**Innovations**

# Economic Growth-Energy Consumption Nexus in Sub-Sahara Africa: Does Institutions and Fragility Matter?

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***Abstract***: *Through the decades, Sub-Sahara African economies have adopted several projects and programmes to boost economic growth through sustainable energy consumption. The growth effect of such policies has remained a contentious and lingering issue given the volatile institutional framework of the sub-region. This study attempt to examine the growth-energy consumption nexus with special emphasis on the effects of institutional factors and fragility The study covered twenty-four (24) economies in sub-Saharan Africa over the period 2000 to 2020. Adopting the GMM estimation technique, the study recognized that energy consumption impacts economic growth positively across full sample and fragility regimes, although the findings are highly sensitive to fragility level since the impact was insignificant in countries that are highly fragile. Thus, the study concludes by suggesting among other policy options that countries in the sub-region should invest conscientiously in the energy sector and improve on their institutional frameworks in order to stimulate sustainable growth.*

***Keywords:*** *sustainable, electricity, regulatory,GMM, institutional quality*

***JEL Classification***: *C23, C51, Q43, O40, O43,*

## 1. Introduction

Energy consumption is central to every sphere of human and economic endeavours. It affects the operations of economic activities which have bearing on food security, education, poverty eradication, health, transportation, climate change adaptation, and education. Ensuring access to sustainable, affordable and reliable energy is among the seventeen (17) Sustainable Development Goals (SDGs). Energy utilization drives industrial, vehicular, and household activities such as cooking and lighting and stimulate economic activities (Odhiambo, 2021; Streimikiene&Kasperowicz, 2016; Efayena et al., 2019;Efayena et al., 2022;Kahsai et al., 2012; Ferguson et al., 2000; Asafu-Adjaye, 2000).

In spite of its potential benefits, access to energy has been swindling globally. For instance, more than 789 million people worldwide do not have access to energy.Around 2.8 billion people, or more than one-third of the world's population, lack access to clean and safe energy for cooking. Most of these individuals are predominantly in sub-Saharan Africa. Specifically, over 645 million people lack electricity accessibility in Africa. The sub region has the lowest power consumption per capita globally, with the sub region producing 181 kilowatts annually. This production rate pales into insignificance when compared with the 13,000 kilowatts produced in the United States on an annual basis (United Nations, UN, 2020; African Development Bank AfDB, 2019). These statistics have both health and economic implications. In sub-Saharan Africa, barely about 28 percent of health facilities have reliable electricity accessibility and this has led to human fatalities given that life-saving machines such as ventilators, incubators and others are rendered redundant. An estimated 600,000 people die annually with pollutants from unsafe cooking fuel being the primary cause. (UN, 2020).

Despite the debate around the theoretical foundations which apply to sub-Saharan Africa, a new dimension has emerged in recent years. Due to renewed sensitization of greenhouse gas emissions, the need to re-evaluate the economic growth-energy consumption nexus has taken renewed attention. Energy constitutes nearly three-and-a-quarter of global emissions, with electricity and heat generation being the largest emitting sector while transportation and manufacturing sectors tag closely (Climate Watch, 2019). There is growing concern about whether or not energy consumption substantially contributes to economic growth especially with the global greenhouse debate. Statistics show that in sub-Saharan Africa, $CO_2$ emissions rose from 402.37 thousand kt in 1990 to 823.77 thousand kt in 2019. That represents over a 100 percent growth in $CO_2$ emissions in the sub region (Climate Watch, 2020). It is expected that there should be a substantial trade-off between growth and energy consumption to accommodate such huge gaseous emissions.

In this study, the goal is to determine the extent to which energy consumption contributes to growth in sub-Saharan Africa. The study also strives to unravel the impact of institutional factors and fragility regimes in the growth-energy consumption nexus. Specifically, the study investigates whether there are differences in energy consumption-led growth between less fragile and highly fragile economies in sub-Saharan Africa. That is, are energy consumption-induced growth higher in less fragile economies than highly fragile economies, or vice versa? How have institutional factors determined economic growth across fragile regimes? It is imperative to state that although various definitions of fragility have been provided, there are several ingredients present in all, namely, political and economic instability, high youth unemployment, low per capita income, weak institutions, soaring poverty and inequality rates, low human capital development, rising inflation, among others (IMF, 2014; Alemayehu, 2017; OECD, 2015; DfID, 2005). Weak institutions constitute variables such as control of corruption, government effectiveness, and regulatory quality. The importance of incorporating the institutional variables as well as fragility regimes into an energy-growth model cannot be overstressed particularly in sub- Saharan African countries with almost all the features of fragility.

Our empirical analysis uses the generalized method of moments (GMM) with panel data across twenty-four (24) economies. The study contributes to the literature in two broad ways. First, the study was able to clearly examine the economic growth-energy consumption nexusby employing growth trends in the variables rather than magnitudes. This results in more viable estimates. Second, the study was able to arrive at more reliable policy implications and conclusions bordering on the impact of institutional factors on economic growth by considering three core components, namely, control of corruption, government effectiveness, and regulatory quality. Moreover, the study extended the analysis to capture the model in two fragility regimes, which to our knowledge, renders this study extremely unique. Most previous studies either consider the issues on individual country basis (Odhiambo, 2021; Dada, 2018; Odugbesan&Rjoub, 2020) or in cases where the consideration was done on a panel data, the effect of institutional factors and fragility differentials among countries are not investigated (Acheampong et al., 2021; Awodumi&Adewuyi, 2020).

The remainder of the paper is structured as follows. The following section and the next present the methods and data that were employed in the study. Section 4 presents and discusses empirical results, while section 5 concludes the study through an evaluation of policy implications and recommendations.

## 2. Methods

### 2.1. Theoretical Framework

There are clusters of theories that seek to explain determining covariates of growth. However, this study begins with the Cobb-Douglas (C-D) production function. The C-D model is based on the constant return to scale assumption and can be expressed as;

$$Y = Af(L, K) \tag{1}$$

Wherein, $Y$ denotes economic growth, $A$ is termed the efficiency parameter and it captures exogenous technology; $L$ and $K$ denote labour and capital inputs, respectively. It is essential to note that $A$ facilitates capital and labour efficiency. Hence, improvements in $A$ will result in advanced efficiency of capital and labour inputs in the production process. A prominent growth model which is based on the C-D production function is the Solow growth model. The model assumes that capital accumulation is the determining factor of economic growth in the long run. Capital accumulation is assumed to be determined by technological progress (technological growth rate), savings rate, and growth rate of the population.

By incorporating human capital variable in the growth model, Mankiw et al. (1992) modified the Solow growth model. The resulting model, Augmented Solow growth model, is expressed below as;

$$Y = Af(L, K, H) \tag{2}$$

The above modification forms the foundation of the endogenous growth model. Unlike the neoclassical view which opined that economic growth is mainly dependent on technological growth rate and other exogenously-determined factors, the endogenous growth model argued that economic growth is dependent primarily on endogenous factors. Furthermore, this growth model strongly refuted the assumption of diminishing returns to scale in capital input. The alluding reason was that since there is continuity of knowledge which keeps expanding, in addition to constant research and development (R&D) programmes, the growth process is expected to be subjected to increasing returns to scale.

In order to customize the growth model to the current study, it was assumed that *ceteris paribus*, energy consumption variable should be incorporated into the model while holding some other factors constant. The study can thus specify the modified growth model as:

$$Y = Af(L, K, H, X) \tag{3}$$

By imposing restriction on the coefficients of $H$, $K$ and $L$, the following expression was obtained;

$$Y = Af(X) \tag{4}$$

Note that $X$ is a vector of growth determining factors. In this study, such factors included energy consumption growth, access to electricity, electricity consumption growth, and institutional factors (control of corruption, government effectiveness, and regulatory quality). Equation (3) can be rewritten thus;

$$Y = f(AX) \tag{5}$$

Equation (5) can be presented explicitly as Equation (6) given as;

$$lnY = lnA + lnX \tag{6}$$

Equation (6) can be modified econometrically considering countries and time path. Equation (7) given below explicitly specified the econometric model, considering countries and time path.

$$GPCG_{i,t} = \varphi_1 GPCG_{i,t-1} + \varphi_2 ECG_{i,t} + \varphi_3 AE_{i,t} + \varphi_4 ELCG_{i,t} + \varphi_5 GE_{i,t} + \varphi_6 RQ_{i,t} + \varphi_7 CC_{i,t} + \varepsilon_{t,s} \text{with} \varepsilon_s \sim i.i.d. N\left(0, \delta_{s,t}^2\right) \tag{7}$$

Where time and countries are captured by $t$ and $i$. $EPCG$ (economic growth) is proxied by GDP per capita growth. The lagged $GPCG$ variable is incorporated into the estimated model to control fordynamics in the growth model as suggested by Canh (2018). $ECG$ denotes energy consumption growth, access to electricity as a percent of total population ($AE$) and electricity consumption growth

(*ELCG*). The study also incorporated selected institutional factors in the model, ultimately to ascertain the effects of institutional quality on the growth. The study employed three dimensions of institutions from the World Bank's Governance Indicators (WGIs) to proxy for the institutional framework. These indicators included government effectiveness (*GE*), regulatory quality (*RQ*), and control of corruption (*CC*). The inclusion of these indicators in a growth model is validated in studies such as Zhang (2016). Going by *a priori* expectation, $\varphi_1>0$, $\varphi_2>0$, $\varphi_3>0$, $\varphi_4>0$, $\varphi_5>0$, $\varphi_6>0$, $\varepsilon$ represents the stochastic error term.

Next, the study divided the sampled economies into two sub-samples based on the strata of fragility. Six economies were selected each from countries rated lowest fragility and highest fragility to ascertain the effect of fragility on the growth model. Countries in these categories were drawn from McKay and Thorbecke (2019) classification of fragility quantile in sub-Sahara Africa. Benin, Gambia, South Africa, Mauritius, Ghana and Cabo Verde were classified under lowest fragility economies category, while Cote d'Ivoire, Guinea, Nigeria, Dem. Rep. Congo, Sudan and Zimbabwe were classified as under the highest fragility economies category. An analysis of these two fragility regimes has immense policy implications for energy decision-making in SSAs.

## 3. Data

Data employed in this study were collected for the period of 2000-2020 for 24 sub-Saharan African countries. Our data was constrained by availability of the governance indicators and energy consumption variable. Countries sampled included South Africa, Gambia, Mauritius, Cabo Verde, Benin, Ghana, Angola, Zambia, Senegal, Sierra Leone, Burkina Faso, Mozambique, Ethiopia, Cameroon, Kenya, Niger, Mali, Congo, Cote d'Ivoire, Nigeria, Sudan, Zimbabwe, Dem. Rep. Congo, and Guinea. All the definitions and sources of variables are presented in detail in Table 1.

**Table 1. Variables, definitions and sources**

| Variables | Definition | Sources |
|---|---|---|
| *GPCG* | GDP per capita growth | World Development Indicators (WDI) |
| *AE* | Access to electricity (% of population) | ” |
| *ECG* | Energy consumption growth | World Energy & Climate Statistics |
| *ELCG* | Electricity consumption growth | ” |
| *GE* | Government Effectiveness indicator | World Governance Indicators (WGI) |
| *RQ* | Regulatory Quality indicator | ” |
| *CC* | Control of Corruption indicator | ” |

*Source*: Authors' compilation

# 4. Results

## 4.1. Descriptive Analysis

Table 2 shows the descriptive statistics for the main variables used in the analyses.

**Table 2. Descriptive Statistics of Key Variables**

| | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| *Full Sample (24 SSA economies)* | | | | | |
| GPCG | 168 | 4.67 | 3.13 | -3.49 | 6.67 |
| ECG | 168 | 3.81 | 7.33 | 0.34 | 31.45 |
| AE | 168 | 1.07 | 4.83 | 6.27 | 10.33 |
| ELCG | 168 | 0.21 | 0.19 | 0.03 | 7.58 |
| GE | 168 | -0.04 | 0.41 | -0.81 | 1.22 |
| RQ | 168 | -0.06 | 0.39 | -1.19 | 0.88 |
| CC | 168 | -0.44 | 0.43 | -1.47 | 0.54 |
| *Lowest fragility category (6 SSA economies)* | | | | | |
| GPCG | 42 | 5.06 | 3.01 | -2.47 | 6.67 |
| ECG | 42 | 2.64 | 5.19 | 11.31 | 31.45 |
| AE | 42 | 1.34 | 4.52 | 6.79 | 10.33 |
| ELCG | 42 | 0.35 | 0.16 | 0.09 | 7.58 |
| GE | 42 | -0.08 | 0.36 | -0.81 | 1.05 |
| RQ | 42 | -0.07 | 0.43 | -1.19 | 0.64 |
| CC | 42 | -0.38 | 0.37 | -1.33 | 0.54 |
| *Highest fragility category (6 SSA economies)* | | | | | |
| GPCG | 42 | 4.67 | 3.29 | -3.49 | 4.11 |
| ECG | 42 | 1.99 | 3.04 | 0.34 | 14.62 |
| AE | 42 | 1.04 | 4.35 | 6.27 | 7.04 |
| ELCG | 42 | 0.23 | 0.11 | 0.03 | 5.13 |
| GE | 42 | -0.04 | 0.42 | -0.91 | 1.22 |
| RQ | 42 | -0.03 | 0.51 | -1.98 | 0.88 |
| CC | 42 | -0.40 | 0.35 | -1.47 | 0.41 |

*Source*: Authors' compilation

Two important facts emerge from the summary statistics. First, ECG is significantly different across countries. For example, the average ECG is 3.81 across all countries, but the standard deviation is about double the average at 7.33, and all country with the maximum ECG has 31.45 percent of EC. Second, electricity consumption seems to be homogeneous across African countries, with an average growth rate of 0.21 percent and a standard deviation of 0.19. This was not significantly different in the sub-samples, although it was relatively higher for countries classified under the lowest fragility categories. This was also the case for other economic determining factors of the growth model.

## 4.2. Energy Consumption and Growth: Baseline Results

The baseline results are presented in Table 2. The test statistics of the Sargan/Hansen and AR(2) tests were presented. It was observed that the *p*-values of these statistics exceed 10 percent which confirmed the suitability of the GMM estimator (Roodman, 2009). A cursory look at the estimates presented in Table 2 portrayed some interesting results. Panel A presents the results of the full sample, while Panels B and C present the results of lowest and highest fragile economies, respectively.

**Table 3. Econometric results**

| | | Fragility Regimes | |
|---|---|---|---|
| | **A** | **B** | **C** |
| **Dependent variable: *GPCG*** | **Full sample** | **Lowest fragile** | **Highest fragile** |
| GPCG(-1) | 0.319*** | 0.128** | 0.007*** |
| | (0.093) | (0.046) | (0.002) |
| ECG | 0.017** | 0.022*** | 0.010 |
| | (0.005) | (0.007) | (0.007) |
| AE | 0.025 | 0.018 | 0.025 |
| | (0.023) | (0.017) | (0.040) |
| ELCG | 0.321 | 0.201 | 0.004 |
| | (0.472) | (0.173) | (0.003) |
| GE | -0.811*** | -0.581** | -0.711*** |
| | (0.165) | (0.207) | (0.132) |
| RQ | -0.819** | -0.510*** | -0.638*** |
| | (0.298) | (0.111) | (0.213) |
| CC | -0.902*** | -0.319*** | -0.773*** |
| | (0.168) | (0.109) | (0.128) |
| No of countries | 24 | 6 | 6 |
| AR(-2) test | -0.91 | -0.58 | -0.73 |
| | [0.318] | [0.710] | [0.472] |
| Sargan/Hansen test | 16.51 | 19.08 | 15.93 |
| | [0.196] | [0.241] | [0.166] |

*Source*: Authors' compilation for STATA 15 output

Note: *,**,*** *denotes significance levels at 1%, 5% and 10%, respectively; parentheses contain standard errors.*

#### 4.2.1. Full Sample Analysis

From Panel A, it can be observed that the GDP per capita growth variable, *GPCG*(-1), is positive and statistically significant. This significant positive impact implies that *ceteris paribus*, higher growth in a current year will stimulate growth in subsequent years. The situation is highly plausible since positive economic growth in a fiscal year will result in economic viable conditions such as higher investments, savings and other economic resources which will positively drive the growth rates in subsequent years. This finding corroborates those of Canh (2018). Specifically, the point estimate of the impact of *GPCG*(-1) on GPCG is equal to 0.31. This resultconnotes thata 1 percent increase in GPCG level in the previous year increases the rate of economic growth by 0.31 percentage points, on average, in the current year.

Energy consumption growth (*ECG*) was found to positively and significantly impact growth. In other words, the estimated parameter for the impact of ECG on growth indicates that ECG has a positive and significant impact on growth. Specifically, with a point estimate of 0.017, the magnitude of the effect implies that a 1 percent increase in ECG on average, will stimulate growth by 0.017 percentage points. This positive impact was also found in previous studies (Gozgor et al., 2018; Dada, 2018), although it negated some studies (Ekeocha et al., 2020; Yadzi&Shakouri, 2017).

Unfortunately, such positive and significant effect of *ECG* on growth was not found in access to electricity (*AE*) and electricity consumption growth (*ELCG*). Although the point estimates of 0.025 and

0.321 for $AE$ and $ELCG$, respectively, imply that economic growth will be stimulated by 0.025 and 0.321 due to a 1-percent increase in $AE$ and $ELCG$, respectively, the impact was not statistically significant.
The impact of institutional factors was also seen in the estimates of the Government Effectiveness ($GE$), Regulatory Quality ($RQ$) and Control of Corruption ($CC$) variables. The point estimates of -0.81, -0.82, and -0.90 for $GE$, $RQ$, and $CC$, respectively, imply that improvement in the efficiency and effectiveness of institutional factors in SSAs will enhance economic growth. It connotes therefore that an improved institutional framework is essential for growth in the SSAs.

### 4.2.2. Fragility Regimes Analysis

In order to assess how levels of fragility in the energy consumption-growth model, the model across SSAs classified under lowest fragility and highest fragility economies was estimated. By dividing the economies on the basis of fragility, the study found a wide gap between the units. Although economic growth in the previous fiscal year, $GPCG$(-1), positively impact that of the current year, the impact was found to be higher for countries in the lowest fragility category. Specifically, the point estimates of 0.128 and 0.007 was found for countries under the lowest fragility and highest fragility, respectively. Interestingly, while growth in energy consumption improve economic growth significantly in lowest fragility economies. The reverse was the case for those in the highest fragility category. Specifically, a 1-percent hike in energy consumption growth increases economic growth by 0.02 percentage points, on the average for countries classified under the lowest fragility category.
For both access to electricity ($AE$) and electricity consumption growth ($ELCG$) variables, their impacts have not significantly improved economic growth in both categories of fragility regimes. A possible reason for the insignificance is the lagging challenges facing electricity supply in sub-Saharan Africa. A sizeable proportion of the population do not have access to electricity (AfDB, 2019). This has significantly affected industrial and other economic activities to such an extent that the significance of electricity on economic growth is barely felt. There is thus urgent need to address these pressing issues by facing the challenges of electricity supply in the sub-region.
Institutional factors in both categories of fragility have negatively impact economic growth. However, the impact is found to be more on economies classified under the lowest fragility category. When the various institutional components are used, the signs are all negative, but the magnitude and statistical significance of their impacts vary across the fragility regimes. The government effectiveness component is both positive and significant statistically in each category. However, among the highly fragile economies, control of corruption ($CC$) contributed more to growth slump than other institutional factors under consideration. This was closely followed by government effectiveness ($GE$) and regulatory quality ($RQ$) consecutively. In the case of countries in the lowest fragility category, government effectiveness ($GE$) exerts more negative impact on growth. This was closely followed by regulatory quality ($RQ$), and control of corruption ($CC$) is the least contributory institutional factor. These findings did not come as a surprise since institutional framework in low-fragile economies is expected to perform better than highly fragile ones. This support the argument that less fragile states are expected to perform economically better than highly fragile states (IMF, 2014; Alemayehu, 2017). This also have implication for economic convergence among countries in sub-Saharan Africa. Building resilient economies should focus on strengthening government, financial, and business institutions in each economy.

## 5. Concluding Remarks

The study collates annual data for twenty-four (24) economies in sub-Saharan Africa to examine the energy consumption-economic growth model incorporating institutional factors (control of corruption, regulatory quality, and government effectiveness) and fragility with an endogenous growth model. The study employed data spanning from 2000 to 2020 adopting the GMM estimation. The study found that energy consumption impacts economic growth positively across full sample and fragility regimes, although the impact was insignificant in countries that are highly fragile. The contribution to growth on the part of electricity accessibility and growth in electricity consumption is found to be insignificant likely due to the general epileptic electricity supply in the sub-region. The institutional factors performed dismally in their contribution to economic growth.

Our findings have a couple of policy implications. First, the electricity consumption as well as its access variables show a crowding-in growth effect during the 2000-2020 period under review. In other words, electricity consumption and access to electricity have increasing growth returns in sub-Saharan Africa. That implies that periodic marginal boosts in electricity supply levels might not have the potential to significantly stimulate growth in sub-Saharan Africa. To maximize the growth potential, a "big-push" in the energy sector will be required for long run performance. Second, fragility has the potential to widen the gap of economic growth in sub-Saharan Africa as it relates to energy consumption. The situation will further worsen given the gapping variation in institutional factors across fragility regimes in sub-Saharan Africa. There is need for regional economic convergence. That can only be achievable when countries in the sub-region invest conscientiously in the energy sector and improve on their institutional frameworks.

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