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THE IMPACT OF ECONOMIC GROWTH, OIL PRICE CHANGE ON ENERGY CONSUMPTION: EVIDENCE FROM SELECTED SUB-SAHARAN AFRICA OIL EXPORTING COUNTRIES

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Abstract
This study aimed at examining, in panel context, the long run relationship between economic growth and energy consumption for selected Sub-Saharan African net oil exporting countries (Angola, Cameroon, The Republic of Congo, Equatorial Guinea, Gabon, Ghana, Nigeria and Sudan) from 1990 to 2014 by using cointegration method of Dynamic Ordinary Least Squares (DOLS) and Fully Modified Ordinary Least Squares (FMOLS). The study utilized the data obtained from world development indicators (WDI) and U.S. Energy Information Administration (EIA). The results from both DOLS and FMOLS indicate that, there exist a long run relationship between the variable of oil price and the interaction term of oil price and GDP per capita, therefore, the two variables are the factors influencing the energy consumption in the study area. Therefore, energy conservation policies for abolition or reducing energy subsidies or elimination of energy price distortions will have little or no impact on economic growth.

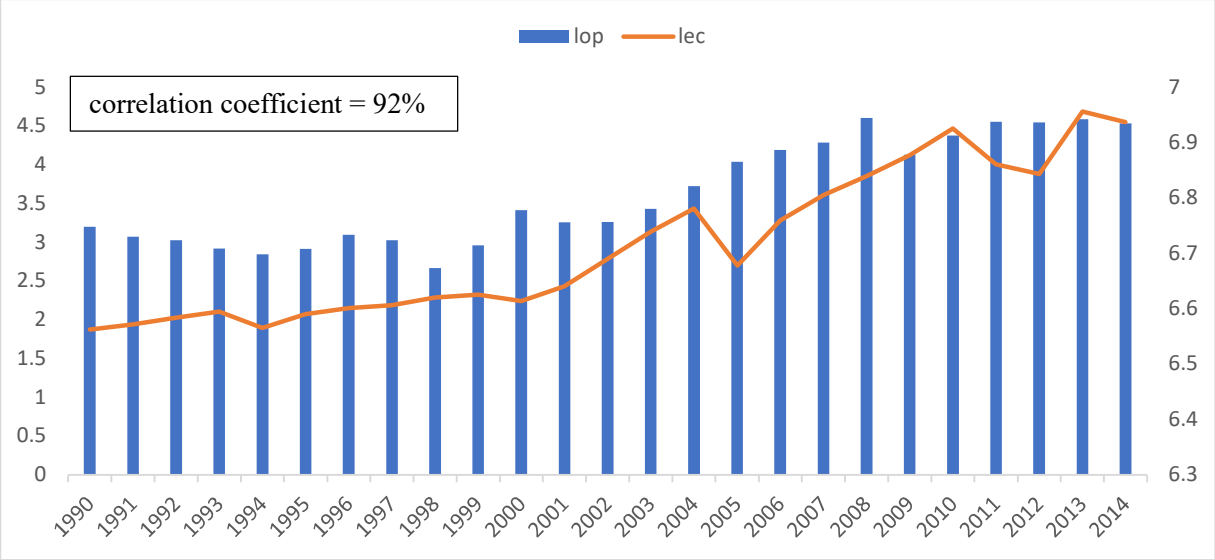
Keywords: economic growth, energy consumption, long run relationship, DOLS, FMOLS
JEL: Q43, E30

1. Introduction

Energy use is an indispensable aspect to all economic activities in particular, and to human wellbeing in general. Absence of reliable and accessible energy constraints economic activities that bring growth and development (Saad and Belloumi, 2015). Among the benefits that energy possess, is that it helps towards achieving economic growth and development of a country. It also enhances the productivity of factors of production and improves standard of living to the citizenry. The importance of energy in playing a great role for the growth of economy cannot be over emphasized. This is due to the fact that in all the sectors of the economy energy is virtually needed in one way or another to run their day-to-day activities, such as manufacturing, communication, transportation and the like, the use of energy for the full operation of such activities cannot alternated to a close substitute (Rafindadi, 2016). However, to most of the oil exporting countries, energy prices are frequently regulated in order to keep the domestic prices lower than that of the international market. In these countries, the energy sector is dominated by few big state-owned companies and it is the government that controls the energy prices through export restrictions and other related measures (Mehrara, 2007).

Increase in GDP has a positive effect on energy consumption. A conservation hypothesis is of the view that, there is a unidirectional causality running from GDP to energy consumption, not reversed (Kraft and Kraft, 1978). This is supported by subsequent studies such as (Ahmad, Hayat, Hamad, and Luqman, 2012); and (Nguyen, Bui, Vo, and Mcaleer, 2019). Oil is a fundamental resource to the economies of countries that exports oil. As oil prices increased, GDP increases too, and that is directly related to energy consumption because energy-use has touched the activities of every sector of the economy in fact it is usage is necessary to all the production processes of goods and services. The energy use may boost economic activities that triggers the increase in foreign export earnings, employment creation and other infrastructural development

Energy consumption is following the trend of oil price changes in SSA oil exporting countries, as oil price increase the government will have more revenue to embark on many projects and that will give rise to the boost in economic activities, at the same time, that makes it necessary to use more energy for industries and other economic activities. Fig 1 shows the trend or co-movement of oil price change and average energy use for the 8 major oil exporting countries of SSA, as the oil price move up the energy usage also move up. The figure shows the two variables are in tandem, with a correlation coefficient of about 92% (Table 1). This implies that changes in oil prices have a significant impact on the energy consumption for the investigated countries.



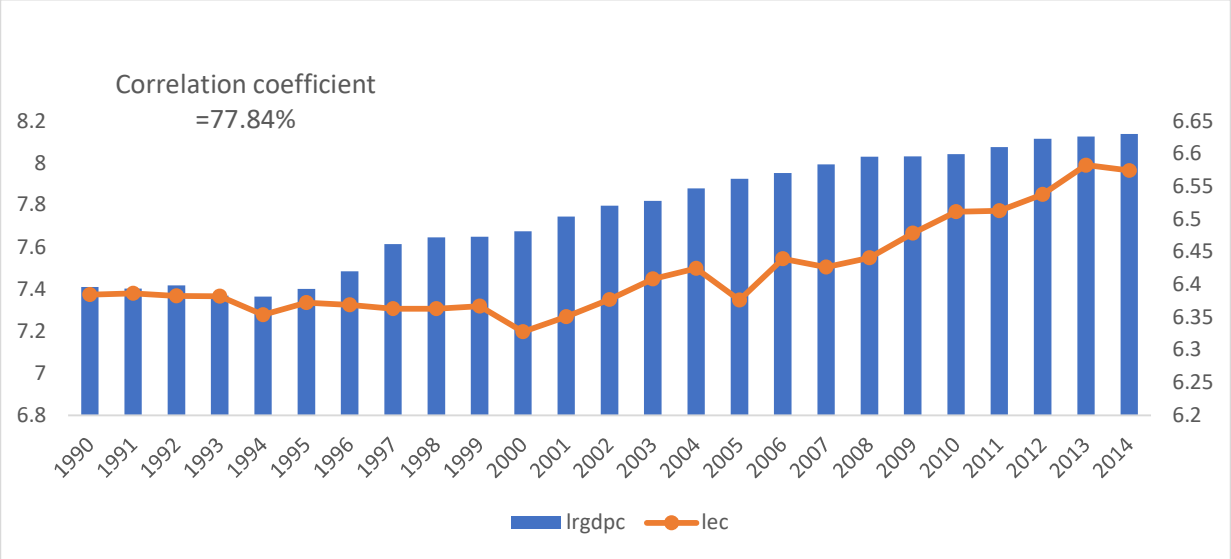
Source: Estimated from the data obtained from WDI
Notes: the countries included are - Angola, Cameroon, Congo Republic, Equatorial Guinea, Gabon, Ghana, Nigeria and Sudan
Figure 1. Oil price and average energy for 8 SSA Oil Exporting Countries (1990 – 2014).

Table 1 Correlation matrix of oil price and average energy use (kg of oil equivalent per capita) for 8 SSA oil exporting countries (1990-2014) N=8

	Lec	Lop
Lec	1.0000	
Lop	0.9172	1.000

Notes: The countries included are - Angola, Cameroon, Congo Republic, Equatorial Guinea, Gabon, Ghana, Nigeria and Sudan

Figure 2 is depicting on how energy consumption is following the trend of real GDP in SSA oil exporting countries, as GDP rises as a result of oil price increase the government will have more revenue to embark on many projects and that will give rise to the boost in economic activities, at the same time, that makes it necessary to use more energy for industries and other economic activities. Fig 2 shows the trend or co-movement of real GDP due to oil price change and average energy use for the 8 major oil exporting countries of SSA, as the real GDP rises due to oil price increase, the energy usage also moves up. The figure shows the two variables are in tandem, with a correlation coefficient of about 77.84% (Table 2). This implies that changes in real GDP due to increase in oil prices have a significant impact on the energy consumption for the investigated countries.



Source: Estimated from the data obtained from WDI
Notes: the countries included are - Angola, Cameroon, Congo Republic, Equatorial Guinea, Gabon, Ghana, Nigeria and Sudan
Figure 2**.** GDP per and energy for 8 SSA Oil Exporting Countries (1990 – 2014).

Table 2 Correlation matrix of average GDP per capita and energy use (kg of oil equivalent per capita) for 8 SSA oil exporting countries (1990-2014) N=8

	Lrgdpc	Lec
Lrgdpc	1.0000	
Lec	0.7784	1.000

Notes: The countries included are - Angola, Cameroon, Congo Republic, Equatorial Guinea, Gabon, Ghana, Nigeria and Sudan

As the price of oil price rose, the revenue of oil exporting countries is increasing and their GDP too, so also the demand for energy is also increasing by the increase in GDP. For majority of the oil exporting countries, when the oil price is high in the international market, the government is always coming with the policies of maintaining the domestic oil price below the international free market level by giving subsidy in the oil price sold to the citizens, and that can give rise to higher rate of domestic energy consumption (Mehrara, 2007). These countries spend substantial amount of the money generated through giving of subsidy to the citizens on the importation of refined

petroleum products (Rotimi and Ngalawa, 2017). The energy prices are being regulated often in the countries that are net exporters of oil. In most of the oil exporting countries, the energy sector is dominated by few big state-owned enterprises and the government control the energy prices through export controlling and other measures. As at 2018, according to the data available the average fossil fuel subsidization rate for some of the major SSA net oil exporters: Angola, Gabon, Ghana and Nigeria stood as 51%, 14%, 5% and 17% respectively and that also took share of each of the different countries' GDP as 1.8%, 0.7%, 0.3% and 0.7% respectively (IEA, 2019).

Implicit energy subsidies will give rise to misallocation of resources, wasting and over consumption of energy products. Consequently, as subsidies on oil price is continuously given, energy consumption might continue to grow also to the extent that it surpasses the rate by which the economic growth is rising. In other words, too much subsidies over time on energy is responsible for incredibly higher energy intensity which may result to high rate of domestic consumption as a result of price distortion which can lastly turn a net oil exporting to net oil importing country. Other problems that may persist are discouraging of needed investments in energy efficient sources of energy (renewable energy), discourage in developing energy infrastructure and raise the countries' vulnerability to volatility of international oil price, large fiscal cost which need to be financed by some combination of large public debt, high tax burden and low public spending that can all retard economic growth in turn. It can also be an inefficient way of supporting low income households as majority of the benefits of lower energy prices are leaking away to the non-poor households (Coady, Parry, Sears, and Shang, 2017).

Against this background, this study aims to investigate the extent to which oil price increase and economic growth influence the rate by which the energy is consumed in the long run by SSA net oil exporting countries.

The rest of the paper is organized as follows: section 2 provides the literature review, section 3 explains the methodology (theoretical background, empirical model, methodology and data); section 4 reports the estimated results of panel unit root test, panel cointegration test, panel cointegration estimations and the interpretations of the findings while the last section (section 5) concludes the discussion.

2. Literature review

The debate on the relationship between energy consumption and economic growth has been discussed extensively in the literature. The existence of long run relationship with GDP or income as determinant of energy consumption has been confirmed by many empirical studies. For instance, in a study to examine the energy-income relationship on 11 oil exporting countries using cointegration analysis by Mehrara (2007), the findings show that economic growth is significantly positive in affecting the rate of energy consumption. In the same vein, to explore the economic growth-energy consumption nexus for Middle East and North African Countries (MENA) net oil exporting countries for the period (1980-2012) using a panel cointegration approach, Kahia, Safouane, Aïssa, and Charfeddine (2016) found that there is a long run relationship between the variables employed and also a unidirectional causality exist running from economic growth to energy consumption. Similarly, in a study on countries with lower-middle income, upper-middle income, OECD, East Africa and Pacific, Middle East and North Africa, South Asia and Sub-

saharan Africa regions, Shahbaz, Sarwar, Chen, and Malik (2017) find that, there is a positive and significant relationship between the economic growth and energy (electricity) consumption for all the regions and countries under the study. In the same way, Ahmad et al. (2012) find the long run relationship between economic growth and energy consumption in Pakistan for the period (1973-2006), using ordinary least squares (OLS) method. The result shows that there is a positive and significant relation between energy consumption and economic growth. The result also shows a unidirectional causality running from GDP to energy consumption.

In addition to that, Lise and Montfort (2007) conduct a study to discover the relationship between energy consumption and GDP in Turkey for the period (1970-2003) using a cointegration analysis. The results show that there is positive and significant relationship between the two variables, and it is a unidirectional causality running from GDP to energy consumption, meaning economic growth influence energy consumption. Again, to explore the cointegral relationship between the energy (electricity) consumption, economic growth, financial development and CO2 emission for South-Africa for the period (1971-2012) , Maladoh and Azam (2017) used ARDL method to carry out that, the findings indicate, there is cointegral relationship between the energy consumption and economic growth and the relationship is significantly positive but there is no causality exists between economic growth and energy consumption, therefore, neutrality hypothesis is what is applied for South Africa. Also, in a study conducted by Akinlo (2008) to investigate the causal relationship between energy consumption and economic growth for 11 sub Saharan Africa countries, using granger causality vector error correction model (VECM) based for the period (1980-2003). The result shows that, there is long run relationship between the variables and unidirectional causality running from economic growth to energy consumption for Sudan and Zimbabwe. The above literature supports the conservation hypothesis that postulates that economic growth is the led determinant of energy consumption, therefore, energy conservation policies in any form will not affect economic growth.

Even though, when it comes to the issue that energy use happened to be changed as a result of economic growth, or energy use to be dependent upon economic growth, there are no clear trends in the literature in relation to that (Mehrara, 2007), but the study tried to make one. Overall, from the strand of literature reviewed, it is shown that the long run relationship between economic growth and energy consumption is in diverse ways. Several studies came out with different findings, some find economic growth as determinant of energy consumption while others find energy consumption as determinant of economic growth and some even find a negative relation between the energy consumption and economic growth. The absence of a clear consensus in the empirical literature could be attributed to the heterogeneity of climate conditions, different pattern of energy consumptions and stages of economic development to various countries (Jacques and Keho, 2016). This is showing a mixed results with no consensus in findings, and that makes it necessary to conduct such research to explore in particular, the long run impact that the economic growth have on energy consumption in SSA countries especially the net oil exporting ones to have a clear picture of effect of GDP (via introducing interaction term of oil price and GDP per capita into the equation 1) on the rate of energy consumption.

3 Methodology

3.1 Empirical model

The empirical specification is aimed at investigating the relationship between energy consumption and economic growth resultant of oil price change for selected SSA oil exporting countries. Thus, the study follow the work of Mehrara (2007), Lise and Montfort (2007), but for the purpose of this study, the model is modified with addition of interaction variable of GDP and oil price to see their moderating effect on energy consumption.

$$lec_{it} = \alpha_{it} + \beta_1 lrgdpc_{it} + \beta_2 lop_{it} + \beta_3 lyop_{it} + \beta_4 lto_{it} + \varepsilon_{it} \quad (1)$$

where *lec* is the natural log of energy consumption (kg of oil equivalent per capita), *lrgdpc* is the natural log of GDP per capita (constant 2010 US$), *lop* is the natural log of oil price (WTI) US$, *lyop* is the residual to represent the interaction term of *gdp per capita* and *oil price (lrgdpc × lop), lto* is the natural log of trade openness (sum of exports and imports of goods and services as share of gdp) and $\mathcal{E}$ is the stochastic error term. The interaction term was placed in the equation 1 through the process of orthogonalization. In this approach, correlated explanatory variables (regressors) are replaced by a smaller of artificial but orthogonal variables (McCallum, 1970). In the orthogonalization process, as suggested by Brambor, Clark, and Golder (2006), the simple product of *lrgdpclop (lrgdp × lop)* was formed. Then, the product was regressed on the two original variables:

$$lrgdpclop = lrgdpc + lop + residual. \quad (2)$$

The residuals were then named as *lyop* and used to represent the interaction term, *lrgdpc × lop.* The issue of multicollinearity was no more because *lyop* has zero mean, and it has zero correlation with both *lrgdpc* and *lop* since it is their residual. As for the expected signs of the parameters, *lrgdpc* is expected to be positive, implying that increase in *real gdp* will increase the activities that will lead to more CO_2 emission and pollution. For the relationship between lrgdp and CO_2 emission, for instance, Chai et al. (2016), Sirag et al. (2017), Alshehry and Belloumi,(2015), and Alam et al. (2016) find out that economic growth is an important factor influencing the rate CO_2 emission. For *lop*, it is expected to be positive since increase in *oil price* will bring more income and economic activities in the economy of oil exporting countries that will lead to more CO_2 emission. Even so, Groot (2015) find that oil price is an important factor determining the rate of CO_2. For the interaction term variable *lyop*, it is also to be positive as increase in real income as a result of the increase in oil price will bring more economic activities and economic growth which is likely to bring more CO_2 emission in the oil exporting countries. For *lto*, it is also expected to be positive as trading of goods and services is expected to increase activities that will lead to more CO_2 emission. Ertugrul et al. (2016), Sun, Clottey, Geng, Fang, and Amissah (2019) find that trade openness affect the rate of CO_2 emission.

3.2 Econometric Methodology

After finding a cointegrating relationship between the variables employed found to integrated of order (1) stationary at first difference, the following stage is the estimation of the long run parameters. Meanwhile, in the presence of cointegration, ordinary least squares (OLS) is leading

to spurious results, and a lot of econometric techniques were proposed to overcome that. The Dynamic OLS (DOLS) was one of such methods for dynamic panel data which is believed to give a better outcome for cointegrated panel. However, the DOLS method has a weakness of not considering the issue of cross sectional heterogeneity (Kao and Chiang, 2000). As such, Pedroni (2000) proposed a fully modified OLS (FMOLS) for cointegrated panel which takes the issue of cross sectional heterogeneity, endogeneity and serial correlation into consideration. The FMOLS also provides a consistent estimate for small sample size.

3.2.1 Dynamic Ordinary Least Squares (DOLS)

To get an unbiased estimator for the long run parameters of equation 1, the study utilized the use of Dynamic OLS (DOLS) proposed by Kao and Chiang (2000). DOLS is an extension of Stock and Watson's (1993) estimator for investigating the long-run relationship among the dependent variable and explanatory variables. The DOLS method augments the static regression with lags, leads and contemporaneous values of the regressors in their first differences. (Pedroni, 2000). Consider the following panel model with fixed effect:

$$y_{it} = \alpha_i + x'_{it}\beta + \mu_{it} \quad (2)$$

$$i = 1 \dots N \quad t = 1 \dots T$$

where y_{it} is a matrix (1,1), β is a vector of slopes (k,1) dimension, α_i is an individual effect, and it is assumed x_{it} (k,1) vector is an autoregressive process of the first order difference:

$$x_{it} = x_{it-1} + \varepsilon_{it} \quad (3)$$

The DOLS method is derived from the following equation:

$$y_{it} = \alpha_i + x'_{it-1}\beta + \sum_{j=-q1}^{j=q2} c_{ij}\Delta x_{it+j} + v_{it,} \quad (4)$$

where c_{it} is the coefficient lead/lag of first differenced explanatory variables.

As such, the DOLS estimate has advantages over certain reasons. Firstly, it has advantage of correcting endogeneity bias and serial correlation thereby allowing for the standard normal inference. Secondly, in order to obtain an unbiased estimator of the long-run parameters, the DOLS estimator augments the static regression with the leads, lags, as well as contemporaneous values of the regressors in their first differences. Therefore, the DOLS estimator is solving the two important limitations of endogeneity problem and small sample bias. Additionally, the cointegrating vector obtained from DOLS estimator are asymptotically efficient. Nevertheless, the DOLS estimator disregards the significance of cross-sectional heterogeneity, therefore Pedroni (2000), introduced a fully modified OLS (FMOLS) to tackle that.

3.2.2 Fully Modified Ordinary Least Squares (FMOLS)

After employing DOLS, the group mean fully modified ordinary least squares (FMOLS) method proposed by Pedroni (2000) is also used to find the estimation of the panel data for equation 1 and

deals with the issue of cross-sectional heterogeneity which the DOLS estimator is ignoring. This particular method incorporates the Phillips and Hansen (1990) semi-parametric correction to the ordinary least squares (OLS) estimator to eliminate the problem of bias due endogeneity of the regressors. Pedroni (2000) particularly indicates that group-mean FMOLS t-statistics β as:

$$\bar{t}_{\hat{\beta}NT} = N^{-1}\sum_{i=1}^{N}\hat{L}_{11}^{-1}\left[\sum_{t=1}^{T}(x_{it}-\bar{x})^2\right]^{-1/2}\left[\sum_{t=1}^{T}(x_{it}-\bar{x}_i)y_{it}^{*}-T\hat{\tau}_i\right]\rightarrow N(0,1) \quad (5)$$

where

$$y_{it}^{*} = (y_{it}-\bar{y}_i)-\frac{\Psi_{21i}}{\Psi_{21i}}\Delta x_{it}$$

$$y_i \equiv \Omega_{21i}+\Psi_{21i}^{0}+\frac{\Psi_{21i}}{\Psi_{21i}}(\Omega_{22}+\hat{\Psi}_{22}^{0}) \quad (6)$$

where the $\hat{\Psi}_i$ *and* $\hat{\Omega}$ are covariances and sums of autocovariances gotten from the equation 1 long run covariance matrix, and the related t-statistics follows standard normal distribution. The FMOLS estimator uses the between group tests. These between group tests have more advantages than within group panel (Pedroni, 2000). As such, the FMOLS estimate is advantageous over certain reasons. Firstly, the group mean FMOLS estimator has a closely minor size distortions in small samples. Secondly, the between-group approach allows for greater flexibility in the presence of heterogeneity across the cointegrating vectors where β_i is allowed to vary. Under the within-group approach, β_i would be constrained to be the same value for each country under the alternative hypothesis. Thirdly, the point estimates of the between-group estimator can be interpreted as the mean value of the cointegrating vectors.

3.3 Data

In this research work, as presented on table 3, annual data was used to estimate the long run relationship between energy consumption and oil price change, and economic growth for selected SSA net oil exporting countries (Angola, Cameroon, The Republic of Congo, Equatorial Guinea, Gabon, Ghana, Nigeria and Sudan) covering the period of 25 years (1990-2014), subject to availability of data. This study, therefore, use Energy consumption proxied by Energy use (kg of oil equivalent per capita) as a dependent variable, whereas the explanatory variables are economic growth proxied *by GDP per capita (constant 2010 US$), oil price (WTI) US$*, the interaction term of *gdp per capita* and *oil price (rgdpc × oil price),* and *Trade openness* (sum of exports and imports of goods and services as share of gdp). The data of *Energy use, GDP per capita* and *Trade openness* are sourced from world development indicators (WDI). The data of *oil prices (US$)* were obtained from U.S. Energy Information Administration (EIA).

Table 3 Summary of annual data set (1990-2014) N=8

Variable	Source	Unit of measurement	Mean	SD	Max	Min

Energy use	WDI	kg of oil equivalent per capita	831.469	740.965	3129.080	226.984
GDP per capita	WDI	Constant 2010 US$	3821.369	4485.237	20512.90	495.728
Oil price	EIA	WTI (US$)	46.753	30.673	99.750	14.400
Trade Openness	WDI	% of GDP	81.452	41.501	168.008	11.087

Summary statistics of the data on Angola, Cameroon, Congo Republic, Equatorial Guinea, Gabon, Ghana, Nigeria and Sudan

4 Results and Discussion

4.1 Panel Unit Root Test

Table 2 presents the panel unit root test for data on 8 selected SSA oil exporting countries by utilizing Levin, Lin and Chu (2002) LLC and Im, Pesaran and Shin (2003) IPS. The test results show that at level, the variables of *lto* is significant at 5% under both LLC and IPS (intercept), *lrgdpc* is significant at 10% under LLC, *lop* is significant at 1% under both LLC and IPS, and *lto* is significant at 5% under LLC (intercept and trend). And then, all the variables are stationary at 1% level of significance under first-difference for both trend and intercept, at the same time for both LLC and IPS tests conducted. That indicates the variables are stationary and make the data satisfied in fulfilling the requirement to go ahead with cointegration estimation, Dynamic OLS (DOLS), Fully Modified OLS (FMOLS).

Table 2 Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS) Unitroot Test

	Level				First Difference			
	Intercept		Intercept and trend		Intercept		Intercept and trend	
	LLC	IPS	LLC	IPS	LLC	IPS	LLC	IPS
Variable								
Lec	0.719	1.492	-1.155	-0.396	-10.191***	-8.680***	-8.014***	-6.584***
Lrgdpc	3.519	5.239	-1.530*	0.755	-4.293***	-3.554***	-4.899***	-5.916***
Lop	1.471	3.777	-3.044***	-1.992***	-8.178***	-8.360***	-6.954***	-6.694***
Lyop	1.060	2.566	0.233	0.315	-10.017***	-9.202***	-8.708***	-7.463***
Lto	-1.786**	-1.811**	-1.693**	0.240	-8.244***	-9.125***	-7.293***	-10.067***

Notes: P-values are in parentheses. ***, **, * Significant at 1%, 5% and 10% respectively

4.2 Pedroni Panel Cointegration Test

Table 3 presents the Pedroni (1999) panel cointegration test between variables energy consumption (*lec*), real GDP *(lrgdpc)*, oil price *(lop)*, interaction term of real GDP and oil price *(lyop)* and trade openness (*lto*) for selected 8 SSA oil exporting countries. For Panel (within dimension) without

trend, two test statistics, *t* and ADF are found to be significant both at 1%. For Group (between dimension) without trend, also, two test statistics, *t* and *ADF* are found to be significant both at 1% respectively. For Panel (within dimension) with trend, two test statistics *t*, and *ADF* are found to be significant both at 1% respectively. For Group (between dimension) with trend, two test statistics, *t*, and *ADF* are also found to be significant at 1% respectively. Afterall, the tests indicate 8 statistics were significant, and the long run cointegration exists between the variables since the null hypothesis of no-cointegration is rejected, and that gives the indication of moving-on with the cointegration estimation.

Table 3 Pedroni Panel Cointegration Test

Panel (Within dimension) v-statistic	rho-statistic	t-statistic	ADF-statistic	Group (Between dimension) rho-statistic	t-statistic	ADF-statistic
No trend						
0.818	0.428	-2.258***	-2.496***	1.155	-2.563***	-2.780***
(0.206)	(0.666)	(0.011)	(0.006)	(0.876)	(0.005)	(0.002)
Trend						
0.656	0.213	-3.720***	-3.247***	1.587	-3.187***	-3.233***
(0.255)	(0.584)	(0.000)	(0.000)	(0.943)	(0.000)	(0.000)

Notes: P-values are in parentheses. ***, **, * Significant at 1%, 5% and 10% respectively

4.3 Results of Dynamic OLS and Fully Modified OLS

The cointegrating relationship between energy consumption, economic growth and oil price change was estimated using DOLS and FMOLS, the result is presented on table 3 below. The results indicate the presence of long run cointegrating relationship. Looking at the DOLS, the variables of oil price and the interaction term of oil price and GDP are both significant at 1%, after being positively related to energy consumption. It is indicated that, a 1% increase in oil price increase energy consumption by 0.113%. And a 1% increase in the interaction variable of GDP and oil price, increase the rate of energy consumption by 0.23%. For FMOLS, it gave a similar result, the coefficients of oil price and the interaction term of oil price and GDP are both significant at 1% and positively signed, indicating a positive relation with the independent variable, energy consumption. The result indicates, an increase in oil price by 1% leads to an increase in energy consumption by 0.09%. Also, an increase in the interaction variable of GDP and oil price by 1% will lead to an increase in energy consumption by 0.236%. The results are consistent with the findings of Shahbaz, Sarwar, Chen, and Malik (2017b), Kahia et al. (2016), Ahmad et al. (2012) that energy consumption is determined by economic growth. However, the study is contrary to the findings of Nguyen et al. (2019), Foon et al. (2016), Yazdi and Mastorakis (2016), Saidi and Hammami (2015) and Al-mulali et al. (2014) who find that economic is being determined by energy consumption. The close values of long-run coefficients for the two estimations confirm the robustness of the estimated results.

Table 3 Results of POLS, DOLS and FMOLS Estimations (Dependent variable: Energy Consumption)

	Dependent variable: Energy Consumption

	DOLS (Lag=1, Lead=1)	FMOLS
Lrgdpc	-0.019	-0.007
	(-0.345)	(-0.221)
Lop	0.113***	0.090***
	(2.612)	(3.773)
Lyop	0.230***	0.236***
	(5.134)	(9.127)
Lto	0.064	0.103
	(0.630)	(1.616)
Adjusted R^2	0.975	0.962

Notes: *,** and *** denote significance at 10%, 5% and 1% levels, respectively. Figures in parentheses are t-statistics

5 Conclusion and Recommendation

This study investigated the long run impact of economic growth via increase in oil price on energy consumption on selected SSA oil exporting countries: Angola, Cameroon, Congo-The Republic, Equatorial Guinea, Ghana, Gabon, Nigeria and Sudan. To achieve the stated objective, Panel Dynamic OLS (PDOLS) and Fully Modified OLS (FMOLS) models were utilized for the period (1990-2014), this is subject to data availability. From the cointegration test result, it was found that energy consumption, real GDP, oil price, interaction variable of oil price and real GDP and trade openness are cointegrated. Equally important, both the PDOLS and FMOLS results reveal that oil price and interaction variable of GDP and oil price have a long run effect on energy consumption in these investigated countries. The most important finding of the DOLS, FMOLS results is that the interaction variable of GDP and oil price is significant. The reason behind this result is the notion that increase in GDP due to the increase in oil price is immensely contributing to the rise in the rate of energy consumption. This statement can be supported by (figure 1 and 2) which shows the trend of energy consumption-oil price change in SSA oil exporting countries, as oil price increase the government will have more revenue to embark on many projects and that will give rise to the boost in economic activities that makes it necessary to use more energy for industries and other economic activities. For policy implication, since the findings show that economic growth is being guided by GDP, the policy of energy conservation can be implemented without affecting the economic growth. The governments of these countries can adopt energy reforms that can look into the matter of energy subsidy and applying of energy preservation policies in any form because that would not make any negative impact to the economic growth

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References

Ahmad, N., Hayat, M. F., Hamad, N., & Luqman, M. (2012). Energy consumption and economic growth: Evidence from Pakistan. *Australian Journal of Business and Management Research*, *2*(06), 9–14.

Akinlo, A. E. (2008). Energy consumption and economic growth: Evidence from 11 Sub-Sahara African countries. *Energy Economics*, *30*, 2391–2400. https://doi.org/10.1016/j.eneco.2008.01.008

Al-mulali, U., Fereidouni, H. G., & Lee, J. Y. M. (2014). Electricity consumption from renewable and non-renewable sources and economic growth: Evidence from Latin American countries. *Renewable and Sustainable Energy Reviews*, *30*, 290–298. https://doi.org/10.1016/j.rser.2013.10.006

Alam, M. M., Murad, M. W., Noman, A. H. M., & Ozturk, I. (2016). Relationships among carbon emissions, economic growth, energy consumption and population growth: Testing Environmental Kuznets Curve hypothesis for Brazil, China, India and Indonesia. *Ecological Indicators*, *70*, 466–479. https://doi.org/10.1016/j.ecolind.2016.06.043

Alshehry, A. S., & Belloumi, M. (2015). Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. *Renewable and Sustainable Energy Reviews*, *41*, 237–247. https://doi.org/10.1016/j.rser.2014.08.004

Bartleet, M., & Gounder, R. (2010). Energy consumption and economic growth in New Zealand: Results of trivariate and multivariate models. *Energy Policy*, *38*(7), 3508–3517. https://doi.org/10.1016/j.enpol.2010.02.025

Brambor, T., Clark, W. R., & Golder, M. (2006). Understanding interaction models: Improving empirical analyses. *Political Analysis*. https://doi.org/10.1093/pan/mpi014

Chai, J., Zhou, Y., Liang, T., Xing, L., & Lai, K. K. (2016). Impact of international oil price on energy conservation and emission reduction in China. *Sustainability*, (May). https://doi.org/10.3390/su8060508

Coady, D., Parry, I. an, Sears, L., & Shang, B. (2017). How large are global fossil fuel subsidies? *World Development*, *91*, 11–27. https://doi.org/10.1016/j.worlddev.2016.10.004

Ertugrul, H. M., Cetin, M., Seker, F., & Dogan, E. (2016). The impact of trade openness on global carbon dioxide emissions: Evidence from the top ten emitters among developing countries. *Ecological Indicators*, *67*, 543–555. https://doi.org/10.1016/j.ecolind.2016.03.027

Foon, C., Wah, B., & Ozturk, I. (2016). Energy consumption and economic growth in Vietnam. *Renewable and Sustainable Energy Reviews*, *54*, 1506–1514. https://doi.org/10.1016/j.rser.2015.10.083

Groot, J. (2015). Quantifying the correlation between oil price and CO2 emissions towards 2030. *International Association for Energy Economics (IAEE)*, 1–9.

H. Stock, J., & Watson, M. W. (1993). A simple estimator of cointegrated vector in higher order integrated systems. *Econometrica*, *61*(4), 783–820.

IEA. (2019). *World Energy Outlook 2019: IEA-Subsidies-2010-18*. Retrieved from https://www.iea.org/weo/weomodel/

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Jounal of Econometrics*, *115*(9526), 53–74. https://doi.org/10.1016/S0304-4076(03)00092-7

Jacques, L., & Keho, Y. (2016). Energy consumption, economic growth and carbon emissions: Cointegration and causality evidence from selected African countries. *Energy*, *114*, 492–497. https://doi.org/10.1016/j.energy.2016.08.010

Kahia, M., Safouane, M., Aïssa, B., & Charfeddine, L. (2016). Impact of renewable and non-

renewable energy consumption on economic growth : New evidence from the MENA Net Oil Exporting Countries (NOECs). *Energy*, *116*, 102–115. https://doi.org/10.1016/j.energy.2016.07.126

Kao, C., & Chiang, M.-H. (2000). On the estimation of a cointegrated regression in panel data. *Advances in Econometrics*, *15*, 179–222.

Kourtzidis, S. A., Tzeremes, P., & Tzeremes, N. G. (2018). Re-evaluating the energy consumption-economic growth nexus for the United States: An asymmetric threshold cointegration analysis. *Energy*, *148*, 537–545. https://doi.org/10.1016/j.energy.2018.01.172

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development*, *3*(2), 401–403.

Levin, A., Lin, C., & Chu, C. J. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of Econometrics*, *108*, 1–24.

Lise, W., & Montfort, K. Van. (2007). Energy consumption and GDP in Turkey: Is there a co-integration relationship? *Energy Economics*, *29*, 1166–1178. https://doi.org/10.1016/j.eneco.2006.08.010

Mahalik, M. K., Babu, M. S., Loganathan, N., & Shahbaz, M. (2017). Does financial development intensify energy consumption in Saudi Arabia? *Renewable and Sustainable Energy Reviews*, *75*(October 2016), 1022–1034. https://doi.org/10.1016/j.rser.2016.11.081

Maladoh, M., & Azam, M. (2017). Investigating the relationship between electricity consumption and economic growth : Evidence from South Africa. *Renewable and Sustainable Energy Reviews*, *80*(February), 531–537. https://doi.org/10.1016/j.rser.2017.05.251

McCallum, B. T. (1970). Artificial orthogonalization in regression analysis. *The MIT Press*, *52*(1), 110–113.

Mehrara, M. (2007). Energy consumption and economic growth: The case of oil exporting countries. *Energy Policy*, *35*(5), 2939–2945. https://doi.org/10.1016/j.enpol.2006.10.018

Mirza, F. M., & Kanwal, A. (2017). Energy consumption, carbon emissions and economic growth in Pakistan: Dynamic causality analysis. *Renewable and Sustainable Energy Reviews*, *72*(May 2011), 1233–1240. https://doi.org/10.1016/j.rser.2016.10.081

Nguyen, H. M., Bui, N. H., Vo, D. H., & Mcaleer, M. (2019). Energy Consumption and Economic Growth: Evidence from Vietnam. *Journal of Reviews on Global Economics*, *8*, 350–361.

Pedroni, P. (1999). Critical values for cointegration tests in heterogenous panels with multiple regressors. *Oxford Bulletin of Economics and Statistics*, *61*(S1), 653–670.

Pedroni, P. (2000). Fully modified OLS for heterogenous cointegrated panels. *Advances in Econometrics*, *15*, 93–130.

Phillips, P. C. B., & Hansen, B. E. (1990). Statistical inference in instrumental variables regression with I (1) Processes. *Review of Economic Studies*, *57*, 99–125.

Rafindadi, A. A. (2016). Does the need for economic growth influence energy consumption and CO2 emissions in Nigeria? Evidence from the innovation accounting test. *Renewable and Sustainable Energy Reviews*, *62*, 1209–1225. https://doi.org/10.1016/j.rser.2016.05.028

Rotimi, M. E., & Ngalawa, H. (2017). Oil price shocks and economic performance in Africa's oil exporting countries. *ECONOMICA*, *13*(5), 169–188.

Saad, A., & Belloumi, M. (2015). Energy consumption , carbon dioxide emissions and economic growth : The case of Saudi Arabia. *Renewable and Sustainable Energy Reviews*, *41*, 237–247. https://doi.org/10.1016/j.rser.2014.08.004

Saidi, K., & Hammami, S. (2015). The impact of energy consumption and CO 2 emissions on economic growth : Fresh evidence from dynamic simultaneous-equations models. *Sustainable*

Cities and Society, *14*, 178–186. https://doi.org/10.1016/j.scs.2014.05.004

Shahbaz, M., Sarwar, S., Chen, W., & Malik, M. N. (2017a). Dynamics of electricity consumption, oil price and economic growth: Global perspective. *Energy Policy*, *108*(January), 256–270. https://doi.org/10.1016/j.enpol.2017.06.006

Shahbaz, M., Sarwar, S., Chen, W., & Malik, M. N. (2017b). Dynamics of electricity consumption, oil price and economic growth: Global perspective. *Energy Policy*, *108*(May), 256–270. https://doi.org/10.1016/j.enpol.2017.06.006

Sirag, A., Matemilola, B. T., Law, S. H., & Bany-Ariffin, A. N. (2017). Does environmental Kuznets curve hypothesis exist? Evidence from dynamic panel threshold. *Journal of Environmental Economics and Policy*, *0*(0), 1–21. https://doi.org/10.1080/21606544.2017.1382395

Sun, H., Clottey, S. A., Geng, Y., Fang, K., & Amissah, J. C. K. (2019). Trade openness and carbon emissions: Evidence from belt and road countries. *Sustainability*, 1–20.

Tsani, S. Z. (2010). Energy consumption and economic growth : A causality analysis for Greece. *Energy Economics*, *32*(3), 582–590. https://doi.org/10.1016/j.eneco.2009.09.007

Yazdi, S., & Mastorakis, N. (2016). Energy consumption and economic growth in Iran: Cointegration and causality analysis. *Latest Trends in Energy, Environment and Development*, (October), 348–354.

Zamani, M. (2007). Energy consumption and economic activities in Iran. *Energy Economics*, *29*, 1135–1140. https://doi.org/10.1016/j.eneco.2006.04.008