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Panel Regression on the impact of Energy Consumption and Trade Openness on Economic Growth in Some Selected Sub-Sahara African Countries

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ABSTRACT

Energy is necessary for a holistic economic system that includes the production, distribution, and consumption of products and services. This suggests that energy access and consumption are either directly or indirectly related to the growth of the majority of developing and growing economies. As a result, energy is essential to the production of goods and services that are either sold elsewhere or consumed locally. Trade openness and energy output are thus two of the most important factors determining a nation's economic health. Thus, this study aimed at examining the impact of energy consumption and trade openness on economic growth in selected Sub-Saharan African (SSA) Countries using panel regression models. The data for the study were collected from World Bank Data Base from 2010 -2022. The data collected were analyzed using Pooled Regression, Fixed Effect (FE) and Random Effect (RE) regression models. The Hausman specification test result revealed that the random effect model is more efficient for modelling the impact of energy consumption and trade openness on economic growth in SSA Countries (Housman specification test statistic = 5.31, $p > 0.05$). The study revealed further that there is presence of random effect (test statistic = 611. 18, $p < 0.05$) and there is cross sectional independence (test statistic = 39.455, $p < 0.05$) in the data. In addition, it was discovered that both energy consumption and trade openness have negative and significant impact on economic growth of selected SSA Countries ($\beta_1 = -1.7342,\ p < 0.05; \beta_2 = 0.4097, p < 0.05$). Based on these findings, it was recommended that policy makers in the selected Countries that should formulated policies that will provide an enabling environment for effective and positive contribution of oil consumption and trade openness to economic growth in Nigeria.

Keywords: Energy Consumption, Fixed Effect, Panel Data, Random Effect, Trade Openness and Economic Growth.

INTRODUCTION

Panel data is a unique kind of pool data that combines cross-sectional and time series data. It involves surveying the same cross-sectional unit across time, such as a family or business. Put differently, panel data are the results of multiple surveys conducted over time on a single (cross-sectional) sample (Adenomon and Micheal, 2017). Panel data has some many advantages (Hsiao, 1985; Solon (1989) and one of the techniques for modelling such data is panel regression model. Panel regression is a statistical technique used to combine data from multiple groups or panels such as individual firms, or countries, to estimate a single regression model. And it aids in capturing individual specific effects like the Random and fixed effects, which help in understanding individual units (country) behavior over a specific time period.

Parameter estimation in regression analysis with cross-section data uses an approach known as Ordinary Least Square (OLS), which yields Best Linear Unbiased Estimation

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(BLUE) as its result. Data from the same individuals observed over a specific time period is known as panel regression data. The panel data will contain $N \times T$ total observation units if the observation was made at time T periods $(t = 1, 2, 3, ..., T)$ and N is the number of individuals $(i = 1,2,3, ..., N)$. And we talk about balanced panel if each individual's sum unit time is the same. Conversely, if each individual's time units differ, the panel is referred to as imbalanced. But before looking at various literatures, it's important to look at the relationship of energy consumption, trade openness and economic growth from a simpler perspective.

Energy is seen to be a vital element of economic activity in an economy. Since energy is a necessary component of many manufacturing and consumption processes, it is a major driver of economic growth. One of the most crucial resources for economic growth is energy. Physically speaking, energy use is essential to the functioning of any contemporary economy as it propels industrial expansion and economic productivity. Energy increases industrial component efficiency. Most nations depend on the energy sector for economic growth, and the world's energy consumption is rising (Le and Sarkodie, 2020). Energy consumption has played a vital role towards the production of goods and services which in turn improve trade and economic activities of a country. Since energy is seen as important element of modern life, its usage creates a strong base for an economic development of any serious economy (Hasson and Masih, 2017). There are also many rationales that give rise to the study of linkage between energy consumption and trade. For instance, if energy use is established to engender trade, then energy conservation policies intended to decrease greenhouse gas emissions will impair trade due to the reduction in energy consumption which lessen the benefits of trade (Akinwale and Muzindutsi, 2019).

Trade openness refers to the flow of goods made in one nation to another for final processing or consumption. Without the efficient use of energy, those commodities cannot be produced. Energy consumption is impacted by trade openness through the scale, technique, and composite effects. Trade openness, all other things being equal, boosts economic activity, which in turn boosts domestic production and ultimately leads to economic growth. Trade liberalization is predicted to boost domestic output, which has historically led to economic expansion. Importing cutting-edge technologies from industrialized nations is also made easier for developing economies (Nasreen and Anwar, 2014). Thus, it is interesting to study the impact of energy consumption and trade openness on economic growth. Hence, this study aimed at evaluating panel regression models on the impact of energy consumption, trade openness on economic growth in sub-Sahara countries by comparing the three models (fixed regression, random regression and pooled regression).

On empirical basis, Thomas (2011) measured foreign direct investment in Taiwan, tried to answer two questions. The first question was, which are the countries that contribute largely to Taiwan FDI? And the second question the paper was what are the factors that draws FDI into Taiwan? Although, most current literature on FDI in other countries indicates relative market size, relative labor cost, distance and literacy rate to be the determinants of FDI. Three versions (Pooled regression model, Fixed Effect (FE) model, and Random Effect (RE)) of the empirical model were estimated. And in the three models, the relative market size hypothesis was consistently proved to be a key determinant of FDI in Taiwan.

Kayode *et al* (2021) examined the impact of electronic payment system on the profitability of commercial banks in Nigeria. Pooled OLS and Panel regression models were fitted on the data extracted from the banks' annual reports, Nigerian interbank settlement scheme, and central bank of Nigeria website. The assessment of the contribution of the various electronic payment systems considered were measured using Breusch and Pagan Lagrangian Multiplier (LM) Test, the Hausman Test, Stationarity Test, The Schwarz Criterion, and the Akaike Information Criterion. Results obtained showed that the random effect model was more appropriate than the fixed effect model for all the electronic payment systems considered in this study. Moreover, it was discovered that there exists a positive relationship between the electronic payment systems and profitability of the commercial banks in Nigeria.

Azeakpono and Lloyd (2020) examined the effect of renewable energy consumption on economic growth in Nigeria for the period 1990 to 2016. The data for the study were analyzed using correlation, co-integration, regression, and granger causality tests. The result showed that although renewable energy consumption and economic growth increased between 1990 and 2016 in Nigeria, renewable energy consumption had no significant positive impact on economic growth in Nigeria. Also, there was no causality between renewable energy consumption and economic growth in Nigeria during the period of study.

Ajao *et al* (2023) modeled a panel data that were characterized by features of no first order autocorrelation using three estimation models: Pool Regression, Fixed Effect, Random Effect models. The study relied on simulation data. The findings of the study revealed that fixed effect model was more preferred for small sample panel structure irrespective of the level of autocorrelation. However, random effect model performed better for moderate and large sample panel structure. Megesa et al (2016) compared some panel data regression model estimators using simulated data. The simulation results showed that the estimator based on large sample is more consistent than those with small sample size.

Based on the empirical literatures reviewed, it was observed that there is little studies that adopted panel regression recently and there also there is no specific study that adopted panel regression model to investigate the impact of energy consumption and trade openness on economic growth in Sub-Saharan African Countries. Thus, this study seeks to fill these gaps identified in the literatures. The remaining part of the paper present the materials and methods, results, conclusion and recommendations.

MATERIALS AND METHODS

Data and Variables

The data use in this research were source from World Bank Data Base from year 2010-2022, which comprises of data from energy consumption (EC), trade openness (TO) and economic growth proxied by gross domestic product per capita (GDPPC) of some selected Sub-Sahara African Countries. The sub-Saharan African Countries selected in this study includes Angola, Benin, Botswana, Cameroon, the Democratic Republic of Congo, the Republic of Congo, Cote d'Ivoire, Ghana, Kenya, Mozambique, Namibia, Niger, Nigeria, Senegal, South Africa, Tanzania, Togo and Zimbabwe. These Countries were selected based on the availability of data. The models used in this research include; fixed effect regression, random effect regression and pooled regression.

Estimation of Panel Data Regression

Among the techniques that can be used in the process of estimating the regression model of

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panel data are:

Common Effect Model or Pooled Least Square

In pooled regression, the data is combined and a single model is estimated using the aggregated data. This assumes that the relationships between variables are consistent across groups. And there are two main types of pooled regression, namely: Pooled Ordinary Least Squares (POLS) which assumes homoscedasticity and no correlation between errors and Generalized Least Squares (GLS) which accounts for heteroscedasticity and/ or correlation between errors. The model is written as:

$$Y_{it} = \alpha + \beta' X_{it} + \varepsilon_{it} \qquad (1)$$

Where:

Y_{it}= is the dependent variable for individual i at time t; X_{it} = is the vector regressors for individual i at time t; α = is the individual specific effect (fixed or random); β' = is the vector of regression coefficient; ε_{it} = error term for individual i at time t; $N =$ is the number of individuals or cross sections (Firm, Countries e.t.c.) and $T =$ is the time period.

Fixed Effect Model

This model assumes that differences between individuals can be accommodated from different intercept. To estimate Fixed Effects model, panel data uses dummy variable technique to capture the differences between intercept of individual cross sections. Nevertheless, the intercept is the same between individual cross sections. This estimation method is often called the technique of Least Squares Dummy Variable (LSDV). The Fixed effect model differs from the common effect (pooled regression), but still uses the ordinary least square principle. The assumption of modeling that produces a constant intercept for each cross section and time is considered less realistic, so more models are needed to capture the difference.

Fixed effects assume that differences between individuals (cross section) can be accommodated from different intercept. In order to estimate the Fixed Effects Model with different intercept between individuals, the dummy variable technique is used. Such estimation models are often referred to as the Least Squares Dummy Variable technique or abbreviated LSDV. The Fixed regression model can be written as:

$$Y_{it} = \alpha_i + \beta' X_{it} + \varepsilon_{it} \qquad (2)$$

Where:

Y_{it}= is the dependent variable for individual i at time t; X_{it} = is the vector regressors for individual i at time t; α_i = is the individual specific intercept effect (fixed); β' = is the vector of regression coefficient; ε_{it} = error term for individual i at time t; $N =$ is the number of individuals or cross sections (Firm, Countries e.t.c.) and $T =$ is the time period.

Random Effect Model

In the Random Effect model, the difference between intercepts is accommodated by the error terms of each group. The advantage of using the Random Effect model is to eliminate heteroscedasticity. This model is also called the Error Component Model (ECM) or Generalized Least Square (GLS) technique. In contrast to fixed effect model, random effect models, assumed that the group specific effects are randomly distributed and uncorrelated with the independent variables. Also, the group specific effects are estimated as random variables rather than fixed parameters. This allows for the estimation of the variation in the outcome due to individual difference between groups as well as variation due to independent variables. The Random effect model is given as:

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$Y_{it} = \alpha + \beta^{'} X_{it} + \mu_i + \varepsilon_{it}$ *(3)*

Where:

$\boldsymbol{Y_{it}}$= is the dependent variable for individual $\boldsymbol{i}$ at time $\boldsymbol{t}$; $\boldsymbol{X_{it}}$ = is the vector regressors for individual $\boldsymbol{i}$ at time $\boldsymbol{t}$; $\boldsymbol{\alpha =}$ is the constant term; $\boldsymbol{\beta}^{'} =$ is the vector of regression coefficient; $\boldsymbol{\mu_i}$ is the random effect for group $\boldsymbol{i}$ (normally distributed with mean zero and variance $\boldsymbol{\sigma^2}$), $\boldsymbol{\varepsilon_{it}}$ = error term (normally distributed with mean zero and variance $\boldsymbol{\sigma^2}$).

Model Specification

The impact of energy consumption (EC), trade openness (TO) on economic growth proxied by gross domestic product per capita (GDPPC) were represented using the functional form of the model for Pooled, fixed and random effect model respectively as below:

$$GDPPC_{it} = \alpha + \beta_1 EC_{it} + \beta_2 TO_{it} + \varepsilon_{it} \quad (4)$$
$$GDPPC_{it} = \alpha_i + \beta_1 EC_{it} + \beta_2 TO_{it} + \varepsilon_{it} \quad (5)$$
$$GDPPC_{it} = \alpha + \beta_1 EC_{it} + \beta_2 TO_{it} + \mu_i + \varepsilon_{it} \quad (6)$$

Where:

$\boldsymbol{GDPPC_{it}}$ = is the gross domestic product per capital for Country $\boldsymbol{i}$ at time $\boldsymbol{t}$;

$\boldsymbol{EC_{it}}$ = is the Energy Consumption for Country $\boldsymbol{i}$ at time $\boldsymbol{t}$;

$\boldsymbol{TO_{it}} =$ is the Trade Openness for Country $\boldsymbol{i}$ at time $\boldsymbol{t}$;

$\boldsymbol{\alpha}$ = is the intercept

$\boldsymbol{\alpha_i}$ = is the Country specific intercept effect (fixed)

$\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$= Vector of Regression Coefficient

$\boldsymbol{\mu_i}$ = is the random effect for group $\boldsymbol{i}$ (normally distributed with mean zero and variance $\boldsymbol{\sigma^2}$).

$\boldsymbol{\varepsilon_{it}}$ = error term (normally distributed with mean zero and variance $\boldsymbol{\sigma^2}$).

RESULT

From figure 1, it can be observed that lnGDP for all the selected Sub-Saharan African Countries where higher as compared to lnTO and lnEC. However, lnGDP, lnTO and lnEC for all the selected SSA were parallel for the whole periods under study though with little fluctuations.

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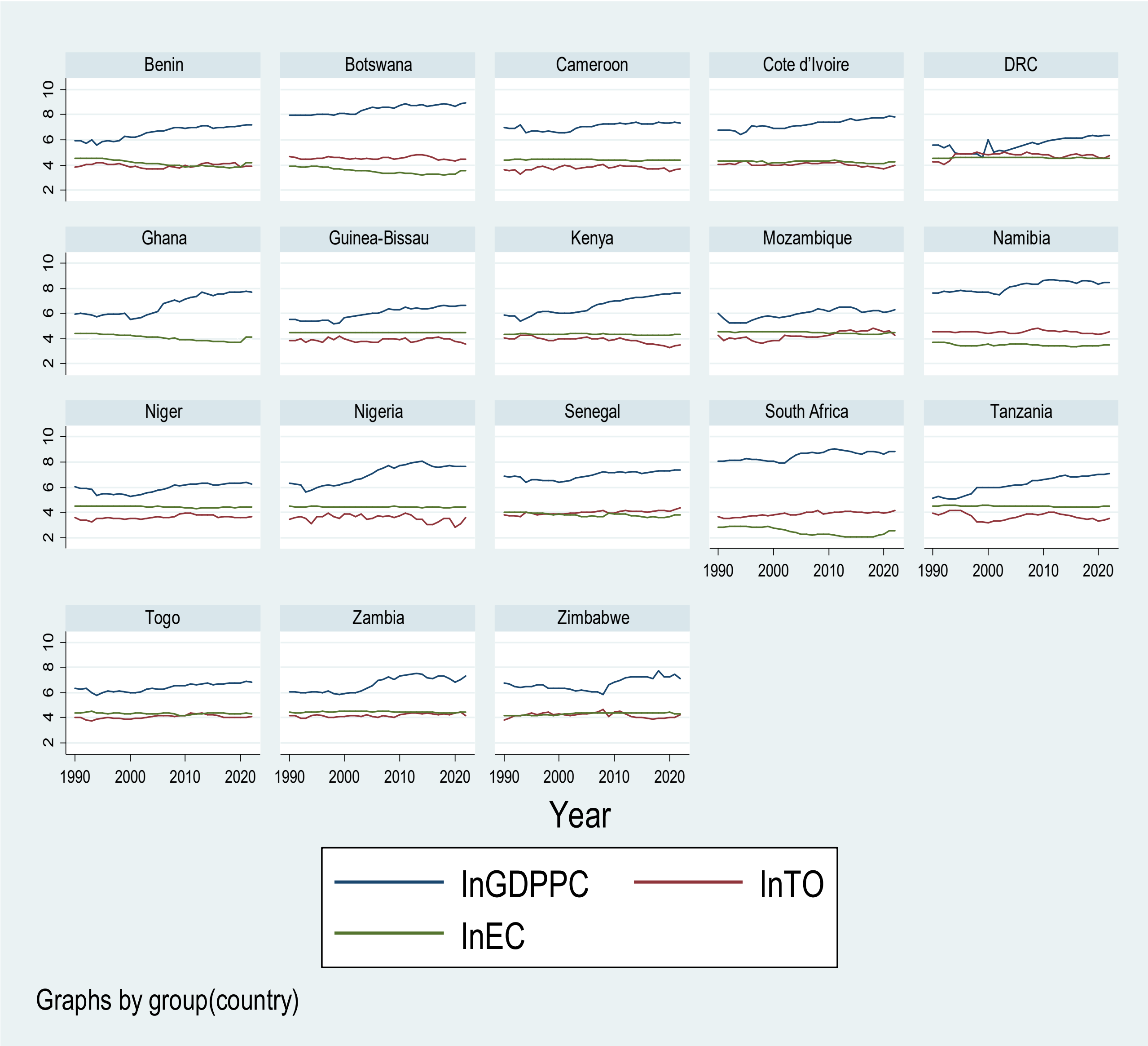

Figure 1: Line graph of lnGDPPC, lnTO and lnEC for the selected SSA

Table 1: Summary Descriptive Statistic

Variables	Statistic	Mean	Std Dev.	Min	Max	Observations	
lngdppc	Overall	6.8178	0.9584	4.6027	9.0753	N	594
	Between		0.8358	5.6254	8.5201	N	18
	Within		0.5076	5.3853	7.9310	T	33
lnTo	Overall	4.0586	0.3772	2.7944	5.0553	N	594
	Between		0.3287	3.5522	4.7432	N	18
	Within		0.2002	3.3008	4.6613	T	33
lnEC	Overall	4.1451	0.5306	2.0438	4.5884	N	594
	Between		0.5270	2.4697	4.5691	N	18
	Within		0.1373	3.7192	4.5980	T	33

Source: Extracted from STATA output

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From Table 1, it can be observed that the overall number of observations for each variable is 594. This is in line with the number of the sampled Sub-Saharan African Countries which is 18, and the study period of 33 years (1990 – 2022). The lngdppc, lnTO and lnEC has a mean value of 6.8178, 4.0586 and 4.1451 resepctively. The minimum and maximum lngdppc were 4.6027 and 9.0753; lnTO were 2.7944 and 5.0553 while that of lnEC were 2.0438 and 4.5883 respectively.

Table 2: Panel Regression Results

Variables	OLS	FE	RE
Constant	12.8560***	16,3895***	15.6691***
lnEC	-1.3772***	-1.8716***	-1.7342***
lnTO	-0.0886	-0.4467***	-0.4097***
R-squared	0.5745		
Adj R-squared	0.5731		
Within		0.2611	0.2611
Between		0.6920	0.6924
Overall		0.5656	0.5658
F-value	398.99	101.43	
Prob>F	0.0000	0.0000	
RMSE	0.62623		
Hausman Specification and Diagnostic Tests			
	Test statistic	P-value	Remark
Hausman Specification	5.31	0.0702	RE
Heteroskedasticity	0.02	0.9020	Absent
Wooldridge test for autocorrelation	10.084	0.0055	Present
Groupwise heteroskedasticity in FE Model	611.18	0.000	Present
Pesaran's test of cross-sectional independence	39.455	0.000	Present
Breusch and Pagan LM test for REs	2150.03	0.0000	Present

Source: Extracted from STATA output

Note: a. lngdppc is the DV

d. Res- Random Effects

c. *** sig at 1%

Table 2 presents the regression results of OLS, FE and RE on the impact of trade openness and energy consumption on gross domestic product per capita. The results from Table 2 for OLS model shows that the adjusted coefficient of determination (Adj. R-squared) which gives the proportion or percentage of the total variation in the dependent variable explained by the independent variables jointly are 0.5731. This implies that about 57.3% changes in lngdppc of the selected Sub-Saharan African are explained by the independent variables (lnEC and lnTO) captured by the models. On the other hand, the overall R-squared in FE and RE results are 0.5656 and 0.5658 respectively, meaning that the independent variables cumulatively explained about 56.6% changes in the lngdppc. Likewise, the OLS F-statistic and P-Values were 398.99 and 0.0000 respectively and FE F-statistic and P-values of 101.43 and 0.0000 respectively proved that the models are fit, since none of the values reaches 0.05.

The regression results based on OLS model revealed that ln*EC* has negative and significant impact on lngdppc (B_1 = -1.3772, $p < 0.05$) while ln*TO* has negative but insignificant impact on lngdppc (B_2 = -0.0886, $p>0.05$). This implies that increase in energy

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consumption significantly decreases gross domestic product per capita of the selected Sub-Saharan African countries while increase in trade openness tend to decrease gross domestic product per capita of the selected SSA countries insignificantly for the period under study.

Also, the results of the analysis based on FE model revealed that *lnEC* and *lnTO* has negative and significant impact on of lngdppc (B_1= -1.8716, $p<0.05$ and B_2 = -0.4467, $p <0.05$). This implies that increase in energy consumption and trade openness significantly decreased gross domestic product per capita of the selected SSA countries for the period under study.

In addition, the regression result based on RE model revealed that lnEC and lnTO has negative and significant impact on lngdppc (B_1= -1.7342, $p<0.05$ and B_2 = -0.4097, $p <0.05$). This implies that increase on energy consumption and trade openness significantly decreases gross domestic product per capita of the selected SSA Countries for the period under study.

The fact that there is a trade-off between the efficiency of the random effect (RE) approach and the consistency of the fixed effect (FE) approach, then the Hausman specification test is performed to decide between fixed or random effect models. Thus, prob>chi2 is the criteria used to determine the efficiency of fixed and random effect regression results, and to also make choice between the two regression models. Therefore, if prob>chi2 is less than 0.05, fixed effect result is more efficient than random effect, and will be selected. On the other hand, if prob>chi2 is greater than or equal to 0.05, the reverse will be the case. The results of the data analysis presented in Table 2 revealed a prob>chi2 values of 0.0702 which is greater than 0.05. Thus, the random effect model was considered to be more efficient in modelling the impact of lnEC and lnTO on lngdppc.

The diagnostic test results revealed absent of heteroskedasticity in the OLS models. However, there was presents of autocorrelation and Groupwise heteroskedasticity in FE Model. The p-value for Pesaran's test for cross sectional independence was less than 0.05 suggesting that the cross sections were independent. The test statistic and p-value (2150.03 and 0.0000 respectively) for Breusch and Pagan LM test for random effects revealed that the random effects are significant.

Table 3: Multicollinearity Test using Variance Inflation Factor

Variable	VIF	$1/_{VIF}$
lnEC	1.02	0.9772
lnTO	1.02	0.9772

Source: Extracted from STATA output

This study adopted variance inflation factor (VIF) was used to test for the presence of multicollinearity in the estimated OLS model. When multicollinearity exists, it will be difficult to differentiate the individual effects of explanatory variables and the OLS estimators may be biased and they even tend to have large variances (Murray, 2006). The VIF in excess of 10 should be taken as an indication of multicollinearity (Gujarati, 2003). This study therefore used VIF to check whether the explanatory variables of the model suffer from multicollinearity. The results of the tests conducted revealed absence of multicollinearity as the VIF values were less than 10 (Table 3).

CONCLUSION AND RECOMMENDATIONS

One of the most actively pursued areas of energy economics literature in recent time has been empirical analysis aiming to confirm or refute the possibility of a relationship between energy consumption and economic growth, even though mainstream economic theories offer no specific evidence of such a relationship. This study aimed at adding to the existing literatures by empirically examining the impact of energy consumption and trade openness on economic growth in some selected Sub-Saharan African Countries using panel regression models. The Pooled, Fixed and random effect regression models were considered in this study. Based on the findings of the study using the Hausman's specification test, it was concluded that the random effect regression model is more appropriate for modelling the impact of energy consumption and trade openness on economic growth in the selected SSA Countries for the period under study. Based on the findings from random effect regression model, it was discovered that both energy consumption and trade openness have negative and significant impact on economic growth of selected SSA Countries for the period under study. Based on this conclusion, it was recommended that policy makers in the selected Countries should formulate policies that will provide an enabling environment for effective and positive contribution of energy consumption and trade openness to economic growth in Nigeria.

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