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ECONOMIC GROWTH, CO2 EMISSIONS, ENERGY CONSUMPTIONS AND URBANIZATION IN SUB-SAHARAN AFRICA

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Abstract

The nexus between economic growth, carbon-dioxide emissions, and energy use in Sub-Saharan African countries have newly started to be discussed at the regional level. This paper investigates this issue by adding urbanization to the model using a panel data of 23 Sub-Saharan African countries over the period 1993 – 2014 (see appendix), by using the Fixed/Random effect model. The study found both carbon-dioxide emissions and urbanization to have a positive and statistically significant impact on economic growth, while energy use is found to have a negative, but statistically significant impact on economic growth.

Keywords: Economic growth, Carbon-dioxide emissions, energy use, urbanization, fixed/Random effect model, Sub-Saharan Africa.

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1. Introduction

Sub-Saharan African (SSA) countries are among the countries with the lowest gross domestic product in the world as well as the lowest economic growth. According to the World Bank (2018), growth in sub-Saharan African is established to have rebounded to 2.4 percent in 2017, after slowing sharply to 1.3 percent in 2016.However, economic growth in the region experiencing a slow growth than expected, as the region is still experiencing negative per capita income growth, weak investment and a decline in productivity growth. Moreover, the energy consumptions of this region grew by around 45% from 2000 to 2012, but accounts for only 4% of the world total, despite being home to 13% of the global population (IEA, 2014), while CO2 emissions increased by 20%.

The interaction between economic growth, energy consumptions and CO2 emissions has been an active research area for a while (Apergis and Payne, 2010; Barleet and Gounder, 2010; Niu et al., 2011; Arouri et al; 2012). In light of the above, one of the critical issues in energy economics literature has mainly focused on determining the relationship between economic growth and environmental pollution. For over two decades, the challenges of climate change which was as a result of increased global warming have been major environmental challenges. Increasing levels of carbon dioxide emission is considered one of the principal causes of global warming andclimate instability (Heidari et al., 2015).

Unlike other regions of the world, urbanization in the African context displays different characteristics from the one witnessed in other regions of the world. However, African cities are experiencing fast growth, which is giving room for the growth of megacities, without the structural transformation urbanization has been complied with in the Asian and Latin American context for instance. SSA according to AGI (2016) is growing with an average annual rate of 1.4 percent, which makes the continent to be the second fastest urbanizing continent, second only to Asia.

According to the World Bank (2015), the share of African's living in urban areas is projected to grow from 36 percent in 2010 to 50 percent by 2030. The continent urbanization rate, the highest in the world, can lead to economic growth.This points highlighted above formed the basis for this study, to examine the impact of carbon dioxide emission (CO2), energy consumption and urbanization on economic growth in the sub-Saharan African countries.

2.0. Literature review

Over the years, the issue of a causal relationship between macroeconomic factors and energy consumption has been investigated by numerous analysts. Energy is viewed as an essential factor in an economy, the most imperative instrument of economic advancement and perceived as a standout amongst the most basic vital items. The causal connection between economicgrowth and energy utilization has been a functioning examination zone. Shahbaz et al., (2012), set up a long-run connection between economicgrowth and energy utilization. Hassan et al., (2015) found a non-direct connection between GDP per capita and energy utilization in five ASEAN nations. This investigation was a deviation from different examinations who have been concentrating on the straight relationship among economicgrowth and energy utilization. Saidi et al., (2015) contemplated the effect of economicgrowth on energy utilization. This was an invert contemplate, be that as it may, the investigation discovered the positive and measurable effect of economicgrowth on energy utilization.

The investigation of Al-Mulali et al., (2012) was in concurrence with Shahbaz et al., (2012). Al-Mulali found the presence of a bi-directional causal connection between energy utilization and GDP per capita. The examination additionally demonstrates that in the short-run, there is a positive bi-directional causal connection between all-out essential energy utilization and GDP per capita. Menegaki et al., (2016) consider were somewhat tilted far from different examinations on energy utilization and economicgrowth, as in, the investigation used file of manageable economic welfare growth (ISEW) instead of GDP and found that energy utilization Granger causes ISEW and the other way around.

Study of Sbia et al., (2017) found a reversed U-molded connection between economicgrowth and energy utilization. Nyiwul (2017) was tilted towards a sustainable power source utilization in SSA, the examination found economicgrowth to have an ideal positive, yet a measurably immaterial commitment to sustainable power source utilization growth. The examination at that point placed that, ongoing economicgrowth in the locale has not been joined by expanded advancement and utilization of sustainable power source, as opposed to exact proof in other creating economies. The investigation of Govindaraju and Tang (2013) demonstrates a solid proof of one directional causality running from economicgrowth to CO_2 outflows. Be that as it may, Ghosh (2010), demonstrating a bi-directional short-run causality between carbon discharges and Indian economicgrowth. This outcome for India had been affirmed in a similar work by Yang and Zhao (2014), where it was set up that energy utilization has a uni-directional causality to carbon emission and economicgrowth, while there is bidirectional causality between carbon emanations and economicgrowth. Another developing economy has been examined by Chang (2010), who showed that, for the Chinese case, economicgrowth instigates a more elevated amount of CO_2 outflows. Comparative outcomes had been found by Farhani, Shahbaz, and Arouri (2013) for 11 Middle East and North African nations, despite the fact that the consideration of urbanization in the ecological capacity improves the last outcomes and emphatically influences the contamination level. Niu et al. (2011) examined eight Asia-Pacific nations and it was proved in the investigation that, there are for quite some time run harmony connections among energy utilization, GDP growth, and carbon outflows. Menyah and Wolde-Rufael (2010) found a unidirectional causality running from contamination discharges to economicgrowth.

The work of Chang (2010); Hassan et al., (2015); Magazzino (2016), found the presence of a causal connection between energy utilization, CO_2 outflow and economic. Comparative outcomes were found in Turkey by Halicioglu (2009) who likewise discovered that the pay had a progressively noteworthy effect in clarifying the CO_2 discharge in Turkey than the energy utilization. Pao and Tsai (2011) found comparative outcomes in Brazil. Lean and Smyth (2010) found a causal relationship running from power utilization and CO_2 discharge to economic yield, and causal relationship exists between CO_2 emanations to energy utilization in the ASEAN nations. Ozturk and Acaravci (2010) found comparative outcomes in Turkey where a short run and long run causal connection between energy utilization, CO_2 discharge and growth exists. Comparative outcomes were found in the BRIC nations by Pao and Tsai (2010). While one directional causal relationship from GDP to energy utilization and from energy utilization to CO_2 discharge exists in Jafari et al., (2015). Menyah and Rufael (2010a) found a long run and a one-directional causal relationship from energy utilization and CO_2 discharge to economicgrowth in South Africa. Pao et al. (2011), likewise discovered comparable outcomes in Russia. Menyah and Rufael (2010b) recommended that atomic energy utilization can decrease CO2 emanation. Khoshneis et al., (2018) found that economicgrowth is the greatest supporter of the ascent in CO2.

Most examinations opined that there is a positive relationship between urbanization and economicgrowth. Numerous researchers utilize an S-shaped curve to portray the economic increments at various rates in various periods of urbanization. Guan et al., (2015), and Sbia et al., (2017) built up the positive nexus between the two factors in full-scale level by concentrate distinctive nations. For causal connections, most examinations demonstrate that the impact of economicgrowth on urbanization is more grounded than the impact of urbanization to economicgrowth. Liddle et al., (2015), set up economicgrowth has a positive causal impact on urbanization in SSA. Though, urbanization has a negative causal impact on economicgrowth. A few scientists report there is no positive nexus among urbanization and economicgrowth in certain nations/regions. Fox 2012; Poelhekke 2011; Issaoui et al., 2015, established thateconomic will diminish as the urbanization level increments toward the starting, utilizing a U-shaped curve to speak to this procedure. Liddle et al.,(2013) found that urbanization is basic and related with economicgrowth, likewise that urbanization's effect on economicgrowth ranges from considerably negative to almost nonpartisan to positive as nations create.

In spite of the fact that there is a considerable literature concentrating on the urbanization procedure and its association with economicgrowth, there have been not very many examinations that straightforwardly explore the bearing (or presence) of causality among urbanization and GDP per capita. The most thorough, regarding nations broke down, was by Bloom et al. (2008), who found that urbanization did not Granger-cause GDP per capita. Be that as it may, their examination included just 4–5 time perceptions for each nation (10-year rates of progress) and did not think about time arrangement based demonstrating or heterogeneity. The main urbanization–GDP Granger-causality thinks about utilizing time-arrangement strategies considered either a solitary nation or generally little boards (for example Solarin and Shahbaz, 2013 and Mishra et al., 2009,). In spite of the fact that not a causality examination essentially, Faisal (2018) researched the connection between economicgrowth, power utilization, exchange and urbanization in Iceland, and found a criticism causal connection among urbanization and power utilizations, however, neglected to set up any connection between economicgrowth and urbanization.

Liddle (2013b) additionally not a causality investigation, developed the McCoskey and Kao examination by including energy/power utilization per capita to the generation work, by tending to cross-sectional reliance in the estimations and by considering pay based boards, which were contained from seventy-nine nations. Liddle assessed board flexibility for urbanization that was sure for high and upper center salary nations, yet close to zero to negative for the lower center and low-pay nations, recommending, as others have contended, that less created nations are over-urbanized. Accordingly, Liddle (2013b) contended urbanization has a 'stepping stool' impact on economicgrowth: it has a solid negative effect for the least fortunate nations, a more positive to nonpartisan effect for nations with moderate earnings and a growth advancing/strengthening relationship for the wealthier center pay nations and wealthiest nations.

From the literature surveyed above, it is clear that different investigations have illustrated the connection between economicgrowth, CO2 emission, and energy utilization in SSA. Notwithstanding, to the best of our knowledge, no examination in the literature exists that has dissected the connection between economicgrowth, CO2 emission, and energy consumption, together with urbanization. Up to this point, Khraief, Shahbaz, Mallick, and Loganathan (2016) evaluated the power request work utilizing urbanization and exchange their examination on Algeria. The relationship between economic growth, CO2 emissions and energy consumptions in SSA together with urbanization will be analyzed in the present. Therefore, this study tries to cover the gap in the literature.

3.0. Research Methodology

3.1 Data: Type and Sources

The data employed in this study to estimate our model are a balanced panel, consisting of twenty-three SSA countries (see appendix) for which data are available for the period, 1993-2014. Economic growth was proxies with GDP per capita (constant 2010 US$). For the CO2 emission, metric tons per capital was used. This comprises of those emissions stemming from the burning of fossils fuel and the manufacture of cement. They include carbon dioxide provided during consumption of solid, liquid, and gas fuels and gas flaring. For energy consumption, energy use (kg of oil equivalent per capita) was used. This is referred to as the use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

The urbanization was measured with the urban population, which World Bank refers to as the people living in urban areas as defined by national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World urbanization prospects.

The data on all the above variables are transformed into natural logarithms before descriptive and estimation are undertaken.

3.2 Method

Estimated Pooled OLS equation was written in a form similar to the simple regression equation. The method of Pooled OLS estimates was to minimize the sum of squared residuals. The estimated of parameters were chosen simultaneously to make sum of square residuals as small as possible (Wooldridge, 2012). The estimated Pooled OLS regression is written as follows:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon \qquad \ldots\ldots\ldots 1$$

Where,$\beta_0$is the estimate of constant, and β_1 are the estimate of slopes correspond to each explanatory variable.

Since panel data is a combination of cross section and time series data, then it may have cross sectional effects, time effects or both. The effects are either fixed effect or random effect. In fixed effects model, it is desirable to assume difference in intercepts across cross sectional or time series, while in random effect model is more to explore about the difference in error variances. In fixed effect model, there are two ways to do estimations which are within effect and between effect estimation. The estimators produce identical slope of non-dummy independent variables but they produce different parameter estimates (Wooldridge, 2012). Between method is divided into two, namely between times and between group estimators.

Fixed effect and Random effect model are presented in (2) and (3) equation as follows:

$Y_{it} = (\alpha + \mu_i) + X_{it}\beta + V_{it}$ ……….. 2

$Y_{it} = \alpha + X_{it}\beta + (\mu_i + V_{it})$………   3

Where:

$Y_{it} =$ Dependent variable

$X_{it} =$ Independent variables

$V_{it} =$ Zero mean random disturbance with variance

$\mu_I =$ an unobserved individual specific effect

β = model coefficient

Random effects model studies how cross section and/or time series affect the error variance. The random effect model is suitable for n individuals (cross sectional units) which are drawn randomly from a large population. In order to estimates random effect model, there are two available estimators. The first one is FGLS method which is used to estimate the variance structure when variance covariance matrix is not known while GLS method is generally used when variance covariance matrix is known. In this paper, GLS method was used since the variance covariance matrix were known.

Fixed effect models treat differences of individual specific effect, μ_I in intercepts and it assume same slope and constant variances across cross sectionals. Since individual specific effect is time invariant, μ_I are allowed to be correlated with other independent variables (Wooldridge, 2009). While random effect models assume intercept and slope as a constant. The random effect models treat differences of individual specific effect in error variance

4.0. Empirical Findings

4.1 Descriptive Statistics

Table 1. Descriptive statistics of the explanatory variables and dependent variable

Variables	***Obs***	***mean***	***std.dev***	***min.***	***max***
lngdp	506	7.19	1.01	5.13	9.39

lnco2	506	-.859	1.30	-4.06	2.29
lnen_use	506	6.19	.66	4.73	8.04
lnup	506	15.25	1.21	13.02	18.23

From table 1, the GDP growth per capital: has a standard deviation equal to (1.0005372) and an average of (7.19058). A minimum of (5.131189) and maximum of (9.386458).

The CO2: has a standard deviation of 1.299502, which indicate that the degree of variation among the observation from the mean value is minimal. It shows an average value of -0.8591777, with -4.058419 and 2.28956 as minimum and maximum value respectively.

As for the energy use, the mean value is 6.192257, while the standard deviation is 0.6599389.Maximum and minimum value stood at 4.731122 and 8.038648 respectively.

The urbanization as it shows on the table has a mean value of 15.25434, while the standard deviation is 1.209529 and minimum and maximum values are 13.01619 and 18.232335 respectively.

In summary, the table above depicts that the variance among the data are at minimal, which could be observed from the standard deviation of each of the variable from the mean. The minimum and maximum value for each of the variables when checked against the mean value indicate that there is no outlier in the data.

4.2. Dependence between variables in our database

To award the existence of dependence relationships between different variables in our database, we refer to the functions of correlations and covariance matrices. From these dependency functions, we identify the presence or absence of relations between the endogenous variables and the explanatory variables.

Table 2: Correlation matrix of variables of interest

	lngdp	***lnco2***	***lnen_use***	***lnup***
lngdp	1.00			
lnco2	0.90	1.00		
lnen_use	0.76	0.81	1.00	
lnup	-0.23	-0.19	0.06	1.00

From this matrix, we can observe that there is no multi-collinearity problem between the explanatory variables.

4.3. Pooled Regression

Table 3. Pooled OLS Regression between Economic growth, carbon dioxide emissions, energy use and urbanization.

IndependentVariables	Coefficient	Std. Error
lnCO2	0.59*	0.03
lnen_use	0.23**	0.05
lnUP	-0.08*	0.01
C	7.50*	0.35
R-squared	0.82	
F-statistic	775.41	
Prob(F-statistic)	0.0000	
DW stat	0.06	

Note: * ındıcate 1% level of sıgnıfıcance

** indicates 5% level of significance

Table 3 reveals the pooled regression results of the relationship between the dependent variable and explanatory variables. Here, we have pooled all the observations in OLS regression, meaning that implicitly, we assume that coefficient (including the intercept) are the same for all the individual countries. The energy use coefficient is positive and statistically significant. The result indicate that a percent change in energy use will impact the economic growth by about 22 percent. However, carbon dioxide emissions coefficient is also positive and statistically significant, this contradict the economy theory and previous research who posited that carbon dioxide emissions has a negative impact on economic growth.

Moreover, urbanization coefficient also shows a negative sign, however, it is statistically significant. In all, the three independent variables are statistically significant individually and their joint contribution (f-statistic) have a very low p-value of almost zero. R-squared shows the fitness of the model and reveals that the three explanatory variables has about 82 percent explanation on the economic growth.

The main issue with this model is that, it does not distinguish between the various countries we have. In other words, it deny the heterogeneity or individuality that may exist among the twenty (23) countries.

4.4. Fixed and Random effect estimation

Table 4: Fixed and Random effect model

Explanatory Variables	Fixed effect		Random effect	
	Coefficient	Std. Error	Coefficient	Std. Error
lnCO2	0.34*	0.02	0.37*	0.02
lnen_use	-0.12*	0.04	-0.07	0.04
lnUP	0.33*	0.03	0.66*	0.02
C	3.24*	0.40	3.86*	0.40
R-squared	0.98		0.56	
F-statistic	1443.61		213.50	
Prob.	0.0000		0.0000	

Note: * ındıcate 1% level of sıgnıfıcance

** indicates 5% level of significance

Table 5: Hausman Test

Test Summary	**Chi-Sq Statistic**	**Chi-Sq. d.f.**	**Prob**
Cross-section random	61.31	3	0.0000

Table 4 shows that our model can be formalized as a panel with individual effects. The table summarizes the two procedures of estimates in the observation of state relationships that describe the linear equation that relates economic growth according to the explanatory variables (Carbon dioxide emissions, energy use and urbanization). Table 5 reveals the Hausman test for the model. The test can be applied to many econometrics specification problem. However, it's most common application is that of specification test of the individual effects panel data. It thus serves to test appropriateness of either fixed or random effect model for any particular analysis.

Under this test, the null hypothesis assumed that, random effect model is appropriate, while alternative hypothesis assumed that fixed effect model is appropriate.

Table 5 summarize the Fixed/Random effect testing for the impact of carbon dioxide emissions, energy use and urbanization on economic growth for 23 SSA countries during a study period from 1993 to 2014. Based on the result, Prob> chi3 = 61.308068 < 0.0000, we therefore choose the fixed effect model.

5.0. Discussion and Conclusion

5.1. Discussion

*LNGDP = C(1)*LNCO2 + C(2)*LNEN_USE + C(3)*LNUP + C(4) + [CX=F] …….4*

LNGDP = 0.336734912304*LNCO2 - 0.123652966787*LNEN_USE + 0.327945648029*LNUP + 3.24299054237 + [CX=F] …….5

Equation (4) and (5) illustrate the fixed effect model and substituted model. From table 5 and equation (5), it could be observed that coefficient of carbon dioxide emissions measured by CO2 emissions (metric tons per capital) relationship with GDP is positive and statistically significant. This result corroborated Govindaraju et al., (2013); Shahbaz et al., (2013); Hassan et al., (2015); Magazzino, (2016); Khoshneis et al., (2018). The result is the same with random effect model which assumed a common mean value for the intercept, the relationship between GDP and CO2 is positive and statistically significant. In other words, both model confirms a positive impact of cardon dioxide emissions of economic growth.

An inverse relationship between energy use and economic growth shows from the result indicate that in SSA countries, energy consumptions have a negative impact on the economic growth. This result is in agreement with Linus (2017) who posited that recent growth in SSA countries has not been accompanied by increased growthand consumption of energy. This is due to the high population growth being witnessed in the region, accompanied by a low-pace economic growth. However, random effect model also shows a negative relationship, but could not established it's significance.

A positive and statistically significant relationship exhibit by urbanization, measured with urban population is in agreement with Guan et al., (2015); Sbial et al., (2017), who had examined the relationship between economic growth and urbanization in other region and found similar result. The result means that in SSA countries, the higher the urban population, the higher and the economic growth. However, the result is in contrast to Liddle et al., (2015), who established in their study that economic growth has a positive causal effect on urbanization in SSA, whereas, urbanization has a negative effect on economic growth. Both fixed and random effect model confirms the positive relationship between economic growth and urbanization and found it to be statistically significant.

The results depict in table 5, reveals that while fixed effect model has an R-squared of 0.986875, which this author is not comfortable with, and random effect model has an R-squared of 0.560609. Interestingly, the two model established the joint contributory impact of the three independent variables (CO2, energy use and urbanization) on economic growth, with their respective p-value that is almost zero percent.

5.2. Conclusion

Economic growth in Sub-Saharan African countries is still slightly weaker than expected. For that reason, some authors have argued the essential role of carbon-dioxide emissions, energy use, and urbanization. Although the literature on energy consumption, CO2 emissions, and economic growth have improved over last few years, there is no study that examined the effect of CO2 emissions, energy consumption and urbanization on economic growth using a fixed and random effect model. We have examined this effect on a regional level. The objective of this paper is to study how the combination of carbon-dioxide emissions, energy use, and urbanization interact to impact on economic growth in SSA countries. This paper contributes to the improvement of studies on economic growth, carbon-dioxide emission, and energy use literature by adding urbanization to the model.

Estimation is conducted with a panel data of 23 sub-Saharan African countries, the countries are the ones with available data for the period under study, using fixed effect estimation. Our findings show that both carbon-dioxide emissions and urbanization have a positive and statistically significant impact on the economic growth in the region, while energy use has a negative, but statistically significant impact on the economic growth. Moreover, the model established the joint contributory impact of the three independent variables (CO2, energy use and urbanization) on economic growth.This implies that the variables are complementary. The policy implication of the findings is that, the policy makers in the sub-Saharan Africa countries should formulate policies that will address the challenges of carbon emission, which will improve the environment quality and enhance economic growth. While urban development policy should be geared towards economic growth enhancement but not to the detriment of environmental quality.

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Appendix

Country Code	**Country Name**
1	Angola
2	Benin
3	Botswana
4	Cameroon
5	Congo, Dem. Rep.
6	Congo, Rep.
7	Cote d'Ivoire
8	Eritrea
9	Gabon
10	Ghana
11	Kenya
12	Mauritius
13	Mozambique
14	Namibia
15	Niger
16	Nigeria
17	Senegal
18	South Africa
19	Sudan
20	Tanzania
21	Togo
22	Zambia
23	Zimbabwe