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Sustainability of Moderating Role of Financial Inclusion and Institutional Quality in the Nexus Between Incidence of Energy Poverty and Government Expenditure: Evidence from Sub-Saharan African Countries

Sahra Altı Afrika Ülkelerinde Enerji Yoksulluğu ve Hükümet Harcamaları Arasındaki İlişkide Finansal Kapsayıcılığın ve Kurumsal Kalitenin Düzenleyici Rolünün Sürdürülebilirliği

Abstract

An important gap within the literature concerning the determinants of energy poverty lies in the potential moderating role of domestic institutional policies and financial inclusion. The interconnections between financial inclusion, institutional quality, and energy poverty imply that these factors may wield significant influence over the relationship between government expenditure and energy poverty, ultimately affecting progress towards sustainable development. This research seeks to bridge this knowledge gap by examining the impact of government expenditure on energy poverty in the context of sub-Saharan Africa. Furthermore, it scrutinizes whether financial inclusion and institutional quality act as moderators within the nexus between government expenditure and energy poverty across the region. Leveraging panel data encompassing sub-Saharan African nations, we employ cross-sectional autoregressive distributed lag modeling and panel-corrected standard error estimation techniques. Empirical findings from both short-term and long-term models validate that augmented government expenditure and economic growth exert a detrimental effect on the accessibility of clean cooking fuels and technologies. These results furnish substantial evidence of the roles played by fiscal policy, financial inclusion, and institutional factors in alleviating energy poverty in sub-Saharan Africa. While renewable energy consumption, income inequality, institutional quality, financial inclusion, and carbon dioxide emissions all contribute to the exacerbation of energy poverty within sub-Saharan African nations. The cross-sectional autoregressive distributed lag modeling underscores the indispensable role of financial inclusion and institutional quality in shaping the relationship between government expenditure and the accessibility of clean cooking fuels and technology. However, the findings vary when energy poverty is modeled in conjunction with the proportion of the population with access to electricity. The panel-corrected standard error estimations reveal that each parameter follows a distinct influence trajectory, and the coefficient values are inconsistent. This study provides critical policy implications for policymakers striving to enhance energy accessibility for the population in the explored subregion.
JEL Classification: O13, G20, E02, E62, P46

Keywords: Energy poverty, financial inclusion, government expenditure, institutional quality, panel data

Öz

Enerji yoksulluğunun belirleyicileri üzerine literatürdeki önemli bir boşluk, yerel kurumsal politikaların ve finansal kapsayıcılığın potansiyel düzenleyici rolündedir. Finansal kapsayıcılık, kurumsal kalite ve enerji yoksulluğu arasındaki bağlantılar, bu faktörlerin hükümet harcamaları ile enerji yoksulluğu arasındaki ilişki üzerinde önemli bir etkiye sahip olabileceğini ve sürdürülebilir kalkınmaya doğru ilerlemeyi nihayetinde etkileyebileceğini göstermektedir. Bu araştırma, Sahra Altı Afrika bağlamında hükümet harcamalarının enerji yoksulluğu üzerindeki etkisini inceleyerek bu bilgi boşluğunu kapatmayı amaçlamaktadır. Ayrıca, finansal kapsayıcılığın ve

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kurumsal kalitenin, bölge genelinde hükümet harcamaları ile enerji yoksulluğu arasındaki bağlantıda düzenleyici olarak hareket edip etmediğini incelemektedir. Sahra Altı Afrika ülkelerini kapsayan panel verileri kullanılarak, kısa ve uzun vadeli modellerden elde edilen ampirik bulgular, artan hükümet harcamalarının ve ekonomik büyümenin temiz pişirme yakıtlarına ve teknolojilere erişimi olumsuz etkilediğini doğrulamaktadır.

Anahtar Kelimeler: Enerji yoksulluğu, finansal kapsayıcılık, hükümet harcaması, kurumsal kalite, panel veri

Introduction

Energy poverty is an escalating global challenge with repercussions at both local and global levels. Numerous vulnerable populations worldwide grapple with the burdens of energy poverty (Ngarava et al., 2022). Interwoven with absolute poverty, energy poverty is intricately linked to gender inequality, economic hardships, and environmental degradation (Chevalier & Ouédraogo, 2009; Hamed & Peric, 2020; Ngarava et al., 2022). Tragically, the absence of affordable and suitable energy resources exacerbates the adverse consequences of poverty while also impeding health outcomes and hampering economic progress. The onset of the coronavirus disease 2019 (aka COVID-19) pandemic has had detrimental repercussions on individuals' health in multifaceted ways, further exacerbating energy poverty (Carfora et al., 2022). The adverse effects of energy poverty are expected to unfold progressively, with significant disparities among nations, ultimately resulting in a widening income gap between relatively prosperous and exceedingly impoverished nations (Carfora et al., 2022). A global trend is emerging, emphasizing the critical dynamics of recognizing energy poverty and the necessity for policy measures to protect vulnerable groups (Bienvenido-Huertas, 2021; Mastropietro et al., 2020). These studies underscore how lockdown measures have exacerbated energy poverty by increasing residential energy demand while reducing household incomes, particularly for low-income families. Diminishing household finances make it increasingly challenging to cover energy expenses (Werth et al., 2021).

Much research has been dedicated to exploring the connection between energy consumption and macroeconomic factors, revealing a positive correlation between energy consumption and economic growth (Shahbaz et al., 2020). Additionally, studies have examined the relationship between energy poverty and economic growth, as exemplified by Ullah et al. (2021), which identified an inverse relationship where energy imports contributed to 10% of gross domestic product (GDP) growth. Numerous empirical studies have investigated the factors contributing to energy poverty, ranging from household spending patterns to variables like education, household size, location, and electricity availability (Awaworyi Churchill & Smyth, 2020; Pereira et al., 2010; Sovacool, 2015), with an emphasis on the critical role of government action. While extensive research has explored the macroeconomic aspects of energy poverty (Nguyen et al., 2021), the comprehensive assessment of government expenditure's impact remains limited, particularly within the context of developing regions characterized by inefficient public spending (Nguyen, 2018). Government expenditure constitutes a pivotal component of fiscal policy, with substantial research highlighting its fiscal implications (Nguyen & Schinckus, 2020). Government spending decisions often necessitate trade-offs between costs and benefits (Dinh & Nguyen, 2019). Government spending can have a U-shaped impact on economic growth, initially bolstering it before excessive spending hinders growth and crowds out private investment (Hajamini & Ali, 2018). Income inequality, exacerbated by government spending, holds significance for growth and exacerbates energy poverty among low-income groups (Crudu, 2015). Institutional frameworks further shape the effectiveness of spending (Nguyen, 2018).

Remarkably, this review reveals a lack of research investigating the impact of government expenditure on energy poverty, while the literature also lacks studies examining how institutional quality and financial inclusion influence government spending in addressing energy poverty. This research paper endeavors to bridge four key knowledge gaps. First, it explores government expenditure and its impact on energy poverty. Moreover, it scrutinizes how institutional quality shapes government spending to address energy poverty. Anticipated outcomes from this study are expected to have substantial policy implications, especially concerning strategies to alleviate energy poverty through government support. Additionally, it investigates how financial inclusion influences government expenditures aimed at mitigating energy poverty. Consequently, the research aims to provide a deeper understanding of the ramifications of government spending on energy poverty, contributing to the sustainable development efforts of countries worldwide. Thus, given the escalating energy demands in sub-Saharan African urban centers, a substantial proportion of the urban poor remain without access to essential energy infrastructure. Sub-Saharan Africa (SSA) underscores several of the major challenges faced by African nations, including a rapidly growing population, a widening wealth gap, and inadequate energy infrastructure. This study endeavors to provide insights into government policies and their relationship to energy poverty, focusing on the influence of government expenditure. To do so, a comprehensive assessment of Sub-Saharan African countries from 2000 to 2019 is conducted, with a particular emphasis on indicators such as access to clean energy sources and technology, as well as total rural access to electricity, which serves as a proxy for energy poverty. The study employs the cross-sectional autoregressive distributed lag modeling (CS-ARDL) estimator to account for endogeneity and heteroscedasticity, with the panel-corrected standard errors (PSCE) technique employed to assess the model's robustness. As such, the subsequent sections of the paper are structured as follows: The next section provides a comprehensive review of the related literature, followed by an explanation of the research methodology in Section 3. Section 4 is dedicated to presenting and discussing the research results, and several policy implications are outlined in Section 5.

Review of Related Empirical Literature

The role of energy policy in economic development has been a subject of significant debate in the development literature. Lower energy prices have several notable benefits, with the foremost being the reduction of expenses for businesses and consumers, thereby increasing disposable income. Additionally, lower energy prices translate to reduced input costs for virtually all goods and services in the economy, ultimately lowering the cost of products and services. In theory, the relationship between energy poverty and economic growth is complex and ambiguous. Nevertheless, a plethora of empirical investigations, including studies by Kongbuamai, Bui, and Nimsai (2021), Singh and Inglesi-Lotz (2021), Acharya and Sadath (2019), Zhang et al. (2019), and Ullah et al. (2021), have predominantly focused on the impact of households' access to energy on economic growth. Acharya and Sadath (2019) conducted an examination of the impact of energy poverty on economic development in India using household-level data. Their findings revealed that energy poverty adversely affected India's economic development, and there was a strong correlation with socioeconomic backwardness. Furthermore, the study indicated that education and income levels both played a role in reducing energy poverty, with education having a more significant impact. A study by Amin et al. (2020) investigated the relationship between energy poverty and key macroeconomic indicators, including employment, per capita income, inflation, and output growth, using panel data from seven South Asian nations spanning from 1995 to 2017. Their findings revealed both short-term and long-term impacts of energy poverty on economic growth and emphasized the importance of transitioning to sustainable and environmentally friendly technologies to address ecological deterioration.

Recent studies have extended this examination to emerging economies. Ullah et al. (2021) explored how dimensions of energy poverty, including energy services, renewables, governance, and affordability, affect Pakistan's growth. Kongbuamai et al. (2021) assessed the impacts of growth, renewable and nonrenewable consumption, industrialization, and environmental policy on ecological footprints for BRICS (a coalition of Brazil, Russia, India, China, and South Africa) countries from 1995 to 2016. Raghutla and Chittedi (2021) emphasized the critical role of electricity access for the economic development of five major emerging economies from 1990 to 2018. These studies underline the intricate interactions between energy poverty, environmental sustainability, and growth patterns in developing economies. While African region has also witnessed a surge in research examining the dynamics of energy poverty and its relationship with various macroeconomic fundamentals. For example, Adusah-Poku and Takeuchi (2019) assessed the effects of energy poverty in Ghana, noting a decline in the proportion of poor individuals with access to energy. Singh and Inglesi-Lotz (2021) utilized the Generalized Method of Moments to evaluate the influence of energy poverty on economic growth in SSA from 1990 to 2016, finding that access to electricity contributed somewhat to economic growth in the region.

Notably, the previous literature predominantly focused on the influence of energy poverty on households, overlooking the role of government spending in mediating the energy poverty–economic growth nexus. This gap is significant because government spending is a crucial component of fiscal policy (Nguyen & Schinckus, 2020), and increased government spending can have a crowding-in effect, boosting economic growth (Bahal et al., 2018). In SSA, energy demands are rising in tandem with urbanization, yet many poor urban communities lack access to electricity infrastructure. This region exemplifies the core challenges facing African nations, from rapid population growth to substantial income disparities, energy poverty, and infrastructural deficiencies. Therefore, this study seeks to contribute to the current body of knowledge by examining how government policy, specifically government spending on addressing energy poverty, can facilitate access to energy infrastructure. This endeavor will expand on the work of Nguyen and Su (2022) and Ogede et al. (2023), offering insights into the relationship between government expenditure and energy poverty in SSA.

Material and Methods

Model Development and Data Description

We specify a baseline model based on the frameworks of Moore (2012) and Nguyen and Su (2022) to address the goal of examining the impacts of government expenditure on energy poverty in SSA. It expresses energy poverty as a function of income, energy consumption, and government expenditure, and a set of control variables:

$$EP_{it} = \omega_0 + \omega_1 INEQ_{it} + \omega_2 REN_{it} + \omega_3 GXP_{it} + \omega_4 Z_{it}' + \mu_{it} \quad (1)$$

where EP_{it} denotes energy poverty proxy with access to clean fuels and technologies for cooking (% of the population) and access to electricity (% of the population); $INEQ_{it}$ represents income inequality; *REN* denotes energy consumption; GXP_{it} denotes government expenditure; Z_{it}' represents the vector of control variables; ω_i denotes parameters to be estimated; and μ_{it} represents the general error term. The dependent variable is energy poverty. The key explanatory variables are government expenditure, energy usage, income inequality, financial inclusion, and institutional quality. The second objective is addressed by incorporating the interaction variables (*FI*GXP*) and (*IQX*GXP*) into equation (1), and the improved form of model (2) is formulated as:

$$EP_{it} = \bullet_0 + \bullet_1 INEQ_{it} + \bullet_2 REN_{it} + \bullet_3 GXP_{it} + \bullet_4 \left(FI_{it} * GXP_{it}\right) + \bullet_5 \left(IQX_{it} * GXP_{it}\right) + \bullet_6 Z_{it}' + \theta_{it} \quad (2)$$

where the variables (*FI*GXP*) and (*IQX*GXP*) are the interaction terms between financial inclusion and government expenditure and institutional quality and government expenditure. By looking at the coefficients of the interaction terms, η4 and η5, we can understand whether or not the long-run marginal effects of government expenditure on influencing or deteriorating energy poverty are dependent on the degree of financial inclusion and the quality of institutions in SSA countries. By analyzing partial derivatives of energy poverty and government expenditure at given levels of financial inclusion and institutional quality, the total effect of government expenditure can be estimated from the marginal effects of government expenditure. Equations (3) and (4) here outline the conditional marginal effects.

$$\frac{\delta lnEP_{it}}{\delta lnGXP_{it}} = \eta_1 + \eta_4 lnFI_{it} \quad (3)$$

$$\frac{\delta lnEP_{it}}{\delta lnGXP_{it}} = \eta_1 + \eta_5 lnIQ_{it} \quad (4)$$

Moreover, we suggest that if all of the derivatives are positive, then complementarity between government expenditure and financial inclusion and government expenditure and institutional quality can be seen as a means of improving energy poverty. A rise in government expenditure or the inclusion of financial services would increase the quality of energy access. The only circumstance for this to happen is if parameters 1, 4, and 5 are all positive. Alternatively, if one or both coefficients are negative, then substitution between the variables is evidence of an interaction. As a result, derivatives can be evaluated within the sample since they depend on either the level of financial inclusion, the level of institutional quality, or both (Brambor et al., 2006). The study, however, utilizes panel data for sub-Saharan African countries from 2000 to 2019 to empirically analyze the research objectives. The data is obtained from various sources, including the World Bank's World Development Indicators, the Financial Development and Structure Database, and the Standardized World Income Inequality Database. The sample includes those SSA countries1 with sufficient available data for the main variables of interest: energy poverty, government expenditure, renewable energy consumption, income inequality, financial inclusion, and institutional quality. Control variables such as GDP per capita and carbon dioxide (CO_2) emissions are also incorporated. This panel dataset allows for an exploration of the heterogeneity within SSA while examining the key relationships between energy poverty, public spending, environmental factors, and socioeconomic inclusion across the region over the past two decades.

Meanwhile, the definition of energy poverty is based on the percentage of the population with access to clean fuels and technology for cooking and the percentage of the population with access to electricity, according to Gonzalez-Eguino (2015), Awaworyi and Smyth (2020), Awaworyi et al. (2020), and Nguyen and Su (2022). Hence, these two indicators can be used for comparing energy poverty in cross-country studies, as they are among the most crucial indicators. As a further proxy, government expenditure is approximated by general government final consumption expenditure (% of GDP), as indicated in Nguyen and Su (2022) and Ogede et al. (2023). In accordance with the study's purpose, the institutional quality index measures the average control of corruption, rule of law, regulatory quality, government effectiveness, political stability, and voice and accountability. This study employs an inequality index to measure income inequality. It builds on previous research by Lecuna (2019), Ogede and Tiamiyu (2022), and others that examined trends in the Gini coefficient and best practices for assessing inequality using available data sources (Lecuna, 2019; Maku et al., 2021; Mocan, 1999; Ogede, 2020). Additionally, following Le et al. (2019), Nguyen (2020), and Ogede and Tiamiyu (2023), a composite financial inclusion index is constructed, capturing three key dimensions: penetration, availability, and usage. The index incorporates variables related to automated teller machines (ATMs), account ownership at financial institutions, and commercial bank branches to provide a multidimensional measure of financial inclusion levels. Detailed descriptions of these variables are provided in Table 1 below.

As a consequence, the descriptive statistics are reported in Table 2. The average of % of the population having access to clean fuels and technology for cooking (EP1), % of the population having access to electricity (*EP2*), government expenditure (*GXP*), renewable energy consumption (*REN*), income inequality (*INEQ*), institutional quality (*IQX*), financial inclusion (*PAFI*), economic growth (*PCG*), and CO_2 emission are 25.133, 39.834, 15.127, 64.109, 45.565, −0.516, 0.159, 2404.3, and 1.117, respectively, from the SSA sample. The variable RE is found to be negatively skewed, while *EP1*, *EP2*, *GXP*, *INEQ*, *IQX*, *PAFI*, *PCG*, and *CE* are seen to be positively skewed. It can be seen that *EP2*, *RE*, and *IQX* are platykurtic, while *EP1*, *GXP*, *INEQ*, *PAFI*, *PCG*, and *CE* are leptokurtic.

Estimation Strategy

The initial econometric analysis examines the panel dataset for cross-sectional dependence and slope heterogeneity given the economic and spatial interlinkages among the selected sub-Saharan African countries. Identifying such issues is crucial, as failing to do so can result in misleading model estimates. The Pesaran (2007) test is applied to detect cross-sectional dependence. Additionally, the Pesaran and Yamagata (2008) approach tests for slope heterogeneity across countries, which is likely due to differing macroeconomic conditions. After checking cross-sectional

1 Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Eswatini, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Madagascar, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Uganda, Zimbabwe.

Table 1.
Variable Description and Expectations

Variable	Descriptions	Source(s)
Economic growth (PCG)	Gross domestic product per capita (constant 2015 US$)	World Bank, WDI
Energy poverty (EP1)	% of the population with access to clean fuels and tech. for cooking	World Bank, WDI
Energy poverty (EP2)	% of the population with access to electricity	World Bank, WDI
Automated teller machines (ATM)	Automated teller machines per 100,000 adults	World Bank, WDI
Account ownership (AMM)	% of pop. ages 15+ having an account at a financial institution/with a mobile-money-service provider	World Bank, WDI
Comm. bank branches (CBB)	The ratio of the commercial bank branches per 100,000 adults	World Bank, WDI
Physical access index of FI (PAFI)	Physical access measures the financial inclusion index generated through PCA of ATM, ACNT, and BRCH	Author's computation
Renewable energy consumption (REN)	% of total final energy consumption to renewable energy consumption	World Bank, WDI
Income inequality (INEQ)	Index of Gini coefficient	SWIID
Institutional quality (IQX)	Institutional quality[1]	Author's computation
Government expenditure (GXP)	General government final consumption expends. (% of GDP)	World Bank, WDI

Note: The data provided in the table are sourced from a research finding.

1 IQX is defined as average of control of corruption, rule of law, regulatory quality, government effectiveness, political stability, and voice and accountability.

dependence and slope heterogeneity, second-generation panel unit root tests are conducted using the cross-sectionally augmented IPS technique developed by Pesaran (2007). This allows for consistent stationarity analysis in the presence of cross-sectional dependencies. Westerlund (2007) and Kao residual cointegration tests determine whether the heterogeneous variables are cointegrated. The study then employs CS-ADRL modeling to examine the nexus between energy poverty and government expenditure and the moderating effects of financial inclusion and institutional quality for a 29-country SSA panel. CS-ARDL is an extension of the Autoregressive Distributed Lag (ARDL) model that accounts for common features among the variables. The technique also accounts for heterogeneity and cross-section dependence by incorporating dynamically common correlated effects. The CS-ARDL model provides short- and long-run estimates to analyze the objectives across the panel dataset with dependencies (Çoban & Topcu, 2013; Yao et al., 2019). However, CS-ARDL models can become complex when dealing with a large number of variables and common features, making interpretation and estimation more challenging. The CS-ARDL is structured as:

Table 2.
Descriptive Statistics

Variable	Mean	Median	Maximum	Minimum	S.D.	Skewness	Kurtosis
EP1	25.133	8.300	100.00	0.100	30.392	1.157	3.209
EP2	39.834	35.249	100.00	1.2537	26.536	0.7613	2.705
GXP	15.127	14.734	39.452	0.9518	5.7315	0.797	4.473
RE	64.109	76.193	96.041	0.709	26.357	−0.921	2.686
INEQ	45.565	43.500	66.100	31.600	7.775	0.979	3.276
IQX	−0.516	−0.579	0.879	−1.66	0.597	0.354	2.558
PAFI	0.159	−0.3509	7.261	−1.286	1.518	1.946	6.682
PCG	2404.3	1152.5	15913.9	278.3	2921.7	2.156	7.823
CE	1.117	0.379	9.094	0.022	1.859	2.631	9.413

Note: The data provided in the table are sourced from a research finding.

$$EP_{it} = \omega_0 + \sum_{j=1}^{p_{ep}} \varnothing_{it} EP_{i,t-j} + \sum_{j=0}^{p_x} \varphi_{it} X_{t-j} + \sum_{j=0}^{p_z} itZ_{t-j} + \mu_{it} \ldots\ldots\ldots\ldots \quad (5)$$

where Z=(ΔEP_{it} , X_t X_t) and "X" represents the explanatory variables set previously discussed. The Panel Corrected Standard Errors (PCSEs) estimator developed by Beck and Katz (1995) was used to reestimate the long-run elasticities for the SSA panel as a robustness check. This is due to its capacity to provide precise standard error estimation with no loss in efficiency (Reed & Webb, 2010).

Results

The estimates of the slope coefficient homogeneity and cross-section dependence (CD) coefficients are provided in Table 3. The coefficient estimates are statistically significant at the 1% level, indicating cross-section dependence. It is also established that the factors across countries share identical properties, leading to the adoption of the null hypothesis. The panel unit root estimates are provided in Table 4 after the CD and slope heterogeneity issues of the data have been confirmed. All different approaches explored for use in this study yielded results that were consistent with the findings. The stationarity of the variables precludes the prediction of spurious regression outcomes. Table 5 summarizes the findings of the panel cointegration investigation. The statistical significance of the test statistics According to Westerlund and Kao's cointegration methodologies, there exist long-run connections between variables in the context of the sub-Saharan African economies studied in this study. The validation of long-run cointegration completes the prerequisite for predicting the long-run elasticities of energy poverty.

After confirming the long-term cointegration relationship among the variables, this study investigates both the short- and long-term impacts of each explanatory variable on energy poverty in the selected economies. Tables 6 and 7 present the empirical findings obtained using the CS-ARDL approach, with EP1 and EP2 serving as alternate dependent variables. Table 6 illustrates the short- and long-term findings for EP1 using the CS-ARDL method. Short-term estimates reveal that in several sub-Saharan African nations, energy poverty, measured by the proportion of the population with access to clean fuels and cooking equipment, is negatively affected by both government spending and economic growth, proxied by per capita income in model 1 (column 1). Renewable energy usage, income inequality, institutional quality, financial inclusion, and CO_2 emissions all have a favorable impact on energy poverty in SSA countries. Specifically, a 1% increase in government spending decreases energy poverty by 0.3%, while a 1% increase in per capita growth results in a 0.001% reduction in energy poverty. The findings align with theoretical considerations suggesting that improved and more inclusive financial services and goods are essential aspects of the institutional framework, as they improve access to clean fuels and cooking technology. However, energy poverty increases by 0.018% for every 1% rise in renewable energy usage, whereas institutional quality improves by 1%, indicating a beneficial influence. A unit increase in income inequality in SSA increases access to clean cooking fuel and technology by 0.163%, while a 1% increase in financial inclusion generates a 0.118% increase in energy poverty. Thus, government investment reduces the availability of clean fuels and technology in SSA nations. These findings are consistent with Nguyen and Su's research (2022). After introducing the interacting variables of financial inclusion and institutional quality to model 2 (column 2), the direction of influence remains consistent, but the magnitude of each variable's coefficient changes. In the short term, the findings suggest that if institutional quality and financial inclusion move in the same direction for a brief period, the results may enhance access to clean technologies and fuels (energy poverty). However, when institutional quality improves, government expenditure positively affects energy poverty. The government's support for inclusive financial services would exacerbate energy poverty in the long run. Therefore, enhancing financial inclusion and institution quality significantly improves citizens' access to cleaner fuels and cooking technology, which are vital for shifting energy spending to promote renewable energy.

The long-term estimates of the CS-ARDL for the same variable in columns 3 and 4 yield different outcomes. Specifically, in column 3, the use of renewable energy, income inequality, financial inclusion, and CO_2 emissions improve energy poverty in SSA nations. Table 3 also indicates that lower access to energy is associated with reduced government spending, institutional quality, and economic growth. A 1% increase in renewable energy consumption, income inequality, financial inclusion, and CO_2 emissions results in a reduction in energy poverty in SSA by 0.148%, 1.176%, 5.026%, and 5.816%, respectively. Government spending, institutional quality, and economic growth, on the other hand, significantly exacerbate energy poverty at 1% and 5% significance levels, respectively. The interactive model in Table 6 (column 4) also illustrates that if institutional quality and financial inclusion continue to move in the same direction over time, the consequences could be beneficial in increasing access to clean technology and fuels. However, when institutional quality improves, government expenditure has a positive impact on energy poverty. The government's support for inclusive financial services would

Table 3.
Result of Cross-Sectional Dependence and Slope Homogeneity Tests

Methods	Statistic	p
Pesaran's cross-sectional dependence test	8.602*	.001
Friedman's cross-sectional dependence test	19.697**	.011
Frees' cross-sectional dependence test	7.506*	.000
Slope homogeneity (delta ($\tilde{\Delta}$) test)	15.125*	.001
Slope homogeneity (adj. delta ($\tilde{\Delta}$) test)	16.206*	.000

Note: The data provided in the table are sourced from a research finding.
$^{**}p < .05$. $^{*}p < .01$.

Table 4.
Results of Panel Unit Root Test

Variables	LLC	BS	IPS	ADF	PP	CIPS
Level *I*(0)						
EP1	−5.314*	1.84506	−1.95439*	87.5283*	167.117*	−1.87437
EP2	−7.677*	2.00778	−5.00149*	136.666*	167.117*	−2.54319
GXP	−0.9104	−0.17054	0.25609	60.0477	63.33	−2.7308
REN	−2.2085*	−0.3471	−0.71205	65.2577	57.4081	−3.1328
INEQ	3.3860	5.87891	4.32179	49.3758	102.599*	−2.4671
IQX	−4.4368*	−2.36271*	−2.86769*	100.843*	88.3728*	−3.1435
CE	−2.5359	−1.2843***	−0.83905	66.7095	72.4741***	−1.6392
PCG	0.25341	4.15164	1.73156	51.9905	51.1533	−2.5794
PAFI	−0.4255	3.44541	2.06407	48.8445	28.2754	−2.8168
FIXP	0.3808	3.39827	1.48183	52.7142	55.6804	−4.1043
IQXP	−5.0902*	−1.84135*	−3.34169*	−3.34169*	92.5512*	−1.87491*
First difference *I*(1)						
EP1	−15.2902*	−5.68153*	−20.1960*	366.682*	512.432*	−8.3542*
EP2	−6.96339*	−8.21646*	−11.9678*	237.943*	543.055*	−9.2471*
GXP	−15.5385*	−9.21384*	−13.3108*	259.121*	370.338*	−7.8342*
REN	−15.7942*	−11.7692*	−13.1032*	246.174*	266.528*	−7.3961*
INEQ	−11.0495*	−9.8742*	−8.83358*	209.025*	242.447*	−9.10351*
IQX	−8.92594*	−7.93820*	−9.50154*	194.218*	399.632*	−11.8947*
CE	−14.6885*	−9.79515*	−10.9713*	213.668*	298.832*	−11.3692*
PCG	−10.6215*	7.58600*	−11.6113*	226.277*	267.932*	−8.9472*
PAFI	−16.9203*	3.95145*	−20.6712*	331.166*	487.288*	−9.19042*
FIXP	−12.1538*	−0.43787*	−10.0467*	219.883*	296.211*	−8.5396*
IQXP	−8.65124	−5.8637	−8.83357	184.594	378.935	−11.4927*

Note: The results are calculated for both intercept and trend. The data provided in the table are sourced from a research finding.
ADF = Augmented Dickey–Fuller; BS = Breitung *t*-stat; CIPS = cross-sectionally augmented IPS; IPS = Im, Pesaran, and Shin; LLC = Levin, Lin, and Chu; PP = Phillips–Perron.
*$p < .01$. **$p < .05$. ***$p < .10$.

exacerbate energy poverty in the long run. Improved access to clean fuels and cooking technologies, as well as support for greater renewable energy usage, necessitate inclusive financial services and institutions. However, financial inclusion statistics indicate that more funds will be available for economic activity due to the positive impact of access to clean fuels and cooking equipment. Given that various electrification efforts have not affected decreasing energy poverty in SSA, this has significant policy implications. For instance, despite significant investments in electrical infrastructure, Nigerians remain without reliable access to energy due to the energy crisis.

Table 7 presents the results from the CS-ARDL method, with the percentage of the population with access to electricity (EP2) as the dependent variable, along with short- and long-term outcomes. Short-term estimates in column 1 reveal that, as shown in Table 6, the coefficients for the direction of influence of each variable have various signs and magnitudes. Short-term estimates suggest that renewable energy consumption, institutional quality, financial inclusion, and CO_2 emissions in model 1 have a negative impact on energy poverty, measured as the proportion of the population with access to electricity in selected SSA nations (column 1). Notably, financial inclusion has an adverse effect on access to power, implying that higher financial inclusion leads to a more significant reduction in energy poverty in SSA countries. This conclusion supports the findings of Koomson and Danquah (2021). In the same model, government spending, income inequality, and the economic

Table 5.
Panel Cointegration Tests

	Kao Statistic	Westerlund Statistic
Modified Dickey–Fuller test	−1.764**	–
Dickey–Fuller test	−2.492**	–
Augmented Dickey–Fuller test	−3.517*	–
Unadjusted modified Dickey–Fuller test	−3.196*	–
Unadjusted Dickey–Fuller test	−3.156*	–
Modified Phillips–Perron test	–	–
Phillips–Perron test	–	–
Variance ratio	–	29.319*

Note: The data provided in the table are sourced from a research finding.
*$p < .01$. **$p < 0.05$.

growth proxy using per capita income all have a positive impact on energy poverty in SSA countries. A 1% increase in renewable energy usage, for example, reduces energy poverty by 0.78%. Similarly, a 1% increase in institutional quality, financial inclusion, and, CO_2 emissions decreases the percentage of the population in specific SSA nations with access to electricity by 4.8%, 14.9%, and 15.9%, respectively. These results contradict the claim by Nguyen and Su (2022) that government spending negatively affects access to power. Conversely, a 1% increase in government spending, income inequality, and economic growth contributes to increased access to electricity by 0.21%, 1.18%, and 0.09%, respectively.

After the incorporation of an interacting factor for financial inclusion and institutional quality in model 2 (column 2), the path of influence for each parameter's coefficient remains constant, but the magnitude of the impact fluctuates. Hence, concentrating on the interaction variable in the near term, specifically in column 2, the findings demonstrate that if institutional quality and financial inclusion move in the same direction for a short period, the effects on improving access to electricity may be negative (energy poverty 2). When the quality of institutions is considered, however, government investment has a positive impact on energy availability. The findings have a number of implications for long-run CS-ARDL calculations. Column 4 particularly mentions government spending, renewable energy consumption, wealth disparity, financial inclusion, and economic growth as factors limiting access to electricity in SSA countries. Increases in government investment, renewable energy consumption, income disparity, institutional quality, financial inclusion, and economic growth of each 1% will result in long-term reductions in access to electricity in SSA. These are 0.212, 0.238, 0.004, 3.281, 4.917, and 0.003, respectively. Table 7 also demonstrates a negative association between *FI*GXP* and *IQX*GXP* and subregional electricity access. Interactions between institutional quality, government spending, and financial inclusion, on the other hand, significantly diminish access to energy at a 5% level of significance. These empirical findings contradict those of Nguyen et al. (2021), who stated that the expansion of the financial sector will increase efficiency in the power industry by adopting consistent regulatory norms to ensure equitable access to electricity.

As previously stated, the robustness of the empirical model and technique will be checked using the PCSE. The outcome of the PSCE is presented in Table 8. The PCSE estimates confirmed that the path of influence for each parameter is diverse in both models and choice of energy poverty indicator. The values of the coefficients are also inconsistent, suggesting that the outcomes depend on the choice of variable and methodology.

Discussion

While existing literature has extensively explored the relationship between government spending and energy poverty, a significant gap remains regarding the specific roles of financial inclusion and institutional quality in moderating this relationship. This study fills this void by investigating the impact of government expenditure on energy poverty in SSA for the period 2000–2019, utilizing panel data encompassing countries within the region. Furthermore, it conducts an analysis of the moderating effects of financial inclusion and institutional quality on the nexus between government spending and energy poverty. To achieve these research objectives, we employ a combination of cross-sectional ARDL modeling and panel-corrected standard error estimation. The results from both short- and long-term CS-ARDL estimates unveil a complex dynamic where increases in government expenditure and economic growth are associated with reduced energy poverty. Intriguingly, the study also reveals that renewable energy consumption, income disparity, institutional quality, financial inclusion, and CO_2 emissions all play a contributing role in exacerbating energy poverty within SSA nations. Equally noteworthy are the findings related to the interplay of determinants: the combination of financial inclusion with government expenditure and institutional quality with government expenditure exhibits a positive association with improved access to clean fuels and cooking technology in SSA. Furthermore, the robustness of the findings was assessed by modeling energy poverty using the proportion of the population with access to electricity in the CS-ARDL framework, resulting in alterations in both the direction of influence and the magnitudes of each coefficient. The use of PCSE estimations further highlighted the unique paths of influence for each parameter, with inconsistent coefficient values, underscoring the influence of various factors, and methodologies on the study's outcomes.

The findings have some important policy repercussions for decision-makers trying to give the people of the SSA access to electricity. First, it was shown that government spending negatively affects energy poverty. For a number of SSA countries, which struggle with financial and energy issues, this is not promising. We recommend a level of government expenditure as a proportion of GDP to address this issue, restricting excessive

Table 6.
Cross-Sectional Autoregressive Distributed Lag Modeling Results for the Sub-Saharan Africa: Energy Poverty

	Short Run			Long Run	
Variables	[1]	[2]	Variables	[3]	[4]
Δ*GXP*	−0.030***	−0.032	*GXP*	0.173*	−0.018**
	{0.017}	{0.026}		{0.184}	{0.020}
Δ*RE*	0.018	0.016	*RE*	−0.148**	0.034*
	{0.031}	{0.029}		{0.140}	{0.025}
Δ*INEQ*	0.163	0.214	*INEQ*	−1.176	0.139
	{0.117}	{0.140}		{0.117}	{0.131}
Δ*IQX*	0.282	0.172**	*IQX*	0.988**	0.186***
	{0.328}	{0.228}		{0.829}	{0.289}
Δ*PAFI*	0.118	0.198**	*PAFI*	−5.026	0.218**
	{0.334}	{0.434}		{4.741}	{0.334}
Δ*CE*	2.498	1.133	*CE*	−5.816**	0.012**
	{1.917}	{0.020}		{7.656}	{2.656}
Δ*PCG*	−0.001	−0.001	*PCG*	0.004*	−0.001
	{0.001}	{0.001}		{0.005}	{0.001}
Δ*FI*GXP*		0.003	*FI*GXP*		0.0003**
		{0.020}			{0.028}
Δ*IQX*GXP*		0.019	*IQX*GXP*		0.008*
		{0.022}			{0.015}
ECM (−1)	−1.351	−1.457*			
	{0.130}	{0. 134}			
Observations	580	580	Observations	580	580
R-squared	0.92	0.91	*R*-squared	0.92	0.91
F-statistic	1.67*	1.70*	F-statistic	1.67*	1.70*

Note: The data provided in the table are sourced from a research finding. Standard error in { }.
*p < .01. **p < .05. ***p < .01.

spending to stop the growth of energy poverty while improving access to energy resources. To maximize benefits from this increase in spending, effective fiscal restraint and better transparency in the distribution and use of public funds should be included. It also calls for a regulatory framework that enables regulators to carry out the required work as part of their long-term plan to improve access to various energy sources in order to advance the sustainability agenda. The government should embrace the global green transition in order to advance the sustainability goal by incorporating environmental and climate change concerns into its financial frameworks and expanding the much-needed renewable energy infrastructure. Second, a policy stimulus is necessary in light of the results that the use of renewable energy, economic inequality, institutional quality, financial inclusion, and CO_2 emissions are all factors that lead to growing energy poverty in SSA countries. According to research showing a strong correlation between energy poverty and income inequality, it is possible that people of SSA nations have more difficulty accessing energy resources as a result of economic disparity. In general, economic disparity would have an impact on how quickly growth makes it possible to reduce energy poverty. In light of the findings, we argue that it is crucial for policymakers in SSA countries to create a framework targeted at taking the externality of income disparity in government spending into account. The position of Nguyen and Su (2022) is justified by this information. Thirdly, financial inclusion and institutional quality are reported to have a beneficial association. As a result of the findings, financial inclusion is a vital component of social inclusion that may be used to relieve energy poverty by opening up previously blocked advancement opportunities for disadvantaged sectors of the SSA population. As a result, policymakers in SSA economies should devise a

Table 7.
Cross-Sectional Autoregressive Distributed Lag Modeling Results for the Sub-Saharan Africa: Energy Poverty 2

	Short Run			Long Run	
Variable	[1]	[2]	Variable	[3]	[4]
Δ*GXP*	0.212	0.026	*GXP*	6.092**	−0.212**
	{0.363}	{0.525}		{0.363}	{0.315}
Δ*RE*	−0.788***	−0.213	*RE*	−7.378**	−0.238**
	{0.426}	{0.404}		{0.192}	{0.158}
Δ*INEQ*	1.184	0.385	*INEQ*	8.252**	−0.004
	{2.706}	{1.706}		{1.021}	{0.629}
Δ*IQX*	−4.821	−2.291**	*IQX*	−7.345	−3.281**
	{7.009}	{4.009}		{3.109}	{5.009}
Δ*PAFI*	−14.97*	−12.71*	*PAFI*	−8.363**	−4.917**
	{5.821}	{0.421}		{3.743}	{6.211}
Δ*CE*	−15.89	−3.655	*CE*	−2.309	0.343
	{30.73}	{31.76}		{16.09}	{14.37}
Δ*PCG*	0.009	−0.008	*PCG*	6.402**	−0.003
	{0.017}	{0.009}		{0.013}	{0.004}
Δ*FI*GXP*		−0.675*	*FI*GXP*		−0.328**
		{0.247}			{0.155}
Δ*IQX*GXP*		−0.258	*IQX*GXP*		−0.212**
		{0.476}			{0.179}
ECM (−1)	−2.31	−2.459			
	{0.134}	{0. 133}			
Observations	580	580	Observations	580	580
R-squared	0.75	0.79	*R*-squared	0.75	0.79
F-statistic	2.55**	1.52**	F-statistic	2.55**	1.52**

Note: The data provided in the table are sourced from a research finding. Standard error in { }.
$^*p < .1$. $^{**}p < .05$. $^{***}p < .01$.

legislative framework that allows regulators to adopt innovative and formal financial services suited to financially excluded sectors of the population, given that demand for financial services differs according to income levels. Similarly, initiatives to improve institutional quality through battling corruption would be more effective than enhancing institutional quality alone in alleviating energy poverty in SSA economies. The importance of renewable energy usage is also emphasized. We contend that renewable energy resources may be used to alleviate energy poverty and boost production. Last but not least, the findings indicating the interaction of financial inclusion and government expenditure upon energy poverty is negative, as well as the relationship between institutional quality and government expenditure on energy poverty, crave attention. Deductively, we infer that financial inclusion and institutional quality increase energy poverty, supporting the financial inclusion and institutional quality-led energy poverty hypothesis, and that government spending is an energy poverty reduction policy tool. The findings also suggest that institutional quality inevitabilities could reduce the negative impact of government spending and could be used as a significant driver through which energy markets provide an opportunity for authorities to promote strategies to address energy poverty and other energy deficiencies.

The current study, despite its valuable insights, is subject to several limitations that open up avenues for future research. First, the study focuses on the SSA region, and the findings may not be directly applicable to other regions with different socioeconomic and energy dynamics. Future studies could expand the geographical scope to include a more diverse range of countries and regions to enhance the generalizability of the

Table 8.
panel-Corrected Standard Errors Results for the Sub-Saharan Africa (Dependent Variable: Energy Poverty 1/Energy Poverty 2)

Variable	EP1 [1]	EP1 [2]	EP2 [3]	EP2 [4]
GXP	0.032**	0.326*	−0.196**	−0.184**
	{0.041}	{0.057}	{0.088}	{0.104}
RE	−0.21*	−0.244*	−0.223*	−0.226*
	{0.030}	{0.033}	{0.057}	{0.059}
INEQ	0.046	0.257*	−0.124**	−0.119**
	{0.042}	{0.048}	{0.087}	{0.085}
IQX	−0.761*	1.761*	0.514*	0.314*
	{0.850}	{0.504}	{1.716}	{1.316}
PAFI	0.492	0.261	0.902	0.502
	{0.429}	{0.209}	{0.970}	{0.704}
CE	1.248**	1.508**	0.881	0.734**
	{0.549}	{0.602}	{0.609}	{0.607}
PCG	0.006*	0.006*	0.005*	0.005**
	{0.000}	{0.000}	{0.001}	{0.001}
*FI*GXP*		−0.019		0.025
		{0.022}		{0.033}
*IQX*GXP*		−0.077***		−0.632
		{0.046}		{0.078}
Observations	580	580	580	580
R-squared	0.709	0.763	0.764	0.886
Wald statistic	359.49*	606.4*	227.39*	164.3*

Note: The data provided in the table are sourced from a research finding. Standard error in { }.
*$p < .1$. **$p < .05$. ***$p < .01$.

findings. Secondly, the analysis is based on data from 2000 to 2019, and it does not account for the potential impact of recent developments and policy changes. Researchers could investigate how more recent data and policy shifts affect the relationship between government spending, financial inclusion, and energy poverty. Thirdly, this study employs a panel data approach, which, while valuable, has its own limitations, such as potential endogeneity issues. Future research could explore alternative methodologies and conduct more in-depth econometric analyses to address these concerns. Lastly, the study primarily focuses on the impact of government spending, financial inclusion, and institutional quality on energy poverty. Future studies could delve deeper into the underlying mechanisms and explore the role of specific policies and interventions in addressing energy poverty, providing more actionable insights for policymakers. Additionally, a comparative analysis of different policy approaches in various countries or regions could further inform effective strategies to combat energy poverty.

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