

Does Globalization Improve Access to Clean Fuels and Technologies for Cooking in African Countries?

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Abstract

This paper analyzes the effects of overall globalization and its three sub-dimensions (economic, social and political globalization) on access to clean fuels and technologies for cooking, using data from 31 African countries from 2000 to 2020. Evidence from instrumental-variable (IV) two-stage least squares (2SLS) approach (IV-2SLS) highlights that the overall, social and political globalization improve access to clean fuels and technologies for cooking. Additionally, the investigation reveals that economic growth, information and communications technology, remittances, environmental degradation and financial development improve transition to clean cooking technologies in the selected countries. We recommend that policies promoting globalization would improve access to clean cooking fuels.

Keywords

Clean Cooking Fuels and Technologies, Pollution, Globalization, Energy Transition, Africa

1. Introduction

Africa has a serious problem of access to clean cooking fuels. According to the latest World Bank statistics, over 881 million people in Africa lack access to clean cooking fuels, and depend largely on traditional polluting fuels and technologies for cooking, with wide disparities between different regions of Africa, and between rural and urban areas. This reliance on non-clean energy for cooking poses a number of (environmental and social) problem (which impede achievement of the 7th SDG). Lack of access to modern and clean cooking fuels impacts the health condition of women and children (Owili et al., 2017; Liu et al., 2020; Dagnachew et

al., 2020; Tian et al., 2021; Bakehe, 2021a; Aemro et al., 2021; Pallegedara & Kumara, 2022), accelerates deforestation process (Bakehe & Hassan, 2022), increases pressure on natural resources such as wood used as solid fuel for cooking (Dagnachew et al., 2020). The non-access to clean cooking energy also increases the time spent by women and children to collect firewood in rural areas (Burke & Dundas, 2015; Biswas & Das, 2022), reduces labor force participation (Stabridis & van Gameren, 2018; Bakehe, 2021b; Bakehe, 2021c), school attendance, years of schooling and appropriate age grade progression among children (Biswas & Das, 2022).

To achieve the sustainable development goal 7 (SDG 7), which aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030, globalization can be an important lever through its positive effects on technologies and knowledge transfer, governance, financial development. Globalization refers to the economic, social and political interconnection between different countries. A large and growing body of studies have highlighted the role of globalization on energy transition, but its effects on access on clean cooking fuels remain insufficiently discussed, particularly in Africa.

The main objective of the paper is to examine the effects of globalization on access to clean fuels and technologies for cooking in 31 African countries for the period 2000-2020. Unlike the previous studies investigating the macroeconomics determinants of access to clean fuels and technologies for cooking. In the best of our knowledge, this paper is the first effort to investigate the effect of globalization on clean cooking fuels. This paper contributes to the literature by investigating the macroeconomics determinants of access to clean fuels and technologies for cooking in developing countries. To the best of the authors' knowledge, this is the first effort to provide empirical evidence on the impact of globalization on rural-urban access to clean cooking fuels and technologies in African countries. Prior empirical studies only Murshed (2023) examined the effect of income inequality on rural access to clean cooking fuels and technologies in Latin American and Caribbean countries. In addition, some emerging empirical studies have the impact of democracy and governance on rural electrification and rural access to clean fuels and technologies for cooking in Latin America and the Caribbean countries.

This paper uses the globalization index, initially developed by Dreher (2006) and improved by Gygli et al. (2019), which decomposes globalization in three sub-dimensions (economic globalization, social globalization and political globalization). Furthermore, the paper applies the Driscoll-Kraay standard-errors (DKSE) and Panel-Corrected Standard Error (PCSE) estimators' techniques to capture the objectives of the study. Both methods are robust to control for cross-sectional dependence, endogeneity, and heterogeneity. In addition, following Dagnachew et al. (2020) and Aemro et al. (2021) who highlight the evidence of large disparities between urban and rural areas in access to clean fuels and technologies for cooking, this takes into account the effects of globalization on the urban-rural dispar-

ities in access to clean fuels and technologies for cooking. Eventually, we investigate the determinants of access to clean fuels and technologies for cooking across geographical region in Africa. For instance, in 2020, only 17% of the population have access to clean cooking fuel in Sub-Saharan Africa, while in North Africa we have about 95%.

The objective of this study is to investigate the effect of globalisation on access to clean cooking fuels. More precisely, we examine the impact of the various dimensions of globalisation on access to clean cooking fuels. Furthermore, we analyse the effect of globalisation across different regions in Africa, distinguishing between rural and urban areas.

This paper contributes to the existing literature in three key ways. First, it enriches the body of research on the relationship between globalisation and access to clean cooking fuels. While some existing studies have measured globalisation solely through trade openness, globalisation extends far beyond the economic dimension to encompass social and political aspects, which could lead to biased results. Second, we differentiate the effects of globalisation by place of residence, geographical region, and de facto versus de jure measures.

The rest of the article is organized as follows. Section 2 provides a summary of the literature review. In Section 3, we provide the methodology. Empirical results and discussions are presented in Section 4. And the last section of the paper concludes and discusses policy recommendations.

2. Literature Review

2.1. Theoretical Underpinnings

Theoretically, there are good reasons to expect that globalization can affect access to clean fuels and technologies for cooking either directly or indirectly. Directly, globalization can affect access to clean fuels and technologies for cooking, on the one hand, through technologies and knowledge transfer. The literature suggests that globalization increases knowledge sharing. On the other hand, globalization improves the expansion of investment in cleaner energy. Indirectly, globalization affects access to clean cooking fuels through its effects on income, economic growth, ICT and financial development. A large body of literature highlights that globalization positively affects income by improving remittances. A lack of income reduces the ability of households to be able to access the clean cooking fuels. Several studies showed that remittances have a positive impact on households income in recipient countries (De & Ratha, 2012). The resulting increase income from remittances alleviates energy poverty and allows households to have access to modern energy sources (Barkat et al., 2023; Djeunankan et al., 2023). The second channel through which globalization affects access to clean cooking fuels is through economic growth. Indeed, as argued by Acheampong (2023), a lack of access to financial service affects access to clean fuels. The last channel is relative to ICT, ICT adoption improves cooking fuels transition from traditional dirty cooking fuels to modern clean cooking fuels. In the same vein, ICT is an important

source of information concerning both the disadvantages of using dirty cooking fuel, and the advantages of using modern clean cooking fuels (Kumar & Igdalsky, 2019; Acharya & Marhold, 2019; Murshed, 2020a).

2.2. Empirical Debate

Draws from the existing literature, two sub-groups of the determinants of cooking fuel choices can be identified. The first category, investigated microeconomic determinants of cooking fuel choices such as economic status (Alem et al., 2016), urbanization (McLean et al., 2019b), electrification (Gupta & Pelli, 2021), price of alternative energy sources (Waleed & Mirza, 2022), education (Hou et al., 2017; Paudel et al., 2018; Liao et al., 2019; Gould et al., 2020; Zhu et al., 2022), information and communication technologies (ICT) (Acharya & Marhold, 2019), household income, household size, fuel price, gender of the household head, and ethnic differences (Alem et al., 2016; Liao et al., 2019; Pallegedara et al., 2021; Shari et al., 2022; Ma et al., 2022).

The second category focused on macroeconomic drivers. For instance, Murshed (2020b) estimates the effect of foreign direct investment (FDI) flows on access to clean cooking fuels and technologies in low- and middle-income countries of the world for the period 2000-2017. The analysis suggests that FDI improves access to clean cooking fuel and technology. More recently, Murshed (2022) highlighted the drivers of cooking fuel transition in low- and middle-income Sub-Saharan African countries for the period 2000-2016. The results suggest that energy efficiency, economic growth, environmental pollution, financial globalization, financial development, and women empowerment improve access to clean cooking fuel and technology.

Abba Yadou et al. (2023) highlight the effect of remittances on energy transition in African countries over the period 2000-2020. The empirical findings from 2SLS with instrumental variable suggest that remittances reduce energy transition in African countries. Acheampong et al. (2023b) documented that globalization contributes to improve access to clean cooking fuels and technologies for cooking in 43 Sub-Saharan African countries over the period 1990-2017. Acheampong (2023) investigates the effect of governance and credit on access and clean cooking technologies in 43 Sub-Saharan African countries over the period 2000-2017. The findings indicate that access to credit and governance variables do not facilitate clean cooking technologies usage. Onyeneke et al. (2023) have investigated the determinants of access to clean fuels and technologies for cooking in 38 African countries over the period 2000-2020. The outcomes from pooled mean group and dynamic fixed effect estimators reveal that rural population, particulate matter emission, and natural resources depletion significantly decreased access to clean cooking fuels and technologies in the long run while the gross domestic product (GDP) per capita significantly increased access to clean cooking fuels and technologies in the long run in Africa.

Acheampong et al. (2023a) investigated the effect of democracy and governance

on rural electrification and rural access to clean fuels and technologies for cooking in 34 Latin America and the Caribbean countries over the period 2000-2020. The outcomes highlight that governance improves rural electrification and rural access to clean cooking fuels and technologies, while democracy of different forms limits rural electrification and rural access to clean cooking fuels and technologies. [Murshed \(2023\)](#) highlighted the determinants of cooking fuel accessibility divide across urban and rural areas in 14 Latin American and Caribbean countries over the period between 2000 and 2020, the outcomes demonstrate that income inequality aggravates the urban-rural inequality in clean cooking fuel accessibility.

In the light of the empirical review, we have two main testable hypotheses.

H1: Globalization improves access to access to clean fuels and technologies for cooking.

H2: Difference in globalization account for variations in the adoption of clean cooking technologies among urban and rural area.

By putting together the concerns of the two sub-groups, it becomes obvious that some important determinants of household's access to clean cooking fuels and technologies have been neglected. This is particularly the case of potential drivers such as environmental degradation, and the effect globalization in adopting clean cooking fuel in rural and urban areas.

3. Methodology

3.1. Data Description

The aim of this paper is to investigate the effect of globalization on access to clean fuels and technologies for cooking in 31 African countries over the period between 2000 and 2020. The periodicity of the investigation and the sample size was constrained by the availability of data and especially of the dependent variables.

3.2. The Justification of Variables

Due to missing data, especially for clean cooking fuels transition, the analysis is restricted to a balanced panel of 31 African countries with data spanning 2000-2020. This is the longest period possible and the maximum number of countries. Data are collected from KOF Swiss Economic Institute ([Dreher, 2006](#)), the World Bank: World Development Indicators of [World Bank \(2022\)](#). Data availability dictates the sample and periodicity. The list of countries is provided in appendix ([Table A1](#)). Descriptive statistics of the variables are provided in [Table 1](#).

3.2.1. Dependent Variable

Following recent literature, we use two indicators to assess the dependent variable. The first measure is the percentage of the total population with access to clean fuels and technologies for cooking from national grids. The second indicators are the percentages of the urban and rural populations with access to clean fuels and technologies for cooking, respectively.

3.2.2. Independent Variable of Interest

The independent variable of interest is globalization, which is measured by KOF globalization index. The globalization index is based on four indices of globalization, including overall globalization, economic globalization, social globalization and political globalization. **Figure 1** presents a scatter plot correlation analysis between globalization and access to clean fuels and technologies for cooking in Africa.

3.2.3. Control Variables

The control variables in this study are chosen based on extant literature on the determinants of access to clean fuels and technologies for cooking. We employ GDP per capita, ICT proxied by fixed telephone, personal remittances received, environmental degradation proxied by CO₂ emissions and financial development to determine their impact on access to clean cooking fuels. GDP per capita is expected to positively affect energy transition (Onyeneke et al., 2023). ICT is expected to positively influence energy transition, provided that digital technologies facilitate access to clean fuels and technologies for cooking. Remittances in energy transition literature is considered as a means through which household improve their income (Abba Yadou et al., 2023). Environmental degradation is expected to positively influence the adoption of clean cooking fuel (Murshed, 2022), financial development is expected to positively influence energy transition (Nguyen et al., 2021). The characteristics of the variables in terms of their mean, standard deviation, minimum and maximum values are presented in **Table 1** of descriptive statistics.

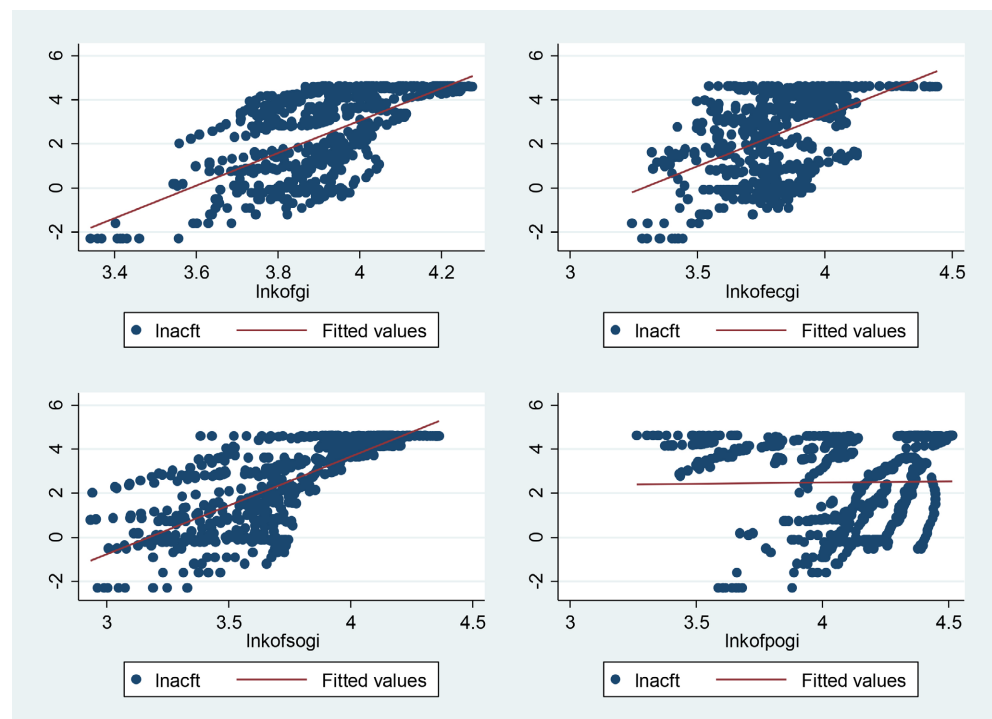


Figure 1. Plots of globalization indicators against clean cooking fuels transition. Source: computation using Stata software.

Table 1. Descriptive statistics.

Variable	Definitions	Obs	Mean	Std. Dev.	Min	Max	Sources
lnacft	Access to clean fuels and technologies for cooking	651	2.496044	1.895543	-2.302585	4.60517	World Development Indicators, 2022
lnkofgi	KOF globalization index	651	3.925694	0.1685153	3.341191	4.277312	KOF Swiss Economic Institute (Dreher, 2006)
lnkofecgi	KOF economic globalization index	651	3.82983	0.2150604	3.243416	4.441321	KOF Swiss Economic Institute (Dreher, 2006)
lnkofsofi	KOF social globalization index	651	3.735	0.316724	2.934296	4.360734	KOF Swiss Economic Institute (Dreher, 2006)
lnkofpogi	KOF political globalization index	651	4.106405	0.2831826	3.265375	4.515117	KOF Swiss Economic Institute (Dreher, 2006)
lngdp	GDP per capita (constant 2015 US\$)	651	7.430872	0.9522036	5.682589	9.725995	World Development Indicators, 2022
lnict	Fixed telephone subscriptions (per 100 people)	651	0.53987	1.543772	-6.076862	3.607797	World Development Indicators, 2022
lnpr	Personal remittances, received (% of GDP)	645	0.3478931	1.590249	-5.404227	3.985764	World Development Indicators, 2022
lnCO2	CO2 emissions (metric tons per capita)	651	-0.5761693	1.346805	-2.944004	2.13377	World Development Indicators, 2022
lnprivate	Domestic credit to private sector (% of GDP)	605	2.676191	1.687673	-6.429156	4.958795	World Development Indicators, 2022

Note: All the variables are in log to reduce the scale-effect.

Obs and Std.Dev refer, respectively to the number of observations, and the standard deviation.

Source: Computation using Stata software.

Table 1 shows the descriptive statistics whereas **Table 2** shows the pairwise correlations between the variables used in the paper. As shown in **Table 2**, there is a significant positive association between different dimension of the globalization and clean cooking fuels transition. **Figure 1** plots the relationship between globalization dimensions, and access to clean fuels and technologies for cooking. As we can see, there is a positive relationship between these two variables. This means that an increase in globalization is associated with an increase in clean cooking fuels transition. However, as correlation does not mean causality. This relationship is investigated empirically in the next section.

3.3. Model Specification

3.3.1. The Baseline Model

In order to explain the effects of globalization on access to clean cooking fuels in African countries, the paper considers a general mathematical equation. This is presented in Equation (1):

$$ACFT_{it} = f(GLOB_{it}, GDP_{it}, ICT_{it}, PRR_{it}, CO2_{it}, PRIVATE_{it}) \tag{1}$$

ACFT_{it} is access to clean fuels and technologies for cooking in country i at the period t. GLOB_{it} is globalization index in country i at period t. GDP_{it} is the economic growth in country i at the period t. ICT_{it} is information and communications technology proxied by fixed telephone subscriptions in country i at period t. PRR_{it} is personal remittances received by country i at period t, CO₂_{it} is environmental degradation proxied by CO₂ emissions, PRIVATE_{it} is financial development proxied by domestic credit to private sector (% of GDP).

Disaggregating GLOB_{it} into overall globalization index (KOFGI_{it}), economic globalization index (KOFecGI_{it}), social globalization index (KOFSoGI_{it}), political globalization index (KOFPoGI_{it}). To avoid heteroskedasticity and produce consistent and efficient results all variables are transformed into natural logarithms (Wang & Dong, 2019). Thus, we have the following equations:

$$\begin{aligned} \text{LnACFT}_{it} = & \delta_0 + \delta_1 \text{LnKOFGI}_{it} + \delta_2 \text{LnGDP}_{it} + \delta_3 \text{LnICT}_{it} + \delta_4 \text{LnPRR}_{it} \\ & + \delta_5 \text{LnCO2}_{it} + \delta_6 \text{LnPRIVATE}_{it} + \epsilon_{1it} \end{aligned} \tag{2}$$

$$\begin{aligned} \text{LnACFT}_{it} = & \beta_0 + \beta_1 \text{LnKOFecGI}_{it} + \beta_2 \text{LnGDP}_{it} + \beta_3 \text{LnICT}_{it} + \beta_4 \text{LnPRR}_{it} \\ & + \beta_5 \text{LnCO2}_{it} + \beta_6 \text{LnPRIVATE}_{it} + \epsilon_{2it} \end{aligned} \tag{3}$$

$$\begin{aligned} \text{LnACFT}_{it} = & \varphi_0 + \varphi_1 \text{LnKOFSoGI}_{it} + \varphi_2 \text{LnGDP}_{it} + \varphi_3 \text{LnICT}_{it} + \varphi_4 \text{LnPRR}_{it} \\ & + \varphi_5 \text{LnCO2}_{it} + \varphi_6 \text{LnPRIVATE}_{it} + \epsilon_{3it} \end{aligned} \tag{4}$$

$$\begin{aligned} \text{LnACFT}_{it} = & \eta_0 + \eta_1 \text{LnKOFPoGI}_{it} + \eta_2 \text{LnGDP}_{it} + \eta_3 \text{LnICT}_{it} + \eta_4 \text{LnPRR}_{it} \\ & + \eta_5 \text{LnCO2}_{it} + \eta_6 \text{LnPRIVATE}_{it} + \epsilon_{4it} \end{aligned} \tag{5}$$

3.3.2. Estimation Technique

To address the endogeneity, Equations (1), (2), (3), (4) and (5) are estimated using instrumental-variable (IV) two-stage least squares (2SLS) approach (IV-2SLS).

Table 2. Pairwise correlation analysis.

	lnacft	lnkofgi	lnkofecgi	lnkofsogi	lnkofpogi	lngdp	lnict	lnprrr	lnCO ₂	lnprivate
lnacft	1.0000									
lnkofgi	0.6541	1.0000								
lnkofecgi	0.5220	0.6512	1.0000							
lnkofsogi	0.7437	0.7811	0.6322	1.0000						
lnkofpogi	0.0190	0.4849	-0.2020	-0.0456	1.0000					
lngdp	0.8339	0.6410	0.5616	0.7745	-0.0731	1.0000				
lnict	0.7712	0.5442	0.5731	0.6639	-0.1365	0.7741	1.0000			
lnprrr	-0.0740	-0.0066	0.0073	-0.0330	0.0131	-0.2591	-0.1095	1.0000		
lnCO ₂	0.8712	0.6897	0.5705	0.7711	0.0115	0.9247	0.7975	-0.1443	1.0000	
lnprivate	0.5439	0.5646	0.4464	0.4626	0.1811	0.4423	0.4843	0.0119	0.4733	1.0000

Source: computation using Stata software.

4. Results and Discussions

4.1. Baseline Results

The baseline results in **Table 3** present outcomes corresponding to the effect of overall globalization, economic globalization, social globalization and political globalization on access to clean fuels and technologies for cooking.

Table 3. Baseline IV-2SLS results.

Variables	lnacft	lnacft	lnacft	lnacft
lnkofgi	3.733*** (0.598)			
lnkofecgi		3.991*** (0.805)		
lnkofsoigi			3.153*** (0.648)	
lnkofpogi				1.398*** (0.224)
lngdp	0.447*** (0.127)	0.319** (0.146)	-0.0134 (0.168)	0.724*** (0.140)
lnict	0.216*** (0.0428)	0.0250 (0.0521)	0.133*** (0.0371)	0.277*** (0.0467)
lnpr	0.0540** (0.0273)	0.0279 (0.0336)	-0.00800 (0.0323)	0.104*** (0.0251)
lnCO ₂	0.376*** (0.105)	0.568*** (0.100)	0.464*** (0.0988)	0.431*** (0.110)
lnprivate	0.0488* (0.0290)	0.0741** (0.0305)	0.109*** (0.0280)	0.0988*** (0.0226)
Constant	-15.52*** (2.509)	-15.03*** (3.099)	-9.284*** (1.852)	-8.798*** (1.768)
Observations	571	571	571	571
R-squared	0.741	0.625	0.728	0.755
Kleibergen-Paap rk LM P Val	0.0000	0.0000	0.0000	0.0000
Kleibergen-Paap rk Wald F stat	99.40	13.39	28.65	120.1
Hansen P Val	0.223	0.241	0.268	0.355

Source: Computation using Stata software. Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

We find that globalization has a positive effect on access to clean fuels and technologies for cooking in African countries. These results mean that overall globalization, economic globalization, social globalization and political globalization improve access to clean cooking fuels. The results suggest that an increase in overall globalization, economic globalization, social globalization and political globalization by 1 unit leads to an increase in the indicator of access to clean cooking fuels by 3.733, 3.991, 3.153 and 1.398 units respectively. These results can be explained by the fact that globalization is associated with knowledge and technologies transfer (Doytch & Uctum, 2016). The outcome matches those of Acheampong et al. (2023b) for 43 Sub-Saharan African countries.

Regarding the control variables, we find that they all have the expected signs. Specifically, we find that GDP per capita, ICT, remittances, environmental degradation and financial development have a positive and statistically significant effect on access to clean fuels and technologies for cooking. In other words, high levels of economic growth, ICT, remittances, environmental degradation and a well-developed financial system are associated with high access to clean technologies for cooking in Africa. These results are similar to those of Murshed (2022), showing that economic growth has a positive impact on access to clean fuels and technologies for cooking in Sub-Saharan African countries. In addition, the outcomes reveal that improving technologies remains imperative for clean cooking fuels technology in Africa. These results support the findings of Acharya and Marhold (2019) concerning cooking fuels transition in Nepal. The coefficient associated with the remittances is positive and statistically significant. This implies that an increase in remittances leads to an improvement in clean cooking technology, which is true for African countries, according to the World Bank, Africa is one of the world's largest recipient of remittances. That contributes to increase income in households (Pan et al., 2020), improve human capital (Gyimah-Brempong & Asiedu, 2015), reduce poverty (Masron & Subramaniam, 2018; Aloui & Maktouf, 2021), and increase financial inclusion (Abba et al., 2021; Eggoh & Bangake, 2021). Our results corroborate with the finding of Hosan et al. (2022) who showed that remittance inflows reduce energy poverty in Bangladesh, Barkat et al. (2023) who disclosed that remittances contribute to alleviate energy poverty in low and middle-income countries, Djeunankan et al. (2023), who confirm the same for developing countries, and Abba Yadou et al. (2023) for African countries.

Environmental degradation improves access to clean cooking fuel transition. These outcomes mean that environmental degradation improves access to clean cooking fuels technologies. It is established that unclean cooking fuels increase CO₂ emissions. As a result, higher CO₂ emissions influence the production of clean cooking fuels. In addition, environmental degradation may also be correlated to a high environmental regulation, which at least to a certain extent contributes to ameliorating the access to clean cooking fuels. The result corroborates the findings of Murshed (2022), who documented that environmental degradation improves access to clean cooking fuel in Sub-Saharan Africa.

4.2. Robustness Checks

4.2.1. Does the Place of Residence Matter?

Rural residents in developing countries, still rely heavily on solid fuels (Aemro et al., 2021). To model that whether or not the place of residence matter in the access of household to clean technologies for cooking. We disaggregate $ACFT_{it}$ into rural ($ACFTR_{it}$) and urban ($ACFTU_{it}$) access to clean fuels and technologies for cooking.

$$\text{LnACFTR}_{it} = \eta_0 + \eta_1 \text{LnOGI}_{it} + \eta_2 \text{LnGDP}_{it} + \eta_3 \text{LnICT}_{it} + \eta_4 \text{LnPRR}_{it} + \varepsilon_{1it} \quad (6)$$

$$\text{LnACFTR}_{it} = \alpha_0 + \alpha_1 \text{LnEGI}_{it} + \alpha_2 \text{LnGDP}_{it} + \alpha_3 \text{LnICT}_{it} + \alpha_4 \text{LnPRR}_{it} + \varepsilon_{2it} \quad (7)$$

$$\text{LnACFTR}_{it} = \lambda_0 + \lambda_1 \text{LnSGI}_{it} + \lambda_2 \text{LnGDP}_{it} + \lambda_3 \text{LnICT}_{it} + \lambda_4 \text{LnPRR}_{it} + \varepsilon_{3it} \quad (8)$$

$$\text{LnACFTR}_{it} = \beta_0 + \beta_1 \text{LnPGI}_{it} + \beta_2 \text{LnGDP}_{it} + \beta_3 \text{LnICT}_{it} + \beta_4 \text{LnPRR}_{it} + \varepsilon_{4it} \quad (9)$$

$$\text{LnACFTU}_{it} = \delta_0 + \delta_1 \text{LnOGI}_{it} + \delta_2 \text{LnGDP}_{it} + \delta_3 \text{LnICT}_{it} + \delta_4 \text{LnPRR}_{it} + \varepsilon_{1it} \quad (10)$$

$$\text{LnACFTU}_{it} = \omega_0 + \omega_1 \text{LnEGI}_{it} + \omega_2 \text{LnGDP}_{it} + \omega_3 \text{LnICT}_{it} + \omega_4 \text{LnPRR}_{it} + \varepsilon_{2it} \quad (11)$$

$$\text{LnACFTU}_{it} = \xi_0 + \xi_1 \text{LnSGI}_{it} + \xi_2 \text{LnGDP}_{it} + \xi_3 \text{LnICT}_{it} + \xi_4 \text{LnPRR}_{it} + \varepsilon_{3it} \quad (12)$$

$$\text{LnACFTU}_{it} = \vartheta_0 + \vartheta_1 \text{LnPGI}_{it} + \vartheta_2 \text{LnGDP}_{it} + \vartheta_3 \text{LnICT}_{it} + \vartheta_4 \text{LnPRR}_{it} + \varepsilon_{4it} \quad (13)$$

The results from the panel data regression analyses for Equations (6), (7), (8), (9), (10), (11), (12), and (13) are provided in **Table 4**. The effect of overall globalization, economic and social globalizations on clean cooking fuels technologies in rural area is non-significant. The result is also non-significant for economic globalization in urban area.

4.2.2. Any Difference Across Geographical Regions?

The above results are carried out on Africa as a sample. However, according to **Table A2** there is a difference in the proportion of the population with access to clean cooking fuels across geographical regions of the continent. For instance, in 2020, only 17% of the population had access to clean cooking fuels in Sub-Saharan Africa, while in North Africa we have about 95%.

The outcomes are discussed and presented in **Table 5**. The results reveal some disparities at the sub-regional level. Globalization positively and significantly determines access to clean cooking fuels in Sub-Saharan Africa and North Africa. This result corroborates the findings of Acheampong et al. (2023b).

4.2.3. Any Difference Amidst de Facto and de Jure Aspects of the Globalization?

The KOF index consists of three dimensions (economic, social, and political) and specifies amid between de jure and de facto aspects; together with its subindexes, which allows for the shedding of more light on the correlation between globalization and economic sophistication. Furthermore, the use of each dimension and/or aspect of the spread of globalization provides different results (Aluko et al., 2021; Fotio & Nguea, 2022). **Table 5** reports the results, showing the positive effect of globalization on access to clean cooking technologies.

Table 4. Effect of globalization on clean fuels and technologies for cooking in Africa (Rural versus Urban).

Variables	Rural				Urban			
	lnacfr	lnacfr	lnacfr	lnacfr	lnacftu	lnacftu	lnacftu	lnacftu
lnkofgi	4.103*** (0.729)				1.172** (0.555)			
lnkofecgi		4.524*** (0.809)				4.321*** (0.847)		
lnkofsogi			1.182 (0.838)				3.810*** (0.598)	
lnkofpogi				1.514*** (0.261)				0.447** (0.208)
lngdp	0.584*** (0.147)	0.439*** (0.164)	0.452** (0.191)	0.879*** (0.156)	0.379*** (0.112)	0.144 (0.151)	-0.230 (0.174)	0.467*** (0.127)
lnict	0.427*** (0.0494)	0.207*** (0.0635)	0.355*** (0.0427)	0.499*** (0.0533)	0.102*** (0.0378)	-0.0711 (0.0543)	0.0523 (0.0403)	0.121*** (0.0411)
lnpr	0.0850*** (0.0284)	0.0554* (0.0335)	0.0793** (0.0341)	0.138*** (0.0261)	0.0585** (0.0250)	-0.00337 (0.0393)	-0.0382 (0.0337)	0.0743*** (0.0236)
lnCO ₂	0.435*** (0.110)	0.648*** (0.109)	0.652*** (0.0879)	0.493*** (0.119)	0.371*** (0.0987)	0.418*** (0.103)	0.248** (0.107)	0.387*** (0.0971)
lnprivate	-0.0950** (0.0425)	-0.0731 (0.0445)	0.0163 (0.0314)	-0.0352 (0.0260)	0.225*** (0.0281)	0.160*** (0.0340)	0.188*** (0.0326)	0.240*** (0.0250)
Constant	-18.64*** (2.924)	-18.58*** (3.230)	-6.109*** (2.204)	-11.12*** (1.999)	-4.770* (2.454)	-14.65*** (3.239)	-9.827*** (1.789)	-2.701* (1.622)
Observations	570	570	570	570	571	543	571	571
R-squared	0.784	0.698	0.832	0.798	0.692	0.438	0.564	0.693
Kleibergen-Paap rk LM P Val	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Kleibergen-Paap rk Wald F stat	98.29	12.40	27.32	121.4	99.40	13.954	28.65	120.1
Hansen P Val	0.383	0.103	0.412	0.589	0.256	0.1056	0.179	0.304

Source: Computation using Stata software. Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5. Effect of globalization on clean cooking fuels in Africa (Sub-Saharan Africa and North Africa).

Variables	Sub-Saharan Africa				North Africa			
	lnacft	lnacft	lnacft	lnacft	lnacft	lnacft	lnacft	lnacft
lnkofgi	5.431*** (1.069)				2.022*** (0.247)			
lnkofecgi		6.854*** (2.296)				1.695*** (0.423)		
lnkofsogi			4.578*** (0.651)				0.566** (0.234)	
lnkofpogi				2.378*** (0.490)				2.138*** (0.301)
lngdp	0.141 (0.158)	0.196 (0.195)	-0.489*** (0.176)	0.620*** (0.172)	-1.059*** (0.118)	-0.586** (0.280)	-1.452*** (0.139)	-0.381*** (0.148)
lnict	0.310*** (0.0522)	-0.0674 (0.102)	0.114*** (0.0375)	0.454*** (0.0745)	-0.229*** (0.0221)	-0.373*** (0.0509)	-0.188*** (0.0346)	-0.271*** (0.0254)
lnpr	0.0611* (0.0324)	-0.00978 (0.0498)	-0.0762** (0.0350)	0.156*** (0.0366)	-0.0489*** (0.0147)	0.00212 (0.0198)	-0.0171 (0.0171)	-0.0548*** (0.0166)
lnCO ₂	0.397*** (0.118)	0.352** (0.142)	0.472*** (0.0927)	0.451*** (0.138)	0.826*** (0.0701)	1.119*** (0.0916)	1.037*** (0.0677)	0.557*** (0.0993)
lnprivate	0.0181 (0.0383)	0.0592 (0.0517)	0.123*** (0.0260)	0.0502 (0.0345)	-0.0330 (0.0517)	-0.0770 (0.0820)	0.0865* (0.0494)	0.108*** (0.0378)
Constant	-19.93*** (3.817)	-25.33*** (8.279)	-11.27*** (1.690)	-11.98*** (2.635)	4.795*** (1.370)	2.847 (3.261)	13.36*** (0.748)	-2.006 (2.098)
Observations	483	481	483	483	88	88	88	88
R-squared	0.688	0.739	0.703	0.651	0.957	0.903	0.960	0.956
Kleibergen-Paap rk LM P Val	0.0000	0.0008	0.0000	0.0000	0.0000	0.0022	0.0000	0.0000
Kleibergen-Paap rk Wald F stat	39.94	11.02	28.19	36.74	60.22	17.55	48.94	17.41
Hansen P Val	0.119	0.225	0.170	0.403	0.119	0.526	0.116	0.334

Source: Computation using Stata software. Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6. De facto versus de jure globalization for Africa.

Variables	lnacft	lnacft	lnacft	lnacft	lnacft	lnacft	lnacft	lnacft
lnkofgidf	3.149*** (0.508)							
lnkofecgidf		2.974*** (0.506)						
lnkofsogidf			2.313*** (0.499)					
lnkofpogidf				0.966*** (0.164)				
lnkofidj					4.387*** (0.746)			
lnkofecgidj						4.327*** (1.071)		
lnkofsogidj							4.335*** (0.921)	
lnkofpogidj								1.887*** (0.286)
lngdp	0.546*** (0.129)	0.565*** (0.146)	-0.123 (0.188)	0.837*** (0.156)	0.315** (0.130)	-0.0668 (0.216)	0.0942 (0.173)	0.620*** (0.127)
lnict	0.230*** (0.0435)	-0.00504 (0.0563)	0.147*** (0.0346)	0.309*** (0.0515)	0.198*** (0.0439)	0.0882 (0.0563)	0.114** (0.0486)	0.240*** (0.0429)
lnpr	0.0424 (0.0277)	-0.0110 (0.0336)	-0.0302 (0.0356)	0.134*** (0.0266)	0.0653** (0.0278)	0.114*** (0.0376)	0.00878 (0.0344)	0.0737*** (0.0251)
lnCO ₂	0.312*** (0.111)	0.460*** (0.101)	0.545*** (0.0882)	0.376*** (0.121)	0.464*** (0.0999)	0.806*** (0.117)	0.362*** (0.123)	0.482*** (0.0983)
lnprivate	0.0629** (0.0289)	0.145*** (0.0258)	0.130*** (0.0253)	0.0954*** (0.0235)	0.0332 (0.0310)	-0.00785 (0.0475)	0.0770** (0.0372)	0.107*** (0.0214)
Constant	-13.84*** (2.269)	-13.36*** (2.491)	-4.958*** (1.140)	-7.739*** (1.695)	-17.25*** (2.917)	-12.77*** (3.110)	-15.02*** (3.133)	-10.24*** (1.878)
Observations	571	571	571	571	571	540	571	571
R-squared	0.741	0.629	0.760	0.739	0.718	0.512	0.608	0.766
Kleibergen-Paap rk LM P Val	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Kleibergen-Paap rk Wald F stat	92.77	88.501	30.88	66.96	60.75	21.847	17.29	224.1
Hansen P Val	0.350	0.8167	0.286	0.434	0.132	0.8527	0.235	0.286

Source: Computation using Stata software. Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6 above offers a comprehensive analysis with instrumental variables for estimating the impact of globalization on access to clean cooking fuel (lnacft) using eight varying model specifications. The findings indicate considerable disparities between de facto and de jure measures of globalization that have profound implications for energy policy in the African continent. The economic aspect of de facto globalization (lnkofecgidf) has the largest effect (2.974), suggesting trade and foreign direct investment as primary drivers for improved clean cooking access. The social (2.313) and political (0.966) aspects have smaller yet significant effects. Most striking is that all de jure globalization measures have larger coefficients than de facto measures, and the overall de jure index (lnkofidj) is even 4.387.

Table 7 and **Table 8** present the results for de facto versus de jure globalisation in rural Africa and urban Africa, respectively.

Table 7 presents the findings of eight instrumental variable regression specifications that examine the differential impacts of dimensions of globalization on access to clean cooking fuels (lnacfr) in African rural areas. The findings present several significant results that require close interpretation.

The economic dimension of de facto globalization (lnkofecgidf) shows a statistically significant positive impact (2.129), though much smaller than the overall de facto index (lnkofgidf at 3.440). Surprisingly, the social dimension of de facto globalization (lnkofsogidf) yields an insignificant statistic (0.854), whereas its political dimension (lnkofpogidf) exerts a significant, albeit small, impact (1.043). This is a pattern that suggests that in rural areas, economic integration through foreign trade and investment flows can have an even more dominant role in determining access to clean cooking than social or political integration. The de jure indicators exhibit a more nuanced scenario. The economic aspect (lnkofecgidj) shows an extraordinarily strong impact (5.608), nearly triple its de facto counterpart. The political aspect (lnkofpogidj) still remains significant (2.050), while the social aspect (lnkofsogidj) has only borderline significance (1.657). The overall de jure index (lnkofidj at 4.866) supports the general trend that policy-driven globalization measures have larger coefficients than their de facto versions.

Table 8 presents instrumental variable regression results examining the effects of de facto versus de jure globalization on clean cooking fuel access (lnacftu) across urban Africa. The analysis reveals several key insights that differ meaningfully from rural patterns, highlighting the importance of context-specific policy approaches.

The economic dimension of de facto globalization (lnkofecgidf) shows a strong positive effect (3.093), significantly larger than the overall de facto index (lnkofgidf at 1.003). This suggests that in urban areas, economic integration through trade and investment flows drives clean cooking access more than composite globalization measures. The social dimension (lnkofsogidf at 2.797) also demonstrates substantial impact, while the political dimension (lnkofpogidf at 0.311) appears relatively weak. This pattern implies urban populations benefit more from economic and social globalization than from political integration alone.

Table 7. De facto versus de jure globalization for in rural Africa.

Variables	Rural							
	lnacfr	lnacfr	lnacfr	lnacfr	lnacfr	lnacfr	lnacfr	lnacfr
lnkofgidf	3.440*** (0.641)							
lnkofecgidf		2.129*** (0.632)						
lnkofsogidf			0.854 (0.619)					
lnkofpogidf				1.043*** (0.191)				
lnkofecgidj					5.608*** (1.111)			
lnkofsogidj						1.657 (1.159)		
lnkofpogidj							2.050*** (0.333)	
lnkofidj								4.866*** (0.855)
lngdp	0.691*** (0.152)	0.691*** (0.148)	0.414* (0.218)	1.000*** (0.174)	-0.0510 (0.236)	0.491*** (0.171)	0.768*** (0.142)	0.438*** (0.147)
lnict	0.444*** (0.0524)	0.245*** (0.0651)	0.362*** (0.0419)	0.535*** (0.0591)	0.261*** (0.0652)	0.346*** (0.0459)	0.458*** (0.0485)	0.405*** (0.0482)
lnpr	0.0723** (0.0304)	0.0481 (0.0338)	0.0713* (0.0392)	0.170*** (0.0277)	0.165*** (0.0397)	0.0855*** (0.0310)	0.106*** (0.0259)	0.0977*** (0.0273)
lnCO ₂	0.366*** (0.121)	0.594*** (0.103)	0.683*** (0.0799)	0.434*** (0.132)	0.935*** (0.124)	0.614*** (0.105)	0.549*** (0.106)	0.532*** (0.100)
lnprivate	-0.0780* (0.0430)	0.0197 (0.0341)	0.0252 (0.0267)	-0.0381 (0.0276)	-0.186*** (0.0541)	0.00251 (0.0401)	-0.0269 (0.0244)	-0.115*** (0.0433)
Constant	-16.71*** (2.729)	-11.70*** (2.879)	-4.464*** (1.239)	-9.952*** (1.910)	-18.20*** (3.243)	-8.364** (3.702)	-12.72*** (2.131)	-20.71*** (3.226)
Observations	570	570	570	570	539	570	570	570
R-squared	0.758	0.748	0.834	0.781	0.643	0.822	0.812	0.797
Kleibergen-Paap rk LM P Val	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Kleibergen-Paap rk Wald F stat	91.74	56.51	29.93	67.79	21.64	15.96	226.3	59.93
Hansen P Val	0.576	0.969	0.382	0.700	0.640	0.429	0.504	0.233

Source: Computation using Stata software. Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8. De facto versus de jure globalization for in urban Africa.

Variables	Urban							
	lnacftu	lnacftu	lnacftu	lnacftu	lnacftu	lnacftu	lnacftu	lnacftu
lnkofgidf	1.003** (0.464)							
lnkofecgidf		3.093*** (0.534)						
lnkofsogidf			2.797*** (0.471)					
lnkofpogidf				0.311** (0.145)				
lnkofecgidj					4.600*** (1.114)			
lnkofsogidj						5.239*** (0.885)		
lnkofpogidj							0.601** (0.277)	
lnkofidj								1.348** (0.666)
lngdp	0.410*** (0.115)	0.459*** (0.147)	0.364* (0.192)	0.504*** (0.138)	-0.213 (0.218)	-0.0999 (0.189)	0.434*** (0.118)	0.339*** (0.110)
lnict	0.107*** (0.0384)	-0.0868 (0.0580)	0.0689* (0.0372)	0.132*** (0.0437)	0.0119 (0.0576)	0.0299 (0.0550)	0.110*** (0.0389)	0.0959** (0.0374)
lnpr	0.0547** (0.0256)	-0.0268 (0.0345)	0.0651* (0.0357)	0.0840*** (0.0240)	0.104*** (0.0395)	-0.0180 (0.0382)	0.0646*** (0.0242)	0.0621** (0.0246)
lnCO ₂	0.350*** (0.105)	0.273*** (0.105)	0.347*** (0.0967)	0.370*** (0.103)	0.634*** (0.118)	0.125 (0.135)	0.404*** (0.0911)	0.400*** (0.0915)
lnprivate	0.229*** (0.0268)	0.236*** (0.0273)	0.213*** (0.0310)	0.239*** (0.0252)	0.0723 (0.0519)	0.150*** (0.0421)	0.243*** (0.0245)	0.221*** (0.0299)
Constant	-4.301* (2.209)	-12.75*** (2.577)	-4.602*** (1.169)	-2.375 (1.503)	-12.38*** (3.248)	-16.76*** (3.101)	-3.152* (1.786)	-5.208* (2.742)
Observations	571	571	571	571	540	571	571	571
R-squared	0.694	0.468	0.620	0.690	0.285	0.332	0.695	0.686
Kleibergen-Paap rk LM P Val	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Kleibergen-Paap rk Wald F stat	92.77	59.53	30.88	66.96	21.85	17.29	224.1	60.75
Hansen P Val	0.304	0.954	0.218	0.329	0.757	0.140	0.281	0.203

Source: Computation using Stata software. Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

De jure measures reveal striking results. The social dimension (lnkofsogidj at 5.239) emerges as the strongest predictor overall, exceeding even economic de jure effects (4.600). This suggests formal policies promoting social integration—such as cultural exchanges, educational partnerships, or technology transfers—may yield exceptional returns in urban contexts. The political dimension remains modest (0.601), while the composite de jure index (1.348) underperforms its components, potentially indicating offsetting effects when dimensions combine.

5. Conclusion and Policy Recommendations

In accordance with the seventh Sustainable Development Goals (SDGs) which pointed out the need to ensure access to affordable, reliable and modern energy for all. This paper analyzes the effects of overall globalization and its three sub-dimensions (economic globalization, social globalization and political globalization) on access to clean fuels and technologies for cooking in selected African countries using data from 2000 to 2017. The methodology involves the Driscoll-Kraay standard errors and the Panel-Corrected Standard Error (PCSE) estimators. The results indicate that the overall globalization, social globalization and political globalization improve access to clean fuels and technologies for cooking. However, economic globalization does not have any significant effect on access to clean fuels and technologies for cooking. The results remains true even when we distinguish rural from urban area, and Sub-Saharan Africa, from North Africa. Additionally, increases economic growth, access to information and communications technology, and remittances seem to involve more transition to cleaner fuels. Established on those results, some important policy implications encouraging the globalization, economic growth, access to information and communications technology, and remittances are suggested.

This paper has some limitations. One of the limitations is related to the sample size and data span. This investigation can be extended to cover all the developing countries. Another limitation of the paper is that it uses macro panel data. Future research can be performed at the micro level.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

Appendix Table A1. List of countries (31).

Algeria	Kenya	Senegal
Benin	Lesotho	Seychelles
Botswana	Madagascar	Sierra Leone
Burkina Faso	Malawi	South Africa
Cabo Verde	Mali	Sudan
Cameroon	Mauritius	Tanzania
Cote d'Ivoire	Morocco	Togo
Egypt, Arab Rep.	Mozambique	Tunisia
Eswatini	Namibia	Uganda
Gabon	Nigeria	
Ghana	Rwanda	

Appendix Table A2. Access to clean cooking, summary by region.

	Proportion of the population with access to clean cooking					Population without access (million)	Population relying on traditional use of biomass (million)
	2000	2005	2010	2015	2020	2020	2020
World	50%	53%	57%	62%	67%	2585	2338
Africa	23%	25%	27%	28%	30%	942	881
North Africa	89%	>95%	>95%	>95%	>95%	1	>1
Sub-Saharan Africa	9%	11%	13%	15%	17%	941	881
Developing Asia	30%	35%	43%	53%	62%	1516	1349
Central and South America	80%	83%	86%	88%	89%	55	49
Middle East	88%	92%	93%	94%	94%	16	10

Source: IEA, World Energy Outlook-2021, based on WHO Household Energy Database and IEA World Energy Balances 2021.