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Sustainable Economic Growth in West African Monetary Zone (WAMZ): Energy Crisis Implications

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ABSTRACT
This study examines the impact of energy crisis on the economies of WAMZ African countries, using energy production, energy utilization capacity, and access to electricity as indicators for energy crisis. The panel fixed effect regression estimator was employed on data period ranging between 1990 and 2021. The results show that energy production and electricity access positively contribute to economic growth, as they stimulate industrialization and reduce production costs, generating demand and creating employment opportunities. However, certain energy sector players, who maintain monopolies, hinder efforts to fully utilize available electricity capacity. The study suggests that the existing energy crisis in WAMZ countries is rooted in under-utilization of available energy sources rather than the absence of energy entirely. The study recommends accelerating electricity production efforts and access, aiming for clean and renewable energy sources, to tackle energy poverty and environmental challenges. This will also stimulate industrialization, promote entrepreneurial innovations, and result in economic expansion.
Keywords: Energy Crisis, Economic growth, WAMZ, energy utilization capacity, Access to electricity, Energy production

1. INTRODUCTION

Energy is essential to the social and economic advancement of every country, and because of its worldwide implications, it should unquestionably be researched from both an economics and a geopolitical standpoint. In this era of globalization, energy have become essential commodities. Although the energy crisis of the 1970s prompted the creation and investigation of alternative energy sources and related technologies, the threat posed by greenhouse gas emissions from climate change has caused the focus of energy issues to shift in recent years (Ugwunna, Ezidimma & Ejeogu, 2024). These days, many nations have made renewable energy (RE) more integrating and creating a road map to achieve net-zero emissions a top priority (Mukhtar et al., 2023).

An energy crisis is a disruption in energy supply, leading to shortages and price spikes. Key impacts include increased production costs, inflationary pressures, reduced economic growth, social and political

instability, and environmental trade-offs. Shortages can reduce industrial output, job losses, and inflation, while higher energy prices can increase transportation and manufacturing costs, erode purchasing power, and reduce consumer spending (IEA, 2022; Emmanuel et al., 2024; IMF, 2023; World Bank, 2023). As consequent, governments may resort to cheaper, polluting energy sources, undermining climate goals and long-term sustainability (UNEP, 2023).

The current worldwide energy crisis has highlighted the need for a quicker roll-out of less expensive and more environmentally friendly energy sources. Equally, food, gasoline, and other commodity costs have skyrocketed as a result of Russia's invasion of Ukraine, further taxing African economies already severely impacted by the Covid-19 outbreak. More than 4% of people were expected to live without electricity in 2021 as against 2019 (Mhlanga & Ndhlovu, 2023). This is as a result of the converging crises impacting on Africa's energy system. Additionally, they are making utilities' financial problems worse, raising the possibility of blackouts and rationing (Neik et al., 2023).

WAMZ is one of the world's least electrified sub-regions, with 135 million people living without access to the grid. This implies that about half of the continent's population is unable to charge their phones, put on a fan to cool themselves, or turn on a light to complete their homework. In the WAMZ, access to power is likewise not socially inclusive. In 2023, almost forty percent of rural residents in WAMZ member nations would not have access to electricity (World Bank, 2023). Human growth in WAMZ even exceeded the rate of electricity access during this period, resulting in a higher proportion of the people living in darkness. With living expenses in all of the WAMZ countries skyrocketing due to persistently high inflation, businesses as well as individuals are being negatively impacted by the high cost of electricity. The main obstacle to the sub-region's continued economic development and expansion may still be the high cost of power. Being among the world's poorest sub-regions, WAMZ residents place a higher priority on healthcare, food, and possibly even their children's education than they do on power. In addition to the financial costs that the impoverished must bear, this may cause people to turn back to using kerosene for lighting, coal for cooking, and open flames for warmth. This could result in a number of environmental degradations and other social evils (World Development Report, 2024).

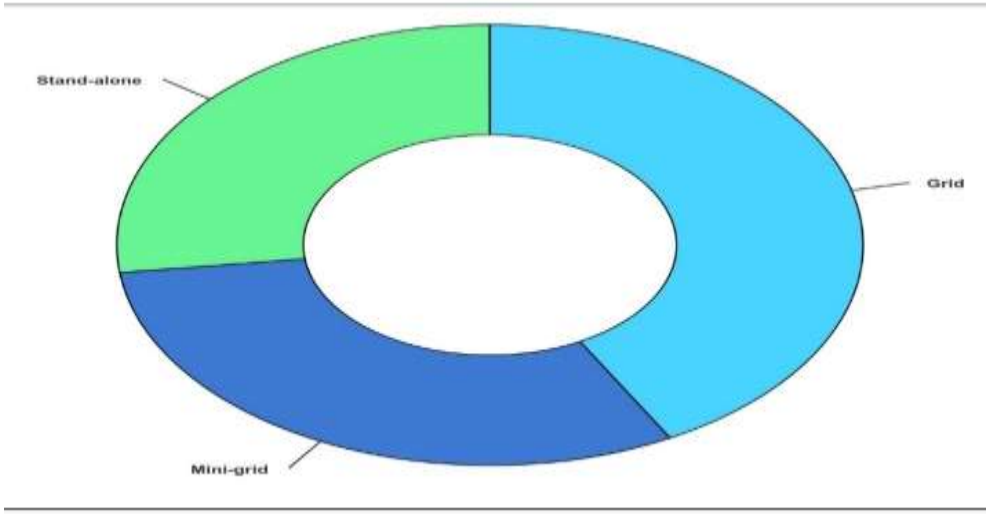

Figure 1: Share of people gaining access to electricity by technology in the West African Monetary Zone Sustainable Africa Scenario, 2022-2030.

According to figure 1 which shows the share access to electricity amongst people in West Africa, access to main grid is 42%, mini grid is 31%, and access to stand-alone electricity is 27%.

WAMZ member countries, including Nigeria and Gabon, have abundant natural resources, particularly energy, but have only recently emerged on the oil and gas map compared to other regions (Enerdata 2020). Despite producing around 3 million barrels per day, the continent's oil reserves make up only 2.5% of the world's total. The oil industry views WAMZ member countries as hotspots for oil production and

exploration, and as top deepwater offshore oil production centers due to their openness to foreign investors. The sub-region relies on private international oil and gas companies to develop its hydrocarbon resources, leading to the marginalization of the gas sector (Copinschi & Smedley 2016). Nigeria is among the top five LNG producers in the world, accounting for 7% of LNG sold internationally. However, African nations have been slow to respond to climate change issues, with power outages costing the country over $28 billion (Ogwu et al., 2023; Copinschi, 2022).

Energy access is essential not only to achieve growth and sustainability goals, but also to lower operating costs, unleash economic potential, and generate employment (Adokwe, Oguanobi & Ugwunna, 2025). A lack of access to electricity results in hundreds of thousands of deaths a year from cooking with wood-burning stoves, hinders hospital and emergency services operations, lowers educational attainment, and raises operating costs (Ogwu, 2021; Adokwe, Oguanobi & Ugwunna, 2025). As a result, universal energy access in the WAMZ member nations would be a major force behind inclusive growth, helping to reduce environmental degradation and open doors for women, young people, and children living in both urban and rural areas.

The goal of this study is to investigate the impact of energy crises on the economic growth of West African monetary zone (WAMZ) countries. The study adopts energy utilization capacity, access to electricity and energy production as proxies for energy crises. Whereas, the fixed effect panel model estimator was employed for empirical analysis after subjecting the dataset to essential diagnostic tests like unit root test, cointegration test, cross sectional dependence test and Hausman decisive test.

The study has five sections. Following this section is the section 2, which is literature; succeeded by the section 3, which contains the methodology. Afterward comes the section 4, dealing with the result and findings, and finally, the conclusion and policy prescription which is the section 5.

2. Literature Review

2. 1. Energy Crises in West Africa Monetary Zone

The WAMZ Africa countries has much-untapped potential when it comes to energy services. Given the comparatively low levels of per capita demand compared to the rest of the globe and the possibilities for a fast increase in wealth and population, this is particularly true for transportation, manufacturing, and cooling in homes and business premises. The growing industrialization and urbanization will drive the need for energy services since cities offer better job and income prospects. According to the Africa Energy Outlook (2022), the continent's demand for industrial products is expected to surge by a significant margin of at least one-third from 2020 to 2030, driven by increased construction activity and industrial production. The expansion of the middle class, its purchasing power, and the widespread availability of modern energy services across Africa are factors driving up demand. Africa's economic and social development is closely tied to expanding energy services for households.

According to the United Nations Sustainable Development Goals, achieving numerous development goals on the continent depends on having access to modern, affordable, dependable, and sustainable energy. Nevertheless, the cost of essential services remains a significant issue in most African nations, where many households still need access to necessities like air conditioning, transportation, or food and medicine storage. Household appliance ownership is significantly lower than in other developing and emerging markets. This includes fans, air conditioners, and freezers. Ownership of a car is still considered a luxury in many regions of Africa when it comes to transportation, but two- or three-wheelers, which can transport both people and goods, are more prevalent.

According to the African Energy Outlook (2022), although 120 million people in WAMZ countries do not have access to electricity and 200 million do not have access to modern, clean cooking solutions, the 300 million homes in this region nevertheless accounted for 56 percent of the continent's total final energy consumption in 2020. There will be a more significant increase in the ownership and usage of appliances and equipment due to increased incomes and access to power, which will cause the demand for energy services to surpass the population growth in the decade leading up to 2030. Electricity accounts for the vast majority of the increase in demand in the WAMZ, with its proportion of total home energy consumption expected to increasing from 6% in 2020 to 26% by 2030. The WAMZ's power demand is

being reined in by policy measures to increase efficiency and ensure everyone has electricity access by 2030. These electricity savings result from stricter minimum energy performance standards (MEPS) and energy labels and a decrease in the import of inefficient used appliances. By 2030, the average stock efficiency for both refrigerators and air conditioners will have increased by almost 50%, making these appliances the most improved.

From 680 TWh to 1,180 TWh, the demand for energy in Africa will increase by over 75% in the decade leading up to 2030 in the SAS (Ozohu-Suleiman, 2021). More than half of the growth has come from homes, thanks to new connections and the continued acquisition of electrical appliances and other equipment by those with access. For the most part, the remainder comes from industry. Although the total demand for power per capita increases from 500 kWh in 2020 to 700 kWh in 2030, it still needs to catch up to other emerging regions. West Africa Monetary Zone is the lowest while having the fastest growth of any region, with a range of 170 kWh to 390 kWh.

Empirical Review

Energy Crisis and Economic Growth

Ozen & Ozili (2022), examined the worldwide energy crisis of 2021–2022. Numerous reasons contributed to the energy crisis of 2021–2022, including the worldwide effort to limit carbon emissions, the conflict between Russia and Ukraine, the COVID-19 pandemic, the depletion of fossil fuel reserves as a result of divesting from fossil fuels, and the suspension of oil production. The empirical findings demonstrate that gas prices increased in the Americas, Asia, Europe, Africa, and the Middle East. The period in which the COVID-19 restrictions were abolished in 2021 and the Russia-Ukraine crisis in early 2022 coincided with the increase in gasoline prices. The correlation data indicate that while there was no substantial correlation in gasoline prices in Africa, there was in the Middle East, Europe, Asia, and the Americas. Amidst the global energy crisis, Gajdzik et al. (2024) conducted a thorough investigation of the intricate correlation among energy awareness, consumption habits, and energy efficiency. The study focused on both individual customers and industries. The literature study, overarching policy documents, energy reports, and other secondary sources served as the foundation for this paper. In addition to consumer preferences and environmental consciousness, the study highlighted the variety of factors that impact energy awareness, which includes consumers' active participation in the energy market and the industries' substantial responsibility in supporting energy-saving initiatives. Kyprianou et al. (2023) examined the difference in energy poverty mortality between urban and rural areas during a period of severe national financial crisis. A linear regression analysis was used to examine temperature, mortality, and macroeconomic indices for the years 2008–2018. The findings showed that metropolitan areas were more robust to the island's falling economic status, but rural areas were significantly affected, with a notable rise in mortality from energy poverty. Low earnings, high energy prices, and inefficient buildings are the three current issues associated with energy poverty. In Cyprus, all three occur simultaneously and intensify during crises, resulting in extremely precarious situations. The energy consumption patterns and preferences of Kenyan households were studied by Mbaka Gikonyo and Kisaka (2018). The data used in this analysis is a cross-sectional sample of 3,663 households from all around Kenya. The study's fundamental goals needed to be determined, and so a battery of diagnostic and specification tests was conducted. Cragg's double-hurdle model was favored on the grounds that it predicts a favorable level of home spending only after consumers overcome two obstacles. To reveal the effects of explanatory factors on the dependent variable, maximum likelihood estimations were produced, and then the marginal effects for participation probability and consumption intensity (conditional and unconditional) were calculated. The findings illustrated the different ways in which different factors affect households' preferences and spending levels, both in terms of volume and direction. Location (rural or urban), education level of the household decision maker, age of the household head, average monthly income, and other factors all have significant impacts on a family's energy usage habits and preferences. The research found that rural areas and households with lower levels of education and lower income groups were the best candidates for clean energy promotion. It is important to reduce the initial cost of purchasing cylinders and the cost of

refilling them in order to stimulate the usage of clean energy sources, such as liquefied petroleum gas, among low-income households in both rural and urban areas.

The connection between Nigeria's increasing demand for energy and the country's expanding economy was studied by Akomolafe and Danladi (2016). In a multivariate framework, this study presents capital formation and labor stock for the years 1990-2011. The Granger causality test, the vector error correction method, the Johansen test for co integration, and the augmented Dickey Fuller and Philip Perron unit roots tests are used. The study's findings demonstrate a direct link between electrical power usage and GDP per capita. In contrast, long-term estimates corroborate Granger causality tests by showing a positive relationship between power usage and real GDP. Further research shows that the correlation between capital formation and real GDP is unidirectional. This means that the contribution of capital formation to the economy in Nigeria, a country that relies heavily on energy, will be relatively determined by the availability of reliable electricity. Using a trivariate VECM, Njindan (2018) analyzed the correlation between Nigeria's electricity usage and GDP growth from 1971 to 2011. In doing so, the paper avoids the pitfalls associated with the use of cross-sectional methods and the omission of important variables. The findings demonstrate a direct link between increasing power use and economic expansion, both in the near and far term. This discovery lends credence to a theory that electricity spurred economic expansion. The report recommends that Nigerian policymakers implement measures to increase power generation and consumption in order to stimulate the economy. Inflation may be kept in check and economic growth boosted with the help of sound monetary policy. The effects of solar power integration on the Seychelles Islands were studied by Brown, Ackerman, and Martensen (2018). According to the report, the target for renewable energy in Seychelles is 5% by 2020 and 15% by 2030. In order to find out where the boundaries of feasibility lie, the local power system operator commissioned a Grid Absorption study. The research looked specifically at how much power the grid can take from photovoltaic (PV) sources. The biggest stumbling block was identified as the upkeep of backup generation reserves to compensate for rapid down-ramping of PV generation. Using an extended neoclassical model, Ogundipe, Adeyemi, and Ogundipe (2018) analyzed the correlation between electricity use and GDP growth from 1970 to 2013. This research takes into account the specifics of the Nigerian economy by examining the connection between power consumption and economic growth while taking into account the impact of institutions, technology, emissions, and the country's specific economic structure. The research used a cointegration analysis that relied on the maximum Likelihood method popularized by Johansen and Juselius (1981) and a vector error correction model. The study used the wald block endogeneity causality test to determine whether or not there is a positive correlation between electricity usage and economic growth. Researchers discovered an adverse relationship between economic growth and power usage in long-run cointegration equations. Similarly, the long-run non-convergence hypothesis was not rejected in the vector error correction model. In conclusion, the study provided evidence for a direct link between economic growth and electrical demand. Small and medium-sized businesses in Kenya had their electricity use and supporting infrastructure analyzed by Muhwezi, Willians, and Taneja (2020). The median consumption of newly electrified SMEs is higher in urban regions than that of their older counterparts, according to the longitudinal study's findings, whereas the median consumption of newly connected SMEs is lower in rural areas. Our research shows that the impact of complementary infrastructure on small and medium-sized enterprises' (SME) electricity usage is greater in rural than in urban locations. For instance, we find a 10%-16% increase in electricity consumption for small and medium-sized enterprises (SMEs) located in rural areas that are in close proximity to roads, markets, or financial service providers, but only a 2% increase for SMEs located in urban areas that are in close proximity to roads. The power use of urban SMEs is unrelated to, or adversely connected with, any other infrastructure characteristics. Using data from 2002 to 2021, Hlongwane and David-Daw (2022) examined the relationship between population increase and energy use in South Africa. This research looks at the variables' relationships by applying Dumitrescu and Hurlin's (2012) causality tests and the Seemingly Unrelated Regression model. According to data collected in South Africa, there is a strong negative correlation between the country's growing population and energy consumption. Additionally, the results show that the correlation between population expansion and electrical demand is one-way. Etongo and Naidu (2022) sought to understand

why individuals in Seychelles are transitioning to solar power, given that all homes there have access to electricity. The study investigated a family's decision to install solar panels using logistic regression and descriptive statistics. At the 1% significance level, the data demonstrated that monthly household income and loan availability affected the uptake of solar PV systems. Factors significant in previous studies, such as family size, gender, age, and education level of household heads, did not play a role in this analysis. In a survey of 60 households, the top four reasons for installing solar PV systems were financial savings (100%), increased reliability of energy supply (91.7%), reduced environmental impact (76.7%), and easier access to financing (56.7%). Solar photovoltaic (PV) systems in Seychelles need to address household adoption hurdles such as low electricity prices (82.9%), high upfront costs (65.7%), current loans (52.9%), and lengthy repayment periods (40%).

The existing literature on the subject suggests no discernible effect, a negative effect, or a favorable impact of renewable energy consumption on economic growth. Again, a gap still exists in the variable scope of this study. In this study energy crisis was proxied by novel variables such as access to electricity and energy capacity utilization, which had not been previously used by previous researchers, including energy production. These variables represent the share of renewable energy in total energy use and constitute the bulk of clean energy sources in the world. Thus, electricity is an essential energy commodity in developing countries like WAMZ due to its wide accessibility and affordability compared to other forms of renewable and clean energy sources. This has been one of the many goals of the SDGs. Furthermore, most of the studies were country-specific without taking due cognizance of the entire sub-Saharan African region. This study fills this gap and expands the empirical literature to include a group of countries bonded by a common economic goal known as the West African Monetary Zone (WAMZ) among the countries of the SSA region. This gives the study a wider scope and a wider range of applications.

3. METHODOLOGY

3.1 Theoretical Framework

The Cobb-Douglas function is a neoclassical production function that describes the reasonable real performance of economies, which was created by labour economists Paul H. Douglas and Charles Cobb in a way to fit Douglas's empirical insights into manufacturing employment, production, and capital stock to production function. The functional form is very popular among economists due to its ease of use and flexibility. It is written below.

$$Y = AK^{a}L^{1-a} \quad (1)$$

We deploy the Cobb Douglas to measure the circular economy development of WAMZ countries. In the model above Y is the output in an economy, K is capita, L is labour and a is a constant that assume values between zero and one and A is a given level of technology.

Since we are analyzing panel time series from many nations, there are three terms involved in estimating the stochastic component (Jorgenson 1990). By combining an energy crises component with the Cobb-Douglas production function, this theoretical framework provides a basis for examining the complex relationship between energy concerns and economic growth. It enables the development of long-term economic growth-promoting strategies and the thorough analysis of trade-offs.

Macroeconomic modelling typically focuses on production functions. For policy reasons, Applied Macroeconomics regresses manufactured single company output on inputs such as labour, capital, and energy to determine the relevance of its parameters. For neoclassical growth theory, the replacement of different inputs into the production function is a particularly pertinent topic. The likelihood that the economy can convert the relative abundance of one input into additional output increases with the ease with which the inputs may be swapped. From a macroeconomic perspective, the elasticity of substitution affects how businesses respond to interest rate changes, how they react as input to increases in trade, and how much labour makes up total income (when $\sigma>1$). More importantly, in terms of economic growth, is the elasticity of substitution.

To model the Cobb-Douglas production function with GDP and an energy crises, let us consider the following modified equation (Keen et al., 2019 and van der Werf, 2007):

$$Y = A.\left(K^{\alpha}.L^{\beta}.EC^{\gamma}\right) \quad (2)$$

where:
Y is the Gross Domestic Product (GDP),
A is the total factor productivity,
K is the capital input,
L is the labor input,
EC is the energy crises variable,
α, β, and γ are the output elasticities of capital, labor, and the environmental pollution and energy variable, respectively.

In order to account for the influence of energy crises on economic output, this update adds the energy crises variables (EC) to the production function. It is noteworthy that the energy crises variable (EC) and its influence on GDP need to be quantified with great attention and the availability of data. The model offers a conceptual framework for examining the connection between energy crises and economic growth, but empirical research would be required to determine the precise values of the parameters based on actual data. Make use of the existing data on GDP, capital, labor, and the energy crises variable to empirically estimate the parameters. That being said, in a small open economy such as the West African Monetary Zone (WAMZ) Countries, any two input factors—labor and capital—can be swapped when one is more measurable than the other. In this instance, labor is more abundant in the form of people than capital inputs. Here, the model is described as follows.

3.2: Model Specification

This model takes into account all of the goals that were established in the study, in accordance with the research of Yu et al. (2022). As a result, we incorporate into our model issues connected to energy crises. A general model is created to account for variables linked to energy crises. As a result, the generic functional form of the study's equation model can be written like this:

$$GDP = f(POP, GFCF, ECU, ATE, ENSPRO,) \quad (3)$$

$$\ln(GDP_{i,t}) = \beta_0 + \beta_1 ENSPRO_{i,t} + \beta_2 ATE_{i,t} + \beta_3 ECU_{i,t} + \beta_4 In(POP_{i,t}) + \beta_5 In(GFCF_{i,t}) + \varepsilon_{i,t} \quad (4)$$

Where $ENSPRO, ATE, ECU$ represents energy crisis indicators, POP and GFCF are the control variables in the model while t, i and μ, stand for time cross-sections and error term, respectively. $\beta_0 - \beta_4$ are the constant term and the stated variables, accordingly. The energy crises indicators are all in their real values. To avoid heteroscedasticity and data noise, the variables for this study are transformed into the natural logarithm procedure.

3.3 Diagnostic Tests

Cross-Sectional Dependence (CD) Test

Cross-sectional dependence is becoming more common in panel data econometrics as a result of trends in the economy as trade, globalization and climatic factors (Tufail et al., 2022). Failure to take into consideration of cross-sectional dependence and assuming that cross-sections are independent of one another can lead to results that are skewed, inconsistent, and misleading (Westerlund and Edgerton, 2007). In order to establish whether or not there is cross-sectional reliance, the author of this study employs a test for weakly exogenous cross-sectional dependence (Pesaran, 2015) in large panel data econometrics. In order to determine if there is cross-sectional dependence, the author conducts this test. The typical equation used in cross-sectional dependence (C.D.) tests is summarized as follows:

$$CSD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{k=i+1}^{N}\hat{\beta}_{ik}\right) \sim N(0,1)i,k \qquad (5)$$

$$CSD = (1,2 \ldots\ldots\ldots 20 \ldots\ldots N)$$

Panel Unit Root Test

In order to find the integration of environmental indicators, Energy crisis indicators and Economic growth, second-generation tests like the cross-sectionally augmented IPS (CIPS) and cross-sectionally augmented DF (CADF) are required. It is essential to use unit root analysis to prevent erroneous regressions. The cross-sectional averages of each of the dependent and independent variables in the model are included in the results of the panel-member specific ADF regressions, which are where the CIPS test is created. As a result, the test is very helpful for determining if unit roots exist in heterogeneous panels. The test statistic has an unconventional distribution, and nonstationarity is the null hypothesis. The equation for the tests mentioned above is presented as follows by Pesaran (2007):

$$\Delta Y_{it} = \emptyset_i + \vartheta_i \gamma_{i,t-1} + \delta_i \widehat{Y_{t-1}} + \sum_{j=0}^{p} \delta_{ij} Y_{t-1} + \sum_{j=1}^{p} \varphi_{ij} \Delta Y_{i,t-1} + \varepsilon_{it} \qquad (6)$$

From the equ (6) Y_{t-1} and $\Delta Y_{i,t-1}$ is given as the relative average for each cross-sectional series' latency and initial difference.

3.3.3 Panel Cointegration

Due to the expected presence of CSD, variation, and non-stationarity in the data, a heterogeneous estimating method is necessary for co-integration detection (Larsson et al., 2001; Pedroni, 2004). The approach proposed by Westerlund (2007) takes into account variations in slope, correlated errors and parameter of determination. In heterogeneous panel data that are cross-sectionally dependent, this technique accurately predicts cointegration features. In order to evaluate whether there is no cointegration across four panels, it additionally computes error-corrected statistics. The second-generation Westerlund (2007) cointegration test often takes the form of the following four equations: (7), (8), (9), and (10).

$$G_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\theta_i}{S.E(\hat{\theta}_I)} \qquad (7)$$

$$G_a = \frac{1}{N}\sum_{i=1}^{N}\frac{T\theta_i}{\theta_I^{`}(1)} \qquad (8)$$

$$P_\tau = \frac{1}{N}\sum_{i=1}^{N}\frac{\theta_i}{S.E(\hat{\theta}_I)} \qquad (9)$$

$$P_a = T\hat{\theta} \qquad (10)$$

From the above equation (Gt and Ga), represents the group statistics while (Pt and Pa) are the panel statistics of the cointegration. The appropriate test results are anticipated when the model variables are supposed to be unrelated, or "null," and the alternative hypothesis is "there are cointegrating relationships."

3.4. Estimation Techniques

Fixed Effect Regression

The fixed-effects regression is the main empirical method employed in this investigation. The fixed effect is used to identify the factors influencing environment and energy variables that could shift depending on how environment and energy variables are distributed throughout the WAMZ countries. According to Agubata et al. (2022), the fixed effect panel estimator has superiority over the common effect (pooled OLS) in that it could account for individual heterogeneity in the cross section. It is a sterilized fact that in a cross sectional sample there are unique characteristics often traceable to individual entities that make the cross-section over time; hence, accounting for this uniqueness is necessary in a given estimate in order to arrive at a robust outcome that suits policy purposes. Thus, the equation (4) can be restated to incorporate the fixed effect accordingly:

$$\ln(GDP_{i,t}) = \beta_0 + \beta_1 ENSPRO_{i,t} + \beta_2 ATE_{i,t} + \beta_3 ECU_{i,t} + \beta_4 In(POP_{i,t}) + \beta_5 In(GFCF_{i,t}) + \gamma_i + \varepsilon_{i,t} \quad (11)$$

Where all the variables maintain their nomenclature as earlier defined, γ_i, is the respective fixed effects for equation

(11). The advantages of the fixed effect earlier outlined is no longer sustainable in the event where time-varying variables exist in the cross section; the fixed effect is unable to capture such a time trend, so a different estimator capable of capturing time variation is required (Ugwunna & Obi, 2023). Hence, the random effect is introduced which is stated as follows:

$$\ln(GDP_{i,t}) = \beta_0 + \beta_1 ENSPRO_{i,t} + \beta_2 ATE_{i,t} + \beta_3 ECU_{i,t} + \beta_4 In(POP_{i,t}) + \beta_5 In(GFCF_{i,t}) + \gamma_{it} + \varepsilon_{i,t} \quad 12)$$

While all the variables still maintain their previous status, the γ_{it} is the random effects for the model equations (12),

which will be estimated for the purposes of testing the proposed hypothesis in this study, while the Hausman test was applied to select the most appropriate in each model equation.

Table 1. Data Sources

Variables	Roles	Acronyms	Data Source
Gross Domestic Product	It is the measure of economic growth rate, i.e. the dependent variable	GDP	World bank Development Indicator (*www.data.worldbank.org*
Population	It plays the role of independent variable. Population density is midyear population divided by land area in square kilometers.	POP	World Bank Development Indicator Data base (2023)
Gross Fixed Capital Formation	It account for the available capital stock in the economy. It is measured as current US dollars.	GFCF	World Bank Development Indicator Data base (2023)
Electricity capacity utilization	Is the share of renewable energy in total final energy consumption.	ECU	World Bank Development Indicator Data base (2023)
Access to electricity (percentage of total population)	Access to electricity is the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources.	ATE	World Bank Development Indicator Data base (2023)
Energy Production	Total energy production	ENSpro	Environmental Protection Agency (2022).

Source: (Researcher's Compilation, 2024)

4. RESULT AND FINDINGS

4.1: Descriptive Statistics and Correlation Analysis

Table 4.1 presents the descriptive statistics used to unravel the structure of the datasets employed in the empirical analysis for the current study. As revealed by the descriptive statistics the log of GDP (LGDP) ranged between 3.0212 and 8.0712 with a mean of 6.3777 indicating that income is rising but at a decreasing rate. This is evident in the falling per capita income and increasing poverty levels, respectively in the WAMZ countries. Logged population (LPOP) ranged between 3.0023 and 5.5639 with a mean value of 4.3876, indicating growing population in the WAMZ countries although the growth in population is higher in some countries compared the others. A typical example is Nigeria which is the most populous country in Africa, where there is little or no control of population alongside several cultural and socio-economic factors encouraging population growth.

However, this population growth have not really translated into economic prosperity nor able to engender environmental sustainability due to inadequate human capita development. Electricity capacity utilization (ECU) ranged between 0.0390 and 27.955 with a mean of 4.4043, and standard deviation of 7.0833 signifying the huge variation in the capacity of electric power used in each country and at different periods. For instance there is a high level of electricity capacity utilization in Nigeria and yet the country still suffers shortage of power supply depicted the existence of energy crisis in the country.

Access to Electricity (ATE) ranged between 1.2827and 86.300 with mean of 37.047, implying that while some of the WAMZ countries such as Ghana, Gambia and Nigeria have high level electricity access the others have lower electricity access. There is also indication of growing electricity access in many of the countries over the sample period with countries like Guinea, Liberia and Sierra Leone having no electricity access at the initial sample periods of about 10 years. This further indicates the existence of energy crisis in these countries and pointing to the general energy status of WAMZ countries, to wit, energy crisis.

Table 2 Descriptive Statistics and Correlation Analysis

	LGDP	ENSPRO	LGFCF	ECU	ATE	LPOP
Mean	6.3777	0.9592	2.8126	4.4043	37.047	4.3876
Median	6.3585	0.0017	2.9185	0.4659	35.749	4.4882
Maximum	8.0712	6.9961	3.9725	27.955	86.300	5.5639
Minimum	3.0212	0.0000	-1.2280	0.0390	1.2827	3.0023
Std. Dev.	0.7320	2.0984	0.6333	7.0833	19.453	0.6704
Skewness	-0.0870	1.8865	-2.2644	1.8494	0.3454	-0.2073
Kurtosis	4.7679	4.7463	14.013	5.5106	2.5679	1.9680
Observations	182	192	159	192	150	192
Correlation Matrix						
LGDP	1					
ENSPRO	0.5463	1				
LGFCF	0.1923	0.2619	1			
ECU	0.7375	0.8678	0.9414	1		
ATE	0.6912	0.3477	0.4415	0.6000	1	
LPOP	0.4509	0.4636	0.4793	0.4892	0.6465	1

Source: Authors Idea

There is also reasonable growth in electricity production (ENSPro) as indicated by the standard deviations of 2.0984 which is greater than the mean value of 0.9592; ranging between 0.0000 and 6.996, which shows that within some periods in the sample that some of the WAMZ countries depended on other countries for their electricity needs. And these are possible factors inhibiting or hampering the economic growth of these countries. Gross fixed capital formation (LGFCF) is ranged between -1.228027 and 3.972595 with a mean of 2.812674 indicating some degrees of variation across periods. This is valid in the face of the rising population size and density which normally orchestrates high energy needs in WAMZ countries. Finally, Table 4.1 further indicates that LGDP, LGFCF and LPOP are negatively skewed while the rest of the variables showed a positive skew. Moreover, LGDP, ENSPro, LGFCF and ECU are fat-tailed, having a kurtosis value greater than 3 while the rest of the variables are lean-tailed as indicated by the kurtosis value of less than 3.

The lower part of Table 4.1 shows the correlation results for the interest variables. It reveals that the strong correlation exists between the response variable and the regressors except for LGFCF which has a very weak correlation with LGDP. Similarly, this correlation observed between LGFCF and LGDP is negative, whereas the rest of the variables have positive correlation with LGDP in WAMZ countries.

4.2: Cross Sectional Dependence and Unit Root tests

Table 4.2 present the Cross Sectional Dependence (CD) test and the Panel unit root tests. According to the CD test result shown in the second column of Table 4.2, there is significant cross sectional dependence as indicated for all the study variables. Furthermore, the table also shows the panel sectionally augmented Im-Pesaran-Shin (CIPS) and the Cross sectional Augmented Dickey Fuller (CADF) unit root tests conducted for the interest variables of this study. These are second generational unit root tests and are necessary where there is cross sectional dependence among the variables of the study, which makes the use of first generation unit root tests of Livin, Lin & Chu (2002), Im, Pesaran & Shin (2003) and Fisher-type tests unreliable. Accordingly, the variables of interest are all integrated of order one I(1) for the CIPS and CADF tests, thus, validating the viability of the dataset for the current study.

Table 3. Cross-section dependency test and Panel unit test

Variables	**CD test**	**CIPS**			**CADF**		
		Level	**First Diff**	**Results**	**Level**	**First Diff**	**Results**
LGDP	15.24***	0.8632	6.8284**	1(1)	0.8687	58.6007***	1(1)
ENSPRO	13.71***	2.1786	-6.4488**	1(1)	4.1733	64.147***	1(1)
LGFCF	16.96***	0.2285	-7.4102***	1(1)	15.0980	69.3926***	1(1)
ECU	10.30***	2.6215	-6.8490***	1(1)	4.7047	72.079**	1(1)
ATE	16.06***	-1.6277	-7.7283***	1(1)	20.9441	74.2936***	1(1)
LPOP	21.69***	-3.3988	-19.499***	1(1)	41.5886	21.3287***	1(1)

Source: Authors Idea

4.3: Westerlund Panel Cointegration Test

The Westerlund Panel cointegration test which is a second generation is presented in Table 4.3 The test was used since the study observed the existence of significance cross sectional dependence in the variables of interest. Accordingly, the Gt, PT and Pa all revealed significant cointegration at the 1% level of significance, thus, indicating that the use of first generation estimators are not suitable for the dataset of this study. As a consequence, a second generational estimator is adopted for the purpose of obtaining a reliable regression outcome fit for policy purposes.

Table 4. Westerlund Panel Cointegration Test

Statistic	Value	Z-value	p-value
Gt	-2.629***	-2.322	0.010
Ga	-9.300***	-0.971	0.166
Pt	-8.362***	-4.844	0.000
Pa	-13.548***	-5.141	0.000

Note: *** represent the rejection of the null hypothesis at 1% significance level.

Source: Author Idea.

Table 4. Hausman Test Results

	Model 1
Chi2	Prob>Chi2
30.60	0.000

The Hausman test results for model one and two based on the objectives of the study is presented in table 4.4, and reveals that fixed model is more suitable for the data of this study compared to the random effect model, hence, the fixed effect model result is used for hypothesis testing and policy prescriptions.

Panel Regression Estimate

Table 4.6 presents the fixed effect and random effect regression estimates used to investigate the effect of energy crises on economic growth in WAMZ countries. Based on the application of the Hausman test as presented in Table 4.4, the fixed effect was deemed more appropriate for Model 2 of this study and is therefore employed for the testing and investigation of the proposed hypothesis in this study. The results of the regression estimates show that capital (LGFCF) has a significant but deteriorating effect on the economic growth of the WAMZ countries, as revealed by the coefficient value of -.195083 and probability value of 0.039, indicating that when LGFCF is increased by a unit, economic growth in WAMZ tends to drop by.195083%, ceteris paribus. Energy capacity utilization (ECU), access to electricity (ATE), energy production (ENSpro), and population (LPOP) exert a positive influence on the growth of WAMZ economies. This effect is particularly significant for ATE, ENSPro, and Population (LPOP), but the case of ECU is statistically insignificant. The model 2 estimates show that a unit increment in ECU will leave WAMZ economies the same in terms of growth, whereas a unit increment in ATE, ENSpro, and LPOP will have a corresponding increment on the growth of the WAMZ economies at a magnitude of.0154743%, 4976602, and.8824988, respectively. From this outcome, the null hypothesis that the energy crisis has no significant effect on the growth of WAMZ economies is rejected, while the alternative is accepted.

Table 5. Panel Regression Estimate

Dep. Var: LGDP	Fixed Effect Model			Random Effect Model		
	Coef.	***T***	***P>|t|***	**Coef.**	**Z**	**P>|z|**
LGFCF	-.195083	-2.08	0.039	-.3447295	-3.73	0.000
ECU	.0217989	1.36	0.177	.0396167	2.87	0.004
ATE	.0154743	2.36	0.020	.0232132	5.60	0.000
ENSpro	.4976602	4.18	0.000	.0030452	0.07	0.944
LPOP	.8824988	1.86	0.065	-.1426423	-1.28	0.202
_cons	1.541522	0.85	0.395	7.022531	12.02	0.000
Number of groups	*5.0000*			5.0000		
Number of obs	*135.0000*			135.0000		
F(5, 125)	*70.21*			208.28		
Prob > F	*0.0000*			0.0000		
R-squared	*0.3205*			0.6175		
Adj R-squared	*NA*			NA		

Source: Authors computation from STATA 16. Also note that selected model is in italics.

Energy production encourages economic progress in the sample countries in Africa, and this is in line with expectations based on economic theory, supporting the fact that oil, which is the major source of the bulk of the energy produced in many low-income oil countries, is the main source of foreign earnings. The results also highlight the possible low investment in and use of renewable and cleaner fuels in the sampled countries in Africa. There is possible interest in the use of electricity for various purposes in the sample country. This agreed with the outcome of the descriptive statistics, although there were few countries without energy, electricity production, or utilization capacity at the initial ten (10) period of this study and, as such, depended on other countries for their electricity needs.

Furthermore, countries that produce their own energy tend to consume more at a lower cost. It encourages industrialization and entrepreneurial setups. It further cut down on the cost of production, positioning the economy on a competitive edge. Although there are still countries with under-utilization of available energy capacity despite the fact that they supply electricity to neighboring countries, a typical example is Nigeria (Ogwu et al., 2023). The rate of under-utilization of electricity in Africa undermines the growth of the economy, and a key barrier to improving utilization is the slow rate of coverage in many countries in the WAMZ. This further indicates that the region is backward in its energy transition efforts, with fossil and solid fuels constituting the bulk of energy produced and available in the region. This barrier validates the manifestation of the energy crisis in WAMZ economies. As a result, there is need to put necessary structures in place to utilize the available capital formed in the economy to orchestrate greater growth especially with the rising population in the WAMZ which is an advantage because of the active labor force it guarantees to utilize the capitals that is employed.

While access to electricity encourages economic growth in the study sample area there also evident that many of the economies in the sample have more job to do in the business of improving access to electricity. A more worrisome issue from the findings is the low rate of capacity utilization in the sample area. While most of these countries have great electricity production capacity the utilization rate is discouraging simply due to poor institutional set ups and low political will on the side of the leaders, to investing in the sector and explore the available capacity to generate electricity for the teeming populace. Taking Nigeria for instance, there some dams in the country that are yet be put to use while many others are still under-utilized. The country is surrounded by numerous rivers and lakes that could exploited to generate electric power. This is also the case with some other countries in Africa. Thus, the existing energy crisis in the region is self-made mostly by the political class and some other players in the energy sector who wants to keep monopoly of the sector at the expense of the economic welfare. In cases where there are more than one players they quickly assume a collusive duopoly in order to keep prices high and control supply. This makes it difficult to eliminate energy crisis in these economies. There is an evidence

of under-utilization of the available capital in the face of expanding population which offers competence labor force for the WAMZ countries. The adequate employment of these capital will further engage the teeming labor force and set the economy on the part of growth.

5. CONCLUSION AND RECOMMENDATION

Due to the pivotal role energy plays in the economy the field has gained global attention, especially among researchers. Many economies in WAMZ Africa are majorly driven by revenue from primary energy production. This study investigated the influence of energy crisis indicators on the economies of WAMZ African countries by applying the fixed effect regression estimator to a data period of 32 years (1990–2021) for the interest variables, which include GDP per capita, energy production, energy utilization capacity and access to electricity. Gross fixed capital formation and population were include for control purposes. Similarly, energy production, energy utilization and access to electricity were used as measures of energy crisis. These variables were chosen based on data availability. The study conducted unit root tests for the chosen variables as well as cointegration tests using the second generation tests of CIPS and CADF (for unit root) proposed by Pesaran and Westerlund for cointegration, due to the presence of cross-sectional dependence in the dataset. According to the findings from the result of the fixed effect regression energy production has a positive and significant effect on the growth of the economies of WAMZ countries. Access to electricity has a positive and significant effect on the growth of the economies of WAMZ countries. Energy utilization capacity has a positive and statistically insignificant effect on the growth of the economies of WAMZ countries.

Energy crisis indicators has a positive and significant effect on the growth of the economies of WAMZ countries. This outcome entails that energy production and electricity access motivate economic growth since they encourage the inflow of revenues and industrialization, reducing the cost of production, which engenders demand and ultimately creates employment avenues. Contrarily, the activities of certain players in the energy sector who wants to keep monopoly of the market in connivance with ruling classes undermines the efforts to attaining full utilization of the available electricity capacity in the WAMZ countries thereby crippling the efforts geared toward eliminating energy crisis. Furthermore, while there is indication of under-utilized capital, the available population could provide sufficient labor force to orchestrate industrialization which is a force to reckon with in the growth process. It can be said at this point that the existing energy crisis in the WAMZ countries of SSA is rooted in under-utilization of available energy sources and those produced rather than the absent of energy in entirety.

The study thus recommend that electricity production efforts and electricity access in the region should be accelerated and expanded while considering the energy transition goal, which is a global goal. This implies that it should be in the direction of clean and renewable energy sources. This will help tackle energy poverty while addressing environmental challenges that arise from energy production and consumption. More electricity access will motivate industrialization, promote entrepreneurial innovations, and ultimately result in economic expansion. Moreover, the employment of the idle capitals in the WAMZ will further spur economic progress through employment of the labor force that the teeming population have made available, according to the study's findings.

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