# IMPACT OF ENERGY CONSUMPTION ON ECONOMIC GROWTH IN AFRICAN LOW-INCOME ECONOMIES

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## ABSTRACT

*This study investigates the impact of energy consumption on economic growth in fifteen (15) low-income African economies (Burkina Faso, Burundi, Chad, Democratic Republic of Congo, Gambia, Guinea, Guinea-Bissau, Madagascar, Mali, Niger, Rwanda, Sierra Leone, Tanzania, Togo, Uganda). Employing data spanning from 2003 to 2022, the study utilises the pooled mean group (PMG) estimator. The findings indicate a positive long-term impact of energy consumption on economic growth in these economies. Likewise, the causality results suggest that economic growth causes changes in energy consumption and vice versa. Consequently, the study concludes that the relationship between energy consumption and economic growth holds considerable significance in these economies. Based on these findings, it is recommended that policymakers in these economies should adopt strategies that promote energy efficiency and sustainable energy sources to foster economic development. Additionally, initiatives focusing on economic growth should consider their potential impact on energy consumption patterns. By adopting a holistic and integrated approach, policymakers can effectively address the intricate relationship between energy consumption and economic growth to enhance the overall well-being of these economies.*

**Keywords:** Economic Growth, Energy Consumption, Low-income Economies; Africa

**JEL Code:** C23, O47, Q43, R11

## INTRODUCTION

Attaining long-term economic growth and development stands as a primary objective for both developed and developing nations. The economic growth rate

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serves as a crucial indicator of economic performance, playing a vital role in generating employment opportunities and reducing poverty (Solow, 1956; Romar, 1986). According to the World Economic Outlook (WEO) in 2021, sustaining an average GDP growth rate of 5.9% was deemed essential for countries aspiring to achieve long-term economic growth and development. Notably, developed countries, such as France (6.8%) and Italy (6.7%), consistently demonstrate substantial economic growth rates. In contrast, many developing nations, including Nigeria, have experienced lower annual GDP growth rates. For instance, in 2021, Ghana registered a growth rate of 5.4%, South Africa at 4.9%, and Nigeria at 3.6%. To bridge this gap, developing countries must prioritise infrastructure investments to bolster their economic growth rates (World Bank, 2022).

Despite the crucial role that long-term economic growth plays in creating employment opportunities and enhancing the well-being of the populace, the World Bank's World Development Indicators (WDI) highlight a consistent decline and fluctuation in economic growth within the African region over the years. Notably, English-speaking African countries, referred to as Anglophone nations, persistently trail behind in terms of economic growth rates when compared to other regions, including Central Europe and North America (WDI, 2022). Numerous initiatives have been implemented to bolster economic growth in developing nations, including African countries. One notable example is the establishment of the Economic Commission for Africa in 1958. This policy aimed to expedite economic growth and foster integration, with the overarching goal of ensuring regional economic cooperation across the African continent.

Elevating economic growth, particularly in African countries, is of utmost importance, and one significant contributing factor to this growth is energy consumption (Chinedu, Daniel & Ezekwe, 2019). Energy holds paramount importance for human survival and serves as a driving force for socio-economic development, particularly in developing economies (Umar & Zakari, 2020). It plays a pivotal role in the production process, facilitating the conversion of raw materials into finished goods, a metric often measured in developing countries, including Nigeria.

Within the African context, the output of the energy sector, encompassing electricity and petroleum products, serves as a crucial support for activities in other sectors. These sectors, in turn, provide essential services for production activities in agriculture, manufacturing, mining, and industry, thereby contributing to economic growth (Chinedu, Daniel & Ezekwe, 2019). Access to modern energy services is pivotal for promoting economic progress in African countries. The impact of energy use extends to productivity, health, and education, leading to a significant increase in energy consumption in both developed and developing economies over the years (Dantama, Abdullahi & Inuwa, 2012).

This study is motivated by the imperative to explore the relationship between energy consumption and economic growth specifically within the context of low-income countries in Africa. The motivation stems from the unique economic challenges faced by these nations and the need for tailored insights to address their specific circumstances. Understanding the interplay between energy and economic growth in this context is crucial for sustainable development. The study aims to contribute valuable insights to inform policies and interventions that cater to the distinct developmental needs of low-income African countries.

## LITERATURE REVIEW

This section provides a review of relevant literature, including conceptual, theoretical, and empirical perspectives.

### *Conceptual Review*

This sub-section provides a conceptual review of the key variables in this study: economic growth, energy consumption, labour force, and gross fixed capital formation.

***Economic Growth***: This refers to the increase in the production of goods and services in an economy over time. Typically measured by the growth in Gross Domestic Product (GDP), economic growth indicates an expanding economy, often associated with higher income levels and improved standards of living (Twerefou, Iddrisu & Twum, 2018).

***Energy Consumption**:* This represents the total energy used by an economy across various sectors, including industrial, residential, and transportation. Managing energy consumption and improving energy efficiency are crucial for reducing emissions and supporting sustainable development (Sharaf, 2016).

***Labour Force**:* This includes all individuals who are of working age and are either employed or actively seeking employment. This variable is an essential driver of economic activity, as a larger or more skilled labour force generally contributes to higher production levels (Androniceanu, & Georgescu, 2023).

***Gross Fixed Capital Formation:*** This is a measure of investments made in physical assets like machinery, infrastructure, buildings, and equipment within an economy. These investments are key indicators of an economy's productive capacity and long-term growth potential. Higher levels of GFCF often signal industrial expansion and modernisation, but they may also result in increased energy demand and emissions, especially if the new capital is resource-intensive (Twerefou, Iddrisu & Twum, 2018).

***Theoretical Framework***

To examine the effect of energy consumption on economic growth in low-income African countries, this study employed and augmented neoclassical growth model as a theoretical framework. This model is a school of thought in economic theory that traces its roots back to the late 19th and early 20th centuries. It was developed by economists like Robert Solow, and focuses on the long-run determinants of economic growth. It is an improvement of classical economics, which was prominent in the 18th and 19th centuries. Neoclassical economics emerged as a response to perceived shortcomings in classical economic thought, particularly in addressing the allocation of resources and understanding the dynamics of markets. This theory suggests that economic growth is driven by increases in labour, capital, and technological progress. It highlights the importance of investments in human (labour), physical capital and improvements in technology to sustain long-term economic growth.

***Empirical Review***

Several empirical studies have been conducted to examine the relationship between energy consumption and economic growth. For instance, Matar and Bekhet (2015) examined the relationship between the electrical consumption and economic growth in Jordan from 1976 to 2011. Using ARDL and Granger causality approaches, the findings showed the existence of long-run equilibrium relationship between the electrical consumption and the real GDP per capita, export, and FD variables in Jordan. Similarly, Sharaf (2016) assessed the causal relationship between energy consumption and economic growth in Egypt during the period 1980-2012. The study used Granger causality test and the result confirmed that energy conservation policy has no negative effect on the growth prospects of the Egyptian economy in the long-run. Wei-Wei (2017) employed co-integration test and ECM and Granger causality tests to investigate energy consumption and economic growth nexus in China during the period of 1992-2016. The findings show that total energy consumption is a one-way causal relationship between economic growths in China.

Twerefou, Iddrisu & Twum (2018) explored the nexus between energy consumption and economic growth for the seventeen countries in the West African sub region over the period of 1986 to 2017. The authors applied Panel co-integration techniques, and the estimation shows that there is no causal relationship running from total energy, electricity and petroleum consumption to growth and unidirectional relationship running from growth to electricity consumption. Similarly, Ozturk and Suat (2018) assessed the impact of energy and economic growth in Turkey using an ARDL approach. The authors discover that economic growth positively affects coal consumption, whereas technological innovation negatively affects it over a long-run. In same vein, Topolewski (2020) investigated the effect of energy consumption on economic growth during 2008-2019 period. The study applied dynamic panel model, taking in to account the Arellano and Bond estimator.The result reveals that in the short-run, an increase in production will result in significant increase in energy consumption.

Resham (2021) investigated the relationship and role of energy consumption and exports on economic growth in Nepal over the period of 1980- 2018. Using ARDL approach, the result shows the presence of a positive and statistically significant impact of exports on economic growth. Energy consumption and economic growth are positively associated and unidirectional causality from energy consumption to economic growth, economic growth to export, and energy consumption to export. Bassongui and Alakono (2021) investigated the nexus between Africa Countries' Energy Efficiency and economic growth evidence from data for the period of 1980-2020. The Function Approach is adopted and the result found that there is energy consumption, economic growth in the African countries. Also, Ioana et al. (2022) assessed the rural and urban populations' access to electricity, energy use and economic development in China during the period of 1995 to 2017. By employing autoregressive distributed lag (ARDL) approach, the result shows that energy use has positive links with economy in China.

Gyimah et al. (2022) examined the relationship between renewable energy consumption and economic growth in Ghana using both the Granger causality and the mediation model in its analysis based on data from 1990 to 2015. The outcome shows a feedback effect among economic growth and renewable energy consumption, but renewable energy consumption does not have a significant indirect impact on economic growth. Renewable energy has a significant total impact on economic growth. Therefore, the increase in renewable energy consumption has a total positive effect on economic growth.

In a more recent study, Androniceanu and Georgescu (2023) investigated the dynamic connection among economic growth, $CO_2$ emissions, energy consumption, and foreign direct investments (FDIs). The panel section considers the period of 2000–2020 for 25 EU Member States excluding Malta and Croatia. The empirical analysis used estimation procedures such as first- and second-generation panel unit root tests (CIPS) and panel ARDL based on the three estimators PMG, MG, and DFE. The Hausman test indicated that the PMG estimator is the most efficient. The PMG and DFE estimators suggested that there exist only short-run causalities from $CO_2$ emissions, energy consumption, and FDIs to GDP growth rate, while the MG estimator proved the existence of both short-run and long-run causalities.

One noticeable gap in the reviewed empirical research is the absence of investigations into the relationship between economic growth and energy consumption in the context of low-income African countries. While numerous studies have explored this relationship alongside other macroeconomic variables, none, to the best of researchers' knowledge, has specifically focused on low-income African nations. Consequently, this study addresses this gap in the existing literature by examining the mentioned relationship within the context of low-income African countries.

## METHODOLOGY

### *Type and Sources of Data*

This study used annual panel data from fifteen (15) low-income African countries ((Burkina Faso, Burundi, Chad, Democratic Republic of Congo, Gambia, Guinea, Guinea-Bissau, Madagascar, Mali, Niger, Rwanda, Sierra Leone, Tanzania, Togo, Uganda) spanning from 2003 to 2022. The selection of countries and the time frame was based on data availability. The dependent variable is economic growth, measured by gross domestic product (GDP) at constant 2015 US$, while the major independent variable is total energy consumption (TEC), measured by British thermal units (quad Btu). Additionally, two control variables expected to directly impact economic growth were considered: Labour force (LF) and gross fixed capital formation (GFCF). These variables are anticipated to have positive effects on economic growth (GDP). Table 1 presents the variable codes, descriptions, anticipated signs, and data sources.

Table 1: Variable codes, descriptions, expected signs, and sources of the data.

| Variables | Description | Signs | Sources |
|---|---|---|---|
| GDP | GDP (constant 2015 US$) | N/A | WDI (2023) |
| EC | Total energy consumption (quad Btu) | + | EIA (2023) |
| LF | Labor force (total) | + | WDI (2023) |
| GCF | Gross Fixed Capital ormation (constant 2015 US$) | + | WDI (2023) |

Note: WDI is World Development Indicators database of World Bank and EIA is Energy Information Administration.

### *Model Specification*

This augmented the neoclassical growth model expressed as:

$$Y = A \cdot F\ (K, L) \quad (1)$$

where: *Y* is the output or Gross Domestic Product (GDP), *A* is total factor productivity, representing technological progress and efficiency; *F*(*K*, *L*) is a production function relating capital (*K*) and labour (*L*) to output.

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$$lnGDP_{it} = \beta_0 + \beta_1 lnEC_{it} + \beta_2 lnLF_{it} + \theta_1 lnGFCF_{it} + \epsilon_{it} \quad (2)$$

Where; GDP is the dependent variable, EC, LF and GCF represent energy consupmtion, labour force, and gross fixed capital fromation respectively. $\beta_0$ is the constant or intercept, while $\beta_1$, $\beta_2$ and $\beta_3$ are parameters. Lastly $u_i$ is the error term.

**Model Estimation Technique**

This study employed the Pooled Mean Group (PMG) of ARDL model, as developed by Pesaran et al. (2001), to examine the impact of energy consumption on economic growth in low-income in African countries. The choice of this method of analysis is advantageous for several reasons. The PMG model is well-suited for dynamic heterogeneous panels, accommodating diverse economic conditions across countries. It combines the strengths of the ARDL approach and the mean group estimator, enabling exploration of short-term and long-term dynamics while considering individual country effects. Additionally, the model addresses endogeneity concerns and is efficient in small sample sizes, making it suitable for empirical studies involving African countries. The PMG model also accounts for cross-sectional dependence, acknowledging regional interconnectedness. The PMG specification is formulated as follows:

$$Y_{it} = \sum_{j=1}^{p-1} \gamma_y^i (y_i)_{t-j} + \sum_{j=0}^{q-1} \delta_y^i (X_i)_{t-j} + \varphi^i (y_i)_{t-1} + \mu_i + \varepsilon_{it} \quad (3)$$

Where $(X_i)_{t-j}$ *the (k x 1) is* vector of explanatory variables for group i and $\mu_i$ represents the fixed effect. In principle, the panel can be unbalanced, and *p* and *q* may vary across countries. This model can be reparametrized as a VECM system:

$$\Delta Y_{it} = \theta_i (Y_{i,t-1} - \beta_i X_{i,t-1}) + \sum_{j=1}^{p-1} \gamma_y^i \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \delta_y^i \Delta (X)_{.t-j} + \mu_i + \varepsilon_{it} \quad (4)$$

Where the $\beta_i$ are the long-run parameters and $\theta_i$ are the equilibrium (or error) -correction parameters. The pooled mean group restriction is that the elements of β are common across countries:

$$\Delta Y_{it} = \theta_i (Y_{i,t-1} - \beta_i X_{i,t-1}) + \sum_{j=1}^{p-1} \gamma_y^i \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \delta_y^i \Delta (X)_{.t-j} + \mu_i + \varepsilon_{it} \quad (5)$$

Where, **y** is economic growth (GDP), **X** is a set of independent variables including the energy consumption, and $\delta$ represent the short-run coefficients of dependent and independent variables respectively, β are the long run coefficients, θ is the coefficient of speed of adjustment to the long run status, while the subscripts **i** and **t** represent the country and time, respectively. The term in the square brackets contains the long-run estimates. Equation (5) was estimated by using PMG estimator.

## RESULTS AND DISCUSSION

### Descriptive Statistics

The summary statistics for the natural logarithms of GDP, energy consumption (LNEC), labour force (LNLF), and gross fixed capital formation (LNGFCF) reveal insightful details about the distributional characteristics of each variable. On average, the natural logarithm of GDP stands at approximately 22.739, with a median of 22.842 and a standard deviation of 1.060, indicating moderate variability. The skewness of -0.227 suggests a slight leftward skewness, while a kurtosis value of 2.585 indicates moderate tail heaviness.

Table 2: Summary statistics of variables

| Statistic/Variables | LNGDP | LNEC | LNLF | LNGFCF |
|---|---|---|---|---|
| Mean | 22.739 | -3.689 | 15.362 | 21.045 |
| Median | 22.842 | -3.567 | 15.361 | 21.278 |
| Maximum | 24.930 | -1.602 | 17.373 | 24.083 |
| Minimum | 20.375 | -5.714 | 12.944 | 17.526 |
| Std. Dev. | 1.060 | 1.088 | 1.085 | 1.369 |
| Skewness | -0.227 | -0.019 | -0.371 | -0.285 |
| Kurtosis | 2.585 | 1.990 | 2.740 | 2.830 |
| Jarque-Bera | 4.722 | 12.776 | 7.712 | 4.430 |
| Probability | 0.094 | 0.002 | 0.021 | 0.109 |
| Observations | 300 | 300 | 300 | 300 |
| Number of Countries | 15 | 15 | 15 | 15 |

*Source: Researchers' Computation (2024)*

The Jarque-Bera statistic of 4.722 with a p-value of 0.094 implies no strong evidence against normality. LNEC, LNLF, and LNGFCF exhibit similar descriptive patterns, with skewness values close to zero, indicating approximately symmetric distributions. However, their Jarque-Bera statistics is significant at the 1% and 5% level, suggesting departures from normality. Each variable has 300 observations, and the dataset includes 15 countries.

### Results of Corelation and Variance Inflation Factor

As part of preliminary analyses, pairwise correlation and variance inflation factor (VIF) are employed to detect the presence of multicollinearity among the independent variables under investigation and the results are presented in Tables 3.

Table 3: Results of Pairwise Correlation and Variance Inflation Factor (VIF)

| Variables | LNGDP | LNEC | LNLF | LNGFCF |
|---|---|---|---|---|
| LNGDP | 1.000 | | | |
| LNEC | 0.920 | 1.000 | | |
| | (0.000) | | | |
| LNLF | 0.939 | 0.346 | 1.000 | |
| | (0.000) | (0.000) | | |
| LNGFCF | 0.966 | 0.263 | 0.381 | 1.000 |
| | (0.000) | (0.000) | (0.000) | |
| Variance Inflation Factor: | | 3.24 | 3.14 | 4.02 |

*Note: P-values in parentheses ( ) and ln: natural logarithm.*
*Source: Researchers' computations (2024)*

The results of the pairwise correlation in Table 3 show a strong positive correlation (0.920) between energy consumption (LNEC) and economic growth (LNGDP), which is significant at the 1% level. This suggests that economic growth in West Africa is closely associated with higher levels of energy consumption. Similarly, labour force (LNLF) and gross fixed capital formation also have strong positive correlation with economic growth (LNGDP). Moving on to the correlation among the independent variables themselves, we can see that labour force has a weak positive correlation with energy consumption (0.346). Likewise, gross fixed capital formation has a weak positive with energy consumption (0.263).

Regarding multicollinearity, the VIF values provide a diagnostic measure. A VIF value exceeding 5 generally signals concern for multicollinearity. In this result, the highest VIF value is 4.04 for gross fixed capital formation (LNGFCF), followed by 3.24 for GDP, both of which are below the critical threshold (5). This indicates that while there is some correlation among the explanatory variables, multicollinearity is not severe enough to raise major concerns for the regression analysis.

**Results of Cross-Section Dependence Test**

The cross-sectional dependence (CD) test assesses whether the variables exhibit interdependence or correlation across the different panel groups, in this case, the West African countries. Cross-sectional dependence can arise from shared regional characteristics or common external shocks affecting all countries. Identifying such dependence is crucial, as ignoring it could lead to biased results in panel data analysis. The results of the Pesaran (2007) CD test are presented in Table 4.

Table 4: Result of Cross-sectional Dependence Test

| Variables | CD-test Statistics | P-values |
|---|---|---|
| GDP | 43.578 | 0.000 |
| EC | 35.887 | 0.000 |
| LF | 45.355 | 0.000 |
| GFCF | 25.345 | 0.000 |

*Notes: The null hypothesis is cross-section independence and P-values close to zero indicate data are correlated across panel groups.*
*Source: Researchers' computations (2024)*

The CD test statistics for each variable, as seen in the table, are significantly high, with p-values equal to 0.000. These low p-values (0.000) strongly reject the null hypothesis of cross-sectional independence. In other words, the results indicate that there is significant cross-sectional dependence for all the variables under consideration. This suggests that the variables are correlated across the different panel groups (low-income African countries), meaning that events or changes in one country are likely to affect others, due to economic and geographical linkages. For instance, in the case of GDP, the CD-test statistic of 43.578 with a p-value of 0.000 indicates that economic growth in one country is highly interconnected with economic growth in other low-income African nations.

**Results of Panel Unit Root and Co-integration Tests**

Results from the panel unit root tests, based on the Pesaran's CADF and CIPS which are robust in the presence of cross-sectional dependence are reported in Table 5.

Table 5: Results of Panel Unit Root and Co-integration Tests

| | CADF | | CIPS | | Stationarity Status |
|---|---|---|---|---|---|
| Variables | Level | 1st Difference | Level | 1st Difference | |
| lnGDP | -2.421 | -3.282*** | -2.553 | -3.641*** | I(1) |
| lnEC | -2.558 | -3.121*** | -2.493 | -4.114*** | I(1) |
| lnLF | -1.596 | -2.808** | -1.491 | -3.033*** | I(1) |
| lnGFCF | -2.814** | -3531*** | -2.891** | -4.058*** | I(0) |
| Westerlund (2007) Cointegration Test | | | | | |
| Variance ratio: | | t-statistic = -3.2855 | | p-value = 0.0003 | |

*Notes*: *** denote significance at 1% level. Lag length are selected based on SIC.

This study considers the estimation with constant and trend so as to exploit potential hidden features. Both tests depict that the null hypothesis of non-stationarity of the variables at levels for all panels of country groups cannot be rejected except for

LNGFCF which was found to be stationary at level. The three other variables have unit root at levels, whilst in their first difference they have no unit root.

The Westerlund (2007) panel co-integration test reveals that, all the variables are co-integrated since the hypothesis of no co-integration is rejected at 1% level of significance level. We can therefore draw a conclusion that, the variables being analysed possess a long-run relationship.

## Pooled Mean Group (PMG) estimation results

After confirming that the variables are co-integrated, the next step is to estimate the long-run and short-run coefficients using the PMG estimator through the ARDL estimation technique and the results are presented in Table 6.

Table 6: Results of Long-run and Short-run Estimated Coefficients

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* |
|---|---|---|---|---|
| | | Long Run Equation | | |
| LNEC | 0.168 | 0.020 | 8.220 | 0.000 |
| LNLF | 0.234 | 0.107 | 2.180 | 0.029 |
| LNGFCF | 0.265 | 0.016 | 16.340 | 0.000 |
| | | Short Run Equation | | |
| $ECT_{t-1}$ | -0.133 | 0.048 | -2.750 | 0.006 |
| D(LNEC) | 0.017 | 0.035 | 0.480 | 0.632 |
| D(LNLF) | 0.748 | 0.320 | 2.340 | 0.019 |
| D(LNGFCF) | 0.020 | 0.018 | 1.060 | 0.290 |
| Constant | 1.903 | 0.685 | 2.780 | 0.005 |

Note: LNGDP is the dependent variable, and Selected Model: ARDL (1, 1, 1, 1)

The results in Table 6 show that the coefficient of energy consumption is 0.168. This positive coefficient signifies that, in the long-run, a 1% increase in energy consumption is associated with an approximately 0.168% increase in GDP. The substantial t-statistic of 8.220 indicates the statistical significance of this relationship. This suggests that energy consumption plays a crucial role in contributing to economic growth. Higher energy usage may be indicative of increased industrial activity, technological advancements, or enhanced productivity, leading to a positive impact on the overall economic output. The coefficient of the labour force is estimated at 0.234. This implies that, in the long-run, a 1% increase in the labour force is associated with a 0.234% increase in GDP. The positive relationship suggests that a larger workforce contributes to economic expansion.

The coefficient of gross capital formation is 0.265, indicating a robust and statistically significant relationship. In the long-run, a 1% increase in gross capital formation is associated with a more substantial increase of approximately 0.265% in GDP. The exceptionally high t-statistic of 16.340 underscores the reliability and significance of this finding. This suggests that investments in capital formation have a pronounced positive impact on economic output. It aligns with economic theory, highlighting the critical role of capital investment in driving productivity, technological progress, and overall economic growth.

The negative coefficient for the error correction term implies that the system corrects itself at a speed of 13% per annum after deviations from the long-run equilibrium. In other words, if there are short-run imbalances between the variables, the system adjusts over time, converging toward the long-run equilibrium. The negative sign suggests a correction mechanism that reduces the gap between the short-run and long-run relationships.

The short-run results of the Autoregressive Distributed Lag (ARDL) model indicate that the coefficient of energy consumption is 0.017. A 1% increase in energy consumption is associated with a 0.017% increase in GDP. However, this relationship is not statistically significant, as indicated by the t-statistic and p-value. Similarly, the results also show that, the coefficient of the labour force is 0.748. A 1% increase in the labour force is associated with a 0.748% increase in GDP. This result is statistically significant, as indicated by the t-statistic and p-value. Finally, the coefficient of gross capital formation is 0.027. A 1% increase in gross capital formation is associated with a 0.020% increase in GDP. Despite the positive coefficient, this relationship is not statistically significant in the short-run.

**Results of Pairwise Panel Causality Tests**

The results of the pairwise panel causality tests examine the directional causality between pairs of variables. The tests are conducted under the null hypothesis that there is no causal relationship between the variables in the panel dataset and the results are presented in Table 7.

Table 7: Results of Pairwise Panel Causality Tests

| Null Hypothesis: | F-Statistic | Prob. |
|---|---|---|
| LNEC does not Granger Cause LNGDP | 6.445 | 0.000 |
| LNGDP does not Granger Cause LNEC | 10.169 | 0.000 |
| LNLF does not Granger Cause LNGDP | 0.079 | 0.925 |
| LNGDP does not Granger Cause LNLF | 0.187 | 0.830 |
| LNGFCF does not Granger Cause LNGDP | 2.037 | 0.133 |
| LNGDP does not Granger Cause LNGFCF | 7.923 | 0.000 |
| LNLF does not Granger Cause LNEC | 5.754 | 0.004 |
| LNEC does not Granger Cause LNLF | 0.624 | 0.537 |
| LNGFCF does not Granger Cause LNEC | 7.342 | 0.001 |
| LNEC does not Granger Cause LNGFCF | 2.283 | 0.104 |
| LNGFCF does not Granger Cause LNLF | 0.078 | 0.925 |
| LNLF does not Granger Cause LNGFCF | 3.275 | 0.039 |

The results in Table 7 show that the causal relationship between LNEC and LNGDP is bidirectional, in the sense that, energy consumption causes economic growth and vice versa. It is also found that strong evidence supports LNGDP causing LNGCF, and LNLF causes LNEC. Similarly, there are bidirectional causality between LNEC and LNGFCF and LNLF cause LNGFCF. These findings offer valuable insights into the nuanced and dynamic relationships among the variables in the panel dataset, guiding a deeper understanding of their causational dynamics.

## CONCLUSION AND RECOMMENDATIONS

This study employs panel data from fifteen (15) low-income economies in Africa to investigate the relationship between energy consumption and economic growth. Utilising data spanning from 2003 to 2022, the study uses the pooled mean group (PMG) estimator. The results reveal a significant positive long-run impact of energy consumption on economic growth in low-income economies in Africa. Similarly, the causality results indicate that economic growth causes changes in energy consumption. Therefore, the study concludes that the interplay between energy consumption and economic growth is substantial in these economies.

Based on these findings, the study recommends that further research delves into the specific mechanisms through which energy consumption influences economic growth in low-income African economies. Policymakers are advised to consider strategies that enhance energy efficiency and promote sustainable energy sources to foster economic development. Additionally, initiatives focusing on economic growth should be mindful of their potential impact on energy consumption patterns. By adopting a comprehensive and integrated approach, policymakers can better address the intricate relationship between energy consumption and economic growth for the benefit of these economies.

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