Do Institutions Moderate the Energy-Growth Affiliation? Evidence from Sub Sahara Africa Countries

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Abstract: This paper aims to look into the role of institutional quality in regulating energy and growth affiliation. The countries of Sub-Saharan Africa (SSA) are studied from 1990 to 2019. CSD and SH tests were used to verify cross-sectional dependency and slope homogeneity properties. CIPS and CADF were used to investigate stationarity features. The Westerlund bootstrap cointegration test was used to analyze the long-tenure equilibrium affiliation among the variables and confirm cointegration in the extended period. To examine the long-short term performance between the variables, the CS-ARDL approach is used. To analyze the flow of causation, the study used the DH causality process. The findings reveal that energy has a negative and significant impact on growth. In both terms, industrialization and population have a negative and positive impact on growth, respectively. The DH heterogenous causality study reveals the mixed effect, i.e. one-way causal associations between growth and institutional quality, two-way causal associations between energy and population, and no causation with industrialization. Furthermore, institutional quality as a moderating variable harms growth. To achieve long-period growth, states should expand investment in renewable energy sectors, create well-resourced institutions, and plan for renewable energy development, according to this empirical research.

Keywords: Institutions, Energy Consumption, Economic Growth, Cross Section Auto Regression Distributed Lag (CS-ARDL), Sub Sahara Africa Countries

List of Abbreviation and Nomenclature

| Abbreviations | Meaning |
|---------------|---------|
| DH            | Dumitrescu & Hurlin |
| GMM           | Generalized method of moment |
| GDP           | Gross Domestic Product |
| OECD          | Organization for Economic Cooperation and Development |
| CS-ARDL       | Cross Section Auto Regression Distributed Lag |
| CIPS          | Cross Section Im, Pesaran, Shin |
| CADF          | Cross Section Augmented Dickey Fuller |
| WDI           | World Development Indicators |
| WGI           | World Governance Indicators |
| IQ            | Institutional Quality |
| CS            | Cross Section |
| CSD           | Cross Section Dependence |
| CD            | Cross Dependence |
| SSA           | South Sahara Africa |
1. Introduction

Energy is scarce in Sub-Saharan Africa. The region's power sector is significantly underdeveloped, whether at energy access, installed capacity, or total usage. Energy shortages in SSA's residential and industrial sectors make it difficult for countries to maintain GDP growth. The stakes are massive. Indeed, the ability of governments and investors to grow the continent's vast energy capacity is vital to the region's and Africa's economic and social potential.

Low energy usage rates (less than 80% of the population) consistently lowers GDP per capita. Only countries with significant natural resource richness have energy consumption rates below 80% and GDP per capita greater than $3,500. Despite this, they are far from reaching economic stability. The ability of the population to access energy and, if so, how much energy they can use are the two most important metrics that can illustrate the extent to which the power industry is fostering growth and national development.

Several empirical studies on the energy-growth nexus in Africa have previously been performed see ((Amoah et al., 2020; Dogan, 2014; Eggoh et al., 2011; Kebede et al., 2010; Lin & Wesseh Jr, 2014; Maji et al., 2019; Ouedraogo, 2013)). According to the existing literature, the relation between energy-growth results typically in four different outcomes. What are these outcomes? When there is a one-way causality between growth and energy use, this is known as the "conservation hypothesis." If energy consumption induces growth, but growth does not stimulate energy, then the "growth hypothesis" persists. The "neutrality notion" occurs when there is no alliance between energy consumption and growth. The "feedback idea" happens if there is a two-way causality between energy and growth (Amoah et al., 2020).

These studies, however, have flaws, especially in terms of the estimation techniques used. Furthermore, the time series estimation techniques used in these studies failed to capture the true dependency link between energy and growth with heterogeneous time series data. The failure of these time series-driven cointegrating techniques can lead policymakers and governments in high-energy-consuming countries to make mistakes, especially regarding energy and growth policy. When the dependency pattern between series with heterogeneous properties is analyzed, one research question arises: what kind of affiliation exists for most SSA countries? As a result, in addition to effectively directing policymakers and governments in SSA countries, it is essential to reinvestigate the energy-growth nexus using more sophisticated estimation techniques, which is the study's key innovation. The limited literature that considers the role of institutions like (Amoah et al., 2020) also limits the indicators of institutions. Again, this literature adopted different variables as controls without non-considering the role of institutions.

In this research, contributions are made in the following ways. For example, the first and most important contribution is creating a single institutional quality index covering all six institutional quality indicators of the WGI that were not covered in previous studies and used as a moderating factor. Second, this study employs key
complicated control variables such as industrialization and population increase to overcome the bias of excluded factors and analyze their causation.

To the authors' awareness, these variables have received little attention, particularly in emerging nations. CS-ARDL was utilized to extract reliable facts and overcome the endogeneity problem for the following reasons:
(i) In a panel data setting, it delivers the best feasible solution in terms of accuracy, efficiency, and robust outputs.
(ii) It avoids the need to evaluate the integration sequence beforehand, efficiently handles CS concerns, and accurately characterizes heterogeneous time series. (iii) It handles slope homogeneity difficulties and indicator feedback effects (iv) It extracts both long and short-haul impacts (Chudik et al., 2016; Chudik et al., 2017; Chudik & Pesaran, 2015; Pesaran & Smith, 1995).

Following this initial portion, which serves as the introduction, the remainder of the work is divided into four parts. Section 2 includes a brief review of the literature. Section 3 discusses the data, model, and technique. Section 4 examines the most important observations and discussions. Section 5 concludes some recommendations.

2. Literature Review

Several studies are evaluating the relationship between energy and growth as we look at the studied research. However, there are only a few studies that look at SSA countries' energy and growth. Furthermore, no research examining the moderating impact of institutions on energy and growth was found in these countries. Also, no research investigating the moderating impact of institutions on energy and growth causality was found in these countries. Because of the various data sets, alternative econometric methodologies, and different country characteristics, the findings are varied. The literature review in this analysis is divided into two parts. The studies exploring the relationship between energy and growth are included in the first section. The studies examining the causality between energy and growth are included in the second section.

2.1 Energy-Growth Nexus

Using panel data assessment systems that capture the CSD and heterogeneity (Bhattacharya et al., 2016; Jebli & Youssef, 2015), find the validity of the growth hypothesis in 69 and 38 countries respectively, for both the alliance between renewable and non-renewable energy and growth. (Shahbaz, Sarwar, et al., 2017) recently examined the complex union between electricity consumption, oil price, and GDP in 157 countries, concluding that developing countries depend heavily on electricity consumption to provide economic development. (Shahbaz, Van Hoang, et al., 2017) investigate the asymmetric relationship between energy and development, concluding that adverse energy shocks have only a minor effect on growth. According to those previous papers, non-renewable energy use is positively unified to economic growth in most countries. However, the renewable energy-growth union is not essential in the majority of cases. (Inglesi-Lotz, 2016), (Carmona et al., 2017), and (Solarin & Ozturk, 2015) in the United States and Latin America, respectively, include R&D expenditures in the K-L model, which uses Pedroni's panel cointegration test to investigate the effects of renewable energy on growth in panel data estimations. Energy can be a good predictor of growth, according to (Bildirici & finance, 2016). The preceeding provides a strong incentive for the current study, which intends to look into the possibilities of using energy to anticipate US GDP growth. The study's context is enhanced because the United States is a highly industrialized economy with high energy usage. The
empirical review identifies a subset of empirical literature separated according to techniques and focuses on renewable or non-renewable energy sources. (Narayan & Doytch, 2017) examines renewable and non-renewable energy sources to show that renewables support the neutrality hypothesis, whereas non-renewables fully endorse the input, growth, and conservative notions.

(Destek & Aslan, 2017) go through renewable and non-renewable energy in further depth. In renewable energy, the findings suggest that Peru has a development hypothesis, Colombia and Thailand have a conservation hypothesis, Greece and South Korea have a feedback hypothesis, and the remaining 12 rising economies have a neutrality hypothesis. The development hypothesis is supported by evidence in China, Colombia, Mexico, and the Philippines; the conservation hypothesis is supported by evidence in Egypt, Peru, and Portugal; the feedback hypothesis is supported by evidence in Turkey. The neutrality supposition is supported by the facts in the remaining emerging markets, according to the report. Another research component is split into three categories: developing, emerging, and developed economies, with varying outcomes. In most African countries investigated, for example, (Bildirici & Ozaksoy, 2017), find more evidence for the conservation concept. (Menegaki & Tugcu, 2017) show that in the long run, G7 economies can reduce energy use without risking long-term economic welfare, but that in the short run, GDP and economic welfare are significantly reliant on energy to accomplish growth.

2.2 Energy-Growth Causality

Most research has been undertaken to study the causation between energy and growth, including those listed below. (Alper & Oguz, 2016; Bakirtas & Akpolat, 2018; Zafar et al., 2019) studied the causal relationship between energy use, urbanization, and growth in new emerging market countries and revealed multiple causalities between the variables using the (Carrion-i-Silvestre et al., 2009) panel unit root test and the DH panel causality test. By disaggregating energy consumption, renewable, and non-renewable energy use, (Kahia et al., 2017) employed the Panel Granger causality test to analyze the energy-growth connection. The findings revealed that renewable energy usage and growth and non-renewable energy consumption and growth are bidirectionally causal.

Correspondingly, (Almozaini, 2019) used the JF Cointegration Test and causality tests to observe the causal connexion among economic growth and energy in countries with high usage and found that Energy-growth has both single and double way causality. (Aali-Bujari et al., 2017) causality analysis and GMM to inspect the effect of energy use on growth in the OECD, finding that the growth rate of energy use per capita has a positive impact on real GDP per capita. His findings [25] find a feedback effect, or double lane causality, running from growth, renewable energy, and non-renewable energy.

There is a single route link between GDP growth and renewable energy, according to research of (Zafar et al., 2019) results. The findings are also supported by (Ocal & Aslan, 2013) and (Xu, 2016). Furthermore, there is a one-way causality between energy use and GDP per capita. According to (Saad & Taleb, 2018), growth and renewable energy have a bidirectional causal link. As a result, the feedback hypothesis persists, showing a reciprocal causal relationship between these two variables and indicating that these variables readjust toward equilibrium after a shock. In their analysis, (Cho et al., 2015) found that there is double lane causation between renewable energy use and growth in the long tenure; thus, the feedback hypothesis exists, implying that an increase in energy contributes to an increase in growth and vice versa. The short-run results of the same study showed the presence of the conservation hypothesis, i.e., a unidirectional causality running from growth to renewable energy.
use, which is consistent with the findings of (Sari et al., 2008) in the United States. These mixed results are due to the various empirical growth models, country samples, and econometric methods. The paper takes a different approach by using the CS-ARDL to moderate the impact of institutions on energy and development. At this point, there is no claim that the empirical model is superior. The study tries to prove that a different approach is needed to improve awareness of the growth-energy nexus. The results show that this new method works well with panel data from 28 SSA countries.

Figure 1: Conceptual Framework of the Study

3. Data, Model & Methodology

3.1 Data

This research used annual data from 28 developing countries from 1990 to 2019. Data availability, especially institutional quality indicators, determines which countries and sample periods are chosen. Institutional quality measures, calculated using six World Bank governance indicators and the moderating variable, are sourced from the online World Bank's WDI database. Following the studies of (Agbloyor et al., 2016; Kose et al., 2009), these metrics are averaged to produce an index of institutional quality. The WB database provided the data for these institutional metrics. Table and figure 2 summarise trends, descriptive statistics, and a matrix of correlations between variables.
The study aims to provide empirical results based on the above hypotheses to investigate the moderating effects of institutions on the energy-growth relationship. This study assumes that growth is a function of energy consumption in workable institutions, growing industrialization, and population factors. The empirical model is estimated using panel data methodology to see a systematic relationship between institutional performance and the degree of energy and growth. Panel data methods allow researchers to account for individual heterogeneity and eliminate the possibility of misleading findings. The research uses CSD, SH, Friedman, CS-ARDL, and DH causality methods for the empirical model to discuss possible country-specific unobserved heterogeneity:

\[ GR_{it} = \beta_0 + \beta_1 IND_{it} + \beta_2 ENE_{it} + \beta_3 POP_{it} + \beta_4 IQ_{it} + \epsilon_{it} \quad (1) \]

Where \( \beta_0 \) infers an unseen time-invariant discrete effect; \( \beta_1 \), and \( \beta_4 \), separately, capture the moderating effect of IQ indicators on the energy-growth link with some control variables thus industrialization and population; \( \epsilon_{it} \) is the error sign, which is usually considered to have an average of zero (0) and variance of \( \sigma^2 \); I is the number of states \( I = (1, 2, 3, ..., N) \); and \( t \) is the time setting (\( t = 1, 2, 3, ..., T \))

3.3 Methods

Cross-sectional reliance was used to analyze sectional characteristics, slope homogeneity, and the Friedman test to determine the presence of heterogeneity along the sequence, among other econometric approaches used in the study. To discuss the long-tenure alliance and causation, the Westerlund and Edgerton
(2007), long-period test, LM bootstrap, and Dumitrescu and Hurlin (2012) causation tests are also utilized. The long and short-run effects of the variables in this analysis are estimated using the CS-ARDL approach.

### 3.3.1 Test of CSD

The study checks for the existence of CSD before estimating the cointegrating relationship between growth and its fundamentals. In the case of countries from the same geographical area, this problem can be particularly acute. Shocks may also be transmitted between countries with similar economic systems, resulting in CSD. The bias-corrected LM test of [40, 41], [42], and [43] was taken into account. The variables' results are shown in Table 2. The following should be considered:

\[ y_{it} = \alpha_i + \beta'_1 X_{it} + \mu_{it} \quad \text{for } i = 1, 2, 3 \ldots N; t = 1, 2, T \ldots (2) \]

\( X_{it} \) and \( \beta \) are \( K \times 1 \) parameters and vector regressors that should be projected. \( \alpha_i \), which defines time-invariant nuisance parameters on an individual basis. The null statement is that over periods and CS units, \( \mu_{it} \) is thought to be self-contained and circulated uniformly (i.i.d.). \( \mu_{it} \) cross-sections can be used as an alternative to serial correlation, but the assumption remains the same. As a result, the meaning presumption is

\[ H_0: \rho_{ij} = \rho_{ji} = 0 \quad \text{for some } i \neq j \]

where \( \rho_{ij} \) is the product-moment link's disturbance figure, which is assumed by

\[ \rho_{ij} = \frac{\sum^{T} \mu_{it} \mu_{jt}}{(\sum_{i=1}^{N} \mu_{it}^2)^{\frac{1}{2}}(\sum_{j=1}^{N} \mu_{jt}^2)^{\frac{1}{2}}} \quad \ldots (3) \]

With \( N \) the number of possible unions \((u_{it}, u_{jt})\) increases.

\[ LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\beta}_{ij}^2 \]

where \( \hat{\beta}_{ij} \) is a sample evaluation of the remaining sets that are correlative

\[ \hat{\beta}_{ij} = \frac{\sum^{T} \hat{\mu}_{it} \hat{\mu}_{jt}}{(\sum_{i=1}^{N} \hat{\mu}_{it}^2)^{\frac{1}{2}}(\sum_{j=1}^{N} \hat{\mu}_{jt}^2)^{\frac{1}{2}}} \quad \ldots \ldots \ldots (4) \]

And \( \hat{u}_{it} \) is the dimension of \( u_{it} \) in Eq (4). LM is asymptotically distributed as on the presumption of null interest. \( \chi^2 \) with \( N (N-1)/2 \) DF. However, when \( N \) is large and \( T \) is small, this test is prone to substantial size biases, expected in systematic applications. This is because the LM figures are not suitably concerned with finite \( T \), and when \( N \) is large, the bias will probably worsen. A counter-proposal was made, which was as follows:

\[ CD = \frac{2T}{N(N-1)} \left( \sum_{j=1}^{N-1} \sum_{j=i+1}^{N} \hat{\beta}_{ij} \right) \quad \ldots (5) \]

It also demonstrated that there is no CSD for \( N \) and \( T \) immense adequate beneath the void statement \( CD \rightarrow d \) \( N \) (0, 1). In a wide range of panel data models, including homogeneous/heterogeneous dynamic models and nonstationary models, the CD statistics, unlike the LM statistics, have a mean of precisely zero for fixed values of \( T \) and \( N \). Both homogeneous and heterogeneous dynamic models are favoured by the standard FE and RE estimators (Nickell, 1981; Pesaran & Smith, 1995). Even at fixed \( T \), the FE/RE residuals would have precisely the average zero, provided that the disturbances are spread symmetrically, given the slight sample bias of the
predicted parameter, hence the CD test is still valid. (Pesaran, 2004) advises a slightly changed version of (3) for unstable tables, as follows:

\[
CD = \frac{2T}{N(N-1)} \left\{ \sum_{j=1}^{N-1} \sum_{i=j+1}^{N} \sqrt{T} \beta_{ij} \right\} \ldots \ldots \ldots (6)
\]

where \( T \) is the number of ordinary explanations in time series among units i and j.

The revised Equation accounts for the fact that not all of the residuals for subsets t are zero. As a result, (Breusch & Pagan, 1980) proposes the Lagrange multiplier (LM) cross-sectional dependence approach for CSD. The panel data model for the Breusch-Pagan LM search is as follows:

\[
y_{it} = \alpha_i + \beta_{i1} X_{it} + \mu_{it} \ldots \ldots \ldots (9)
\]

The subscripts \( i = 1,2,\ldots, N \) and \( t = 1,2,\ldots, T \) denote the CS and time scopes, respectively; \( X_{it} \) means the explanatory variables \( k \times 1 \) vector, and alpha and \( \beta \) signify distinct intercepts and coefficients of slope across nations. As a result, the figures for the Breusch-Pagan LM test can be calculated as follows:

\[
LM = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T_{ij} \beta^2_{ij} X_{it}^N (N-1) \ldots \ldots \ldots (10)
\]

Where \( \beta_{ij} \) raises to the pair alliance coefficient calculated from the distinct OLS evaluations in Equation (10). In Breusch-Pagan LM exploration (\( H_0: \text{Cov} (\mu_{it}, \mu_{jt}) = 0 \) for all \( t \) and \( i \neq j \)), the alternative CSD supposition was compared to the null assumption of no CSD. (\( H_1: \text{Cov} (\mu_{it}, \mu_{jt}) \neq 0 \) for at least one pair of \( i \neq j \)). (Pesaran et al., 2008) advocate that the Breusch-Pagan LM test is insufficient when \( N \) is high, as it will miss power if the average population union is near zero on average. The Breusch-Pagan LM test, a bias-adjusted variant of the Breusch-Pagan LM test, is recommended by (Pesaran & Yamagata, 2008). As a result, the statistics for the bias-adjusted LM test (also known as the Pesaran LM test) will be postulated as ensues:

\[
LM = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T_{ij} \beta^2_{ij} X_{it}^N (N-1) \ldots \ldots \ldots (11)
\]

Where \( k \) denotes the number of regressors and \( \mu_{T_{ij}} \), and \( \nu^2T_{ij} \) discusses the exact average and variance of \( (T-k)\beta^2_{ij} \).

3.3.2 Test of SH

Due to substantial CSD, the dynamics of the economic development process in any country may be comparable. As a result, \( N \) is chosen relative to \( T \) to gauge the slope's homogeneity. (Swamy, 1970) gives a basis for the presumption of homoscedasticity. As a result, M. (Swamy, 1970) test extension for large panels with \( N \) and \( T \), as modelled by (Pesaran & Yamagata, 2008):

\[
\hat{S} = \sum_{i=1}^{N} (\hat{\beta}_i - \hat{\beta}_{WFE})^2 \frac{Y_i M_{it}}{\sigma^2_i} (\hat{\beta}_i - \hat{\beta}_{WFE}) \ldots \ldots (12)
\]
with \( \hat{S} \) is the adjusted Swamy exam (i.e., Pesaran and Yamagata SH exam) figure, \( \beta \) stipulates the joint OLS values, \( \hat{\beta}_{WE} = \sum_{i=1}^{N} (X'_i \Delta \text{M} \Delta \text{M} r X_i / \hat{\sigma}^2) \) labels the weighted FE joint estimator, \( \hat{\sigma}^2 = \left( (\hat{\sigma}^2 - X_i \hat{\beta}1 \text{M} \Delta \text{M} r X_i) / (T-k-1) \right) \) signifies the estimate of \( \sigma^2 \), \( \hat{x} \) states the identity matrix is symbolized by and the matrix holding the instructive variables in average deviations is denoted by \( \text{Mr} \). Moreover, the void statement of SH is violated. (H0: \( \beta i = \beta j \) for all \( i \)). The Pesaran and Yamagata slope homogeneity test is likened to the alternative postulation of slope heterogeneity. (H1: \( \beta i \neq \beta j \) for all \( i \)). The succeeding is the usual dispersal statistics:

\[
\hat{\Delta} = \sqrt{N \left( \frac{N^2 \hat{S} - k}{\sigma^2} \right)} \quad \text{(13)}
\]

The bias-adjusted type of the \( \hat{\Delta} \) exam can be modelled in the following way:

\[
\hat{\Delta}_{adj} = \sqrt{N \left( \frac{N^2 \hat{S} - \hat{S} \hat{\hat{\Delta}}}{\sqrt{\text{Var}(\hat{\Delta})}} \right)} \quad \text{(14)}
\]

where \( E (\hat{\Theta}T) = k \) and \( \text{Var}(\hat{\Theta}T) = (2k (T-k-1)) / (T+1) \) indicate the mean and variance, respectively.

### 3.3.3 Test of Panel Unit Root

Traditional panel root unit tests like ADF are unsuccessful when the sequence is CSD and heterogeneous. Pesaran (2007) overcomes this problem by combining cross-sectional averages of the delayed levels and initial differences of the individual sequences with standard ADF regressions, yielding a new panel unit root test that accounts for cross-sectional dependence and heterogeneity. As follows is the CADF regression:

\[
\Delta y_{it} = a_i + b_i \tilde{y}_{i,t-1} + c_i y_{i,t-1} + d_i \Delta \tilde{y}_{i,t-1} + e_{it} \quad \text{(15)}
\]

With subscriptions \( i=1,2, \ldots N \) and \( t=1,2, \ldots T \) characterize the CS length and period, discretely.; \( y_{i,t} = N^{-1} \sum_{t=1}^{N} y_{i,t} \) denotes the CS average of \( y_{i,t} \); and \( \Delta y_{it} = N^{-1} \sum_{i=1}^{N} \Delta y_{it} \) implies the 1\(^{st}\) Difference of \( \Delta y_{it} \). Also, the unit root null report is (H0: \( \beta i = 0 \) for all \( i \)). The CADF exam assesses the alternative supposition of no unit root. (H1: \( \beta i < 0 \) for some \( i \)). Pesaran (2007) is also scheming the CS augmented Im, Pesaran, and Shin (CIPS) is the average of individual CADF studies was used to create a framework unit root test for the whole community. The succeeding is the results of the CIPS test figures:

\[
\text{CIPS} = N \sum_{i=1}^{N} \text{CADFi} \quad \text{(16)}
\]

Where CADFi indicates a CADF is an Equation (16) cross-sectional unit ith test statistic

### 3.3.4 Test of Bootstrap Cointegration

When constructing a concept for panel long-tenure research, the level of stationarity of the variables influences the type of test to be performed. Cointegration methods will be employed following the stationarity checks to determine whether the variables have a long-term relationship. The series under consideration in this review has both heterogeneity and cross-section dependency. As a result, the error-correction-based panel cointegration test devised by (Westerlund & Edgerton, 2007) will be utilized to test for cointegration between the panel data variables in this study, which accounts for CSD. (Westerlund & Edgerton, 2007) proposes four different panel cointegration statistics to look for cointegration. Two of these data are community average metrics (Ga, Gt), whereas the other two are panel figures (Pa, Pt). The four experiments were conducted using the long tenure panel method of Westerlund and Edgerton (2007) are expressed in the state of an ECM, which can be inscribed as:
\[ \Delta Y_{it} = \delta_{it} + \alpha_i y_{i,t-1} + \sum_{j=1}^{p_i} \beta_{ij} X_{i,t-j} + \sum_{q=1}^{p_i} \gamma_{iq} \Delta x_{i,t-q} + e_{i,t} \] (17)

Where \( \delta_{it} \) stands for deterministic elements while \( p_i \) and \( q_i \) stand for lag lengths and lead orders vary across CSs.

The two group-average test statistics \( G_t \) and \( G_a \), as well as the two-panel test statistics \( P_t \) and \( P_a \), can be described as follows in the Westerlund and Edgerton (2007) cointegration research:

\[ G_t = \frac{1}{N} \sum_{i=1}^{N} \frac{\hat{a}}{\hat{a}(1)} \] (18)

\[ G_a = \frac{1}{N} \sum_{i=1}^{N} \frac{\hat{a}}{\hat{a}(1)} \] (19)

\[ P_t = \frac{\hat{a}}{\hat{a}(1)} \] (20)

\[ P_a = T \hat{a} \] (21)

The importance of these test statistics refutes the null hypothesis that the variables in the model have long-term relationships. Long-run approximations must have cointegrating affairs to be evaluated using appropriate regression procedures.

3.3.5 Test of CS-ARDL

The CS-ARDL strategy of (Chudik et al., 2016; Chudik & Pesaran, 2015) is used to estimate and publish long-run estimates using the MG estimator because it is the study's most accurate and efficient option. The CS-ARDL technique eliminates the necessity for a preliminary evaluation of the integration order (1). Both the simultaneous determination of growth regressors and the excluded bias of variables are reliable methods. This method's validity is contingent on two factors: first, the factors have a long-tenure bond, and second, the model's flexible specification is considerably enlarged to make the regressors weakly exogenous and serially unconnected to the residual model. The CS-ARDL technique, described below, successfully handles cross-sectional dependencies while accounting for heterogeneous time effects.

For example, the Mean Group (MG) technique estimates individual equations for each country. It compares the average of calculated coefficients across countries (Pesaran & Smith, 1995). It illustrates that the MG technique delivers reliable estimations of the average parameters when the data's time-series dimension is sufficiently high. The Mean Group (MG) method is at one extreme, calculating different equations for each country and examining the average of calculated coefficients across countries. (Pesaran & Smith, 1995) show that the MG technique offers consistent estimations of the parameters' average when the data's time-series dimension is big enough. The cross-sectionally augmented ARDL (CS-ARDL) method was established by (Chudik et al., 2017) and initially proposed by (Chudik et al., 2016; Chudik & Pesaran, 2015) is used to solve this problem and account for CSD and feedback effects between CO2 and institutional quality measures. Equation (1) can be expressed as

\[ y_{it} = C^* y_{it} + \sum_{l=1}^{p_y} \varphi_{il} y_{it-l} + \sum_{l=0}^{p_x} \beta^*_{il} x_{i,t-l} + \sum_{l=0}^{p_z} \psi_{il} \bar{Z}_{l,t-j} + \epsilon_{i,t} \] (22)

with \( \bar{Z} = (\bar{y}_{i,t}, \bar{x}_{i,t}^{-1}) \), \( p_z = T^{1/3} \) there are two choices for the outstanding lag instructions: ARDL(2,1) description, \( p_y = 2 \) and \( p_x = 1 \), and ARDL(1,0) requirement, \( p_y = 1 \) and \( p_x = 0 \). The distinct average equal coefficient CS-ARDL evaluations are then assumed by:
\[ \hat{\theta}_{CS-ARDL, \rho} = \sum_{t=0}^{p} \hat{\beta}_t \] 

wherever the evaluations of short-tenure \( (\hat{\phi}_i, \hat{\beta}) \) are constructed on Equation (24). The average long-tenure influence are valued as \( N^{-1} \sum_{t=1}^{N} \hat{\theta}_{CS-ARDL, i} \) and the interpretation are grounded on the traditional nonparametric estimator of the asymptotic modification of the average cluster estimator. Again, \( i = 1, 2, ..., N, t = 1, 2, ..., T, \) and \( x_i \) is \( k_i \times 1 \) vector of regressors specific to CS unit \( i \) at period \( t; c^*_i \) and \( c_i \) are discrete FE for unit \( i, \) \( g_i \) is \( k_i \times 1 \) vector of covariates precise to unit \( i \) (not detected in the panel data type).

### 3.3.6 Test of Panel Causality

The Dumitrescu and Hurlin [39] test is an enhanced variation of the Granger causality test for heterogeneous tables. The Granger causality test is used to calculate the average of individual Wald tests for cross-sectional units. Three distinct statistical values are calculated in the Dumitrescu and Hurlin (2012) panel causality test as follows:

\[ W_{N,T}^{Hnc} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \ldots (24) \]

With \( W_{N,T}^{Hnc} \) as the average value of each Wald statistic. According to Dumitrescu and Hurlin (2012) when \( T \) and \( N \) approach infinity, the mean statistics converge sequentially with the Equation below, assuming that the different residuals are unilaterally divided among all the CS, and their covariances are equal to zero.

\[ Z_{N,T}^{Hnc} = \sqrt{\frac{N}{2K}} (W_{N,T}^{Hnc} - K) \xrightarrow{d} N(0,1) \ldots (25) \]

With \( Z_{N,T}^{Hnc} \) as z-stats is, \( N \) is the number of CS and \( K \) is the optimum duration of the lag. Even if \( T \) approaches infinity, the individual Wald values are allocated unilaterally identically, according to Dumitrescu and Hurlin (2012), with the average individual Wald values equal to \( K \) and the variance equal to \( 2K. \) Then, given the mean Wald stats of the HnC null supposition, an approximately standardized Z-stats is determined, which can be stated as:

\[ Z_{N}^{Hnc} = \frac{\sqrt{N} [W_{N,T}^{Hnc} - N^{-1} \sum_{i=1}^{N} E(W_{i,T})]}{\sqrt{N^{-1} \sum_{i=1}^{N} \text{Var}(W_{i,T})}} \xrightarrow{d} N(0,1) \ldots (26) \]

The following is the null declaration and alternative assumption for the calculated panel statistics

\[ H_0; \beta_i = 0 \ \forall \ i = 1, 2, ..., N \]

\[ H_1; \beta_i = 0 \ \forall \ i = 1, 2, ..., N1 \]

\[ \beta_i \neq 0 \ \forall \ i = N1 + 1, N1 + 2, ..., N \]

typical panel data prototype.
4. Results and Discussions

4.1 Results and discussions on descriptive properties of variables

The science of quantitatively defining the most relevant properties of a set of data, or the quantitative description itself, is known as descriptive statistics. Because descriptive statistics can be used to evaluate and analyze data, they are crucial. Descriptive statistics aims to summarise the sample rather than learn about the population that the sample of data is supposed to represent. The use of descriptive and summary statistics has a long history, and the sample tabulation of population and economic data was the first method of introducing the subject of statistics. The term "exploratory data analysis" was coined to describe a collection and summarization technique. The sample in this study contains more than one variable used to describe the relationship between two variables. Table 1 provides the summary statistics for all variables in which the kurtosis of the coefficients, a measure of the distribution's tail thickness, is very large. The kurtosis of a Gaussian (normal) distribution is three, meaning that the assumption of Gaussian for the distribution of the variables in question cannot be made. This result is confirmed by the JB test for normality, which yields exceptionally high values in this case, discarding the null proposition of normality at any vital stage. The skewness for GR and POP is also negative, with positive values for all other variables. The other half of the table shows the predicted outcome of the interaction between the variables. The positive relationship between GR and IQ can be seen in this table. It also shows that GR negatively correlates with the other variables, including IND, ENE, and POP.

| Variable | GR  | IND  | ENE  | POP  | IQ   |
|----------|-----|------|------|------|------|
| Mean     | 1.4713 | 26.1928 | 9.3680 | 2.5700 | -0.1438 |
| Median   | 1.8332 | 23.3061 | 7.2995 | 2.7003 | -0.0759 |
| Maximum  | 37.5355 | 77.4137 | 50.1347 | 8.1179 | 1.0517 |
| Minimum  | -47.5033 | 6.0940 | 1.6527 | -6.7662 | -2.7808 |
| Std. Dev. | 4.7927 | 12.9052 | 6.9400 | 0.9678 | 0.5207 |
| Skewness | -1.4463 | 1.5950 | 2.3954 | -2.7034 | -0.5102 |
| Kurtosis | 21.6919 | 5.6005 | 10.6384 | 27.2787 | 3.8598 |
4.2 Results and discussions on cross-sectional dependence and slope homogeneity tests

Before analyzing heterogeneous panel results, it is crucial to perform CSD tests and SH tests, as previously mentioned. Since the economies of the SSA countries analyzed in this analysis are highly integrated, CSD and SH must be considered, and the results are shown in Table 1. First, three statistics were used to assess CSD: LM (Breusch & Pagan, 1980), CD (Pesaran, 2004), and CDadj (Pesaran et al., 2008), with the null hypothesis being no CSD. The variables are ignored at a p = 0.01 significance stage, according to the outcomes. As a result, the null hypothesis is dramatically denied, showing that these explanatory factors affect the variable of economic growth in each nation and the regression error terms between countries. The findings show that the economies of the SSA countries investigated in this research are strongly interrelated and that when one of them is hit by a shock, it will spread to the others. Table 1 also displays SH tests conducted using (Swamy, 1970) and (Pesaran & Yamagata, 2008) methods. The statistics are from (Swamy, 1970), \( \hat{\alpha} \) and \( \hat{\alpha}_{\text{adj}} \) (both from (Pesaran & Yamagata, 2008)), after doing the regression analysis of Eq. (2), the null proposition is that the slope coefficients of the explanatory factors are the same across all nations surveyed. The data disprove the null hypothesis of homogenous slope and support the alternative hypothesis of country heterogeneity, which implies that their distinct characteristics influence separate countries.

The failure of the homogeneous slope hypothesis suggests that enforcing the slope homogeneity limitation will lead to erroneous results.

Table 2: CSD, SH, SC & FM Results

| Tests                             | T. Stats | Prob. |
|-----------------------------------|----------|-------|
| Pesaran's test of CSD             | 14.634   | 0.000c |
| Test for SH (\( \hat{\alpha} \) test) | 8.406   | 0.000c |
| Test for SH (\( \hat{\alpha}_{\text{adj}} \) test) | 9.399 | 0.000c |
| Friedman                          | 131.703  | 0.000c |

NB: \( a,b,c \) denotes significance at 10,5 & 1%

4.3 Results and discussions on CSD stationarity test

The analysis verifies the nonstationary property and order of integration of the variables as a first step. Countries have different features, and the panels may contain CSD, resulting in inaccurate and unfair results. (Pesaran, 2007) proposed two-unit root tests for dealing with CD ambiguity: IPS cross-sectional (CIPS) and augmented Dickey-Fuller (CADF). Table 4 summarises the findings of the CIPS and CADF panel unit root studies.

Two of the variables at the level of CIPS and three at the level of CADF reflect nonstationary effects. However,
the null proposition is dismissed at 1% since the variables reflect the stationary effects at first difference. As a result, the analyses for CIPS and CADF are close. In conclusion, the results show that the order of integration of the individual series is either I(0) or I(1), but not I(2) and that there is significant error CSD, indicating that the Panel CS-ARDL(p, q) method is sufficient.

Table 3: CIPS & CADF Stationarity Results

| Variables | CIPS | CADF |
|-----------|------|------|
|           | Cons & Trend | Cons & Trend (1st) | Cons & Trend | Cons & Trend (1st) |
| GR        | -4.440c | -6.157c | -7.869c | -19.722 |
| IND       | -2.188 | -5.179c | 0.378 | -10.193c |
| ENE       | -2.010 | -4.893c | 2.717 | -7.509c |
| POP       | -2.445c | -1.851 | -14.114c | -8.014 |
| IQ        | -2.358c | -5.106c | 1.899 | -12.59c |

NB: abc denotes significance at 10, 5 & 1%

4.4 Results and discussions on Westerlund-based bootstrap long run test

Following the first-order integration of variables, the cointegration process among variables was investigated further. The [38] was used because it produces and manages the CSD. Table 4 reveals that the alternative hypothesis of cointegration is embraced, implying that the variables under consideration shift together in the long run. The estimation mentioned above test results using (Westerlund & Edgerton, 2007) cointegration bootstrap method is the same. At the 1% significance level, the robust P-values were significant. This demonstrates a long-tenure affiliation between GR, IND, ENE, and IQ in the SSA zone over the time studied.

Table 4: Westerlund Bootstrap Results

| Var | G1 | G2 | P1 | P2 |
|-----|----|----|----|----|
|     | Z-Val | Robust P-Val | Z-Val | Robust P-Val | Z-Val | Robust P-Val | Z-Val | Robust P-Val |
| IND | -12.173 | 0.000c | -16.356 | 0.000c | -13.156 | 0.000c | -19.303 | 0.000c |
| ENE | -12.448 | 0.000c | -13.639 | 0.000c | -12.470 | 0.000c | -17.845 | 0.000c |
| POP | -15.859 | 0.000c | -15.260 | 0.000c | -16.267 | 0.000c | -18.346 | 0.000c |
| IQ  | -12.044 | 0.000c | -15.915 | 0.000c | -15.673 | 0.000c | -24.526 | 0.000c |

NB: abc denotes significance at 10.5 & 1%

4.5 Results and discussions on Long and Short-Run Effects

The results of both the short and long-run analyses are shown in Table 4. The results show that in all specifications, the coefficient of the lagged dependent variable is negative and statistically significant. This means that the model is reaching equilibrium. In each specification, the speed of adjustment is more significant than 100%. The signs and significance of the variables within these two results remain the same, portraying the outcomes' robustness. The estimated coefficients show that the institution quality index (IQ) has a non-significant and adverse effect on economic progress in SSA countries during the study period. GE, RQ, PS, COC, ROL, and VOA levels are low or non-existent in SSA countries. This finding confirms and illustrates the low standard of the institutional climate in SSA countries. The findings support the concept in growth literature that institutions determine the 'rules of the game' and the conditions under which economic agents work in an economy (Butkiewicz & Yanikkaya, 2006; Kostevc et al., 2007; Vukotić & Bačović, 2006).
The findings support (Acemoglu et al., 2003) argument that macroeconomic variables (i.e., inflation, government spending, exchange rates, etc.) have no predictive power in growth models once institution quality indexes are included in the study. (Easterly et al., 2004) found that macroeconomic policies had little impact on economic performance; similarly, (Rodrik & Subramanian, 2003) found that macroeconomic variables such as trade have no direct effect on income once institutions are included in the study. When we look at the results for the policy variable in Table 5, we can see that, although the coefficient of IND retains the negative sign implied by economic theory, it is not essential. This could be because the financial systems of many SSA countries have been weakened by large structural fiscal deficits and volatile monetary and exchange rate policies.

Furthermore, energy stimulates growth, and affiliation is incompatible when moderating with institutional quality. This means that a 1% rise in energy demand would result in a 1.9116% reduction in growth. From an economic standpoint, this result is counter-intuitive since the coefficient of the energy variable is negative, suggesting that further energy delays growth. However, as previously mentioned, several factors are at play, including inefficient energy usage, which SSA countries are attempting to address. As a result, energy conservation should be used to save energy and reduce pollutant emissions. This empirical evidence backs up (Menyah & Wolde-Rufael, 2010) and (Acheampong, 2018) findings that energy consumption hurts growth. This proof contradicts the observational evidence discovered by (Omri, 2013).

In the short and long term, population density can be seen to have a positive and substantial impact on economic development. In concrete terms, increasing population density by one unit boosts economic growth by .2627% in the short run and .2060% in the long run. "At a higher level of growth, higher population density contributes to accumulated human resources, which increases per capita income or greater population is likely to increase per-capita welfare in a more developed society," Becker et al. (1988, 147) in (Peterson, 2017) explain. Population growth contributes to economic growth in the long run. In response to a 1% increase in population growth, the size of economic growth increases by 76%. This response is undoubtedly inflated. In any case, the above-mentioned upbeat outlook is vindicated here. This finding is in line with (Essien, 2016; Nwosu et al., 2014; Tartiyus et al., 2015) findings on the influence of population growth on economic growth. Studying the demography of BRICS and economic development, (Basu et al., 2013) discovered that the working population positively affects BRICS growth potentials. (Akintunde et al., 2013; Hamza, 2015) found that population harms economic progress in rising countries, specifically SSA and Asia.

From the above, the results point that there is an inverse link between industrialization and economic growth. This result reveals that an increase in industrialization in terms of proficient division of labour and technological innovation to solve problems shrinks economic growth in SSA Countries. In their respective studies, Mc Millan, et al. [65], [66] clearly stated that industrialization underpins economic growth. Both authors did not consider industrialization as a determinant of economic growth, which goes a long way to confirm the study's results. In all, empirically, industrialization cannot be a driver for an increase in economic growth.

Similarly, the findings of (Jelilov & Enwerem, 2016) research indicate that industrialization harms economic development. They said that practical policy efforts should be put in place to support human capital development to use new technology and disseminate it in industrial production, enhancing overall efficiency
across all sectors and assuring long-term development. The government should work to create a favourable climate for industrial development.

### Table 5: CS-ARDL Short-Long Period Results

| Variables | Short-Period Results | Long Period Results |
|-----------|----------------------|---------------------|
|           | Coef. | Std. Err. | z     | P>|z| | Coef. | Std. Err. | z     | P>|z| |
| L.GR      | -1.2352 | .0473 | -26.10 | 0.000c | -2.2352 | .0473 | -47.22 | 0.000c |
| IND       | -0.0492 | .2546 | -0.19  | 0.847  | -0.0173 | .1014 | -0.17  | 0.865  |
| ENE       | -1.9116 | .6113 | -3.13  | 0.002c | -0.8081 | .2631 | -3.07  | 0.002c |
| POP       | .2060   | 3.2659 | 0.06   | 0.950  | .2627   | 1.4340 | 0.18   | 0.855  |
| IQ        | -3.0147 | 2.8920 | -1.04  | 0.297  | -1.2109 | 1.1632 | -1.04  | 0.298  |

NB: abc denotes significance at 10, 5 & 1

### 4.6 Causal route test results and discussion

The presence of cointegration means that causality exists in at least one direction. The study discovered that GR, IND, ENE, POP, and IQ have a long-term relationship. The next move is to use the panel causality test to see a causal association between these variables. A causality analysis is used to see if possible predictability of power from one predictor to another. Table 6 displays the practical effects of the causality test for the entire Panel. The causality test indicates a bidirectional causal relationship between GR and ENE and GR and POP for the SSA countries. The results of GR and ENE suggest that GR and ENE are mutually dependent; thus, policy directions should be towards promoting energy on the one hand and growth on the other hand. As a result, energy and growth policies would need to be implemented in tandem. Reliable energy and growth policies should be implemented for efficient energy usage and long-term sustainable growth in the area. A handful of literature evidenced the feedback hypothesis of GR and ENE (see (Carmona et al., 2017; Sebri & Ben-Salha, 2014; Wang et al., 2016)).

Growth and energy have bidirectional causality, according to (Wang et al., 2016). Using the VECM, (Sebri & Ben-Salha, 2014) discovered bi-directional causality between growth and renewable energy use in the BRICS countries, validating the feedback hypothesis. To study the causation among energy consumption and growth (Carmona et al., 2017), split both series into a nonstationary natural component and a stationary (transitory) cyclical component. Energy consumption and growth have a bidirectional causal relationship, according to the report.

The findings show that there is a two-route causal link between population and growth. On the one side, when the difference in time and between regions is considered, the result shows that growth positively impacts the population. This finding is critical for decision-makers at the regional level as they develop policies to revive the population. On the other hand, the degree of growth was negatively affected by population as a dependent variable, indicating a situation similar to the post-revolutionary SSA society's transition era, when population decline could have favoured growth. The established causality relationships need a more nuanced approach to understand further how the relationships between the two variables stand, as seen above. Studies from (Mahmoudinia et al., 2020) and (Jemna, 2015) confirmed this hypothesis, indicating that population and growth are causally mutual. (Jemna, 2015) aim to illustrate causality between growth and fertility by using the VAR methodology and the approach. The empirical discoveries express a bidimensional causality relationship between fertility and growth and that each variable's invention has a long-term effect on the other. (Mahmoudinia et al., 2020) stated that when GDP growth and capital stock are dependent variables, panel cointegration and causality
techniques indicate a long-run relationship. In the long term, population growth has a positive and statistically significant effect on growth. Also, for OIC countries, the short-run bidirectional relationship between population and growth has been agreed upon. Theoretically, population growth is a national saving that expands the economy's potential. Given these considerations, it can be argued that population growth is a catalyst for growth rather than a hindrance. As a result of this negative view of the population and its power, economic policymakers must eliminate significant economic barriers by reforming systems, improving management capacity, and enacting appropriate monetary and fiscal policies.

In another scenario, the findings revealed a non-causal relationship between GR and IND. As a result, neither growth nor industrialization seems to be mutually exclusive. A more significant services sector than a manufacturing sector, on the other hand, does not refute Kaldor's arguments about the latter's growth-enhancing properties; instead, it is a product of a maturing economy (Kaldor, 1966). Manufacturing productivity, on the other hand, has been questioned as a source of growth. (Timmer & De Vries, 2009; Vries et al., 2014) show that recent growth acceleration episodes in developed countries were driven by productivity improvements in the services sector, rather than manufacturing, by implementing a new system of productivity accountability. On the other hand, the scientists argue that there is no causal link between these results and growth.

Finally, on the causal front, the findings show a one-way causal connexion between overall institutional efficiency and growth. The causality runs from institutional quality to growth, suggesting that higher institutional quality contributes to higher growth, but higher economic progress does not always lead to higher institutional quality. This contradicts the common perception that institutions and growth have a two-way relationship. Better institutions contribute to more significant growth, and more remarkable growth necessitates the creation of higher-quality institutions. The efficiency of the institutional climate is one of the most significant factors in deciding growth, according to (Alexiou et al., 2014; Asghar et al., 2015; Kilishi et al., 2013). The effect of institutional efficiency on growth in Asia's emerging economies was also investigated. The findings of their panel causality test indicate that there is unidirectional causality between institutional efficiency and growth. As a result, they concluded that improving institutional quality in these developing countries is essential to ensure high economic growth. (Kilishi et al., 2013) conducted an empirical study in Sub-Saharan Africa to determine if institutions matter for regional growth and, if so, which ones matter the most. Their findings show that institutions matter for economic activities, with regulatory quality appearing the most relevant. They suggest that improving regulatory quality could improve the region's economic performance.

Furthermore, (Siddiqui & Ahmed, 2009) used the extended tenure technique and the causality test to investigate the affiliation between institutional efficiency and economic performance. The results of their cointegration test show that institutional efficiency and growth have a long-term relationship. Furthermore, the findings of their causality test reveal that the causality between institutional quality and growth is unidirectional, with the causality flowing from institutional quality to growth.

Table 6: DH Causation Results

| Causal Assessment | W-bar Stats | Z-bar tilde Values | Causal path |
|-------------------|-------------|-------------------|-------------|
| GR→IND            | 1.3077      | 0.7271            | No Causal Path |
| IND→GR            | 1.3519      | 0.8701            |             |
| GR→ENE            | 2.0239      | 3.0474            | Two-way path |
| ENE→GR  | 2.1475  | 3.4480* |
|----------|---------|---------|
| GR→POP  | 1.8222  | 2.3939* |
| POP→GR  | 2.3307  | 4.0416* |
| GR→IQ   | 0.9241  | -0.5159 |
| IQ→GR   | 2.5333  | 4.6980* |

Two-way path

One-way path

NB: a,b,c denotes significance at 10,5 & 1%

Figure 4: Causality Directions, ↔, →, − defines feedback, one way, and no causality, respectively

5. Conclusion and Policy Implications

The study's main goal was to examine the moderating effects of institutional efficiency on the energy-growth relationship. The empirical findings in the paper demonstrated the following significant points using data from SSA countries for the period 1990-2019 and based on (Chudik & Pesaran, 2015) approximate CS-ARDL model and DH’s robust Granger causality test.

I. Energy harms growth mutually in the brief and extended tenure, according to statistical evidence. Again, there is insufficient evidence to suggest that institutional efficiency influences economic growth. Industrialization has a negative and negligible relationship with growth; the only variable that positively affects growth in both terms is population.

II. The "feedback hypothesis" suggests a two-way causality between energy and growth, as well as a one-way causal route between growth and institutional quality, with the flow beginning from institutional quality to growth for the significant variables of interest. There is a "neutrality hypothesis" for the control variables; according to this study, there is no statistically significant causation between growth and industrialization, although there is a two-way causality with population.

The empirical findings also indicate the following consequences for public policy:

I. An interregional energy production plan should be established quickly and include a fixed rate of energy increase that corresponds to SSA countries' economic growth rate.

II. SSA countries should focus on developing energy conservation awareness among individuals and businesses and investing in new renewable and sustainable energy sources.
III. Switching to renewable and sustainable energy-efficient appliances and intelligent equipment (such as automatic on/off operations) is one option for enhancing renewable and sustainable national energy output in SSA countries.

IV. Governments and administrations should ensure that institutions are free of political control and that all institutions function independently.

V. Governments and administrations should provide good services to different organizations and institutions to fulfil their roles and obligations effectively and efficiently.

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