<0.05$) and trade openness ($p<0.05$) were the major long-run and short-run determinants of emissions (Green House Gas emissions) on the continent. The findings which agreed with other environmental economists' and Kuznet's postulation informed us to recommend that African countries should begin to take proactive measures that will bring about green economy on the continent.

Keywords: Green House Gas Emission in Africa, Economic Growth, Trade Openness, Urbanization

1. Introduction

As far as the atmosphere is concerned Africa is faced with three major issues, namely: climate variability; climate change; and air quality (GRID-Arendal, 2002). In terms of air quality (air pollution) the most significant variable and proxy is level of CO2 emission (Lamla, 2009). Greenhouse gases trap heat in the earth's atmosphere, causing it to warm up (Tauita, 2002). The greenhouse gases include carbon dioxide, methane and nitrous oxide. These gases account for 98% of the greenhouse effect. Other greenhouse gases, are various fluorocarbons and sulphur hexafluoride. There has been growing public concern in recent years over the effects of population growth on resource use and the state of the natural environment in different continents of the world as well (Turton & Hamilton, 1999; Stern, 2006; & Lamla, 2009). Turton and Hamilton (1999) noted earlier that much of the opposition to continued high levels of immigration to Australia was based on these concerns, and terms such as 'carrying capacity' and 'ecologically sustainable population' have encroached into the lexicon of environmental studies. Calls for stabilization of population growth on environmental grounds have been met by arguments that environmental decline is caused by other factors and that the effects of increasing numbers of people can be offset by changes in consumption habits and the technologies used to produce goods and dispose of wastes. Green house gas emissions are well known for their significant effects on global warming and climate change. Even though Africa's ranking in terms of Green House Gas (GHG) emissions globally is still low Intergovenmental Panel of Climate Change (IPCC) concluded that Africa is very vulnerable to climate change and unfortunately lacks the capacity to respond and adapt (United Nations Development Programme, UNDP, 2001). Hence, there are growing concerns about the effects of climate change on the livelihoods and economy of the continent. It was observed that Africa is characterized by considerable climatic variations, both spatial and temporal, and extreme events such as flooding and drought have been recorded for thousands of years (Verschuren, Laird & Cumming 2000 as cited in GRID-Arendal, 2002). The equatorial belt generally has high rainfall, whereas northern and southern African countries and those in the Horn of Africa are typically arid or semi-arid. All parts of Africa, even those that usually have high rainfall, experience climatic variability and extreme events such as floods or droughts. Most of Eastern, Central and Southern Africa, as well as the Western Indian Ocean Islands, are affected by the El Nino/Southern Oscillation (ENSO) phenomenon. The 1997-8 ENSO triggered very high sea surface temperatures in the south-western Indian Ocean causing high rainfall, cyclones, flooding and landslides across most of Eastern Africa whereas south-western Africa experienced drier conditions. The higher sea temperatures also caused extensive bleaching of corals on the Eastern African coast and in the Western Indian Ocean Islands (Obura, Suleiman, Motta, & Schleyer 2000, PRE/COI 1998 as cited in GRID-Arendal, 2002).

Against the foregoing background a need to empirically investigate the influences of the most hypothesized determinants of greenhouse gas emissions becomes compelling. Outcomes of such studies will be relevant in order to build more knowledge base for policy making in Africa which will mitigate and build resilience for the effects of climate change on African economies. The foregoing underlies the need for this study.

This study was designed to empirically determine the influences of economic growth, increased urbanization and trade openness on attainment of clean air (proxied by Carbon dioxide, CO2 emissions) in Africa from 1960-2010. The study also attempted to answer the question of whether African economic growth follows the Environmental Kuznets Curve (EKC) hypothesis pattern or not.

2. Environmental Kuznets Curve (EKC)

It had been established that greater economic activity leads to a higher level of pollution. However, Lamla (2009) noted that this relationship is just partly true. Apart from Lamla, the most outstanding theory that questions this linear relationship is the Environmental Kuznets Curve hypothesis. The Environmental Kuznets Curve proposes a inverted U-shaped relationship between economic activity and pollution (Kuznets, 1955). Theoretically, the Environmental Kuznets Curve (EKC) had been adjudged the most accredited hypothesis. A substantial body of theoretical models exists that leads to such an inverted U-shaped relationship. Even though many other models supported the EKC theory, it has been criticized of producing the desired outcome by imposing a specific set of ex-ante assumptions (Stern, 2005).

Lamla (2009) provided evidence in favour of the environmental Kuznets curve irrespective of the pollution proxy in use. After a certain threshold of per capita income a further rise in output reduces environmental degradation. Furthermore, Lamla found that efficient production technologies affected the level of environmental degradation significantly. The less energy used to generate one dollar of output the higher was the environmental quality recorded. These variables, he maintained, were relevant with respect to robustness (in terms of the conditioning set), but also concerning their overall effect as measured by the impact of a one standard deviation shock. Apart from that, a specific set of variables affected the proxies for environmental degradation. Notably, air pollution proxies showed strong similarities in their set of long-run determinants. It was concluded that variables not directly related to production do matter for the level of environmental quality and so there was need to consider the role of inequality, the degree of urbanization, the political leaning of the chief executive and the political systems of economies.

Earlier, some scholars emphasized the significance of pure economic growth (in terms of income per capita) as a major source of environmental degradation (Grossman & Krueger, 1995; Shafik, 1994 as cited in Costantini & Monni, 2006). In a similar vein, Costantini and Monni (2005) observed that a higher value of trade and manufacture were associated with higher CO2 emissions, isolating the composition effect and the scale effect claimed for a supply-side explanation of the EKC. This, they noted was in agreement with previous scientists including Chichinilsky (1994); Suri & Chapman, (1998). They noted that increasing openness to trade was associated with increasing pollution emissions especially for developing countries due to the delocalization of polluting industries known as the pollution heaven effect (Copeland & Taylor, 2004).

Yandle, Vijayaraghavan and Bhattarai (2002) agreed that the normal EKC implied that as the development process picked up, when a certain level of per capita income is attained, economic growth helped to undo the damage done in earlier years. If economic growth were good for the environment, policies that stimulate growth (trade liberalization, economic restructuring and price reform) ought to be good for the environment, they added. However, income growth without institutional reform is not likely to be enough; and that the improvement of the environment with income growth is not automatic but depends on policies and institutions. GDP growth creates the conditions for environmental improvement by raising the demand for improved environmental quality and makes the resources available for supplying it. Whether an environmental quality improvement materializes or not, when and how depends critically on government policies, social institutions and the completeness and functioning of markets.

Rapidly increasing toxic intensity does not seem to characterize all manufacturing in less developed countries in the 1970s, when environmental regulation in industrialized countries became stricter. Rather, toxic intensity in manufacturing has grown much more rapidly in economies that are relatively closed to international trade, added Yandle, Vijayaraghavan and Bhattarai (2002). This point was stressed by Grossman and Krueger (1991) when they observed that open economies improved their environments. More open economies have had higher growth rates of labour-intensive assembly activities that are also relatively low in toxic intensity. Highly protected economies had more rapid growth of capital-intensive smokestack sectors, they noted.

Similarly, trade economists developed a conceptual framework for examining how trade opening can affect the environment, especially climate change (World Trade Organization, WTO, 2013). This framework, according to WTO, which was first applied to study the environmental impact of the North American Free Trade Agreement (NAFTA), separates the impact of trade liberalization into three independent effects: scale, composition and technique.

Similarly, it was found by Verburg et al (2008) that liberalization leads to a further increase in greenhouse gas emissions adding to an already observed increase in emissions observed in the baseline scenario. CO2 emission increase, they noted, was caused by vegetation clearance due to a rapid expansion of agricultural areas in South America and South East Asia. They equally found that increased methane emissions also calculated in these areas were caused by less intensive cattle farming. The observation agreed with a previous study by van Meijl et al (2006) who noted that regional changes in crop and livestock production could affect greenhouse gas emissions since the production of ruminant livestock increases methane emissions strongly. Cropland and pastures were known for storing CO2 to a certain extent, they noted.

In their own findings, Cropper and Griffith (1994) as cited in Yandle, Vijayaraghavan and Bhattarai (2002) found that per capita income levels in most countries in Latin America and Africa were to the left of (lower than) the respective peaks of their estimated EKCs ($5,420 and $4,760 in 1985 U.S. dollars), or about $8,900 and $7,800 in 2001 U.S. dollars. In other words, they have not reached their turning points. However, for countries in these two continents, as income increased, the rate of deforestation leveled off.

In a study to ascertain the nature of relationship between urbanization and green house gas emission levels, Satterthwaite (2009) reviewed carbon dioxide emission levels for nations and how they changed between 1980 and 2005 (and also between 1950 and 1980). It was found in the study that there was little association between nations with rapid population growth and nations with rapid greenhouse gas emission growth. The study indeed noted that it was mostly nations with very low emissions per person (and often only slowly growing emissions) that had the highest population growth rates. This findings need to be tested with respect to African case. This study rises up to this challenge.

3. Research Methodology

The study focused on African continent’s economy. According to Maps of World (2013) Africa's latitude and longitude lies between 9.1021° N, 18.2812° E. It covers a total land area of almost 30.2 million square kilometers (11.7 million square miles) which is more than one-fifth of the world's land area. Africa is a continent with a population of 0.8 billion and a per capita Gross National Income (GNI 1998=100) of 122. Her population growth rate was estimated at 2.5% and 2008 GNI per capita was estimated at $1,082 (World Bank, 2013). Agriculture provides source of livelihood for about 75 percent of her population. According to the World Bank (2013) the global financial crisis halted a half decade of high economic growth in many African countries significantly pulling down the average growth rates from 6.2 percent in 2007 to a projected 1.7 percent in 2009. Remittances and the private capital flows were also diminished, slowing down progress toward the Millennium Development Goals.

The major data used for empirical analysis in this work were obtained from the World Bank data base available at World Bank’s website. The data, which were all economic development indicators were secondary data spanning across 51 years (1960 – 2010) were used for the study. The sampling was purposive: only the number of years that had available data on all the variables of interest was chosen. The selected variables included the annual CO2 emission levels, GDP, Trade Openness, forestry import and export values, trade (total merchandise) and rate of urbanization in Africa.

4. Analytical Framework: Bound Testing Approach

Bounds technique’s use is predicated on three validations. In the first stage, Pesaran et al. (2001) advocated the use of the ARDL model for the estimation of level relationships because the model suggests that once the order of the ARDL has been identified, the relationship may be estimated by OLS method. Secondly, the bounds test permits a mixture of I(1) and I(0) variables as regressors, that is, the order of integration of appropriate variables may not necessarily be the same. Therefore, the ARDL technique has the advantage of not requiring a specific identification of the order of the underlying data. Thirdly, the technique is appropriate for small or finite sample size (Pesaran et al., 2001).

In line with Pesaran et al. (2001) and Atif , Jadoon, Zaman, Ismail and Seemab (2010), the vector autoregression (VAR) of order p, denoted VAR (p), for the following CO_2 emission function were thus assembled:

$$Z_t = \mu + \sum_{i=1}^{p} \beta_i z_{t-i} + \varepsilon_t \qquad (1).$$

where z_t is the vector of both x_t and y_t, where y_t is the dependent variable defined as CO2 emission levels (CO2), x_t is the vector matrix which represents a set of explanatory variables i.e., trade openness (TOP), GDP growth rate (gdpgrwth); urban population (URBANPOP) and *t* is a time or trend variable. According to Pesaran *et al*. (2001), y_t must be I(1) variable, but the regressor x_t can be either I(0) or I(1). In addition a vector error correction model (VECM) was developed as follows:

$$\Delta z_t = \mu + \alpha t + \lambda z_{t-1} + \sum_{i=1}^{p-i} \gamma_t \Delta y_{t-i} + \sum_{i=1}^{p-1} \gamma_t \Delta x_{t-i} + \varepsilon_t \quad (2)$$

where Δ is the first-difference operator. The long-run multiplier matrix λ as:

$$\lambda = \begin{bmatrix} \lambda_{YY} \lambda_{YX} \\ \lambda_{XY} \lambda_{XX} \end{bmatrix} \quad (3)$$

The diagonal elements of the matrix are unrestricted, so the selected series can be either I(0) or I(1). If , then Y is I(1). In contrast, if , then Y is I(0).

According to Atif et al (2010), the VECM procedures described above are imperative in the testing of at most one cointegrating vector between dependent variable y_t and a set of regressors x_t. Therefore to derive the empirical model, the postulations made by Pesaran et al. (2001) in Case III, that is, unrestricted intercepts and no trends was followed. After imposing the restrictions $\lambda_{YY} = 0, \mu \neq 0$ and $\alpha = 0$, the GIIE hypothesis function can be stated as the following unrestricted error correction model (UECM):

$$d(\log(CO_2)) = b_o + b_1(CO_2)_{t-1} + b_2(GDPGRWT)_{t-1} + b_3(TOP)_{t-1} + b_4(URBANPOP)_{t-1} + b_5\sum d(CO_2)t\text{-}_1 + b_6 \sum d(CO_2)\text{-}_1 + b_7 \sum d(GDPGRWT)\text{-}_1 + b_8 \sum d(TOP)\text{-}_1 + b_9 \sum d(URBANPOP)\text{-}_1 + u \quad (4)$$

Where, d = differenced operator; CO_2 = level of mean annual CO_2 emissions on the continent in kilotonnes; GDP = Gross Domestic Product (Million US dollars); TOP = Trade Openness (X+M/GDP); URBANPOP = Urban population in millions (count); u = noise disturbance term; $b_1 - b_0$ = slope coefficients estimates of respective explanatory variables. log = logarithm to base 10 of the variable.

Equation (4) also can be viewed as an ARDL of order (p, q, r). Equation (4) indicates that CO_2 emissions tend to be influenced and explained by its past values. The structural lags are established by using minimum Akaike's information criteria (AIC). From the estimation of UECMs, the long-run elasticities are the coefficient of one lagged explanatory variable (multiplied by a negative sign) divided by the coefficient of one lagged dependent variable (Bardsen, 1989 as cited in Atif et el, 2010). For example, in equation (4), the long-run inequality, investment and growth elasticities are (β_2 / β_1) and (β_3 / β_1) respectively. The short-run effects are captured by the coefficients of the first-differenced variables in equation (4).

5. Hypothesis Development

After regression of Equation (4), the Wald test (F-statistic) was computed to differentiate the long-run relationship between the concerned variables. The Wald test can be carried out by imposing restrictions on the estimated long-run coefficients of CO_2 emissions, GDP, TOP and URBANPOP. The null and alternative hypotheses are as follows:

$H_0 = \beta_1 = \beta_2 = \beta_3 = 0$ (no long-run relationship) (5)

Against the alternative hypothesis $H_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq 0$ (a long-run relationship exists) (6)

The computed F-statistic value were then evaluated using the critical values tabulated in Table CI (iii) of Pesaran et al. (2001). Pesaran et al held that the lower bound critical values assumed that the explanatory variables x_t were integrated of order zero, or I(0), while the upper bound critical values assumed that x_t are integrated of order one, or I(1). Therefore, if the computed F-statistic is smaller than the lower bound value, then the null hypothesis is not rejected and it would be concluded that no long-run relationship exists CO_2 and its determinants. Conversely, if the computed F-statistic is greater than the upper bound value, CO_2 emissions and its determinants share a long-run level relationship. On the other hand, if the computed F-statistic falls between the lower and upper bound values, then the results are inconclusive.

6. Estimation of the Models/Discussion

Augmented Dickey-Fuller (ADF) unit root test was applied in checking the order of integration of the series. The results of the estimates are reported in Table 1. Based on the ADF test statistic, it was indicated that out of four variables, 2 have unit roots i.e., CO_2 and TOP, while GDPGRWT and URBANPOP were I(0).

Table 1.0 Results of Unit Root Tests on the series using Augmented Dickey Fuller Approach

VARIABLES OR SERIES	ADF STATISTICS AT LEVELS	ADF 1st DIFFERENCE STATISTICS	REMARK
CO_2	-2.5929 (NS)	-2.7478*	I(1)
TOP	-1.5327 (NS)	-6.718430***	I(1)
GDPgrwth	3.85108***	NA	I(0)
Urbanpop	-2.6668 *	NA	I(0)

***NB:** The null hypothesis is that the series is non-stationary [I(1)], or contains a unit root. The rejection of the null hypothesis is based on MacKinnon (1996) critical values. The lag length are selected based on SIC criteria, this ranges from lag zero to lag two. *, ** and *** indicate the rejection of the null hypothesis of non-stationary at 1%, 5% and 10% significant level, respectively.*

It is important to note that the mixture of both I(0) and I(1) variables would not be possible under the Johansen procedure. This therefore, gives a good justification for using the bounds test approach, or ARDL model, which was proposed by Pesaran et al (2001). The estimation of Equation (5) using the ARDL model is reported in Table 2. Using Hendry's general-to-specific method, the goodness of fit of the specification, that is, *R*-squared and adjusted *R*-squared, is 0.977 and 0.973 respectively. The robustness of the model has been validated by several diagnostic tests such conducted including Breusch-Godfrey serial correlation LM test (F-stat = 0.816, p = 0.449); Jacque-Bera normality test (See Figure 1) and CUSUM test (to ascertain the stability of the residuals of the model. See Figure 2). It passed almost all the diagnostic tests against serial correlation (Breusch-Godfrey test) and normality of errors (Jarque-Bera test). However, when it was noticed that the residuals tested positive to heteroscedasticity the researchers applied White heteroskedasticity-consistent standard errors and covariance option in estimating the final model. The regression for the underlying ARDL equation (4) fits very well and the model is globally significant at 1% statistical level.

The result of stability test indicates the absence of any instability of the coefficients because the plot of the CUSUM statistic falls inside the critical bands of the 5% confidence interval of parameter stability. Given the above results we can conclude that the outcomes reported are serially uncorrelated, normally distributed and homoskedastic. Hence, the results reported are valid for reliable interpretations.

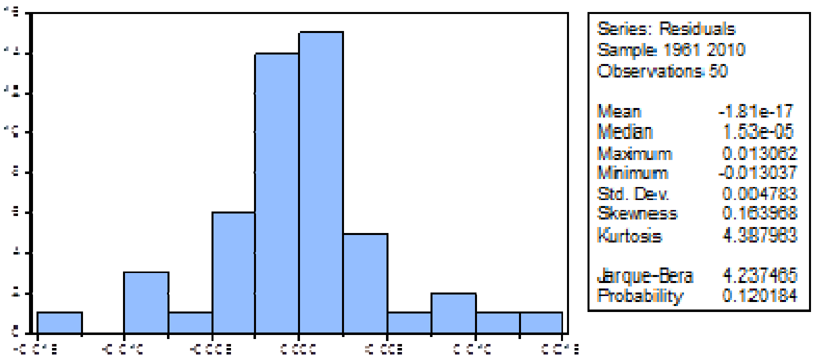

Figure 1. Normality of Residual Test results (Jarque-Bera test)

Equation (5) and Table 4 indicates that both GDP growth rate and trade openness (in their first lags) exerted negative and positive influence on CO2 emission levels in Africa respectively over the period in review. The lagged value of CO2 emissions in the immediate past year (1st lag) equally exerted significant positive effect on the level of environmental quality in Africa too. If there is one percent increase in economic growth rate CO2 emission levels decreased by -0.083 percent. On the other hand CO2 emissions increased by a unit increase in trade liberalisation level by 0.014 percent within the period in review in Africa. The outcome of these findings indicated that, in the long-run, the hypothesis that GDP growth rate (as demonstrated in Environmental Kuznet's Curve hypothesis and Lamla, 2009) have a negative influence on environmental pollution holds true for Africa too. See Figure 3.

Table 2: Estimated Model Based on Equation (4)
Dependent Variable: Log (CO2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.9398***	0.0376	25.027	0.00
(CO2)-1	-0.0199**	0.0087	-2.298	0.03
(GDPGRWT)-1	0.0016**	0.0007	2.537	0.02
(TOP)-1	-0.0003*	0.0001	-1.950	0.06
(URBANPOP)-1	-0.0006	0.0013	-0.424	0.67
D(CO2)-1	0.9513***	0.0285	33.326	0.00
D(GDPGRWT)-1	-0.0011***	0.0005	-2.259	0.03
D(TOP)-1	-0.0001	0.0002	-0.278	0.78
D(URBANPOP)-1	-0.0402	0.0421	-0.955	0.35

R-squared	0.978	F-statistic	223.859
Adjusted R-squared	0.973	Prob(F-statistic)	0.000
S.E. of regression	0.005	Akaike info criterion	-7.508
Sum squared resid	0.001	Schwarz criterion	-7.163
Log likelihood	196.688	Durbin-Watson Stat.	1.840
		Wald Statistics	576.732*** (F = 0.000)

NB: . *, ** *and* *** *indicate the rejection of the null hypothesis of not being statistically significant at 1%, 5% and 10% significant level, respectively.*

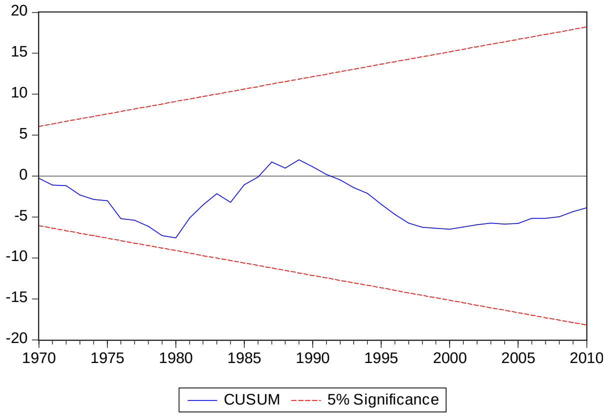

Figure 2. Results of CUSUM Test (for stability of the parameters)

Paradoxically it was indicated from the study's outcome too that trade liberalization (Trade Openness) exerted negative influence on attainment of clean air (proxied by CO_2 emission) in the continent over the period in review. The findings is in tandem with Copeland and Taylor (2004) who noted that increasing openness to This implies that Africa had attained the level of GDP growth rate at which increase in economic growth was influencing the level of environmental quality attainment positively.

Table 3: Bounds Test for Cointegration Analysis

Critical value	Lower Bound Value	Upper Bound Value
1%	3.74	5.06
5%	2.86	4.01
10%	2.45	3.52

Note: *Computed F-statistic: 223.86 (Significant at 0.01 marginal values with 5.06 as upper bound value).Critical Values are cited from Pesaran et al. (2001), Table CI (iii), Case 111: Unrestricted intercept and no trend.*

Table 4 : Long-Run Elasticities of CO_2 Emissions in Africa: Based on Equation (4)
Dependent Variable: d(Log of CO_2 emissions)

Variables	Normalized Coefficients	P values	Remarks
(CO2)-1	1.000	0.020	**
(GDPGRWT)-1	-0.083	0.037	**
(TOP)-1	0.014	0.032	**
(URBANPOP)-1	0.028	0.566	NS

*NB: ** , *** denote significant at 5% and 1% statistical significant levels.*

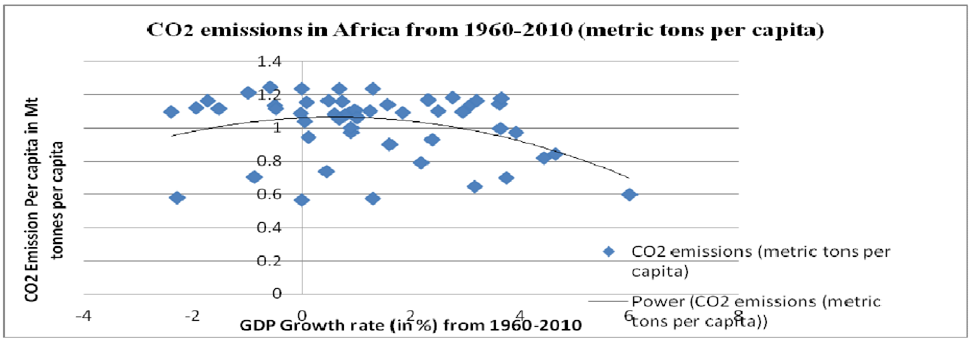

Figure 3. Plots of GDP growth rates on CO_2 emissions levels at different years exhibiting an EKC hypothesis trend. It can be noticed that after some optimal level of GDP growth rate, the level of CO_2 emissions in the continent was decreasing with further increase in GDP.

trade was associated with increasing pollution emissions especially for developing countries due to the delocalization of polluting industries known as the pollution heaven effect. It also agreed with Chichinilsky (1994); Suri and Chapman, (1998) and Costantini and Monni (2005) who observed that a higher value of trade and manufacture were associated with higher CO_2 emissions, isolating the composition effect and the scale effect claimed for a supply-side explanation of the EKC.

The dynamic short-run causality among the relevant variables is shown in Table 5. According to Atif et al (2010), the causality effect can be acquired by restricting the coefficient of the variables with its lags equal to zero (using Wald test). Thus if the null hypothesis of no causality is rejected, it can be concluded that a relevant variable Granger-caused the dependent variable (i.e. CO_2 emission levels, in this case). From this test, we found that both variables i.e., economic growth and trade openness were statistically significant to Granger-caused CO_2 emissions at 1 percent and 5 percent levels of

Table 5: Short-run Causality Test (Wald Test F-statistic) of CO2 Emissions in Africa: Based on Equation (4)

Dependent Variable: d(Log of CO2 emissions)

Variables	Wald Test F-statistic	Marginal Significant Values	Remarks
(CO2)-1	0.179	0.6738	Not Significant
(GDPGRWT)-1	1110.617***	0.000	Significant at 1%
(TOP)-1	5.105**	0.029	Significant at 5%
(URBANPOP)-1	0.077	0.782	Not Significant

NB: *** , *** denote significant at 5% and 1% statistical significant levels.*

statistical significance respectively. Summing up the findings of the short-run causality test, we conclude that there exist causality running from economic growth to CO_2 emissions and trade openness to CO_2 emission levels respectively. However, it was noted that urban population levels in their lagged forms exerted no significant influence on the level of CO_2 emissions in Africa over the period in review. This may not be a final assertion that urbanization cannot influence African CO_2 emission levels or clean air attainment drive. It is possible that using other econometric models with different combinations of explanatory variables, it may be possible to glean at a more conclusive evidence of the role of urban population growth on CO_2 emission in Africa. This is left for further research. However it is instructive to note that Satterthwaite (2009) reviewed carbon dioxide emission found that there was little association between nations with rapid population growth and nations with rapid greenhouse gas emission growth. In principle therefore, our finding agree with existing.

7. Concluding Remarks

This paper applied a reliable econometric approach to estimate the impact of economic growth trade openness and urban population levels on attainment of a greener economy in Africa by using time series data from 1960-2010 using Bound Testing approach. The analysis indicated that on the long-run, economic growth rate exerted a positive influence on attainment of environmentally clean or green economy. Both variables equally exhibited short-run effects on the level of CO_2 emission on the continent. Therefore African economies at this time still need to pursue policies that will usher in economic growth into their economies. Efforts should however be made to make the drive to attain economic growth more inclusive and green by implementing policies that will build resilient to the threatening effects of climate change on the continent. Existing efforts at attaining greener economies such as development of clean energy use and adaptation to climate change capacity building, especially in agriculture and other sectors of her economy should be stepped up. The findings that trade liberalization was exerting positive effects on CO_2 emission rates in Africa is a signal that caution must be maintained in the trade liberalization drive of African economies. Policies that promote land grabs by foreign economies, unsustainable mining and foreign direct investment coming from outside Africa can subject the continent to unhampered plunder of her natural resources without minding the sustainability of resource use in Africa. This can lead to air pollution with its attendant deleterious consequences on the continent. The short-run effects exhibited by trade openness and economic growth on air pollution level are clear manifestation of the fact that CO_2 emission levels in Africa (attainment of clean air quality) is very sensitive to changes in both economic growth and trade liberalization policies. Hence, the government of African economies should pursue effective macro-economic policies along with quantum leaps in improvements in the structure and functioning systems of governance for stabilizing economic growth and moderating trade liberalization reforms in order not to jeopardize the environmental health of her citizens as well as the threats of extreme climate change events on the continent. The continent can use appropriate environmental laws/agreements and regional trade unions to achieve these.

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