



## EMPIRICAL ANALYSIS OF ENERGY CONSUMPTION AND ECONOMIC GROWTH IN TANZANIA: BASED ON ENGEL AND GRANGER TEST

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### ABSTRACT

**Purpose** - This article aims to investigate the effect of energy consumption on economic growth in Tanzania. It is a quantitative investigation that is structured by the time series data from the World Bank (WB) database which started from 1990 to 2019. The article uses variables of Energy consumption (EC) and Economic growth (GDP). The variables are measured in GDP (Constant US\$) and EC (MTOE).

**Methodology** - To obtain the significant estimated results, this study uses econometric tools for both theoretical and empirical analysis such Augmented Dickey-Fuller (ADF) test for identifying stationary and nonstationary time series data, Engel and Granger test for determination of the existence or absence of cointegration relationship, Vector Error Correction Model (VECM) for determining the speed of adjustment (ECT) and Classical Granger-causality test for a causal relationship between economic growth and consumption.

**Findings**- The core findings from the study are; the cointegration relationship between Energy consumption (EC) and Economic growth (GDP), a bidirectional causal relationship between energy consumption (EC) and Economic growth (GDP) in Tanzania. Therefore, the study accepts the energy feedback hypothesis that revealed to exist both a long-run effect and short-run effect between the energy consumption and economic growth in Tanzania.

**Conclusion**- The estimated results of this study provide the information to Tanzanian policymakers with a new dimensional approach to Tanzanian economic growth through an increase in energy consumption use. Although Tanzanian government has a huge and long term sustainable project of increasing energy power by adding 2115 megawatts to Tanzanian national grid using the Stigler gorge or Julius Nyerere Hydroelectric power at Rufiji River but also Tanzania should invest to the short energy projects consumptions that can facilitate and improve the economic development of domestic hoods.

**Keywords:** Tanzania, GDP, EC, Engel and Granger test, Granger Causality test.

**JEL Codes:** B23, Q43, O55

## 1. INTRODUCTION

Energy sources are key elements or an engine of the country's GDP. When efficiency energy sources are implemented well and established within the country, it often contributes by improving the GDP of the country. EC and GDP have a direct correlation. Sorely, increasing the rate of EC in the economic sectors like an agricultural sector in the case of cultivating cash products using machines, transportations and the communication sector, investment, and trade sector contributes a significant performance on the country's GDP. The country which has better economic performance is associated with advanced in science and technology which is related to effective investments in terms of public and private sectors. The demand of energy consumptions within the state is almost high. More energy will be demanded to facilitate economic activities. It is different from countries that perceive or consume less amount of energy per year definitely, they cannot produce standard and good quality services from the industries that compete or meet international world market requirements. Less distribution of energy consumption affects the housing hood, firms, and industries economically by consuming a small amount of energy on economic activities. It makes it difficult for the domestic hood to achieve a good and standard of their livelihood. Therefore EC has a direct significant contribution to the GDP of the country. Sorely energy

consumption often depends on the availability of energy sources. Therefore, Tanzania has abundant energy sources that are significant to the GDP of the country. The energy sources which are found in Tanzania are natural gas, biomass, geothermal, brown coal, hydroelectric power, nuclear materials, and solar power energy through which its domestic consumptions are very low (Napendael, 2004). Other energy sources are agriculture residual, solid factories waste, animal dung, and landfill biogas. Natural gas reserves in the offshore of Songo-Songo are estimated to be at 783BCF (Besta, 2013), Mnazi Bay, the natural gas has been discovered (Boma, 2013.15-19). Msimbati area has reserved of natural gas that it makes about 46TCF to 55TCF. Natural gas has discovered in the year of 2009 and 2013. The area of natural gas is found in the southern part of Tanzania in the region of Mtwara which has got a massive deposit of natural gas. Therefore it makes Tanzania to be accounted among the country that has enough reservation of the natural gas in the world (Kamat, 2017.304-306). The other areas that contain natural gas like Mkuranga, Kilwa North, and Nanyuki, generally the amount of natural gas that deposited in Tanzania is about 27trillion (Kusekwa and M.A, 2013. 241). Table 1 indicates energy sources that are found in Tanzania concerning to their regions and districts.

**Table 1: Energy Sources in Tanzania**

Energy Source	Amount of Deposition	Region	District
Natural gas	30bcf [IEA,2013]	Lindi	Songwe-Songwe Island
	817bscf [RPS, Energy Canada]	Mtwara	Mnazi Bay
Natural gas	30bcf [IEA,2013]	Lindi	Songo- Songo Island
	817bscf [RPS, Energy Canada]	Mtwara Pwani Lindi Ruvuma	Mnazi Bay Mkuranga (Madimba) North Kilwa Ntorya
	46Tcf to 55Tcf [TPDC]	Mtwara	Msimbati
Coal	9.1bt extra per capital year [TMAA]	Mbeya	Kiwira
		Ruvuma	Ngaka
Geothermal		Arusha	Lake Natron
			Lake Manyara
		Kilimanjaro	Lake Natron
			Lake Manyara
			Meru province Rungwe
		Rukwa , Morogoro,Dododma, Singida, Rufiji and Shinyanga	
Uranium		The northern part of Tanzania	Tarosero volcano-sedimentary rocks of Chimala
		The Central part of Tanzania	Manyoni, Bahi, Mbuga, Makotopola and Lake Hombolo
		The southern part of Tanzania	Namtumbu {Mtakuja and Madaba}
IEA TPDC TMAA tcf bcf RPS, Canada	International Energy Agency Tanzania Petroleum Development Cooperation Tanzania Minerals Audit Agent Trillion cubic feet Billion cubic feet Rural Planning Services energy company in Canada		

The main focuses of this study to explore the relationship between EC and the GDP of Tanzania. Therefore the study intends to address the following questions; the presence of the cointegration effect between EC and GDP in Tanzania, what kind of causal relationship is found between the EC and GDP, does it, a unidirectional or bidirectional relationship between EC and GDP. To support these equations this study cements the following hypothesis; EC depends on GDP energy in Tanzania (conversation hypothesis), EC affects GDP in Tanzania (economic growth), GDP and EC depend on each other (feedback relationship, and the last assumption. There is a neutral relationship between GDP and EC in Tanzania (Neutral relationship) (Ocal and Aslan,2013.495). The study contributes by adding knowledge about issues the EC and GDP in the academic world.

The study uses quantitative methods to examine a specific case study and made use of empirical research methods. More emphasis has been laid on secondary sources of data from the World Bank database. The study applies the ADF test, Engel-Granger test, VECM, Granger Causality test, and Post estimations test for data analysis. The policymakers will develop energy and economic policies that will contribute a significant effect on the GDP of Tanzania. Furthermore, it adds a new dimension in the literature review especially in the field of EC and GDP in Tanzania. The study spans from 1990 to 2019. Therefore the justifications of the topic have drawn great attention from many thoughts of scholars in the economic field, especially in EC and GDP, the pioneer Kraft was the emphasis the investigation of EC and GDP economic (Kraft, 1978). The organization of the study is constructed as follows; the next sections are reviews of the literature, analysis of data, methodology, estimated results, literature, and conclusion.

## **2. LITERATURE REVIEW**

Different Thoughts of schools discuss the effect of EC and GDP, how the causal relationship among the variables behave. They come with the conclusion that the causal relationship among the variables is not constant. The relationship between EC and GDP depends on the different factors that include economic factors, technological factors, demographic factors, and empirical methodological factors. Thus to determine the connection between EC and GDP is found to be non-consensus. The Kraft contributed a lot to EC and GDP (Kraft, 1987). Kraft found unidirectional moves from the GDP to EC. In the U.S uses the bivariate model through the study of Kraft no causal relationship between EC and GDP (Kraft, 1987). The Kraft contributed a lot to the determination of the causal relationship between EC and GDP. Kraft found unidirectional moves from the GDP to EC (Kraft, 1987). Also, Kraft investigated the causal relationship between EC and GDP in the U.S. He investigated by applying the bivariate model through the study of Kraft, and he found no causal relationship between EC and GDP (Kraft, 1987). Liu (2017) on his study, related energy consumption, and economic growth argued that higher an increase of EC leads to a higher GDP (Liu and Zhang. 2015, p.401).

The research revealed a bidirectional relationship between EC and GDP. Odhiambo (2008) conducted his research related to EC and GDP in Tanzania. He used three variables identified as EC, GDP, and Electricity. The study applied an ARDL bound test for finding the cointegration. The empirical analysis from this study found that there is cointegration effect between EC and GDP. The results show that there is a unidirectional causal relationship that moves from EC to GDP. Seemingly there is a causal connection that flows from Electricity to GDP (Odhiambo, 2009). Nyoni (2013) investigates the relationship between EC and GDP in Tanzania. He applied the cobb-Douglass production function that includes EC, capital investment, and labor. The study finds the unidirectional causal relationship which is running from the GDP to EC (Nyoni, 2013). Vinay (2017) conducted his research identified as the powering of the nation. From his study included natural gas and GDP. Vinay argued Tanzania can use natural gas protection to employ Tanzanian. Sorely the GDP of the country will be improved by reducing the unemployment rate and to increase the employment gap to the communities (Kamat.2017). Another study was conducted by Campo and Sarmiento (2013) in Latin America. The study examines the relationship between EC and GDP of 10 Latin American states. The study applied Pedroni's test for cointegration and the outcomes from the study show the bidirectional causal relationship between EC and GDP, and long-relationship between EC and GDP was found (Campo and Sarmiento, 2013).

Not all the studies show the positive correlation between EC and GDP, there some studies that show a negative relationship between EC and GDP. For instance, the study conducted by Aqeel and Mohammed (2001) related to EC and GDP in Pakistan. The study applied technic of cointegration and Hsiao version of the Granger causality test. In this study, the findings show that EC leads to petroleum consumption and no causal relationship between Petroleum consumption towards GDP (Aqeel and Mohammed, 2001). Makala (2019) investigates the impact of natural gas on GDP in Tanzania. He applied the ARDL test and Granger causality test to examine the causal relationship between natural gas and GDP. Makala argued that there is no cointegration effect between natural gas and GDP in Tanzania. The analysis revealed that there is no long-run relationship between natural gas and GDP in Tanzania (Makala and Zongmin, 2019).

According to Sankaran (2019) investigates the effect of electricity consumption for industrial countries. Sankaran used ARDL bound test and Toda-Yamamoto. The study revealed that electricity consumption has a significant contribution to industrial countries. Therefore electricity distribution to the industries leads to the enhancement of technological productions in the

industries (Sankaran and Das, 2019). The following table represents different studies with different results as the literature reviews that demonstrate the study of EC and GDP are non-consensus.

**Table 2: Energy Consumption and Economic Growth Studies**

<b>Single country of Non-SSA research for EC and GDP</b>					
<b>Authors</b>	<b>Countries</b>	<b>Methodologies</b>	<b>Limitation</b>	<b>Results</b>	<b>Hypothesis</b>
Lee (2008)	Taiwan	Tar	{1955,2003}	EC leads to GDP	Growth
Warr (2000)	U.S.A	Engel – Granger	{1946, 2000}	EC leads to GDP	Growth
Lotfalimpour (2007)	Iran	Today Yaamoto	{1967,2007}	GDP leads to Petrol	conservation
Pao and Tsai (2011)	Russia	Engel-Granger	{1990,2007}	GDP leads to EC	feedback
Fallahi (2011)	U.S.A	Markov- Var	{1960-2005}	GDP ↔ EC	feedback
Zhang (2011)	China	OLS	{1985 – 2007}	EC ↔GDP	feedback
Lai (2011)	Macao saar	Engel Granger	{1999,2008}	GDP leads Electric	conservation
Behi (2008)	Portugal	Johansen Cointegration	{1980,2008}	GDP lead to Oil	feedback
<b>Sub-Saharan Africa researches for energy and economic growth</b>					
Jumbe (1999)	Malawi	Engle Granger	{1970,1990}	GDP ↔ Electric	feedback
Akinlo (2009)	Nigeria	Johansen-Juselini	{1980,2006}	Electricity → GDP	Growth
Odhimbo (2009)	Tanzania	ARDL bounds test	{1971,2006}	Electricity → GDP	Growth
Odhimba (2006)	S.Africa	Johansen-Juseli	1971 - 2006	GDP ↔ Electricity	Feedback
Ouedraogo (2013)	Bukin-Faso	ARDL bounds test	1968 - 2003	GDP ↔ Electricity	Feedback
<b>Multiple countries study Non-Sub</b>					
Jinke (2005)	China	Engel Granger	{1980,2005}	GDP leads to coal	conservation
	India			GDP ≠ coal	Neutral
	Japan			GDP → Coal	conservation
	S. Korea			GDP ≠ coal	Neutral
	S.Africa			GDP ≠ coal	Neutral
<b>Sub-Saharan African studies</b>					
Ebohon (1981)	Tanzania	Granger causality	1960 - 1984	GDP ↔EC	Feedback
Murray (1990)	Kenya	Granger causality	1970 - 1990	GDP→ Electricity	Conservation

Chontanaw (2000)	Congo Rep	Johansen-Juselius	1971- 2000	EC → GDP	Growth
Odhiambo (2006)	S. Africa	ARDL bounds te	1972 - 2006	EC → GDP	Growth
<b>Sub Saharan Africa studies</b>					
Ozturk (2005 )	LMI	Pedroni and VECM	1971 - 2005	GDP → EC	Conservation
	LMI	Pedroni and VECM	1971 - 2005	GDP ↔ EC	Feedback
Eggho (2011)	21 African countries	Pedroni and PMG	1970 - 2006	GDP ↔ EC	Feedback
Al-mulali (2009)	30 SSA	Pedroni and VECM	1980 - 2008	GDP ↔ EC	Feedback

Note Vector Error Correction Model (VECM), Auto-Regressive Model (VAR), Auto-Regressive Distributed Lag (ARDL), Environment Kuznets curve (EKE), Energy Consumption(EC), Economic growth (GDP), Emission of carbon dioxide gas ( $CO_2$ ).

The thoughts of scholars demonstrate that the relation between EC and GDP is not constant. Mostly the relationship depends on the demographic conditions, technological invention, kind of methodology that has been applied during the econometrical analyzing the results. On top of that, the level of the country's income is determining the fact of the relationship between the GDP and EC in the country. For instance, the industrial countries the rate of its EC is different in terms of its consumption compared to the nonindustrial countries.

### 3. DATA AND METHODOLOGY

Annual data of Energy consumption (EC) measured in Millions Tone equivalent (MTOE) and Economic growth (GDP) measured in 2010 US\$ are obtained from WDI and UNCTD from the year 1990 to 2019. This study is based on a quantitative methodology in which all statistical calculations and estimations are presented. Consequently, this section focuses on theoretical and empirical analysis. It is started with theoretical analysis and ends with empirical analysis. This study uses an econometric model to analyze the estimated results. The econometric tools which are used in this study are ADF, Engel-Granger test, VECM, and Granger causality. The econometric tools have been used to specify, contrast, and compare the indicated results from the hypothesis theories, after being tested.

Unit root test; if the variable is discovered to be nonstationary, then it should be converted from nonstationary to stationary by taking the differentiation. The process of differentiation converts the variable from Nonstationary series to Stationary is called the order of integration and is presented by I (d) (Charemza and Deadman, 1997).

Augmented Dicky and Fuller test is a statistical test that has been proposed by Sargan and Bhargava 1983 (Harris, 1992.p.401-402). The ADF has been used to identify stationary or nonstationary of GDP and EC variables (Giovannetti, 1987.p.494). By using the ADF test all variables must integrate at the same order (Saboori, 2013.p.402). Therefore, the variables should be integrated at the same order, the process can be continued up to second order I(2) if and only the stationary conditions are not found to be at the first level (Giovannetti,1987.p.494). Mathematically the ADF can be represented as follows:-

$$\Delta X_t = \beta X_{t-1} + \sum_t^p \theta_i X_{ti} + \varepsilon_t \quad (1)$$

Where p represents the maximum value of the lag length, and  $\varepsilon_t$  stands for the error term. There are different types of lag length. However, in this research, the selected lags are AIC and SBC lags. The criteria of choosing these lag lengths are based on their properties of accepting the small number of data size, and in most cases, the lags are used by OLS and ECM (Ibrahim, 1999.p.220 - p.222). Ibrahim, M. (1999). The chosen lag AIC and SBC have developed a model selection criterion, especially for likelihood estimation and maximization techniques. It minimizes the natural logarithmic of residual of adjusted squares for sample size "n" and "k" represents parameters (Maysami and Koh,2000.p.84). Akaike Information Criterion lags can be represented as follows

$$AIC = n \ln(\text{sum of the residual square}) + 2k$$

where "n" represents sample size and "k" represent parameters and SBC lag, it minimizes the natural

$$SBC = n \ln(\text{Residual sum of squares}) + k \ln(n)$$

The AIC and SBC are models that are created just for maximization likelihood estimation techniques.

The ECM is built to represent the information lost in the difference. It is used to determine cointegration. In this analysis, two variables have been imported, which are GDP and EC, mathematically will be presented as follows:-

$$\Delta GDP_t = \alpha_1 + \alpha_{11} ECT_{t-1} + \sum_{j=1}^{p-1} \phi_{1j} \Delta GDP_{t-j} + \sum_{j=1}^{p-1} \theta_{1j} \Delta EC_{t-j} + \varepsilon_{1t} \quad (2)$$

$$\Delta EC_t = \alpha_2 + \alpha_{21} ECT_{t-1} + \sum_{j=1}^{p-1} \phi_{2j} \Delta GDP_{t-j} + \sum_{j=1}^{p-1} \theta_{2j} \Delta EC_{t-j} + \varepsilon_{2t} \quad (3)$$

Equations 2 and 2 represent the ECM with ECT. The equations are used to determine the cointegration. The ECT at the equations is used to measure cointegration and coefficients parameters indicate the short-run. The probability of ECT for both EC and GDP should be significant and lower than 5%. Negative Signe represents a convergence of economic trends. The negative sign (-) indicates the presence of the cointegration. Generally, ECT intends to measure the speed of EC to return to the normal equilibrium after diverging from the normal trend.

The ECT can be represented as follow;

$$ECT_{t-1} = GDP_{t-1} + (\alpha_{21}/\alpha_{11})EC_{t-1} \quad (4)$$

$$ECT_{t-1} = EC_{t-1} + (\alpha_{11}/\alpha_{21})GDP_{t-1} \quad (5)$$

The ECT is also representing the Error of correction or speed of adjustment of research (Ang, 2007, p.475).

The ECM is an efficiency to minimize or to prevent carrying some errors from one step to another during the analysis phase. The ECM estimates the long-term effects and analyzes the short-term adjustment process within the same model (Maysami, 2000,p.83; Bhashkara, 2007, p.17). The ECM occupies two or more variables; since the economic model of this research contains two variables, therefore, ECM is justified to be suitable for this study. The most advantage of ECM has a smooth and straightforward interpretation for determining the long-run term and short return term equations.

Error Correction Model is built up if and only if the GDP and EC are cointegrated. The cointegration between the GDP and EC indicates the long-run effect. ECM contains lag length, represented by letter p. Thus the lag lengths in the equation model are composed by (p-1) for GDP and EC where p stands for lags in ECM. The theoretical approach is based on testing EC and GDP using the Granger causality test (Granger, 1969, p.200). In addition to that, Engel Granger (1987) makes a significant contribution to the co-integration technique towards testing of EC and GDP. The presence of the cointegration process leads to the finding of error correction technic (ECT), which is based on the adjustment of disequilibrium of the speed of the long-run effect between GDP and EC. General equations of ECM together ECT and their lags are represented as follows;

$$\Delta Y_t = \sum_{i=1}^k \theta_{1i} \Delta Y_{t-i} + \sum_{i=1}^n \beta_{1i} \Delta X_{t-i} + \sum_{i=1}^r \delta_{1i} ECT_{r,t-1} + U_{1t} \quad (6)$$

$$\Delta X_t = \sum_{i=1}^k \theta_{2i} \Delta Y_{t-i} + \sum_{i=1}^n \beta_{2i} \Delta X_{t-i} + \sum_{i=1}^r \delta_{2i} ECT_{r,t-1} + U_{2t} \quad (7)$$

From the two equations coefficients of  $\beta$  and  $\delta$  stands for explanatory of  $\Delta Y$ ,  $\Delta X$ , and ECT respectively, letter k, n represents the maximum numbers of the explanatory variables, and 'r' represents the number of co-integration equation. For determination of the causal relationship between the dependent variables of  $\Delta Y$  and  $\Delta X$ , the parameters of  $\beta_{1i}$  for  $\Delta X_{t=1}$ ,  $\Delta Y_t$  and parameters of  $\theta_{2i}$  for  $\Delta Y_{t-1}$  both respectively cannot be equal to zero. When the coefficients become equal to zero, means the related independent variable also becomes equal to zero. Therefore the causal relationship between the two variables cannot be found. This is the reason why these coefficients are not equal to zero.

Equation 6 and 7 represent the change of the dependant variables which is equal to  $\sum \Delta X_t$  and  $\sum \Delta Y_t$  represent the change of the sum of the explanatory variables, coefficients, ECT, white noises, and with their respective number of lags (Kar and Pentecost, 2000, p.9). The equations above are VECM which is acting as the source of the causation between GDP and EC. The test of the joint aggregate sum of the number of lags of every regress using Wald test, the second test is associated with lagged ECT statistic and the third, the test of joint used to sum of the regress variable and ECT's lagged statistic, this test is recognized as the strong propensity test (Charemenza and Deadman, 1997). For more clarification of this test, we can have an example if the null hypothesis of EC which states that GDP does not cause granger relation is ignored if  $\beta_{1i}$  is significantly different from zero, the same analysis if the null hypothesis is not obeyed if  $\delta_{1i}$  is significant or  $\beta_{1i}$  and  $\delta_{1i}$  are jointly significant apart of zero (Kar and Pentecost, 2000. p.10).

#### 4. ESTIMATED RESULTS

This section represents an empirical analysis that represents the findings obtained through the econometric technique, as highlighted from the methodology section. It started by checking the ADF test then followed other econometric tools. The

estimations are determined once the causal co-integration is found. After determining the co-integration, the stability test using the CUSUM and CUSUMSQ, correlogram Q test, correlogram, and AR test are used to determine the stability of parameters. To archive the best efficiency of the analysis, the stationary test should be included to monitor the stationarity of the data. Therefore the following part describes the stationarity of the time-series data.

**Estimated results; ADF test** defines the existence of stationary data from the time series. The stationarity of the data is related to the order of integration, therefore ADF indicates the order of integration during the empirical analysis. The essence of stationary data is to help the analysis phase to be free from the problem of spurious regression. The problem of spurious might happen if the dependent variable shows uncorrelated series with independent variables and the relationship between them is significant but the two variables are not correlated. The research uses a standard ADF test for stationary (Liew, 2004,p.314). The table below is the ADF table that computed using the time series data from 1990 to 2019, which contain variables of the model obtained at the level and I(1).

**Table 3: Augmented Dicky–Fuller (Constant and Trend)**

Var	At level I (0)		First difference (1)	
	t-stat	Prob**	t-stat	Prob**
GDP	-1.766273	0.6938	-3.747286	(0.0361 )*
EC	-2.038669	0.5558	-4.741599	( 0.0042)***

Note, that \*, \*\*, \*\*\* represent the 10%, 5%, 1% level respectively

From the ADF indicates that the Critical value at 5 percent and 1 percent are 0.036, and 0.0042 respectively. The ADF indicates that the GDP and EC are integrating at I(1). Then, the analysis can proceed with estimating an OLS regression of GDP and EC by subjecting the residuals to a stationary test, and if the residuals are stationary, then EC and GDP integrating. Below are OLS estimation results.

**Table 4: Residuals of GDP**

Independent var	coefficient	Std error	t-statistic	Prob
C	542.8538	936.3458	0.579758	0.5669
EC (MTOE)	8.064446	0.275644	29.25671	0.0000

**Table 5: Residuals of EC**

Variable	coefficient	Std error	t-statistic	Prob
C	21.09089	114.9566	0.183468	0.8558
GDP(constant 2010 US\$)	0.120209	0.004109	29.25671	0.0000

Tables 4 and 5 both indicate the simple regression models in which GDP stands for the dependent variable for 4 EC is an independent variable, while 5 EC is dependent and GDP is independent variables. The letter C for both tables stands for the constant of the regression equations. The regression equations show that there are positive correlations between variables. The coefficients of EC and GDP are significant because their probabilities are less than 5%. Therefore, both coefficients have a positive correlation to their dependent variables. In table 4, the coefficient estimate of EC is 8.06, meaning that the one-unit increase in EC leads to an 8.06 change of economic growth. Also, in table 5, the coefficient estimate of GDP is 0.12, meaning that the one-unit increase in GDP leads to 0.12 changes in EC. The aim of estimating regression equations is to obtain the rapport of EC and GDP simultaneously finding residual equations which are used in finding the co-integration between the GDP and EC. The next step is to find the ADF test for the residual values.

**Table 6: Augmented Dickey-Fuller (ADF) Residuals at I (0)**

GDP is the dependant variable			
Null hypothesis: U is nonstationary		t-statistic	Prob*
ADF statistic		-3.6	0.053
Critical t-stat values :	1%	-4.34	
	5%	-3.79	
	10%	-3.23	
R-squared	0.708615		
Durbin-Watson stat	1.833156		

**Table 7: Augmented Dickey-Fuller (ADF) Residual I (0)**

EC is the dependant variable			
Null hypothesis: U nonstationary		t-statistic	Prob*
ADF-stat		-3.517359	0.0525
Test for t-critical:	1%	-4.33	
	5%	-3.59	
	10%	-3.22	
R-sqr	0.709		
D.Watson stat	1.833		

Tables 6 and 7 both indicate ADF t-stat values, which 3.558900 and 3.517359 respectively, are greater than the Engel and Granger, which is 3.28 ADF of critical test statistics at 5% which are significant for both levels respectively. This suggests the hypothesis of no cointegration is ignored, and analysis indicates that the presence of cointegration for both table 6 and table 7. It concludes that GDP and EC, EC and GDP are cointegrating and long-run is present Furthermore, when Durbin-Watson and R-square are compared, the Durbin-Watson statistic is greater than R-square indicates that the system model of the data is free from the spurious problem.

**Table 8: Error Correction Technique (ECT) of  $\Delta$ GDP**

Independent variables	Coefficient	Std error	t-statistic	Prob
C	1136.101	361.0291	3.146840	0.0042
$\Delta$ (EC)	2.345391	1.000718	2.343709	0.0273
ECT	-0.360502	0.120008	-3.003977	0.0060

Note: ECT represents the Error Correction technique/speed of adjustment,  $\Delta$ EC represents the first difference of energy consumption variable, C represents a constant value

**Table 9: Error Correction Technique (ECT) of  $\Delta$  EC**

Independent variables	Coefficient	Std error	t-statistic	Prob
C	48.93487	77.70457	0.629755	0.5346
$\Delta$ (GDP)	0.080674	0.0333744	2.390780	0.0247
ECT	-0.444319	0.191948	2.314791	0.0291

Note: ECT represents Error Correction Technique/ speed of adjustment,  $\Delta$ GDP represents the first difference of economic growth variable and C represent the constant value

Tables 8 and 9 both report the estimated ECM results of both  $\Delta$ GDP and  $\Delta$ EC models. From empirical analysis shows that the ECT is negative and significant, this indicates that the GDP and EC convergent to equilibrium. For instance, Table 8 demonstrates ECT is -0.360502, suggesting that the  $\Delta$ GDP model adjusts itself to equilibrium by 36.05% annually. The ECT is significant at a 1% level, while table 9 shows that ECT is -0.444319 suggesting that the  $\Delta$ EC model adjusts itself to equilibrium by 44.43% annually. Again, the negative of ECT indicate the cointegration of GDP and EC in this model. The coefficient of  $\Delta$ GDP as 0.080674 represents the short-run effect is significant at 5% because its probability value is 0.024, which is less than 5% at a significant level. The coefficients of the short-run have the following meaning economically; first, the EC attained in Tanzania is the most significant short-run determinant value in the GDP of Tanzania. The significant effect of EC on GDP indicates that the appropriate EC was being used in the growth of Tanzanian's economy. Second, the GDP attained in Tanzania is the most significant short-run determinant value in the EC of Tanzania. Third, the significant positive effect of EC on GDP indicates that the appropriate EC was being used in the growth of the Tanzanian economy to the same case to the significance of GDP on EC indicates that the appropriate GDP was being applied to the EC of Tanzanian. The analysis shows that EC and GDP are depending on each other. Therefore However Tanzania government is engorging to the massive long-run projects for energy productions like Stigler's Gorge Hydropower Project. Natural gas also should have short plan strategies for energy productions. It seems that there are significant contributions to the short-run effects of EC on the GDP of Tanzania.

**Table 10: Cointegration Equation**

Independent Variables	Coefficient	Std error	t-stat
EC	7.937856	0.50707	15.6544
C	12.528		

The table above indicates the cointegration equation, which indicates a significant correlation between EC and GDP in Tanzania.

**Table 11: Vector Error Correction Model (VECM)**

ECT	Coefficient	Std error	t-stat	Prob
ECT of GDP	-0.343417	0.17987	-1.91429	0.0060

The two tables show VECM and ECT as the adjustment speed of GDP per year. The analysis indicates that the ECT of GDP is 34.34. The negative sign has a significant meaning. It represents the cointegration, sorely long run has been shown among the EC and GDP.

**Table 12: Causal Relationship between GDP and EC (using Wald test)**

Dep Var	Wald-test		t-stat
	$\sum \Delta GDP$	$\sum \Delta EC$	$ECM_{-1}$
$\Delta GDP$		$X^2(1) = 7.614 (0.0058)***$	$-4.628905 (0.001)***$
$\Delta EC$	$X^2(1) = 4.538443 (0.0331)**$		$-0.776405 (0.0462)**$

**Table 13: Joint Sources of Causation Using Wald test**

Wald Test	
$(\sum \Delta EC, ECM_{-1})$	$X^2(2) = 25.39298 (0.0)*$
$(\sum \Delta GDP, ECM_{-1})$	$X^2(2) = 5.184489 (0.0749)**$
	<ol style="list-style-type: none"> <li>1. EC represents Energy consumption</li> <li>2. GDP represents Economic growth</li> <li>3. ECM represents Error Correction Model</li> <li>4. (-1) represents the number of lag</li> <li>5. <math>\Delta</math> represents the first difference</li> <li>6. <math>\sum</math> sum of coefficients with respective lags</li> <li>7. *, **, *** represent significant level 0.1, 0.05, 0.01 respectively</li> <li>8. () p-value</li> </ol>

The sources of causation from the table 12 with three estimations can be explained as follows;- the first case is a test of the joint which is aggregated together with a lag of independent variable, in turn, using a Waldy<sup>2</sup>. It is observed that in table 12, the  $\Delta GDP$  dependant variable and  $\sum \Delta EC$  independent factor. Independent  $\sum \Delta EC$  concerning its lag is tested and shows that the  $\sum \Delta EC$  is significant at 5%. In the same case, when the  $\Delta E$  dependent variable and  $\sum \Delta GDP$  independent variable, concerning its lag, is tested, it shows that the  $\sum \Delta GDP$  is significant at 5%. The second case is the t-statistic test on the lagged ECM and the value of  $\Delta GDP$  as the dependent. Shows the  $\Delta GDP$  is significant, and the ECM of  $\Delta EC$  is significant at 5%. The last in table 8.1 is about the joint test between the sum of the variables with their lags with ECM shows that the  $(\sum \Delta EC, ECM_{-1})$  and  $(\sum \Delta GDP, ECM_{-1})$  both are significant. Table 12 indicates the causation source from the analysis is ECT of four cases (between  $\Delta GDP$  and  $\Delta GDP$ ,  $\Delta EC$ , and  $\Delta GDP$ ) and shows the ECT is significant at a different level of 5% and 10%. Not only ECT is acting as the source of the causation, but there some other sources of causation such as the statistical significance of the explanatory variables. Table 13 indicates the causal relationship between GDP and EC by corresponding to the ECT. Empirical analysis shows connections that move from EC to GDP, meaning that the EC depends on GDP to the same case the causality states run from GDP to EC. The analysis shows the bidirectional causal relationship between EC and GDP in Tanzania.

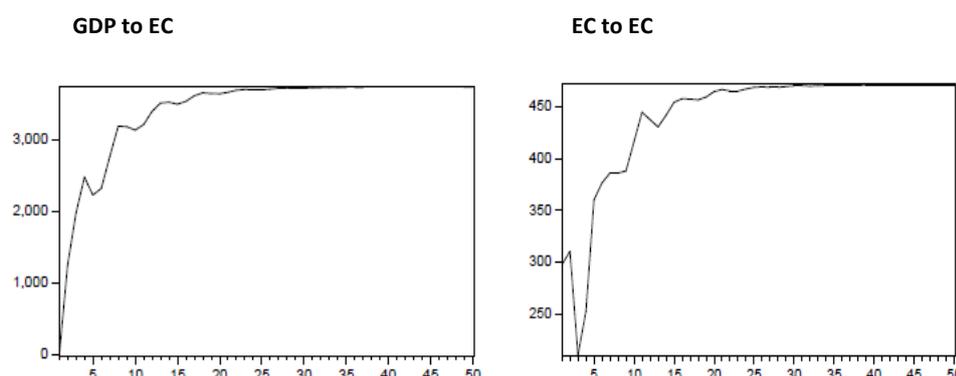
**Table 14: Summary of the Sausal Relationship between EC and GDP**

$\Delta EC$ to $\Delta GDP$	Energy consumption leads to Economic growth	
$\Delta GDP$ to $\Delta EC$		Economic growth leads to energy consumption

Note: EC represents Energy consumption and GDP represents Economic growth.

Table 14 indicates the bidirectional relationship between the variables.

**Figure 1: Impulse Response of GDP and EC**



Overall, the impulse responses summarized in Figures 1 for GDP to England EC to GDP as follows. The two graphs appear to be generally growing with expected positive trends. Expect in the case of the EC graph declines from a period of one to two, and then it starts to grow positively.

**4.1. Post Estimation Results**

The post-estimation test of this research focused on the efficiency, significance, and desirability of the model. The test includes - Heteroscedasticity test, serial correlation test, Normal distribution test, and stability of the model. The Heteroscedasticity is being the first to be analyzed.

**Table 15: The Heteroscedasticity Test**

<b>Null hypothesis: Model has heteroscedasticity</b>			
F-stat	0.806809	Prob**	0.54
Ob*Rsqr	2.6	Prob* Chisqr	0.52

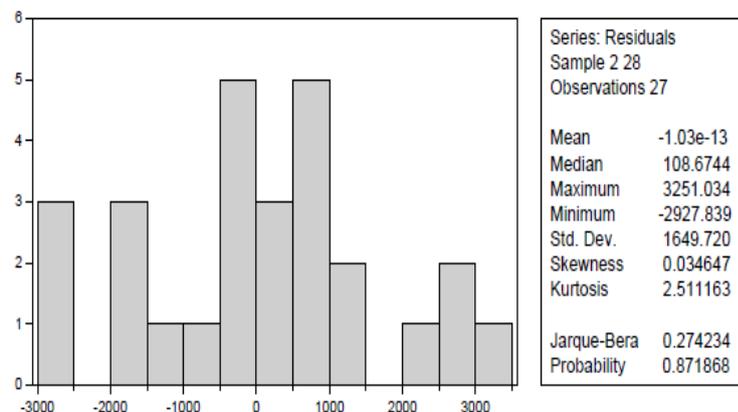
The analysis above using the Breusch-Pagan-Godfrey testing type, for Heteroscedasticity indicate that the Prob. Chi-Square (3) is 64.76, which greater than 5%, indicates that we can ignore the Null hypothesis and results show that the system model does not suffer from the heteroscedasticity problem. Therefore the system is desirable for giving the estimation.

**Table 16: The Serial Correlation**

<b>Null hypothesis: Model has the serial correlation</b>			
F-stat	0.545017	Prob**	0.66
Obs*R-sqr	2.081800	Prob** Chi sqr	0.56

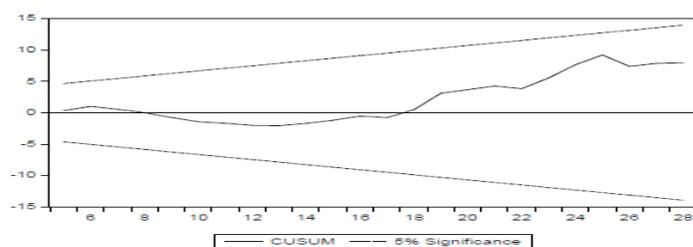
Analysis from Serial correlation indicating that Prob. Chi-Square (3) is 55.56, which is more than 5% indicates we cannot ignore the Null hypothesis. Therefore, the system of data analysis cannot be affected by the serial correlation problem. Therefore, the data can be used for estimation.

**Figure 2: Histogram of Normality Test**



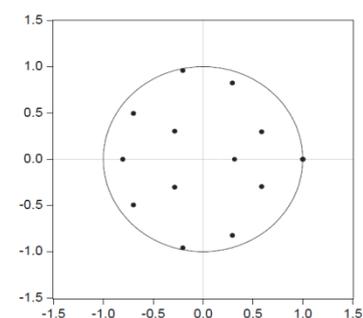
The analysis from the Histogram Normal distribution above indicates that the Jarque-Bera is 27.42349% which is greater than 5%. The analyses represent the normal distribution of the system data.

**Figure 3: System Stability**



Looking at the graph above, we can deduce that the graph of the CUSUM lies within the interval of a 5% significance level indicate the model is stable. If a trend is found within the boundaries, meaning that does not cross the boundaries indicates that the system model is stable. There is no effect of break structure effects within the data system.

**Figure 4: The AR Unit Root Test**



The AR unit root contains the dotted particles which are deposited inside the cycle. The definition of this analysis is that the system model significant. If and only if these particles are found outside the cycle means that the analysis is not significant.

**5. CONCLUSION**

The article investigates the impact of energy consumption on economic growth in Tanzania. The article applies two variables which are identified as Economic growth and Energy consumption from the WB database which spans from the year of 1990

to 2019. To obtain the estimated results the study employs ADF, PP, Engle and Granger, VECM, and Granger causality test. The study finds that Economic growth and Energy consumption are integrated at the same order which is I (1). The study finds the cointegration between Economic growth and Energy consumption. The existence of cointegration meaning that there is the long-run and short-run relationship between Energy consumption and Economic growth in Tanzania. The study revealed the bidirectional causal relationship which runs from the Economic growth to Energy consumption and from Energy consumption to Economic growth. Therefore, the study justifies the feedback hypothesis relationship. The study revealed that Energy consumption has a significant contribution to the Economic growth of Tanzania and the Economic growth of Tanzania depends on Energy consumption. Therefore although Tanzania has a different long project for energy investment, it should focus on short runs projects. Because the empirical analysis shows that there are effects of energy consumption for both the short-run and long-run effects.

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