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The political economy of energy transition: The role of globalization and governance in the adoption of clean cooking fuels and technologies

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Abstract: The need for substantial economic, political, and social integration among economies and an effective domestic governance system to create a more inclusive and clean energy economy cannot be underestimated. Overreliance on biomass and other dirty fuels for cooking in developing countries has contributed to the global climate change challenge. In this study, we examine the impact of globalization and governance on adopting clean fuels and cooking technologies in sub-Saharan Africa (SSA). Regarding analytical approaches, we deploy econometric techniques such as Driscoll-Kraay and instrumental variable generalized method of moment techniques to control econometric issues such as autocorrelation, heteroskedasticity, cross-sectional dependence, and endogeneity. The findings indicate that globalization (economic, social, and political) and governance (government effectiveness, control of corruption, political stability, and the rule of law) drive the adoption of clean fuels and technologies for cooking. The results further reveal that right-wing political leaders contribute significantly to adopting clean cooking fuels and technologies in SSA, while left-wing and center-wing political leaders do not. These findings differ among the sub-regions in SSA. Furthermore, interaction and marginal effect analysis suggest that improving the governance system enhances the effect of globalization on access to clean cooking fuels and technologies. Hence, improving the efficacy of the domestic governance system would enable globalization to speed up the adoption of clean fuels and technologies for cooking in SSA.

Keywords: *Governance; Globalization; COP26; Energy transition; clean cooking fuels and technologies; Sub-Saharan Africa*

JEL classification: F6; P48; Q4

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1. Introduction

Alleviating energy poverty and enabling access to modern energy are major goals of many governments worldwide. They are also deeply rooted in the United Nations Sustainable Development Goals (SGDs); Goal 7 seeks to "ensure access to affordable, reliable, sustainable and modern energy for all." Access to modern energy is essential in driving economic development, improving health, food security, and working towards the achievement of almost all the SDGs. Despite the importance of modern energy access, it remains a privilege rather than a right for many in developing countries. Projections of the International Energy Agency (IEA) indicated that about 770 million people did not have access to electricity in 2019, and the majority of these people come from Africa and Asia (IEA, 2020). Despite concerted efforts that have reduced the number of people without electricity, about 580 million people in sub-Saharan Africa (SSA) did not have electricity in 2019.

Regarding the energy access predicament in developing countries, a major concern has been access to clean cooking energy. Access to modern energy is a drive toward clean energy (Dogan, Chishti, Alavijeh & Tzeremes, 2022). In 2019, about 2.6 billion people did not have access to clean cooking energy. In SSA, more than a third of the people do not have access to clean cooking energy (IEA, 2020). The major emphasis on using clean cooking energy is the effect of inefficient cooking energy on environmental degradation (through deforestation and emissions from burning of dirty fuel) that eventually exacerbates climate change and its impact (Lambe, 2015; World Bank, 2014; Khalfaoui et al., 2022; Udemba & Tosun, 2022). In recent years, the efforts of the United Nations and other multilateral organizations have contributed immensely to reducing reliance on inefficient means of energy, especially for cooking. Increasing globalization is also noted to be a major force in influencing the drive toward the adoption of clean cooking energy. Kammerlander & Schulze (2021) indicate that globalization may improve access to modern and cleaner technology.

Notably, the advent of internet technology in the past couple of decades has increased the pace of globalization the world over. Globalization is a process that erodes national boundaries, integrates national economies, cultures, technologies, and governance, and produces complex relations of mutual interdependence (Aluko, Chen, and Opoku, 2021; Clark, 2000; Gygli et al., 2019). Globalization has become one of the significant pillars or issues defining the world economy today (Acheampong, Adams, and Boateng, 2019). Like any other concept, globalization is debated to have both adverse and beneficial effects on the environment and energy consumption. As pro-globalization activists argue that globalization reduces environmental degradation (Christmann and Taylor, 2001), the critics contend that globalization worsens environmental degradation (Wijen and Van Tulder, 2011). Globalization's contribution to adopting clean energy cannot be overemphasized. Globalization makes new green technologies visible and easily transferrable from one country/place to the other. The drive to clean energy for all is a global agenda. Kammerlander & Schulze (2021) assert that globalization may also lead to better transmission of information and environmental awareness, which may result in stricter environmental policies, hence the adoption of clean energy. Globalization paves the way for all to see each country's and entity's progress, increasing the motivation for others to follow good examples. Increasing globalization makes the transfer/movement of skills (expertise) and equipment promoting clean energy technologies very plausible. Gallagher (2014), in his book, gives a vivid account of the globalized phenomenon of the development and deployment of cleaner energy technologies. He visited a factory of solar photovoltaic (PV) manufacturer in China and asserted;

> Here was a Chinese … from an Australian university supervising the assembly of a new factory line that was being constructed with mostly Japanese and German manufacturing equipment. German technicians were assembling parts of the line, … The PV modules being packed by Chinese workers at the end of the assembly line were being shipped … especially to Germany, Spain, and the United States, …" (Gallagher, 2014, p.1-2).

To combat the numerous challenges concomitant with energy consumption (i.e., increasing emissions, threats of climate change, energy poverty, and others), hastened global circulation of clean energy technologies is immediately required (Adedoyin, Erum & Ozturk, 2022). Despite the perceived effect of globalization on the diffusion of clean energy technologies, Gallagher (2014) contends that there are considerable barriers and motivations to dispersion across borders. Most obstacles to the diffusion and adoption of clean energy technologies rest at the doorpost of government. They are issues of policy and government involvement. This makes a country's governance/institutional framework important in energy investment, development and distribution. In some circles, the substantial financial outlay required for energy infrastructure calls for government intervention. In many developing (African) countries, governments subsidize the energy cost so it may be accessible to all. In many of these countries, companies in the energy business are state-owned enterprises; hence, the effectiveness of government or governance, in general, is important for the effective running of these enterprises. For example, the IEA (2014) asserts that improving governance in Africa is the way forward to yield higher levels of investment in the energy sector to boost access to electricity. Adams, Klobodu, and Opoku (2016) assert that energy policy in many African countries is about efficiency and net political gains. Similarly, Kammerlander & Schulze (2021) opine that environmental control is not simply a reaction to environmental problems but the result of a political process. In the wake of globalization, strong institutions and governance in countries form important factors in attracting foreign investment into the energy sector and others (Gregory and Sovacool, 2019; Liu et al., 2021). Hence, poor governance will be a bane to doing business and inhibit the effect globalization may have. Good governance safeguards competitive markets, efficient allocation of resources, and protection and security of investments (Kayalvizhi and Thenmozhi, 2018; Kucera and Principi, 2017).

Though globalization is a key feature of the future of energy markets in the transition to low-oil and low-carbon development trajectories (Waisman et al., 2014), there has not been much research from the academic arena on this. This motivates our study. A chunk of the existing studies has focused on the effect of globalization on environmental degradation (Acheampong, Adams, and Boateng; 2019; Aluko, Opoku, and Ibrahim; 2021; Langnel and Amegavi, 2020; Saint Akadiri et al., 2020) with just a little attention to energy consumption or demand (Shahbaz, 2018; Gozgor et al., 2020; Gozgor et al., 2020; Huang, Zhang, and Duan, 2020; Doğan et al., 2022) and no special focus on clean cooking energy technologies. However, considering the race towards the achievement of the SDGs and the incessant efforts of governments globally to reduce emissions and mitigate the effect of climate change, a focus on clean energy (especially for cooking) is imperative (Adedoyin, Erum & Ozturk, 2022). In this study, we concentrate on clean cooking technologies, particularly following SDG7 of ensuring affordable and clean energy. Generally, in this paper, we evaluate the effect of governance on the relationship between globalization and clean cooking energy technologies. The general objective of the paper is to examine the impact of globalization and governance on adopting clean fuels and cooking technologies. Specifically, we attempt to address the following research questions:

1. *What is the effect of globalization on the adoption of clean fuels and cooking technologies in SSA?*

2. *What is the effect of governance on the adoption of clean fuels and cooking technologies in SSA?*
3. *Does governance moderate the effect of globalization on the adoption of clean fuels and cooking technologies in SSA?*
4. *Does the effect of governance and globalization on the adoption of clean fuels and cooking technologies differ among subregions in SSA?*

By addressing the questions above, we contribute to the empirical literature in at least three ways. Firstly, our study constitutes an essential contribution to the literature on ways to expand access to clean cooking energy technologies and identifies the political economy fundamentals necessary in different sub-regions of SSA to accelerate clean energy adoption. We focus on clean cooking technologies, certainly the most important energy strand on the energy transition agenda (World Bank, 2014). The World Health Organization (WHO) estimates that close to 2.6 billion people globally use dirty/polluting cooking fuels/energy such as kerosene, biomass (wood, charcoal, animal dung, and crop waste), and coal (WHO, 2021). The downside of this is that polluting energy poses dangerous health conditions. Air pollution emanating from dirty cooking energy causes, among others, stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD), eye problems (cataracts), and lung cancer (WHO, 2021). The WHO (2021) estimates that nearly 4 million people die prematurely globally due to polluting or inefficient cooking technologies. The World Economic Forum (WEF) describes cooking with polluting energy as a silent killer (WEF, 2021). Household air pollution is considered the second-highest health risk factor concerning death and disability in the SSA region (Lambe, 2015; World Bank, 2014).

Secondly, we consider how the prevailing institutional framework (governance) moderates globalization's effect on adopting clean cooking technology. The impetus for doing this is that governmental infrastructure, initiatives, and decisions mainly drive energy decisions. Hence, the quality of governance cannot be overemphasized. To the best of our knowledge, this is the first study to look at how governance interacts with globalization to impact the adoption of clean cooking technologies or access to energy in general. Lastly, we focus on SSA, the region with the greatest access to energy difficulty in the world. More than 80% of the region's population relies on polluting energy sources for cooking (WEF, 2021), which increases the likelihood of deaths from household air pollution from inefficient cooking technologies or dirty fuels. As air pollution accounted for close to 1.1 million deaths in Africa, nearly 697,000 deaths were attributable to household air pollution (Fisher et al., 2021). The findings from our study offer a vital insight and blueprint on the necessary measures to be taken by the government and policymakers to enhance access to clean cooking energy and ameliorate the harmful impact of using solid fuels in the SSA region.

We consider answers to the research questions imperative to policymaking, policymakers, and the international community as they address some pressing challenges of the 21st century, i.e., emissions, climate change effects (costs), and mitigation strategies. The World Bank (2014) estimated that cooking with solid fuel in SSA accounted for up to 1% of global greenhouse gas emissions. The economic cost/loss of air pollution emanating from inefficient cooking energies and other sources is estimated to be about 3.3% of global GDP annually, which is about $2.9 trillion (IEA, 2020). In SSA, Fisher et al. (2021) estimate that economic output loss as a result of air pollution-related health conditions and deaths was $3.02 billion in Ethiopia (1.16% of GDP), $1.63 billion in Ghana (0.95% of GDP), and $349 million in Rwanda (1.19% of GDP) for the year 2019. These costs significantly burden the already struggling healthcare systems and constrain economic growth and opportunities. This necessitates the need for urgent actions toward relieving millions who are clean cooking energy poor, and this study contributes to that regard.

The structure of the remainder of the paper is as follows; the next subsection presents a profile of clean cooking technologies in SSA. Section two offers succinct literature (theoretical and empirical) on the topic, and section three presents the methodology and data of the paper. Section four presents and discusses the empirical results, and section five concludes the paper.

1.1 Access to clean fuels and technologies for cooking in Sub-Saharan Africa (SSA)

Among the regions of the world, SSA has the least access to electricity rate. Data from the World Development Indicators (WDI) show that SSA's access to electricity (as a percentage of the population) increased from 26% in 2000 to 29% in 2005, 33% in 2010, 39% in 2015, and 48% in 2020. The world's averages over the same periods have been 78%, 81%, 83%, 87%, and 91%, respectively. Figure 1 shows the trend of access to electricity from 2000-2020 for SSA. It depicts that even though less than 50% of the population has access to electricity, there has been a consistent upward trend over the years. Figure1 also shows that SSA substantially lags the global average over the years.

Table 1: Access to clean fuels and technologies for cooking (% of population)

Year	EAS	ECS	LCN	MEA	NAC	SAS	SSA	WLD
2000	42	95	80	89	100	21	9	49
2001	42	95	81	90	100	22	9	50
2002	43	95	82	91	100	23	9	50
2003	44	95	82	92	100	24	10	51
2004	45	96	83	93	100	25	10	52
2005	47	96	83	93	100	26	10	52
2006	48	96	84	94	100	27	11	53
2007	50	96	84	94	100	28	11	54
2008	52	96	85	95	100	30	11	55
2009	54	96	85	95	100	31	12	56
2010	56	96	86	95	100	33	12	57
2011	58	96	86	96	100	34	13	58
2012	61	96	86	96	100	36	13	59
2013	63	96	87	96	100	38	14	60
2014	66	96	87	96	100	41	14	62
2015	68	96	87	96	100	44	14	63
2016	70	96	88	96	100	47	15	64
2017	72	96	88	96	100	50	16	66
2018	74	96	88	96	100	53	16	67
2019	76	95	88	96	100	57	17	68
2020	77	95	89	96	100	60	18	70

NB: EAS, ECS, LCN, MEA, NAC, SAS, SSA, and WLD are, respectively, East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, North America, South Asia, Sub-Saharan Africa, and World. The Table is constructed with data from the World Development Indicators of the World Bank.

More alarming, however, is the rate of access to clean fuels and technologies for cooking. From 2000 to 2010, the percentage of the global population with access to clean fuels and technologies for cooking (such as gas and electricity) rose from 49% to 57%. From 57% in 2010, it increased to about 70% in 2020 (see Table 1). East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, and South Asian regions have seen access to clean fuels and technologies for cooking (as a percentage of population) increasing from 42%, 95%, 80%, 89%, and 21% respectively in the year 2000 to 56%, 96%, 86%, 95% and 33% in 2010 (Table 1). Even though the Europe and Central Asia region witnessed a drop to 95% in 2020 from 96% in 2010, East Asia and Pacific, Latin America and the Caribbean, the Middle East and North Africa, and South Asian experienced an increase to 77%, 89%, 96%, and 60% respectively in 2020. Countries in North America have had a 100% access rate over the period 2000-2020.

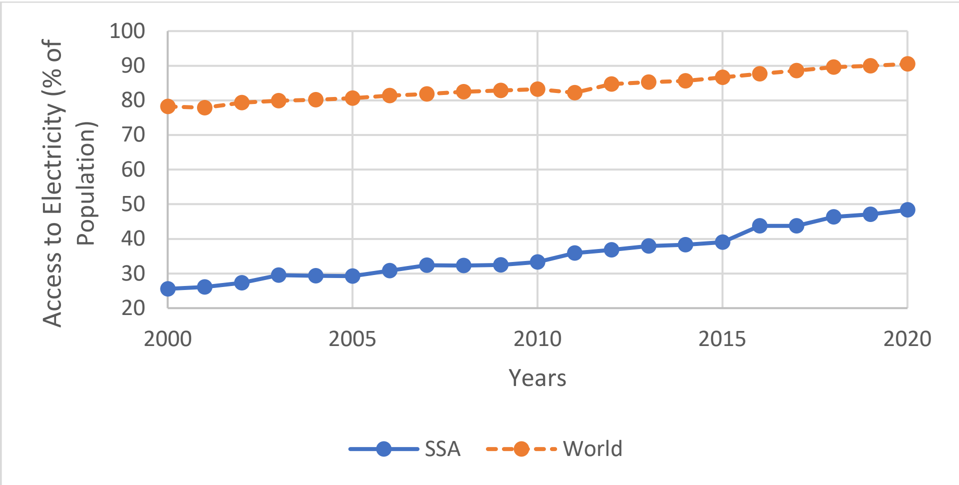


Fig. 1: Access to Electricity (as a percentage of population) in SSA

NB: The Figure is constructed with data from the World Development Indicators of the World Bank.

Progress in SSA has, however, been very slow; in the year 2000, just about 9% of the population had access to clean fuels and technologies for cooking. Access rates have only increased marginally over the years for the SSA region; in 2005 (10%), 2010 (12%), 2015 (14%), and 2020 (18%) (Table 1). A chunk of the population (about 80%) in the SSA region relies on polluting and inefficient technologies for cooking. Philibert (2022) estimates that about 2.6 billion people globally and 1 billion people in SSA use mainly biomass/solid fuel for cooking. This has an adverse impact on the environment, public health, and the attainment of the SDGs. The continuous use of biomass fuel counters the mitigation initiatives of climate change (Lu, Mahalik, Mahalik, & Zhao, 2022). The World Bank (2014) estimates that the production and consumption of solid fuels for cooking in SSA take up more than 300 million tonnes of wood annually. Production of charcoal alone consumes about 130-180 million tonnes of wood, contributing substantially to deforestation, forest degradation, and biodiversity loss (World Bank, 2014). Another downside of using biomass fuels is the loss of time and money in searching for these fuels. Using biomass fuels affects women disproportionately as they generally take the more significant burden of household work. Women can spend close to 20 hours per week searching and collecting biomass fuels, and cooking with these fuels could take up to 4 hours per day (World Economic Forum, 2021). This deprives some women of the time for engaging in income-generating activities.

Philibert (2022) asserts that efficient electric cooking can be cheaper than the use of biomass fuels, just that a high upfront cost has to be incurred. If this cost can be broken down into practicable repayment terms, it will hasten the transition to cleaner cooking fuels, especially in less rich regions such as SSA. This is where the government comes in handy. Many governments in SSA have jumped on several global initiatives to finance manufacturers of cleaner cooking fuels and distribute and promote these fuels. Some of these initiatives/organizations have been the Global Alliance for Clean Cookstoves, the World Bank's Africa Clean Cooking Energy Solutions program, the United Nations' Sustainable Energy for All, the Global Villages Energy Partnership, Global Liquefied Petroleum Gas (LPG) Partnership, and the Africa Biogas Partnership Programme (World Bank, 2014). As a result, many of these countries, including Ethiopia, Ghana, Malawi, Nigeria, Rwanda, Senegal, and Uganda, have embarked on national cookstove programs to boost cleaner cooking fuels. In Ghana, for instance, the government in 2013 relaunched an initiative that originally commenced in 1989 to promote the use of LPG as the main cooking fuel, mainly in rural areas. The Rural LPG Promotion Programme initiative sought/seeks to distribute gas cylinders and stoves to rural folks for free at the first instance to stimulate the transition from charcoal and firewood to cleaner cooking energy, LPG. The initiative also includes education on the essence of energy transition and the use of the LPG. The World Bank (2014) recounts that growing interest from multilateral donors, nongovernmental organizations, and industry players in supporting clean and sustainable cooking technologies in SSA and political will are part of the significant hurdles to circumvent.

2. Literature Review

This section discusses the linkage between governance/globalization and access to clean fuels and technologies for cooking. Sub-section 2.1 discusses the theoretical and empirical studies on the relationship between governance and clean energy, while the theoretical and empirical relationship between globalization and clean energy is discussed under sub-section 2.2. Fig. 2 provides a summary of how governance and globalization play a critical role in the adoption of clean fuels and technologies for cooking.

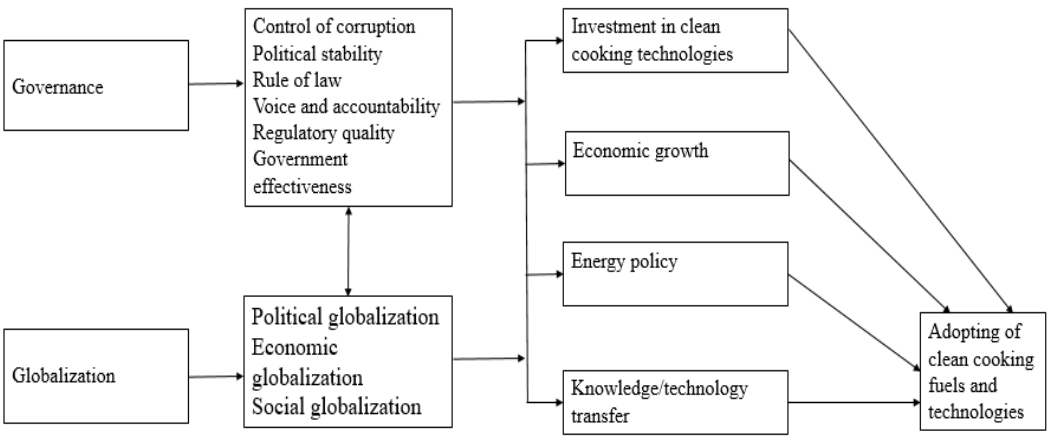


Fig. 2: Conceptual model linking governance and globalization to clean fuels and technologies for cooking
Source: Constructed by Authors

2.1 Governance and Clean cooking fuels and technologies

In discussing governance issues resulting from a political process, it is essential to briefly touch on how political ideologies can influence matters of the environment and renewable energy production and consumption. Ideologies are essentially the theoretical and practical lenses through which societies are viewed and give political, social, and economic directions to governments (Gromet, Kunreuther & Larrick, 2013; Thonig et al., 2021). Political ideologies go beyond being democratic; they exhibit governments' stands on political, social, and economic issues. For example, countries running governments aligned to the ideologies of left-wing parties are believed to enact more stringent environmental policies relative to right-wing parties. It is considered that they protect the environment more because their supporters are more prone to environmental degradation and can afford health care less (Kammerlander & Schulze, 2021). Hence, energy and environmental policies have been some of the major policy issues of left-wing governments. Right-wing political parties and individuals are more likely to relegate issues of environmental protection (to, for instance, tackle climate change) and favor policies that protect free market opportunities for businesses by lessening environmental regulations (Gromet, Kunreuther & Larrick, 2013). Gromet, Kunreuther & Larrick (2013) opine that environmental concerns are part of a politically liberal ideology in the United States; however, political conservatives diminish the value of these concerns. In their empirical study, Kammerlander & Schulze (2021) find that left-wing governments perform better in the environment relative to right-wing governments for a panel of 134 countries over the period 2007–2016. Kammerlander & Schulze (2021) hence emphasize that political orientation matters. Potrafke & Wuthrich (2020) find contrary results in analyzing data for Germany. They argue that the Fukushima nuclear disaster in Japan made a green political party win election in the German state of Baden-Wuerttemberg (BW). Green parties promote and promise to foster renewable energies and improve environmental quality. However, Potrafke & Wuthrich (2020) find no evidence that the Green government generally influenced CO_2 emissions or increased renewable energy usage in the BW state. Voters, however, expect green governments to improve energy and environmental outcomes (Potrafke & Wuthrich, 2020). In a study by Gromet, Kunreuther & Larrick (2013) in the United States, they found that more politically conservative individuals were less in favor of investment in energy-efficient technology relative to those more politically liberal.

Governance is essential in enabling or inhibiting structural changes, including expanding energy access and, for that matter, a transition towards clean cooking fuels and technologies (Moe, 2010). The role of governance becomes crucial in providing energy as it affects access to physical energy infrastructure, energy service delivery (quantity and reliability), equity, growth, and investment in the energy sector. Examining data from 236 renewable energy companies between 2000 and 2017 the world over, Liu et al. (2021) demonstrate that a country's legal system influences growth, opportunities, and investment in the renewable energy sector. Specifically, they find that countries following the common law system (based on the English legal tradition) are more responsive to growth opportunities in renewable energy investment. This reechoes the essence of governance infrastructure in shaping the sustainable energy agenda. The prevailing governance system defines the legal rights of investors, creditors, and other players in the energy sector (Djankov, McLiesh, and Shleifer, 2007). The governance system also administrates the efficiency of contract enforcement and accountability (Liu et al., 2021).

2.2 Globalization and Clean cooking fuels and technologies

The concept of globalization is broad; hence, it has received several definitions in the literature. For example, Held et al. (1999, p.2) define it as "... the widening, deepening and speeding up of worldwide interconnectedness in all aspects of contemporary social life, from the cultural to the criminal, the financial to the spiritual ...", Holm and Sorensen (1995, p.1) view it as "... the intensification of economic, political, social and cultural relations across borders ...", and to Gygli et al. (2019, p.546) it is the " … process of creating networks of connections among actors at intra- or multi-continental distances, mediated through a variety of flows including people, information and ideas, capital, and goods". The concept of globalization covers several dimensions, including economic (trade, investment, and finance), social (exchange of ideas and information), and political (government policy diffusion) (Aluko, Chen, and Opoku, 2021; Clark, 2000; Gygli et al., 2019). Considering that, in most cases, energy use involves exchange (transported over long distances) and interconnectedness between countries, Overland (2016) argues for a conceptualization of energy globalization. Taking cognizance of several definitions of globalization, Overland (2016) defines energy globalization as the growing interconnectedness of the world's energy supplies through the movement of growing volumes of energy over greater distances across international borders. Globalization allows energy products, resources, and pipes to cross borders (Shahbaz et al., 2018).

Globalization strives for openness and integration of countries. Governments are the forerunners of the globalization agenda as they hold the keys to openness and integration of economies. Hence, their efforts at all levels of globalization (economic, social, or political) cannot be undermined. Governance, thus, becomes an important factor in driving the globalization move. Globalization eases trade, investment, and connections between countries by reducing taxes (tariffs) and dismantling artificial barriers (Egger, Nigai, and Strecker, 2019). Lowering taxes and increasing connectedness expand economic activities and exchange among countries. All these fall under the ambit of governance. Kahler & Lake (2003) assert that globalization incorporates massive transformations in world politics: developing political connections at the global level, destruction of local space and time as bases of economic life, and homogenization of social life through global standards, products, and culture. These, however, are mainly resultant effects of government policies and initiatives, making governance vital in the globalization agenda. Poor governance – which could be seen, for example, in the absence of or the ineffective rule of law, poor regulatory quality, political instability, government ineffectiveness, corruption, unaccountability) - could limit globalization, as it will be a bane to doing business and exchanging ideas and information with others. Good governance safeguards competitive markets, efficient allocation of resources, and protection and security of investments (Kayalvizhi and Thenmozhi, 2018; Kucera and Principi, 2017).

Three channels through which globalization affects energy consumption can be identified. The first is the scale effect, which proposes that increased economic activities will be associated with an increase in energy consumption (Cole, 2006; Soytas, Sari, and Ewing, 2007). This is the case as energy is a significant input in production. This hypothesis has had some support in the empirical literature; for example, using quarterly data over the period 1970Q1-2015Q4 from Netherlands and Ireland, Shahbaz et al. (2018) find that energy consumption is strongly related to globalization in the long run. Gozgor et al. (2020), using data from 1970-2015 in 30 OECD countries, found that increasing economic globalization increases renewable energy consumption. The second, the technique effect, considers globalization as a means through which countries can be sustainable by reducing energy consumption by importing new energy technologies to support the increase in economic activities (Dollar and Kraay, 2004; Shahbaz, 2018; Gozgor et al., 2020). This hypothesis has also found some support in the literature. For example, Shahbaz et al. (2016) examined the globalization effect on India's energy demand using data from 1971–2012. They found that, in the long run, increased globalization leads to a reduction in energy demand.

The third is the composition effect, which suggests that energy consumption decreases with increased economic activities (Stern, 2007). Since globalization enhances transfers of technologies and norms, clean cooking energies and technologies and best energy practices can easily flow from one country to another. In line with this, Wang et al. (2021) found that economic globalization promotes green growth (environmentally adjusted multifactor productivity growth) in China using data from 1990-2018. Some other studies have found mixed results regarding the energy-globalization nexus. For example, Doğan et al. (2022), using data from 1971-2018, found that in the short-run, economic globalization reduces energy demand but increases energy demand in the long run in upper-middle-income and lower-middle-income countries in their sample of 63 countries. Using data from 98 countries from 1980-2016, Huang et al. (2020) found an inverted U-shaped relationship between globalization and energy consumption in the long run. This implies that energy consumption increases with globalization, and after a certain threshold of globalization, it begins to fall. Shahbaz et al. (2019) found similar results for 64 out of 86 high-and middle-and low-income countries from 1970–2015.

A chunk of the empirical literature also links globalization to clean or renewable energy, usually from the viewpoint of the effect of globalization on the environment. From this viewpoint, the anti-globalization agenda argues that globalization will lead to environmental degradation as globalization increases economic activities and trade, thereby increasing energy consumption (Wijen and Van Tulder, 2011; Shahbaz et al., 2108). Increased energy consumption deteriorates the environment. A large amount of global energy production and consumption are from fossil sources, exacerbating environmental degradation (Lu, Mahalik, Mahalik, & Zhao, 2022). Considering that the energy sector is the major emitter of greenhouse gases (Su et al., 2022), notably CO_2, most of the related empirical literature has looked at the effect of globalization on emissions. For example, Shen, Li, and Hasnaoui (2021), examining the carbon neutrality targets for BRICS (excluding Russia), find that globalization increases carbon emissions and works against carbon neutrality. In defining globalization as the opening of markets or the integration of the world economy through trade, foreign direct investment (FDI), and finance, Acheampong et al. (2019) find that as FDI mitigates emissions, trade intensifies emissions in 46 SSA countries over the period 1980-2015.

However, the pro-globalists argue that globalization leads to improvement in environmental quality as globalization promotes the use of efficient energy and sustainable practices through the advocacy of stringent environmental regulations (Christmann and Taylor, 2001). Chen, Gozgor, Koo & Lau (2020), examining data from 36 OECD countries from 1970 to 2016, find that political globalization decreases CO_2 emissions. The argument that globalization supports environmental quality aligns with the pollution halo hypothesis. The hypothesis presents an optimistic view of the effect of globalization (measured as FDI/openness) on the environment. The hypothesis postulates a negative relationship between FDI inflows and environmental degradation (Eskeland and Harrison, 2003). The pollution halo hypothesis hypothesizes that FDI has positive environmental spill-overs parallel to the positive productivity spill-overs that may come with FDI. These positive externalities of FDI are mainly considered to emanate from the potential of foreign investors (multinational enterprises) from developed countries to transfer superior technologies to developing countries (Cole, 2004). Hence, FDI leads to the diffusion of environmentally clean technologies. Environmental pressures and regulations/standards in foreign investors' home countries (Garcia-Johnson, 2000) mainly motivate this. Apergis, Gozgor & Lau (2021) assert that globalization indicators are the leading determinants. Some evidence of the pollution halo hypothesis has been found in the literature. For example, using data from the United States, Eskeland and Harrison (2003) found that foreign plants were significantly more energy efficient and used cleaner energy types that contribute to environmental quality. Ahmad, Jabeen, and Wu (2021) also found evidence for the pollution halo hypothesis in 15 Chinese provinces but argued that the establishment of the hypothesis depends on the development level. However, there is a plethora of evidence that globalization (openness) promotes environmental degradation (see Cole, 2004; Wagner and Timmins, 2009; Solarin et al., 2017; Singhania and Saini, 2021; Sun et al., 2022). This supports the pollution haven hypothesis (Copeland and Taylor, 1994; Low and Yeats, 1992) that developing countries could serve as pollution havens. With increasing globalization, when trade is liberalized, industries that engage in pollution-intensive activities tend to move from developed countries characterized by stringent environmental regulations to developing countries with lax regulations (Cole, 2004). Contrariwise, industries promoting clean production and technologies move to developed countries.

Scrutiny of the literature reveals that a chunk of the empirical literature focuses on the effect of globalization on the environment (emissions). With the handful of studies that consider energy, the focus has instead been on total energy consumption (with mainly no distinction between clean nor unclean energy) but not (clean) cooking fuel and energy technologies, which is the focus of this current paper. In this paper, we fill this gap by examining the impact of globalization on clean cooking fuel and energy technologies in SSA. This region has the least energy access and suffers the most from using dirty energy in cooking. It is also revealed that a chunk of the empirical studies has focused on economic (mainly FDI, financial, and trade) globalization rather than a broader measure of globalization. Globalization is, however, a multidimensional concept that incorporates much more than economic indicators. It also comprises people from different countries connecting and exchanging ideas and information or governments working jointly to deal with political problems of global concern (Acheampong, 2022; Gygli, 2019). In this study, we employ the newly constructed globalization indices of Gygli et al. (2019) that cover economic, social, and political globalization, as well as a composite index of these three. This enables us to understand the effect of globalization more broadly on many fronts vis-à-vis economic, social, and political channels. Also, considering that decisions (regarding the production, distribution, and pricing) of energy are mainly public policy issues in SSA, we consider how the governance framework of the countries interacts with globalization to affect clean cooking fuels and technologies.

3. Methodology and Data

This section describes the methods and data employed in this study. Fig. 3 summarizes the process involved in estimating the empirical results. Sub-section 3.1 includes a specification of the empirical models and econometric estimation techniques used in this study, while a description of the variables is discussed under subsection 3.2.

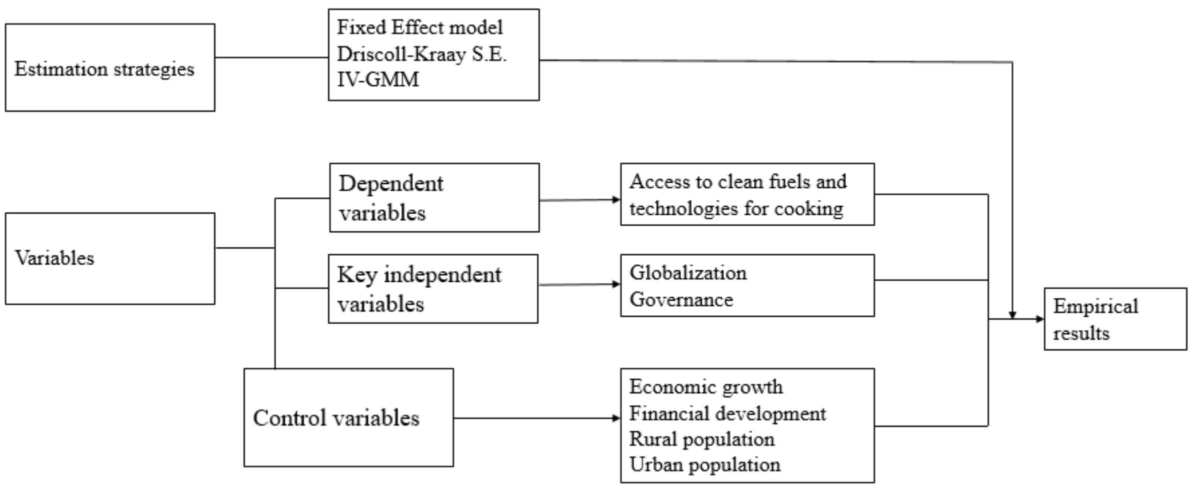


Fig. 3: Estimation process
Source: Constructed by Authors

3.1 Empirical Model and Estimation Strategies

The study examines the effect of globalization and governance on the adoption of clean cooking technologies in SSA. For modeling purposes, this study adopts the reduced-form equation to estimate the impact of globalization and governance on clean cooking fuels and technologies in SSA. Equation (1) is the reduced-form empirical model suggesting that globalization, governance, and other control variables explain clean cooking fuels and technologies.

$$lnClean_{i,t} = \alpha_0 + \beta_1 GLO_{i,t} + \beta_2 WGI_{i,t} + \delta_j lnX_{i,t} + \varepsilon_{it} \quad (1)$$

To extend the literature, this study argues that governance can condition globalization to affect clean cooking fuels and technologies usage in SSA. The literature suggests that good governance characterized by a stable political climate, enforcement of the rule of law, avoidance of corruption, effective government policy, accountability, and effective regulatory system can attract foreign investment and promote trade among countries (Asiedu, 2006; Opoku et al., 2022). We, therefore, hypothesize that governance interacts with globalization to affect the adoption of clean cooking fuels and technologies. Equation (2) is therefore used to examine the interactive effect of governance and globalization on clean cooking technologies.

$$lnClean_{i,t} = \alpha_0 + \beta_1 GLO_{i,t} + \beta_2 WGI_{i,t} + \beta_3 (GLO \times WGI)_{i,t} + \delta_j lnX_{i,t} + \varepsilon_{it} \quad (2)$$

Where:

$i = 1 — N;\ t = 1990 — 2017$

$lnClean =$ *natural logarithm of clean cooking fuels and technologies*[2]

$lnGLO =$ *globalization variables (social, political and economic globalization indices*

$WGI =$ *governance variables (the rule of law, regulatory quality, political stability, government effectiveness, control of corruption, accountability)*

$lnX =$ *natural logarithm of control variables (economic growth, financial development, urban population, and rural population). These variables are gleaned from studies such as Shahbaz (2018), Gozgor et al. (2020), and Huang, Zhang, and Duan (2020)*

$\alpha_0 =$ *coefficient of the constant parameter*

$\beta_1 — \beta_3 =$ *coefficients to be estimated*

$\delta_J =$ *coefficients on the control variables to be estimated*

$\varepsilon_{it} =$ *error term*

This study applies the fixed-effect estimator to estimate the bassline results. While the fixed-effect estimator is essential for addressing country-specific unobserved heterogeneity and time-invariant omitted variables (Baltagi & Baltagi, 2008; Hsiao, 2022), it has a limitation in addressing cross-sectional and temporal dependence and endogeneity. To present findings that are robust to cross-sectional and temporal dependence and endogeneity, Driscoll and Kraay (1998) and Baum et al. (2002) instrumental variable generalized method of moment (IV-GMM) estimators were used as the main estimation approaches. The Driscoll and Kraay (1998) estimator assumes that the error structure of Eq. (1) is heteroskedastic, autocorrelated up to some lag, and perhaps correlated between the panels. This suggests that the Driscoll and Kraay (1998) estimator is essential for capturing autocorrelation and heteroskedasticity. Also, the Driscoll–Kraay estimator generates robust estimates of both cross-sectional and temporal

[2] This is measured as access to clean fuels and technologies for cooking (as a percentage of the population).

dependence (Hoechle, 2007). Further, the Driscoll and Kraay (1998) estimator can handle missing data series and works with balanced and unbalanced panels (Hoechle, 2007). We further applied the Baum et al. (2002) IV-GMM technique. This estimation technique helps to cater for endogeneity, which is one of the significant challenges in applied research. In addition to addressing the endogeneity issue, the IV-GMM estimator allows consistent estimations in the presence of AR (1) autocorrelation within panels and heteroscedasticity (Baum et al., 2002). Also, the IV-GMM estimator is consistent with Driscoll and Kraay's (1998) standard errors that are robust to 'spatial' and temporal cross-sectional dependence even when the time dimension becomes relatively large. Post-estimation statistics such as the Hansen J-statistics and the Cragg-Donald/Kleibergen-Paap Wald F-statistics were used to test the reliability of the IV-GMM estimates. The estimates of the IV-GMM are reliable when the Hansen J-statistics rejects the null hypothesis that the instruments are over-identified[3]. Also, we compared the Cragg-Donald/Kleibergen-Paap F-statistics values to the Stock-Yogo weak ID test critical values. When the Cragg-Donald F-statistics values exceed the Stock-Yogo weak ID test critical values, it indicates that the instruments are not weak. The IV-GMM estimator has been applied in several studies, including Acheampong, Boateng, Amponsah, and Dzator (2021), Acheampong, Shahbaz, Dzator, and Jiao (2022) and Boateng, Agbola, and Mahmood, 2019 (2021).

3.2 Data Description

We use comprehensive panel data for 43 SSA that ranges between 1990 to 2017 to investigate the role of globalization and governance in adopting clean cooking technologies (see the Appendix Table 1 for the list of countries). The number of countries and years chosen are necessitated by data availability for all the variables used in the study. In this study, the adoption of clean cooking fuels and technologies is measured using the percentage of people with access to modern and clean cooking fuels and technologies. Also, four globalization indices, namely, the composite globalization index, economic globalization index, social globalization index, and political globalization index, are used in the analysis. The de facto and the de jure dimensions of the globalization indicators are used. The Word Governance Indicators, namely, the rule of law, government effectiveness, control of corruption, regulatory quality, voice and accountability, and political stability, are used to capture governance. In addition to these disaggregated governance measures, we applied the principal component analysis to these six individual governance indices to generate a composite governance indicator. The six individual governance measures range from approximately -2.5 to 2.5, with higher values corresponding to better governance outcomes (see Kaufmann et al., 2011). For the control covariates, financial development was proxied using domestic credit provided by the financial sector (% of GDP). Urban and rural populations were measured using total urban and rural population, respectively. GDP per capita (constant 2010 US$) is used as a proxy for economic growth. Political ideology variables were also included in the analysis. The description and sources of the variables used in the paper can be found in Table 2, and the variables' descriptive statistics are presented in Table 3. The variables are transformed using natural logarithms except for the governance and globalization indicators for estimation purposes.

Figures 4A-4B show the bivariate relationships between globalization, governance, and clean cooking fuels and technologies. From Figure 2A, economic, social, and composite

[3] The lags 1 and 2 of globalization indicators were used as the as instruments.

globalization indices positively correlate with access to clean cooking technologies, while political globalization has an inverse relationship with clean cooking fuels and technologies. Observation from Figure 4A shows that the positive correlation between globalization indices (economic, social, and composite globalization) and clean cooking technologies is higher in countries such as Mauritius, Seychelles, South Africa, Cabo Verde, and Botswana while lowest in countries such as Rwanda, Sierra Leone, Liberia Burundi, and the Central African Republic. This is intuitive because, on average (2000-2017), access to clean fuels and technologies for cooking has been highest in Mauritius (91%), Seychelles (86%), South Africa (72%), Cabo Verde (64%) and Botswana (55%) while on average (2000-2017), approximately less than 1% of the population in Rwanda, Sierra Leone, Liberia Burundi, and the Central African Republic have access to clean fuels and technologies for cooking. At the same time, Mauritius, Seychelles, South Africa, Cabo Verde, and Botswana are among the SSA countries that are highly integrated economically and socially. The average (2000-2017) economic globalization scores for Mauritius, Seychelles, Botswana, South Africa, and Cabo Verde are 73.1, 70.1, 57.7, and 50.5, respectively while the economic globalization scores for the Central African Republic, Burundi, Sierra Leone, and Rwanda are 29.2 30.2, 35.9 and 37.7 respectively. In addition, the average (2000-2017) scores of social globalization for Mauritius, Seychelles, Cabo Verde, Botswana, and South Africa are 71.5, 68.5, 60, 59.6, and 59.1, respectively, while the social globalization scores for Burundi, Central African Republic, Sierra Leone, and Rwanda are 24.5, 27.4, 32 and 32.9 respectively. These bivariate results indicate that countries highly integrated economically and socially have higher access to clean cooking fuels and technologies and vice versa. Contrarily, the inverse relationship between political globalization and access to clean cooking fuels and technologies is more pronounced in Ghana, Nigeria, Senegal, and Kenya because these countries, on average, are very politically integrated. For instance, on average (2000-2017), the political globalization scores for Nigeria, Senegal, Ghana, and Kenya are 83.5, 79, 78.8, and 76.2, respectively, while in Seychelles, Cabo Verde, and Botswana, the political globalization scores are 33, 34.7 and 44.6 respectively. This indicates that countries that are least integrated politically have higher access to clean cooking fuels and technologies and vice versa.

Also, Figure 2B indicates that all the governance indicators positively correlate with access to clean cooking fuels and technologies. Observation from Fig. 4B revealed there is a division between countries based on their governance scores. Most countries with weak (negative scores) governance are at the left of the y-axis, while countries with better (positive scores) governance are at the right of the y-axis. This observation shows that differences in governance effectiveness among countries also explain some variation in countries' access to clean fuels and cooking technologies. For instance, SSA’s countries, such as Botswana, Cabo Verde, Seychelles, Mauritius, Namibia, South Africa, Rwanda, and Lesotho, have better (positive values) governance scores and higher access to clean cooking fuels and technologies. On the other hand, Togo, Uganda, Kenya, Guinea, Cameroon, Burundi, Congo, Rep., Central African Republic, Nigeria, Guinea-Bissau, Sudan, Zimbabwe, Angola, Chad, Congo, Dem. Rep., Ghana, and others have less access to clean cooking fuels and technologies because they, on average, have weak governance scores. This result shows that countries with weak governance have less access to clean cooking fuels and technologies than countries with better governance.

The observations from the simple bivariate analysis suggest that globalization indices (economic, social, and composite globalization) and governance variables are generally associated with increased access to clean cooking fuels and technologies, while political globalization is associated with less access to clean cooking fuels and technologies. While the bivariate correlation analysis provides some preliminary insight into the association between governance, globalization, and access to clean cooking fuels and technologies, we cannot rely on this simple analysis for more constructive policy recommendations. We, therefore, applied advanced econometric techniques to estimate the effect of globalization and governance on clean cooking fuels and technologies while accounting for other variables such as economic growth, rural population, urban population, and financial development in the empirical model. In the next section, we present and discuss the results from the Driscoll and Kraay (1998) and IV-GMM estimators.

Table 2: Variable Description

Variables	Indicators	Description	Sources
Clean cooking technologies	*lnCLEAN*	*Access to clean fuels and technologies for cooking (% of population)*	WDI
Economic growth	*lnRGDPC*	*GDP per capita (constant 2010 US$)*	WDI
Financial development	*lnDCPF*	*Domestic credit provided by the financial sector (% of GDP)*	WDI
Rural population	*lnRURALPOP*	*Total rural population*	WDI
Urban population	*lnURBPOP*	*Total urban population*	WDI
Composite governance index	*WGI*	*Principal Component Analysis of the individual governance indicators to derive a composite governance index*	Authors
Control of Corruption	*CORRUP*	*Control of Corruption Index*	*WGI*
Government Effectiveness	*EFFEC*	*Government Effectiveness Index*	*WGI*
Political Stability	*POLITSTAB*	*Political Stability Index*	*WGI*
Regulatory quality	*REGUL*	*Regulatory quality Index*	*WGI*
Rule of Law	*LAW*	*Rule of Law Index*	*WGI*
Accountability	*ACCOUN*	*Accountability Index*	*WGI*
Composite globalization index	*KOFGI*	*KOF globalization index*	Gygli et al. (2019)
Economic globalization index	*KOFEcGI*	*KOF economic globalization index*	Gygli et al. (2019)
Social globalization index	*KOFSoGI*	*KOF social globalization index*	Gygli et al. (2019)
Political globalization index	*KOFPoGI*	*KOF political globalization index*	Gygli et al. (2019)
De facto composite globalization index	kofgidf	*KOF De facto composite globalization index*	Gygli et al. (2019)
De facto economic globalization index	kofecgidf	*KOF De facto economic globalization index*	Gygli et al. (2019)
De facto social globalization index	kofsogidf	*KOF De facto social globalization index*	Gygli et al. (2019)
De facto political globalization index	kofpogidf	*KOF De facto political globalization index*	Gygli et al. (2019)
De jure composite globalization index	kofgidj	*KOF De jure composite globalization index*	Gygli et al. (2019)
De jure economic globalization index	kofecgidj	*KOF De jure economic globalization index*	Gygli et al. (2019)
De jure social globalization index	kofsogidj	*KOF De jure social globalization index*	Gygli et al. (2019)
De jure political globalization index	kofpogidj	*KOF De jure political globalization index*	Gygli et al. (2019)
Right-wing leader	*Leader right*	*Dummy variable*	Herre (2022)
Left-wing leader	*Leader left*	*Dummy variable*	Herre (2022)
Center-wing leader	*Leader center*	*Dummy variable*	Herre (2022)

Note: WDI = Word Development Indicator database. WGI = World Governance Indicator database

Table 3: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
lnCLEAN	1.813	1.656	-1.897	4.536
lnRGDPC	6.876	0.955	5.087	9.557
lnDCPF	2.851	1.265	-5.942	5.261
lnRURALPOP	15.254	1.679	10.471	18.380
lnURBPOP	14.590	1.534	10.441	18.364
KOFGI	42.757	9.337	22.282	72.038
KOFEcGI	41.757	10.958	15.862	84.907
KOFSoGI	34.383	14.203	6.396	78.212
KOFPoGI	51.818	16.093	12.362	89.343
WGI	-0.644	0.607	-2.405	1.211
CORRUP	-0.585	0.618	-1.723	1.217
EFFEC	-0.702	0.604	-1.885	1.049
POLITSTAB	-0.513	0.916	-2.845	1.282
REGUL	-0.629	0.575	-2.298	1.127
LAW	-0.654	0.643	-2.130	1.077
ACCOUN	-0.504	0.700	-1.859	1.007
Kofgidf	41.523	10.057	18.829	71.777
Kofecgidf	47.410	15.198	14.449	91.489
Kofsogidf	30.249	14.012	5.796	74.985
Kofpogidf	46.124	20.901	6.315	92.672
Kofgidj	44.031	10.205	19.793	80.911
Kofecgidj	36.135	11.261	13.331	81.091
Kofsogidj	38.347	15.420	6.579	84.637
Kofpogidj	57.512	14.350	7.122	87.296
Leader right	0.333	0.471	0	1
Leader left	0.584	0.493	0	1
Leader center	0.045	0.208	0	1

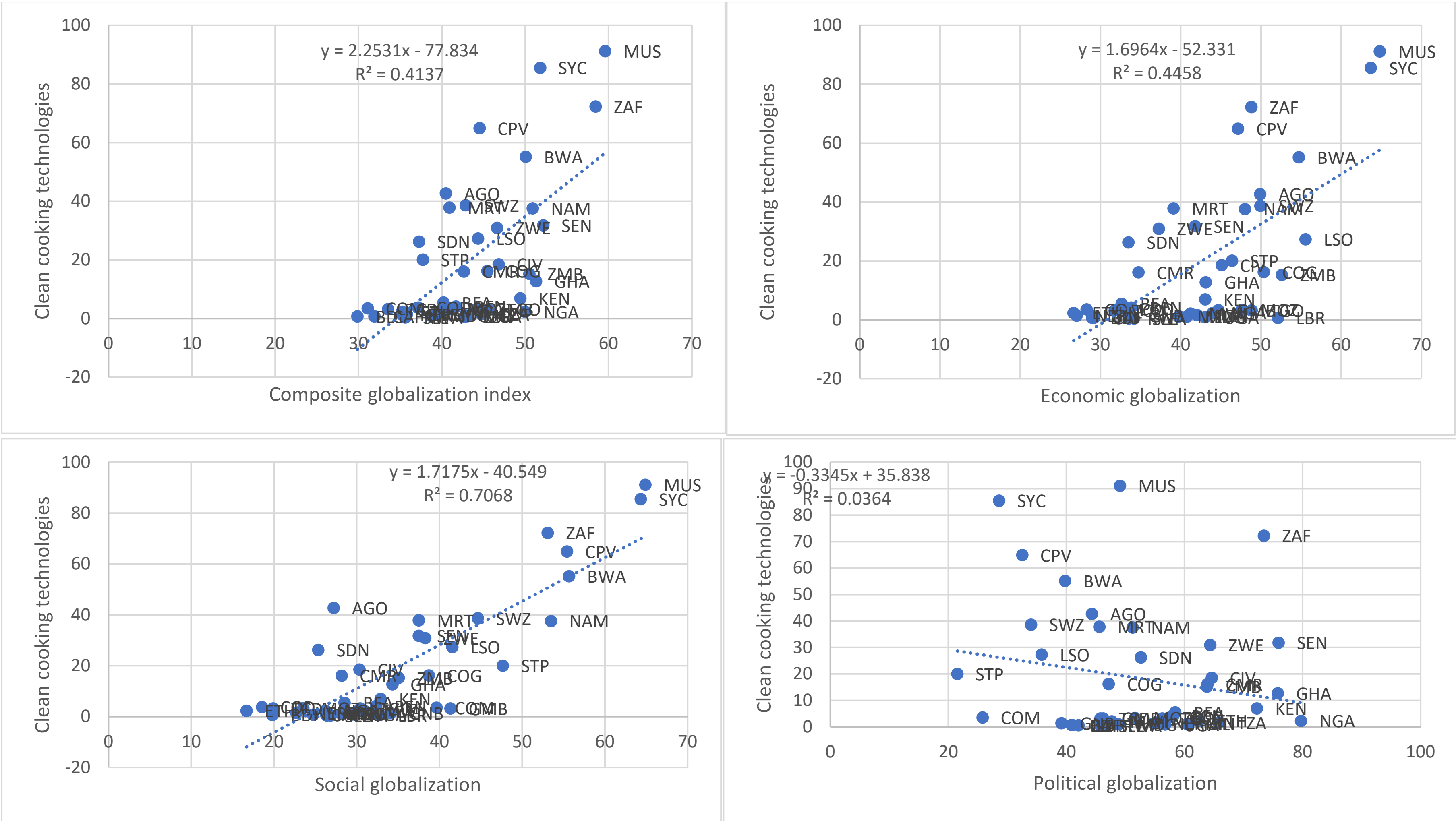
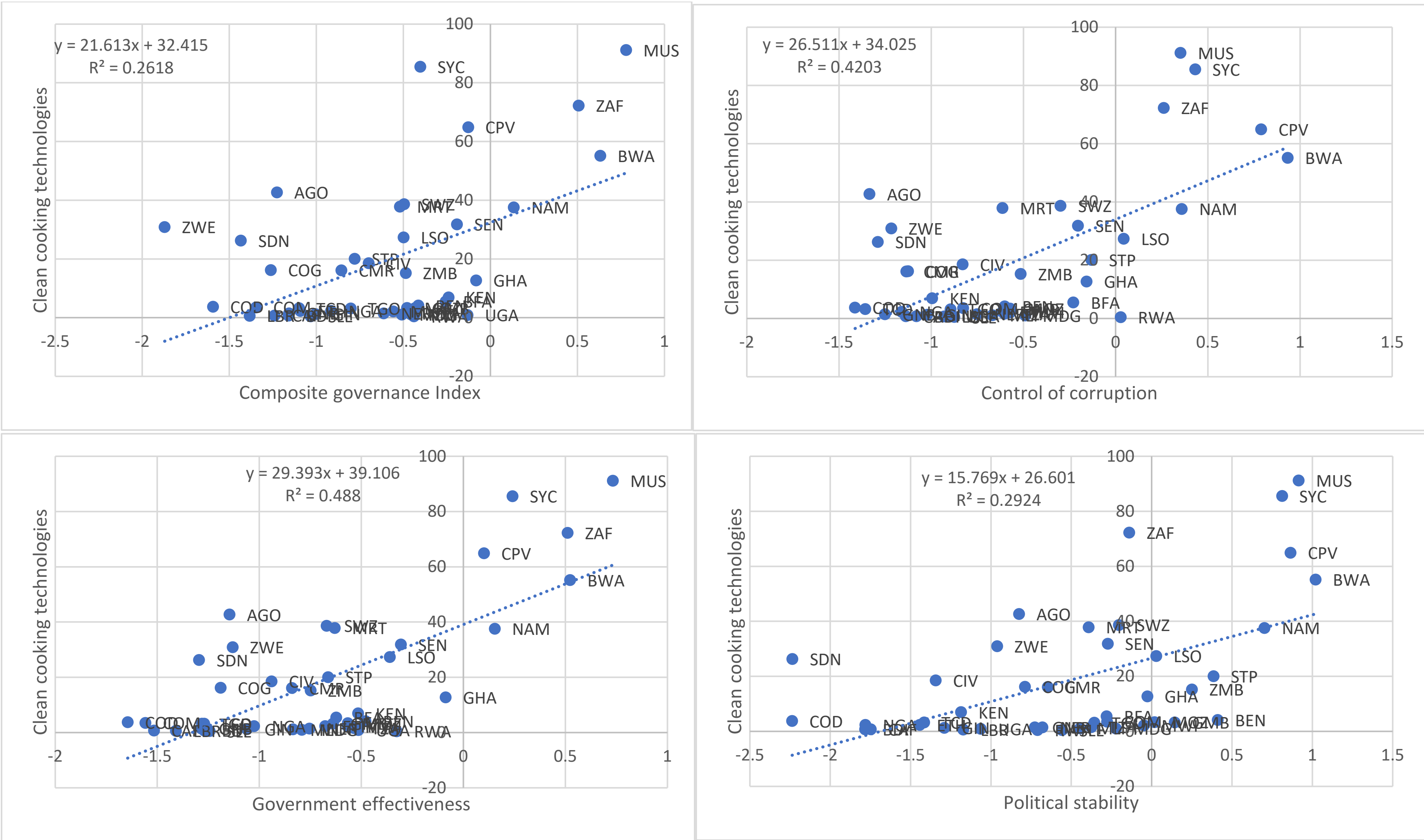


Fig. 4A: Relationship between globalization variables and clean cooking technologies



y = 21.613x + 32.415
R² = 0.2618
Clean cooking technologies
Composite governance Index
MUS
SYC
ZAF
CPV
BWA
AGO
NAM
ZWE
SDN
SEN
LSO
COG
ZMB
GHA
UGA
y = 26.511x + 34.025
R² = 0.4203
Clean cooking technologies
Control of corruption
MUS
SYC
ZAF
CPV
BWA
AGO
MRT
SWZ
NAM
ZWE
SDN
SEN
LSO
STP
CIV
ZMB
GHA
KEN
BFA
RWA
y = 29.393x + 39.106
R² = 0.488
Clean cooking technologies
Government effectiveness
MUS
SYC
ZAF
CPV
BWA
AGO
NAM
ZWE
SDN
SEN
LSO
STP
COG
ZMB
GHA
KEN
RWA
y = 15.769x + 26.601
R² = 0.2924
Clean cooking technologies
Political stability
MUS
SYC
ZAF
CPV
BWA
AGO
SWZ
NAM
ZWE
SDN
SEN
LSO
CIV
STP
ZMB
GHA
KEN
COD
BEN

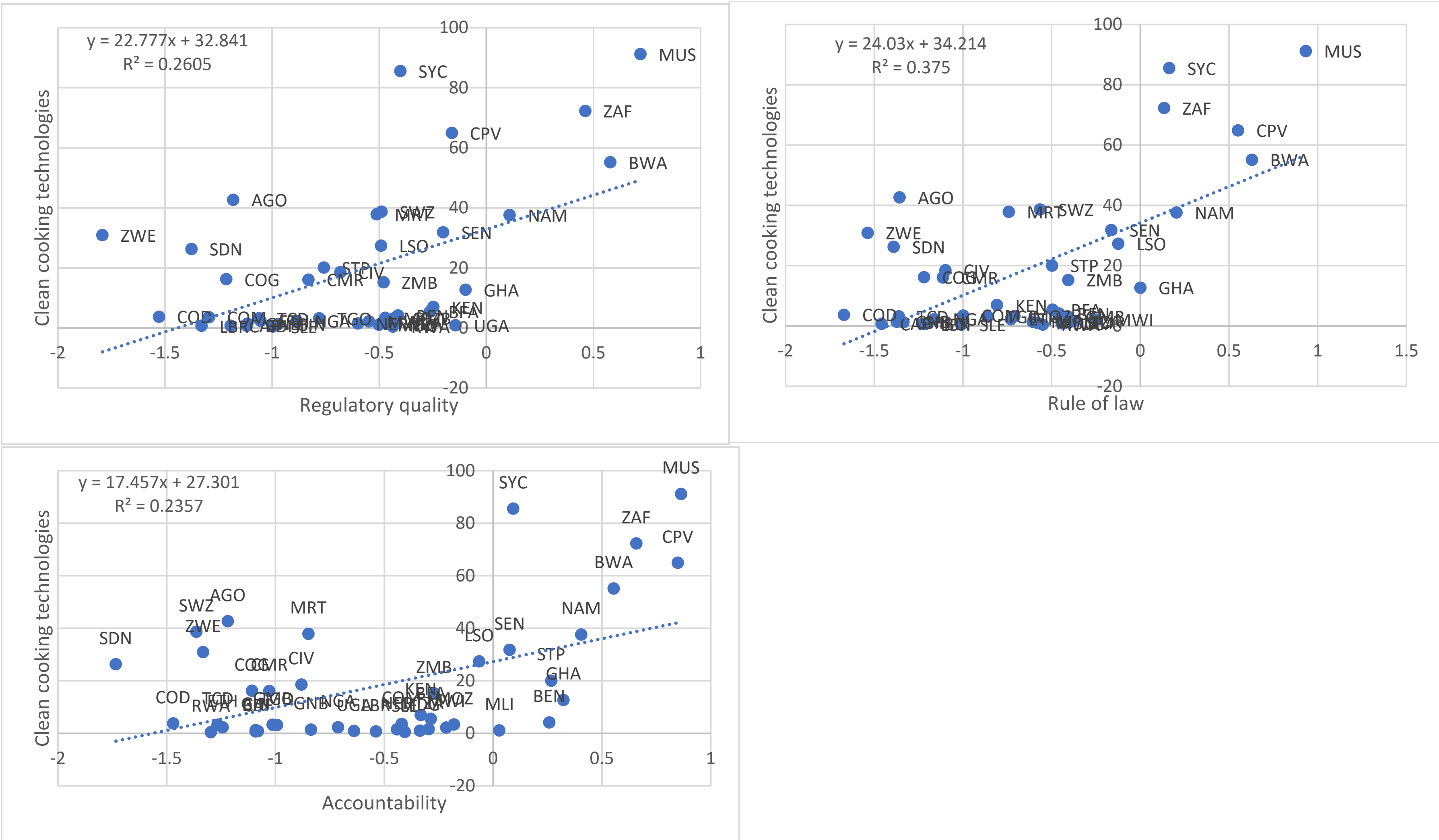


Fig. 4B: Relationship between governance variables and clean cooking technologies

4. Results and Discussion

We break down the results and discussion into three main sub-sections. In sub-section one (4.1), we focus on aggregated level or full-sample estimations. Sub-section two (4.2) provides insights from regional-level estimations to account for sub-regional heterogeneities, and the final sub-section (4.3) delves into the analysis of the interactive and marginal effects to cater for moderating effect possibilities. Before presenting the results from the Driscol-Kraay and the IV-GMM estimators, the fixed effect estimator was used to estimate the baseline results[4].

4.1.Aggregated level (full sample) analysis

We begin our discussion with the full sample or aggregate level estimations by first accounting for the possibility of cross-sectional dependence (CSD) among the variables. To do this, we employ the Driscoll-Kraay estimator with the results reported in Table 4. Within the panel framework, it is ubiquitous to account for CSD possibility due to common shocks and unobserved components, which could bias the estimates (De Hoyos & Sarafidis, 2006; Yao et al., 2019). The rationale for using the Driscoll-Kray estimator is rooted in the fact that it tends to produce heteroscedasticity and autocorrelation-consistent standard errors that are robust to general forms of spatial and temporal dependence (see Hoechle, 2007; De Hoyos & Sarafidis, 2006). Thus, Table 4 reports the preliminary results based on the Driscoll-Kraay estimator for the aggregate sample consisting of 19 models. We include the control variables (economic growth-*lnRGDPC*, financial development-*lnDCPF*, rural population-*lnRURALPOP,* and urban population-*lnURBPOP*) in all the models, whereas the main explanatory variables of globalization indices (composite economic globalization index-*KOFEcGI*; composite social globalization index-*KOFSoGI* and composite political globalization index-*KOFPoGI*) and governance indicators (corruption-*CORRUP*, government effectiveness-*EFFECT*, political stability-*POLITSTAB*, regulatory quality-*REGUL*, rule of law-*LAW*, accountability-*ACCOUN*) are presented in models 1-18. Model 19 caters for the aggregate or composite indexes for both globalization and governance, respectively (composite globalization index-*KOFGI* and composite governance index-*WGI*).

Starting with the estimates of globalization explanators (in Table 4), the results indicate a generally positive and statistically significant relationship between clean cooking fuels and technologies and the globalization indicators across almost all the models. At the preliminary level, this finding suggests that an increase in economic, social, and political globalization efforts can spur the adoption of clean cooking fuels and technologies in SSA. On the governance indicators, the results show government effectiveness, political stability, and the rule of law to have a positive and statistically significant relationship with clean cooking fuels and technologies at the conventional levels. Interestingly, the result reveals no statistical significance for the coefficient of the composite governance index (WGI), while the composite globalization index (KOFGI) shows a significant positive linkage with clean cooking fuels and technologies. For the control variables, the coefficients of economic growth and urban population are positive and statistically significant at the 1% level. This implies that an increase in both economic growth and urban population stimulates the adoption of clean cooking fuels and technologies. On the contrary, the coefficients of financial development and rural population are negative and statistically significant at the 1% level implying that the rise in financial development and rural population do not necessarily spur clean cooking fuels and

[4] See Appendix Table 2 for the fixed effect results. Because of the limitations of the fixed-effect estimator in addressing cross-sectional and temporal dependence and endogeneity, we did not discuss the fixed-effect estimation results.

technologies. We must add that while these findings sound interesting and intuitive so far, the Driscoll-Kraay estimations do not consider endogeneity possibilities within the data. Hence, we take the results here with caution and to be preliminary at best.

In the next stage, we employ the instrumental variable generalized method of moment (IV-GMM) technique to cater for possible endogeneity issues. Indeed, the IV-GMM approach is well known for handling sources of endogeneity, including reverse causality, omitted variable bias, and measurement errors. Furthermore, in the presence of heteroscedasticity and autocorrelation within panels, the IV-GMM tends to provide consistent estimations and is equally able to account for temporal-cross sectional dependence (Baum et al., 2002, Acheampong et al., 2022). We present the estimates from the IV-GMM technique in Table 5 for the full or aggregated sample. Given that the IV-GMM estimator considers endogeneity issues and provides robust estimates for spatial and temporal CSD, we consider it our main estimation method. The number of models and presentations are the same as discussed from the Driscoll-Kray estimator (Table 4).

The results in Table 5 are largely consistent with our Driscoll-Kray estimates but with a slightly more significant number of coefficients. Starting with the main explanatory variables, the results reveal that the different components/indices of globalization and governance indicators positively and statistically significantly impact clean cooking fuels and technologies. The implication from the statistically significant positive coefficients is that improvement in globalization levels is critical for quicker adoption of cleaner cooking technologies within the SSA region. Indeed, the findings are consistent with the composite effect channels by which globalization efforts impact clean energy (Stern, 2007). The mechanism here is that globalization often tends to boost transfers/exchange of best practices, including technologies and norms, cooking energies, and clean technologies between countries. This is also corroborated in the recent study by Wang et al. (2021). For example, economic globalization in the form of trade and capital flows could allow the exchange or import of new energy technologies, and equally, information and cultural flows via social globalization can enable information sharing regarding best practices for the adoption and implementation of clean cooking energies (see, Shahbaz et al., 2016, 2018). In particular, economic globalization via FDI inflows bring financial capital, managerial expertise, know-how, and greater energy efficiency via the so-called technology leapfrogging, which stimulates the adoption of clean energy technologies. This is in line with Gallagher and Zarsky (2007), Keeley and Ikeda (2017), Kumar and Sinha (2014) and Przychodzen and Przychodzen (2020).

Shifting to the governance indicators, the results reveal that control of corruption, government effectiveness, and the rule of law improve the adoption of clean cooking fuels and technologies at the conventional significance levels, ceteris paribus. This result implies that an increase in control of corruption levels coupled with an improvement in the effectiveness of government and the rule of law bodes well for clean cooking fuels and technologies adoption in SSA. This is consistent with a few studies in the literature, including Moe (2010), Liu et al. (2021), and Djankov et al. (2007). The understanding is that governance infrastructure in the form of the rule of law, government effectiveness, and reduction of corruption levels provides an enabling environment and protection for investors, creditors, and other players interested in the administration of cleaner energy investments and clean cooking technology projects (Liu et al., 2021). As Asongu and Odhiambo (2021), poor political and institutional governance negatively impact clean energy adoption in SSA, thus corroborating our results on the importance of good quality governance infrastructure to expand access to clean cooking fuels and technologies. Intriguingly, the result in model 19 for the composite governance index (WGI) is not statistically significant, but the coefficient for the composite globalization index (KOFGI) is statistically significant and positively associated with clean cooking fuels and technologies. This result again echoes that an increase in globalization efforts via FDI, trade, knowledge transfers, and information sharing can stimulate clean cooking technology use in SSA.

Turning to the control variables, the results indicate coefficients of both economic growth and urban population variables to be statistically significant and positively related to clean cooking fuels and technologies. In particular, a 1% increase in economic growth and urban population, respectively, is expected to lead to, on average, 1.234%-1.360% and 0.162%-0.279% increment in clean cooking fuels and technologies adoption at the 1% level of significance, ceteris paribus. This finding is rather intuitive and consistent with a host of extant studies, including Ghosh (2002), Gregori & Tiwari (2020), Karanfil & Li (2015), Opoku, Kufuor & Manu (2021), and Yoo & Kim (2006). For example, an increase in GDP or economic growth provides greater opportunities for access to jobs and income levels, which leads to higher purchasing power. As income rises, people can demand and pay for modern energy, including clean cooking fuels. Based on the "energy ladder" theory, the implication is that a rise in average household income levels (due to increasing economic growth) could trigger the switch away from traditional fuels to cleaner cooking energies (see Van der Kroon., 2013). Thus, economic growth is vital for accelerating clean cooking technologies among SSA countries.

Regarding the urban population, the results imply that, all other things equal, an increase in urbanization is associated with a rise in the adoption of clean cooking fuels and technologies. This is rather unsurprising and consistent with the fact that for most SSA countries, electricity provision and other amenities are generally more accessible in urban cities than in rural areas. In addition, increasing migration levels to urban areas often pressure governments to provide basic amenities and electricity (a manifest of urban bias theory), which bodes well for clean cooking fuel usage. Given that most well-paying jobs are in urban cities, migrants can increase their income levels, and with the contemporary lifestyle, they can switch from using unconventional cooking fuels to clean fuels (as most urban homes have clean cooking technology facilities). Our finding is in line with Busso et al. (2021), Selod & Shilpi (2021), Gregori & Tiwari (2020), and Su (2020).

On the contrary, the coefficients for the financial development and rural population are found to be negative and statistically significant at the 1% level throughout our models. The negative coefficients suggest that increased financial development and rural population do not stimulate clean cooking fuels and technologies (full sample). Although this finding is inconsistent with Çoban & Topcu (2013); Ji & Zhang (2019), and Sadorsky (2011), it is plausible that with access to cheap credits, switching to clean cooking fuels may not be a priority for an average rural household faced with a myriad of basic needs such as healthcare, education, food and shelter which is a common plague across the SSA region. In addition, the negative relationship between clean cooking fuels and technologies and the rural population is unsurprising, given that most rural areas are still largely without access to electricity and very limited social amenities. This also corroborates the urban bias theory, which argues that resource allocation and provision of social amenities are often disproportionately devoted to urban cities at the expense of rural areas. Additionally, for the rural poor, access does not equate to affordability; hence, the results further lead credence to the poor economic and income levels in rural SSA, thus militating against the adoption of clean cooking energy. This is consistent with Joon et al. (2009), who document that in India, for example, firewood and solid biomass are the dominant cooking fuels even in households with LPG cooking connections due to affordability concerns.

Table 4: Driscoll-Kraay results for Aggregated sample

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	1.275***	1.256***	1.320***	1.246***	1.232***	1.285***	1.293***	1.266***	1.344***	1.290***	1.262***	1.343***	1.269***	1.262***	1.310***	1.301***	1.250***	1.360***	1.247***
	(0.051)	(0.034)	(0.027)	(0.052)	(0.041)	(0.029)	(0.034)	(0.026)	(0.016)	(0.043)	(0.032)	(0.024)	(0.032)	(0.024)	(0.007)	(0.029)	(0.037)	(0.012)	(0.047)
lndcpf	-0.111***	-0.117***	-0.115***	-0.114***	-0.118***	-0.116***	-0.108***	-0.115***	-0.112***	-0.107***	-0.115***	-0.112***	-0.115***	-0.118***	-0.118***	-0.105***	-0.114***	-0.111***	-0.127***
	(0.012)	(0.011)	(0.012)	(0.010)	(0.011)	(0.012)	(0.011)	(0.011)	(0.014)	(0.010)	(0.010)	(0.013)	(0.011)	(0.011)	(0.013)	(0.013)	(0.010)	(0.014)	(0.010)
lnruralpop	-0.212***	-0.189***	-0.250***	-0.240***	-0.222***	-0.274***	-0.193***	-0.169***	-0.232***	-0.215***	-0.178***	-0.259***	-0.229***	-0.213***	-0.263***	-0.207***	-0.174***	-0.262***	-0.184***
	(0.037)	(0.035)	(0.040)	(0.031)	(0.035)	(0.031)	(0.047)	(0.051)	(0.042)	(0.040)	(0.045)	(0.039)	(0.038)	(0.040)	(0.035)	(0.049)	(0.051)	(0.052)	(0.048)
lnurbpop	0.263***	0.264***	0.232***	0.276***	0.279***	0.259***	0.245***	0.247***	0.210***	0.248***	0.245***	0.208***	0.276***	0.278***	0.257***	0.241***	0.247***	0.190***	0.162***
	(0.021)	(0.030)	(0.032)	(0.024)	(0.030)	(0.034)	(0.033)	(0.036)	(0.037)	(0.033)	(0.039)	(0.043)	(0.027)	(0.030)	(0.029)	(0.038)	(0.041)	(0.038)	(0.051)
KOFEcGI	0.011**			0.010			0.012*			0.012**			0.010			0.014*			
	(0.005)			(0.005)			(0.006)			(0.006)			(0.006)			(0.007)			
KOFSoGI		0.012***			0.010***			0.013***			0.015***			0.009**			0.019***		
		(0.002)			(0.002)			(0.004)			(0.003)			(0.003)			(0.006)		
KOFPoGI			0.008***			0.005***			0.008***			0.009***			0.006***			0.012***	
			(0.002)			(0.001)			(0.001)			(0.001)			(0.001)			(0.002)	
Corrup	0.146	0.130	0.161																
	(0.141)	(0.151)	(0.163)																
Effec				0.199*	0.196*	0.219*													
				(0.095)	(0.103)	(0.125)													
Politstab							0.079*	0.071*	0.082*										
							(0.039)	(0.035)	(0.044)										
Regul										0.053	0.017	0.057							
										(0.071)	(0.076)	(0.093)							
Law													0.169***	0.159***	0.187**				
													(0.046)	(0.051)	(0.070)				
Accoun																-0.010	-0.074	-0.033	
																(0.040)	(0.053)	(0.045)	
WGI																			-0.081
																			(0.061)
KOFGI																			0.030***
																			(0.007)
Constant	-7.798***	-7.998***	-7.013***	-7.237***	-7.398***	-6.615***	-8.025***	-8.224***	-7.219***	-7.761***	-8.127***	-6.838***	-7.587***	-7.739***	-6.962***	-7.944***	-8.328***	-6.821***	-7.542***
	(0.168)	(0.141)	(0.234)	(0.118)	(0.095)	(0.115)	(0.353)	(0.398)	(0.317)	(0.258)	(0.211)	(0.143)	(0.249)	(0.290)	(0.219)	(0.275)	(0.353)	(0.227)	(0.253)
Obs	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636
No. of Countries	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
r2	0.717	0.716	0.716	0.719	0.718	0.717	0.717	0.716	0.715	0.716	0.715	0.714	0.718	0.717	0.717	0.716	0.716	0.714	0.719

Standard errors in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: IV-GMM results for Aggregated sample

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
lnrgdpc	1.275***	1.256***	1.315***	1.247***	1.232***	1.281***	1.294***	1.266***	1.338***	1.291***	1.262***	1.338***	1.270***	1.261***	1.305***	1.302***	1.250***	1.354***	1.242***
	(0.060)	(0.065)	(0.055)	(0.061)	(0.066)	(0.059)	(0.056)	(0.064)	(0.050)	(0.060)	(0.064)	(0.058)	(0.058)	(0.064)	(0.054)	(0.057)	(0.065)	(0.049)	(0.060)
lndcpf	-0.112***	-0.119***	-0.118***	-0.114***	-0.121***	-0.118***	-0.108***	-0.117***	-0.114***	-0.107***	-0.117***	-0.115***	-0.115***	-0.121***	-0.120***	-0.105***	-0.117***	-0.114***	-0.130***
	(0.025)	(0.025)	(0.026)	(0.025)	(0.024)	(0.025)	(0.025)	(0.025)	(0.026)	(0.025)	(0.025)	(0.026)	(0.025)	(0.025)	(0.026)	(0.025)	(0.025)	(0.027)	(0.026)
lnruralpop	-0.211***	-0.187***	-0.253***	-0.240***	-0.219***	-0.276***	-0.193***	-0.166***	-0.237***	-0.215***	-0.175**	-0.262***	-0.230***	-0.210***	-0.266***	-0.207***	-0.171***	-0.268***	-0.180***
	(0.061)	(0.063)	(0.060)	(0.060)	(0.064)	(0.059)	(0.062)	(0.063)	(0.060)	(0.063)	(0.068)	(0.060)	(0.061)	(0.066)	(0.059)	(0.061)	(0.064)	(0.059)	(0.066)
lnurbpop	0.263***	0.265***	0.222***	0.276***	0.280***	0.248***	0.245***	0.248***	0.201***	0.248***	0.246***	0.197***	0.276***	0.278***	0.245***	0.241***	0.247***	0.179***	0.157**
	(0.055)	(0.055)	(0.063)	(0.054)	(0.055)	(0.064)	(0.056)	(0.056)	(0.063)	(0.056)	(0.057)	(0.069)	(0.055)	(0.057)	(0.067)	(0.056)	(0.057)	(0.065)	(0.063)
KOFEcGI	0.011***			0.010**			0.011***			0.012***			0.010**			0.013***			
	(0.004)			(0.004)			(0.004)			(0.004)			(0.004)			(0.004)			
KOFSoGI		0.012**			0.010*			0.013**			0.015**			0.010			0.019***		
		(0.006)			(0.006)			(0.006)			(0.006)			(0.006)			(0.006)		
KOFPoGI			0.009*			0.007			0.010**			0.011**			0.007			0.014***	
			(0.005)			(0.005)			(0.005)			(0.005)			(0.005)			(0.005)	
Corrup	0.147*	0.128	0.156*																
	(0.087)	(0.092)	(0.090)																
Effec				0.200**	0.192**	0.212**													
				(0.082)	(0.087)	(0.087)													
Politstab							0.080	0.069	0.078										
							(0.051)	(0.052)	(0.053)										
Regul										0.055	0.016	0.049							
										(0.094)	(0.101)	(0.103)							
Law													0.170**	0.156*	0.179**				
													(0.077)	(0.086)	(0.082)				
Accoun																-0.010	-0.073	-0.041	
																(0.054)	(0.066)	(0.061)	
WGI																			-0.084
																			(0.102)
KOFGI																			0.031***
																			(0.008)
Constant	-7.803***	-8.055***	-6.851***	-7.241***	-7.471***	-6.472***	-8.025***	-8.283***	-7.037***	-7.757***	-8.181***	-6.671***	-7.586***	-7.806***	-6.800***	-7.945***	-8.371***	-6.626***	-7.530***
	(0.675)	(0.691)	(0.697)	(0.759)	(0.797)	(0.737)	(0.642)	(0.647)	(0.657)	(0.784)	(0.840)	(0.734)	(0.695)	(0.733)	(0.697)	(0.676)	(0.696)	(0.699)	(0.785)
Obs	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636
r2	0.717	0.716	0.716	0.719	0.718	0.717	0.717	0.716	0.715	0.716	0.715	0.714	0.718	0.717	0.717	0.716	0.716	0.714	0.719
Hansen J	0.883	0.347	0.478	0.862	0.313	0.465	0.980	0.352	0.457	0.937	0.395	0.458	0.922	0.329	0.501	0.939	0.432	0.433	0.433
No. of Instruments	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of countries	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
F-statistics	2660.072	9680.697	2043.769	2525.601	9720.129	1696.068	2727.001	10405.099	1988.858	2524.942	8541.353	1546.993	2577.249	7516.676	1717.218	2761.717	8723.154	1898.610	2855.353
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: IV-GMM results for West Africa sample

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	1.774***	1.588***	2.117***	1.687***	1.494***	2.113***	2.196***	1.865***	2.163***	1.759***	1.612***	2.054***	1.929***	1.708***	2.193***	2.245***	1.933***	2.240***	1.744***
	(0.179)	(0.180)	(0.132)	(0.148)	(0.160)	(0.122)	(0.133)	(0.153)	(0.094)	(0.128)	(0.136)	(0.110)	(0.154)	(0.164)	(0.117)	(0.158)	(0.162)	(0.114)	(0.112)
lndcpf	-0.231*	-0.132	0.153	-0.150	-0.035	0.164*	-0.031	-0.002	0.165*	-0.088	0.016	0.156*	-0.121	-0.066	0.178*	-0.073	-0.035	0.187**	-0.145*
	(0.126)	(0.093)	(0.097)	(0.127)	(0.096)	(0.091)	(0.135)	(0.098)	(0.091)	(0.121)	(0.100)	(0.093)	(0.126)	(0.092)	(0.092)	(0.132)	(0.086)	(0.088)	(0.079)
lnruralpop	0.457***	0.602***	0.313***	0.548***	0.574***	0.318***	0.748***	0.831***	0.324***	0.464***	0.434***	0.283***	0.530***	0.662***	0.349***	0.714***	0.928***	0.376***	0.914***
	(0.151)	(0.139)	(0.105)	(0.127)	(0.114)	(0.093)	(0.140)	(0.118)	(0.099)	(0.115)	(0.105)	(0.093)	(0.140)	(0.122)	(0.099)	(0.154)	(0.133)	(0.101)	(0.092)
lnurbpop	-0.685***	-0.719***	-1.644***	-0.834***	-0.718***	-1.641***	-0.994***	-0.957***	-1.736***	-0.786***	-0.644***	-1.518***	-0.809***	-0.823***	-1.753***	-1.096***	-1.143***	-1.774***	-1.597***
	(0.179)	(0.158)	(0.159)	(0.146)	(0.124)	(0.145)	(0.158)	(0.129)	(0.129)	(0.134)	(0.115)	(0.153)	(0.163)	(0.136)	(0.156)	(0.174)	(0.145)	(0.131)	(0.131)
KOFEcGI	0.030***			0.041***			0.028***			0.033***			0.025**			0.028***			
	(0.010)			(0.010)			(0.010)			(0.009)			(0.010)			(0.011)			
KOFSoGI		0.047***			0.047***			0.049***			0.031***			0.045***			0.061***		
		(0.010)			(0.010)			(0.010)			(0.010)			(0.010)			(0.010)		
KOFPoGI			0.098***			0.097***			0.103***			0.089***			0.103***			0.102***	
			(0.007)			(0.008)			(0.008)			(0.010)			(0.008)			(0.006)	
Corrup	0.829***	0.589***	0.056																
	(0.142)	(0.149)	(0.143)																
Effec				1.075***	0.807***	0.073													
				(0.127)	(0.136)	(0.150)													
Politstab							0.382***	0.271***	-0.064										
							(0.078)	(0.079)	(0.087)										
Regul										1.332***	1.128***	0.278							
										(0.117)	(0.130)	(0.179)							
Law													0.665***	0.479***	-0.088				
													(0.119)	(0.123)	(0.136)				
Accoun																0.098	-0.131	-0.165*	
																(0.108)	(0.111)	(0.096)	
WGI																			0.570***
																			(0.121)
KOFGI																			0.123***
																			(0.011)
Constant	-7.254***	-8.757***	0.588	-6.236***	-7.730***	0.549	-10.771***	-11.277***	1.096	-6.016***	-6.972***	0.279	-7.772***	-9.090***	0.705	-9.126***	-10.960***	0.298	-5.351***
	(1.219)	(1.174)	(1.056)	(1.135)	(1.083)	(1.056)	(1.049)	(0.958)	(1.340)	(1.001)	(0.991)	(1.073)	(1.157)	(1.100)	(1.068)	(1.301)	(1.261)	(1.132)	(0.897)
Obs	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
r2	0.678	0.692	0.779	0.705	0.711	0.780	0.669	0.687	0.779	0.735	0.732	0.784	0.679	0.693	0.779	0.640	0.676	0.782	0.788
Hansen J	0.370	0.402	0.136	0.767	0.256	0.143	0.328	0.468	0.121	0.774	0.331	0.163	0.484	0.350	0.121	0.463	0.769	0.129	0.117
No. of Instruments	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of countries	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
F-statistics	355.073	2664.139	318.821	332.765	2878.381	269.336	361.223	2851.705	312.836	354.631	2489.062	168.377	359.580	2658.309	259.421	349.950	2775.091	468.604	446.321
Stock-Yogo Weak ID test Critical values																			

10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: IV-GMM results for East Africa sample

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	19
lnrgdpc	1.442***	1.638***	1.634***	1.664***	1.852***	1.821***	1.388***	1.503***	1.584***	1.618***	1.696***	1.774***	1.553***	1.677***	1.724***	1.494***	1.675***	1.665***	1.713***
	(0.084)	(0.110)	(0.084)	(0.092)	(0.103)	(0.077)	(0.080)	(0.118)	(0.088)	(0.078)	(0.095)	(0.066)	(0.082)	(0.106)	(0.075)	(0.073)	(0.109)	(0.090)	(0.086)
lndcpf	0.702***	0.723***	0.744***	0.740***	0.785***	0.784***	0.687***	0.682***	0.721***	0.697***	0.736***	0.776***	0.732***	0.736***	0.766***	0.745***	0.722***	0.748***	0.754***
	(0.057)	(0.054)	(0.052)	(0.055)	(0.053)	(0.053)	(0.054)	(0.053)	(0.049)	(0.055)	(0.053)	(0.053)	(0.057)	(0.056)	(0.055)	(0.057)	(0.056)	(0.055)	(0.055)
lnruralpop	-0.128	-0.042	0.253*	0.301**	0.298***	0.505***	-0.260*	-0.158	0.207	0.379***	0.304***	0.476***	0.042	0.111	0.416***	-0.112	0.037	0.399***	0.297***
	(0.117)	(0.108)	(0.130)	(0.143)	(0.110)	(0.119)	(0.139)	(0.144)	(0.161)	(0.135)	(0.105)	(0.106)	(0.121)	(0.109)	(0.120)	(0.126)	(0.110)	(0.131)	(0.102)
lnurbpop	0.267**	0.142	0.213**	-0.054	-0.080	0.009	0.393***	0.265**	0.268**	-0.080	-0.023	0.019	0.166	0.066	0.122	0.314**	0.114	0.194*	0.016
	(0.114)	(0.100)	(0.108)	(0.136)	(0.104)	(0.108)	(0.130)	(0.132)	(0.127)	(0.126)	(0.101)	(0.095)	(0.116)	(0.103)	(0.105)	(0.128)	(0.102)	(0.118)	(0.103)
KOFEcGI	-0.011*			0.004			-0.012**			0.013*			-0.009			-0.021***			
	(0.006)			(0.007)			(0.005)			(0.008)			(0.006)			(0.005)			
KOFSoGI		-0.024***			-0.019***			-0.018**			-0.005			-0.018**			-0.030***		
		(0.008)			(0.007)			(0.008)			(0.008)			(0.007)			(0.009)		
KOFPoGI			-0.036***			-0.031***			-0.037***			-0.025***			-0.038***			-0.045***	
			(0.006)			(0.006)			(0.006)			(0.006)			(0.006)			(0.007)	
Corrup	-0.554***	-0.567***	-0.484***																
	(0.104)	(0.083)	(0.085)																
Effec				-0.749***	-0.590***	-0.500***													
				(0.104)	(0.062)	(0.068)													
Politstab							-0.310***	-0.280***	-0.211***										
							(0.064)	(0.067)	(0.063)										
Regul										-0.912***	-0.699***	-0.598***							
										(0.119)	(0.082)	(0.067)							
Law													-0.494***	-0.444***	-0.343***				
													(0.112)	(0.094)	(0.090)				
Accoun																-0.207**	-0.123	-0.083	
																(0.091)	(0.098)	(0.087)	
WGI																			-0.601***
																			(0.099)
KOFGI																			-0.012
																			(0.011)
Constant	-12.425***	-12.923***	-17.496***	-16.910***	-16.873***	-20.187***	-11.599***	-11.934***	-16.979***	-17.761***	-17.165***	-19.913***	-14.490***	-14.654***	-19.211***	-13.227***	-13.506***	-19.016***	-17.374***
	(0.891)	(0.905)	(1.165)	(1.027)	(0.874)	(0.995)	(0.848)	(0.948)	(1.265)	(0.951)	(0.823)	(0.881)	(0.928)	(0.909)	(0.985)	(0.828)	(0.941)	(1.249)	(0.801)
Obs	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184	184
r2	0.906	0.912	0.917	0.912	0.916	0.919	0.903	0.904	0.911	0.921	0.920	0.925	0.903	0.905	0.913	0.895	0.896	0.905	0.920
Hansen J	0.495	0.340	0.012	0.974	0.363	0.006	0.922	0.615	0.027	0.432	0.240	0.046	0.874	0.569	0.022	0.995	0.573	0.033	0.450

No. of Instruments	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of countries	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
F-statistics	421.563	3554.631	342.891	242.885	3021.835	273.877	459.160	2142.969	269.349	228.698	1949.171	242.251	307.964	2005.518	287.692	528.577	2181.765	265.541	510.618
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: IV-GMM results for Central Africa sample

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	19
lnrgdpc	1.279***	1.262***	1.201***	0.846***	0.857***	0.928***	0.717***	0.887***	0.938***	0.960***	0.990***	1.009***	0.963***	1.016***	0.995***	1.242***	1.227***	1.178***	0.824***
	(0.080)	(0.081)	(0.106)	(0.079)	(0.089)	(0.101)	(0.134)	(0.103)	(0.118)	(0.117)	(0.097)	(0.105)	(0.100)	(0.090)	(0.107)	(0.077)	(0.083)	(0.101)	(0.126)
lndcpf	-0.285***	-0.296***	-0.321***	-0.265***	-0.289***	-0.311***	-0.225***	-0.277***	-0.302***	-0.304***	-0.324***	-0.344***	-0.257***	-0.282***	-0.303***	-0.261***	-0.270***	-0.295***	-0.314***
	(0.037)	(0.032)	(0.037)	(0.024)	(0.025)	(0.026)	(0.032)	(0.026)	(0.035)	(0.031)	(0.026)	(0.028)	(0.031)	(0.030)	(0.034)	(0.033)	(0.031)	(0.037)	(0.025)
lnruralpop	0.046	0.091	-0.080	-0.059	0.047	-0.199***	-0.013	-0.033	-0.220**	-0.208**	-0.126	-0.313***	-0.070	-0.070	-0.190**	0.058	0.118	-0.038	-0.091
	(0.169)	(0.136)	(0.182)	(0.067)	(0.081)	(0.072)	(0.107)	(0.106)	(0.094)	(0.089)	(0.097)	(0.086)	(0.101)	(0.098)	(0.095)	(0.134)	(0.108)	(0.143)	(0.093)
lnurbpop	0.452***	0.423***	0.372***	0.462***	0.411***	0.495***	0.454***	0.504***	0.514***	0.644***	0.605***	0.584***	0.529***	0.548***	0.489***	0.491***	0.450***	0.394***	0.407***
	(0.146)	(0.113)	(0.129)	(0.056)	(0.070)	(0.082)	(0.103)	(0.094)	(0.117)	(0.084)	(0.084)	(0.110)	(0.088)	(0.085)	(0.104)	(0.105)	(0.084)	(0.105)	(0.115)
KOFEcGI	0.009			0.024***			0.035***			0.022**			0.021**			0.009			
	(0.012)			(0.006)			(0.010)			(0.011)			(0.008)			(0.009)			
KOFSoGI		0.012			0.024***			0.019**			0.020**			0.012			0.012		
		(0.009)			(0.007)			(0.008)			(0.008)			(0.008)			(0.009)		
KOFPoGI			0.021*			0.014			0.016			0.019*			0.018			0.021**	
			(0.011)			(0.009)			(0.013)			(0.011)			(0.011)			(0.010)	
Corrup	1.059***	0.956**	0.741																
	(0.369)	(0.388)	(0.453)																
Effec				1.151***	1.121***	0.983***													
				(0.130)	(0.139)	(0.176)													
Politstab							0.621***	0.482***	0.401***										
							(0.110)	(0.095)	(0.135)										
Regul										1.079***	0.979***	0.810***							
										(0.286)	(0.253)	(0.289)							
Law													1.224***	1.113***	1.013***				
													(0.244)	(0.242)	(0.291)				
Accoun																1.027***	0.981***	0.851***	
																(0.248)	(0.262)	(0.303)	
WGI																			0.886***
																			(0.244)
KOFGI																			0.054***
																			(0.015)

Constant	-13.095***	-13.375***	-10.511***	-9.116***	-9.913***	-7.962***	-9.956***	-10.924***	-8.843***	-10.447***	-11.189***	-8.658***	-10.447***	-10.812***	-8.625***	-13.793***	-14.052***	-11.281***	-9.307***
	(0.882)	(0.849)	(1.630)	(0.904)	(0.940)	(1.366)	(1.018)	(1.147)	(1.481)	(1.036)	(1.093)	(1.363)	(1.054)	(1.196)	(1.500)	(1.001)	(0.914)	(1.669)	(1.072)
Obs	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86
r2	0.909	0.909	0.903	0.944	0.945	0.935	0.931	0.924	0.916	0.925	0.925	0.915	0.931	0.928	0.922	0.922	0.922	0.916	0.926
Hansen J	0.986	0.855	0.481	0.771	0.359	0.702	0.433	0.998	0.458	0.918	0.992	0.806	0.601	0.629	0.552	0.899	0.698	0.323	0.781
No. of Instruments	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of countries	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
F-statistics	125.393	726.491	32.578	104.458	790.572	37.921	93.417	773.627	36.679	113.921	801.336	34.680	106.058	733.010	35.925	126.140	793.777	34.284	143.053
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: IV-GMM results for Southern Africa sample

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
lnrgdpc	1.083***	0.982***	1.045***	1.093***	1.045***	1.081***	0.926***	0.779***	0.778***	1.124***	1.018***	1.109***	1.074***	0.950***	1.034***	1.057***	0.941***	0.972***	1.062***
	(0.062)	(0.091)	(0.060)	(0.061)	(0.078)	(0.058)	(0.080)	(0.099)	(0.054)	(0.054)	(0.064)	(0.051)	(0.064)	(0.099)	(0.059)	(0.071)	(0.108)	(0.076)	(0.054)
lndcpf	-0.099**	-0.109**	-0.160***	-0.098**	-0.093*	-0.112**	-0.060	-0.081**	-0.144***	-0.064	-0.101***	-0.141***	-0.087*	-0.099**	-0.142***	-0.097**	-0.100**	-0.153***	-0.118***
	(0.045)	(0.046)	(0.048)	(0.045)	(0.049)	(0.050)	(0.041)	(0.037)	(0.036)	(0.041)	(0.037)	(0.042)	(0.049)	(0.043)	(0.046)	(0.049)	(0.049)	(0.051)	(0.036)
lnruralpop	0.213**	0.189*	-0.012	0.239**	0.244**	0.161	-0.129	-0.180	-0.519***	0.185**	0.232***	0.091	0.182*	0.153	-0.014	0.206*	0.173	-0.040	0.132
	(0.099)	(0.106)	(0.150)	(0.093)	(0.095)	(0.122)	(0.126)	(0.116)	(0.102)	(0.090)	(0.086)	(0.096)	(0.108)	(0.108)	(0.162)	(0.109)	(0.116)	(0.183)	(0.089)
lnurbpop	-0.139**	-0.124**	-0.109*	-0.139**	-0.135**	-0.135**	0.063	0.116	0.195***	-0.118**	-0.114**	-0.122**	-0.119*	-0.089	-0.088	-0.107	-0.057	-0.023	-0.113**
	(0.060)	(0.062)	(0.064)	(0.061)	(0.062)	(0.064)	(0.075)	(0.074)	(0.057)	(0.058)	(0.053)	(0.055)	(0.065)	(0.070)	(0.073)	(0.075)	(0.086)	(0.099)	(0.055)
KOFEcGI	-0.009			-0.012			0.000			0.006			-0.006			-0.010			
	(0.011)			(0.010)			(0.009)			(0.008)			(0.010)			(0.010)			
KOFSoGI		0.014**			0.009			0.014***			0.017***			0.017**			0.012*		
		(0.007)			(0.006)			(0.005)			(0.005)			(0.008)			(0.007)		
KOFPoGI			0.017**			0.007			0.022***			0.014***			0.015**			0.017*	
			(0.007)			(0.006)			(0.004)			(0.004)			(0.008)			(0.009)	
Corrup	-0.141**	-0.324***	-0.364***																
	(0.066)	(0.099)	(0.115)																
Effec				-0.127*	-0.265**	-0.247**													
				(0.069)	(0.106)	(0.118)													
Politstab							-0.394***	-0.500***	-0.625***										
							(0.083)	(0.080)	(0.057)										
Regul										-0.368***	-0.443***	-0.413***							
										(0.072)	(0.076)	(0.071)							
Law													-0.185**	-0.375***	-0.363***				
													(0.083)	(0.131)	(0.137)				
Accoun																-0.101*	-0.225***	-0.277**	
																(0.059)	(0.086)	(0.119)	
WGI																			-0.476***
																			(0.080)
KOFGI																			0.027***
																			(0.007)
Constant	-5.570***	-5.781***	-3.581**	-5.918***	-6.765***	-5.717***	-2.696**	-2.110*	1.523	-6.757***	-7.054***	-5.387***	-5.549***	-5.703***	-3.790***	-5.703***	-6.140***	-3.878***	-6.459***
	(1.148)	(1.105)	(1.519)	(1.101)	(0.907)	(1.065)	(1.255)	(1.238)	(1.068)	(0.908)	(0.873)	(0.913)	(1.123)	(1.031)	(1.451)	(1.125)	(1.024)	(1.480)	(0.871)

Obs	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116
r2	0.885	0.889	0.893	0.884	0.883	0.885	0.915	0.922	0.936	0.905	0.914	0.915	0.886	0.893	0.896	0.884	0.886	0.893	0.917
Hansen J	0.495	0.945	0.349	0.530	0.769	0.277	0.840	0.331	0.200	0.466	0.894	0.145	0.522	0.815	0.390	0.461	0.681	0.297	0.482
No. of Instruments	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of countries	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
F-statistics	143.728	894.318	787.971	172.553	1238.211	916.529	177.591	1721.528	864.978	137.286	1710.775	811.750	127.320	1027.696	746.395	143.682	1097.974	344.612	1082.551
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2. Sub-regional analysis

Bearing in mind that across the SSA region, developmental levels and macroeconomic fundamentals of countries are not at the same level but vary in so many other respects, we perform a sub-regional analysis to ascertain whether there exists any difference across our sample and to account for sub-regional heterogeneities. Thus, we divide our aggregated sample into four sub-regional samples: 1. West Africa, 2. East Africa sample, 3. Central Africa sample, and 4. Southern Africa sample. The results for each sub-regional sample are reported in Tables 6-9.

4.2.1 West Africa sub-region

Table 6 presents the results based on the IV-GMM technique for the West-Africa sub-sample. Starting with our main explanatory variables, globalization and governance indices, the result generally reveals a positive and statistically significant relationship with the adoption of clean cooking fuels and technologies, which is consistent with the aggregated analysis. This finding suggests that globalization efforts (including FDI, trade, information sharing, and technology transfers) are critical for adopting clean and modern cooking energy in West African countries. The mechanism remains the same, as explained in section 4.1, and our results are consistent with Kumar and Sinha (2014), Wang et al. (2021), and Przychodzen and Przychodzen (2020). Indeed, as argued by Mishkin (2009), globalization could facilitate technological transfer and diffusion from developed to developing countries, boosting clean cooking energy adoption. Moving to the governance variables, the results demonstrate that an improvement in the governance variables (corruption levels, government effectiveness, political stability, regulatory quality, and the rule of law), except accountability, significantly drives the adoption of clean cooking fuel and technologies, ceteris paribus. Regarding accountability, we find a negative relationship with a weak statistical significance. Like the aggregated-level results, the findings imply that the quality of governance is paramount for adopting clean cooking fuels and technologies across the West African sub-region. Without a stable political regime and government effectiveness, it will be difficult for any cleaner energy investments, which often rely on FDIs and technological transfers (see, Asongu and Odhiambo, 2021). Furthermore, unlike the aggregated results, we found the coefficients for the composite governance indicator (WGI) and composite globalization index (KOFGI) to have a positive and statistically significant relation with clean cooking energies. This implies that good governance in general and a rise in globalization could accelerate clean cooking energy access in West Africa.

On the control variables, we find that economic growth has a positive and significant coefficient (between 1.494% and 2.245% on average). This is consistent with our explanation in section 4.1 that increasing economic growth creates job opportunities that raise income levels and empower people to demand or switch to cleaner energy use for cooking. Rather interestingly, our results reveal that an increase in rural population could stimulate cleaner energy access, whereas an increase in urban population depresses adoption of clean cooking fuels and technologies. In detail, we note that a 1% increment in rural population leads to, on average, a 0.283%-0.914% increase in clean cooking fuel and technologies adoption at the 1% significance level. On the contrary, a 1% increase in the urban population causes clean cooking fuel and technologies access to decrease by, on average, between 0.644% and 1.774% at the 1% significance level. This finding is somewhat at odds with the literature (see Karanfil & Li, 2015; Su, 2020) and our aggregate-level results but lends credence to our motivation for the disaggregated analysis. A possible reason for the findings could be that most of the urban cities in West Africa are heavily congested, which means a further increase in urbanization puts extra pressure on already limited space, such as housing and other amenities. And with the inadequate accommodation facilities driving higher house prices, some new urban arrivals (rising levels of urban population) will have to resort to living in slums/ghettos or sometimes in shantytowns without adequate access to clean cooking facilities and technologies. On the positive coefficients of the rural population, the finding aligns with the global initiative to finance manufacturers of cleaner cooking fuels in terms of distribution and promotion of these fuels. Coupled with the fact that rural areas are often the most deprived of clean cooking fuels, some governments in the sub-region and international bodies such as Global Alliance for Clean Cookstoves have targeted efforts to scale up clean stove programs in rural communities. For example, in Ghana, the government has since 2013 launched a Rural LPG Programme to distribute gas cylinders and clean stoves to rural households as a way of weaning them away from traditional cooking fuels. Such efforts, including education on the impact of dirty cooking fuels and LPG adoption initiatives, are gaining traction in Nigeria, Senegal, and other parts of the sub-region. Thus, the findings' implication suggests that rural gasification or LPG programs are somewhat effective in boosting clean cooking technologies adoption in West African countries. Lastly, the coefficients for the financial development reveal a somewhat mixed (both positive and negative) relationship with clean cooking energies. The negative coefficients seem to suggest that an increase in access to cheaper credits does not improve clean cooking technologies adoption, which is inconsistent with Ji & Zhang (2019), whereas the positive coefficients imply that financial development stimulates clean cooking energy adoption (Çoban & Topcu, 2013; Ji & Zhang, 2019; Sadorsky, 2011).

4.2.2. East Africa

Table 7 reports the results for the East-Africa sub-sample. Intriguingly, the results for our main explanatory variables (globalization components and governance indicators) reveal a rather negative and statistically significant relationship with the dependent variable-clean cooking technologies. These results suggest that globalization (whether economic, social, or political components) in the East Africa sub-region and governance indicators do not necessarily accelerate access and adoption of clean cooking fuels and technologies, which is directly opposite to the West Africa sub-region. For the governance indicators, the results indicate that control of corruption, government effectiveness, political stability, regulatory quality, the rule of law, and accountability, significantly impede the adoption of clean cooking fuels and technologies in East Africa. In addition, the coefficient of the composite governance indicator (WGI) is found to have negative and statistically significant relation with clean cooking fuels and technologies, whereas the composite globalization index (KOFGI) is also negative but statistically insignificant. Although these findings are inconsistent with Wang et al. (2021), Przychodzen and Przychodzen (2020), Moe (2010), and Liu et al. (2021), they nonetheless reveal a more profound and perhaps context-specific effect. This conclusion is consistent with Asongu and Odhiambo (2021) that political and institutional governance are negatively related to renewable energy consumption and clean cooking fuels. As noted by Asongu and Odhiambo (2021), governance variables are often negatively skewed, and thus, an increase in governance variables only ends up spawning an undesirable outcome on the dependent variable, which we believe to be a likely reason in our case. For the control variables, the estimates show the coefficients of GDP growth, financial development, and rural and urban populations to be positive and statistically significant at the conventional levels for most models. Specifically, a 1% rise in GDP growth, financial development, and rural and urban population can enhance the adoption of clean cooking fuels and technologies by, on average, 1.388%-1.852%, 0.682%-0.785%, 0.297%-0.505% and 0.194%-0.393%, ceteris paribus, respectively at the conventional levels. In other words, all things being equal, for the East Africa sub-region, adoption of clean cooking fuels and technologies can be stimulated through improvement in the above macro fundamentals, which is consistent with Ji & Zhang (2019); Sadorsky, (2011); Busso et al. (2021) and Selod & Shilpi, (2021).

4.2.3. Central Africa

The results for the Central Africa sub-region are displayed in Table 8. Like the West Africa sub-region results, the estimates for globalization and governance variables are positive and statistically significant at the conventional levels. This implies that all things being equal, advancement in globalization levels and governance quality infrastructures could accelerate the adoption of clean cooking fuels and technologies across these countries. The findings suggest that the governance indicators, such as control of corruption, government effectiveness, political stability, regulatory quality, the rule of law, and accountability, significantly enhance the adoption of clean cooking fuels and technologies in Central Africa. This finding is consistent with Mishkin (2009), Kumar and Sinha (2014), Wang et al. (2021), and Przychodzen and Przychodzen (2020). Additionally, the coefficient of the composite governance indicator (WGI) and composite globalization index (KOFGI) are found to have a positive and statistically significant relation to clean cooking fuels and technologies. In detail, a 1% increase in WGI and KOFGI could stimulate adoption of clean cooking fuels and technologies by 0.886% and 0.054%, respectively, in the Central Africa sub-region. Thus, the implications are consistent with our findings for the aggregate-level samples. Interestingly, the control variables estimate reveals both negative and positive linkage. Specifically, a 1% increment in GDP growth and urban population could stimulate clean cooking fuels and technologies adoption by, on average, 0.824%-1.279% and 0.372%-0.644%, respectively, at the 1% level. Thus, all things being equal, economic growth and urban population rise can promote clean cooking fuels and technologies adoption via the energy ladder theory and urban bias theory, where higher income levels mean people can afford clean cooking energy and the availability of clean cooking technology facilities in urban homes. Our finding is in congruence with Busso et al. (2021) and Selod & Shilpi (2021). On the contrary, a 1% increment in financial development and rural population dampens clean cooking technologies by, on average, 0.225%-0.344% and 0.190%-0.313%, respectively. This result is inconsistent with Çoban & Topcu, 2013 and Ji & Zhang, 2019 but concurs with our findings from the aggregated analysis based on the same explanations.

4.2.4. Southern Africa

Results for the Southern Africa sub-sample are reported in Table 9. The findings indicate that social and political globalization indexes are positive and statistically significant, whereas the economic globalization index is insignificant. The implication for the positive coefficients of social and political globalization is consistent with our explanation for the aggregate sample, West Africa, and Central Africa sub-sample analysis, indicating that globalization efforts bode well for clean cooking fuels and technologies. Additionally, we found all the governance variables to be negative and statistically significant, implying a dampening effect of governance quality on clean cooking fuels and technologies. These results are also consistent with the East Africa sub-sample findings. The control variables have similar effects as the West Africa results with positive GDP growth and rural population, while financial development and urban population have adverse and statistically significant effects.

4.3. Interactive effect results

This section reports the interactive results for SSA (aggregated sample) and the sub-regions in Tables 10 and 11, respectively. From Table 10, the aggregated results indicate that the interaction terms of corruption, government effectiveness, regulatory quality, the rule of law, and accountability with economic and political governance indices have negative coefficients, implying that in the presence of governance, economic and political globalization do not improve adoption of clean cooking fuels and technologies. However, in the presence of political stability, social globalization enhances access to clean cooking fuels and technologies. The composite variables show that the interaction between the composite governance indicator (WGI) and composite globalization index (KOFGI) has a negative and statistically significant coefficient. Generally, the interactive results at face value indicate that in the presence of governance, globalization does not improve the adoption of clean cooking fuels and technologies at the aggregated level. Moving on to the sub-sample analysis, Table 11 shows contrary evidence compared to the aggregated sample.[5] In particular, the results imply that globalization enhances the adoption of clean cooking fuels and technologies in the presence of governance. This is the case as the coefficient of the interactive term between the composite governance indicator and composite globalization index registers as positive in West Africa, Central Africa, and Southern Africa sub-region. In contrast, the coefficient for East Africa is positive but statistically insignificant.

We make good sense of the interactive results by calibrating the marginal effects of the interactive estimates. We report the results in Figs. 5a to 5g. From Fig 5a, the slopes for all the globalization indexes are positive, indicating that when corruption is controlled (or lower), economic, social, and political globalization will improve the adoption of clean fuels and cooking technologies in SSA. Fig. 5b also suggests that when government effectiveness is improved in SSA, economic, social, and political globalization will enhance the adoption of clean cooking fuels and technologies. Fig. 5c also suggests that when political stability and the absence of violence are improved in SSA, economic, social, and political globalization will enhance the adoption of clean cooking fuels and technologies. Fig. 5d also suggests that when regulatory quality is improved in SSA, economic, social, and political globalization will enhance the adoption of clean cooking fuels and technologies. Fig. 5e also suggests that when the rule of law is improved in SSA, economic, social, and political globalization will enhance the adoption of clean cooking fuels and technologies. Fig. 5f also suggests that when voice and accountability are improved, economic, social, and political globalization will enhance the adoption of clean cooking fuels and technologies. Fig. 5g also suggests that when governance generally improves in SSA, globalization, in general, would enhance the adoption of clean cooking fuels and technologies. The takeaway message from the marginal plots is that an effective governance system is needed to enable globalization to speed the adoption of clean fuels and cooking technologies in SSA.

[5] To conserve space, we only report results for the composite variables for the sub-samples.

Table 10: Interactive effect results for the aggregated results (IV-GMM results)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	1.313***	1.254***	1.310***	1.294***	1.249***	1.280***	1.288***	1.230***	1.360***	1.312***	1.257***	1.334***	1.295***	1.248***	1.295***	1.306***	1.218***	1.365***	1.267***
	(0.061)	(0.066)	(0.053)	(0.060)	(0.067)	(0.060)	(0.057)	(0.064)	(0.046)	(0.060)	(0.065)	(0.058)	(0.058)	(0.065)	(0.053)	(0.057)	(0.066)	(0.052)	(0.062)
lndcpf	-0.102***	-0.120***	-0.114***	-0.099***	-0.114***	-0.113***	-0.111***	-0.125***	-0.125***	-0.101***	-0.119***	-0.106***	-0.105***	-0.125***	-0.117***	-0.104***	-0.124***	-0.105***	-0.119***
	(0.026)	(0.025)	(0.025)	(0.026)	(0.025)	(0.025)	(0.025)	(0.025)	(0.027)	(0.026)	(0.025)	(0.026)	(0.026)	(0.025)	(0.025)	(0.026)	(0.024)	(0.026)	(0.026)
lnruralpop	-0.201***	-0.186***	-0.252***	-0.214***	-0.222***	-0.275***	-0.198***	-0.165***	-0.241***	-0.199***	-0.176**	-0.274***	-0.216***	-0.208***	-0.266***	-0.205***	-0.167***	-0.248***	-0.176***
	(0.061)	(0.062)	(0.059)	(0.059)	(0.064)	(0.058)	(0.062)	(0.063)	(0.061)	(0.062)	(0.069)	(0.058)	(0.060)	(0.066)	(0.058)	(0.062)	(0.064)	(0.061)	(0.065)
lnurbpop	0.230***	0.265***	0.224***	0.226***	0.278***	0.252***	0.257***	0.267***	0.197***	0.226***	0.246***	0.209***	0.248***	0.280***	0.247***	0.237***	0.247***	0.168***	0.151**
	(0.056)	(0.055)	(0.063)	(0.055)	(0.055)	(0.062)	(0.059)	(0.058)	(0.064)	(0.056)	(0.057)	(0.066)	(0.056)	(0.057)	(0.065)	(0.057)	(0.057)	(0.065)	(0.061)
KOFEcGI	0.004			0.001			0.012***			0.007*			0.005			0.013***			
	(0.005)			(0.005)			(0.004)			(0.004)			(0.004)			(0.004)			
KOFSoGI		0.012**			0.007			0.016***			0.016***			0.011*			0.023***		
		(0.006)			(0.006)			(0.005)			(0.006)			(0.006)			(0.006)		
KOFPoGI			0.007			0.001			0.012**			0.002			0.003			0.011**	
			(0.005)			(0.005)			(0.005)			(0.006)			(0.005)			(0.005)	
corrup	0.732***	0.110	0.357																
	(0.232)	(0.226)	(0.250)																
Corrup # KOFEcGI	-0.013***																		
	(0.005)																		
Corrup # KOFSoGI		0.000																	
		(0.005)																	
Corrup # KOFPoGI			-0.004																
			(0.005)																
Effec				0.856***	0.391**	0.701***													
				(0.186)	(0.187)	(0.198)													
Effec # KOFEcGI				-0.015***															
				(0.003)															
Effec # KOFSoGI					-0.005														
					(0.004)														
Effec # KOFPoGI						-0.009**													
						(0.004)													
Politstab							-0.023	-0.145	-0.181										
							(0.146)	(0.112)	(0.212)										
Politstab # KOFEcGI							0.003												
							(0.004)												
Politstab # KOFSoGI								0.006**											
								(0.003)											
Politstab # KOFPoGI									0.004										
									(0.004)										
Regul										0.464**	-0.051	0.887***							
										(0.203)	(0.189)	(0.238)							
Regul # KOFEcGI										-0.009***									
										(0.003)									
Regul # KOFSoGI											0.002								
											(0.003)								
Regul # KOFPoGI												-0.015***							
												(0.004)							
Law													0.570***	0.033	0.622***				
													(0.165)	(0.166)	(0.234)				
Law # KOFEcGI													-0.009***						
													(0.003)						
Law # KOFSoGI														0.003					
														(0.003)					
Law # KOFPoGI															-0.008*				

															(0.004)				
Accoun																0.065	-0.431***	0.337	
																(0.166)	(0.151)	(0.214)	
Accoun # KOFEcGI																-0.002			
																(0.003)			
Accoun # KOFSoGI																	0.009***		
																	(0.003)		
Accoun # KOFPoGI																		-0.007*	
																		(0.004)	
WGI																			0.515**
																			(0.260)
KOFGI																			0.023***
																			(0.008)
WGI # KOFGI																			-0.012**
																			(0.005)
Constant	-7.438***	-8.066***	-6.777***	-6.821***	-7.385***	-6.223***	-8.102***	-8.441***	-7.191***	-7.578***	-8.180***	-6.152***	-7.333***	-7.851***	-6.505***	-7.927***	-8.393***	-6.733***	-7.295***
	(0.693)	(0.706)	(0.657)	(0.766)	(0.796)	(0.711)	(0.646)	(0.650)	(0.602)	(0.790)	(0.840)	(0.708)	(0.699)	(0.734)	(0.654)	(0.674)	(0.687)	(0.744)	(0.776)
Observations	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636
r2	0.720	0.716	0.716	0.723	0.718	0.720	0.717	0.718	0.716	0.718	0.715	0.720	0.720	0.717	0.719	0.716	0.718	0.716	0.721
Hansen J	0.950	0.347	0.505	0.910	0.297	0.483	0.937	0.330	0.446	0.958	0.401	0.487	0.925	0.335	0.511	0.964	0.456	0.415	0.471
No. of Instruments	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of countries	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
F-statistics	1317.101	6740.573	1252.624	1389.542	8103.625	1040.891	2604.034	10118.666	1461.653	1425.379	7643.750	907.357	1553.758	6534.409	1028.324	2230.577	8404.751	1564.507	2214.135
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Interactive effect results for the Sub-Samples (IV-GMM results)

Variables	West Africa	East Africa	Central Africa	Southern Africa
lnrgdpc	1.789***	1.705***	0.783***	0.841***
	(0.106)	(0.093)	(0.116)	(0.062)
lndcpf	-0.168**	0.751***	-0.313***	-0.105***
	(0.080)	(0.058)	(0.023)	(0.031)
lnruralpop	0.995***	0.289**	0.003	-0.050
	(0.102)	(0.117)	(0.118)	(0.081)
lnurbpop	-1.688***	0.023	0.280*	-0.089*
	(0.144)	(0.117)	(0.147)	(0.052)
KOFGI	0.146***	-0.011	0.187***	0.043***
	(0.016)	(0.011)	(0.064)	(0.007)
WGI	-0.942	-0.650**	-3.352*	-3.003***
	(0.579)	(0.260)	(1.785)	(0.437)
WGI # KOFGI	0.033***	0.001	0.107**	0.050***
	(0.012)	(0.004)	(0.045)	(0.008)
Constant	-6.586***	-17.344***	-13.891***	-3.367***
	(0.803)	(0.818)	(1.835)	(0.907)
Observations	250	184	86	116
r2	0.789	0.920	0.920	0.936
Hansen J	0.112	0.449	0.335	0.516
No. of Instruments	9	9	9	9
No. of countries	16	12	6	9
F-statistics	161.259	385.067	11.385	743.925
Stock-Yogo Weak ID test Critical values				
10%	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

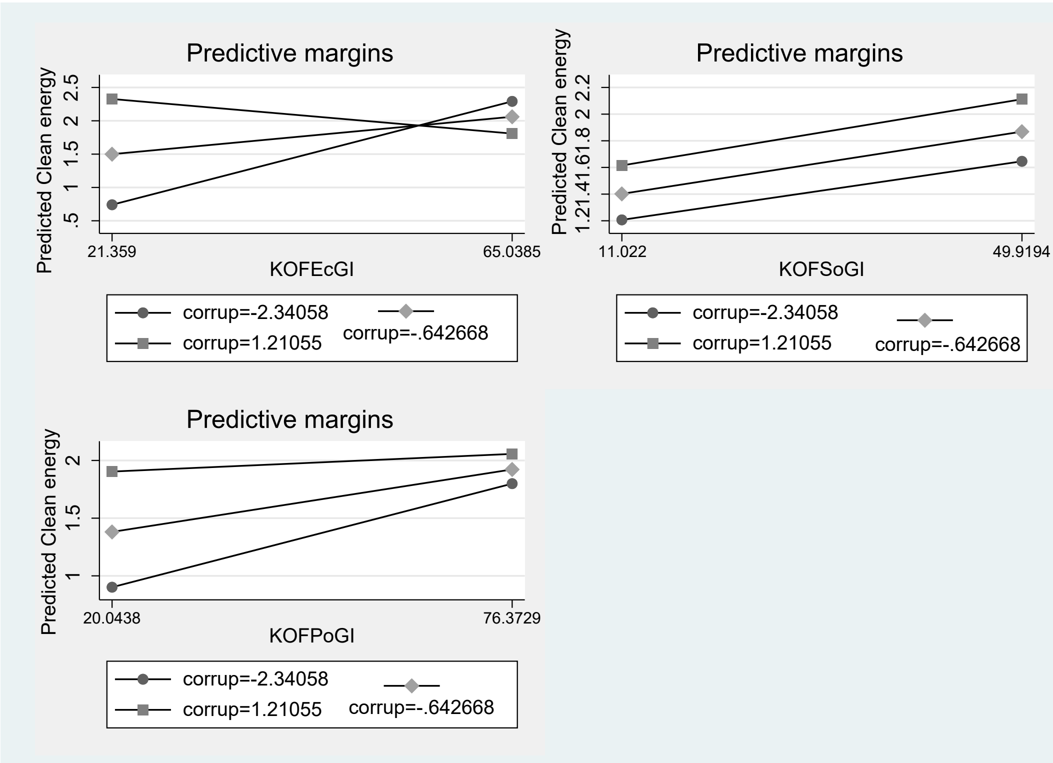


Fig. 5a: Predictive marginal effects of globalization variables conditioned by control of corruption on clean fuels and cooking technologies

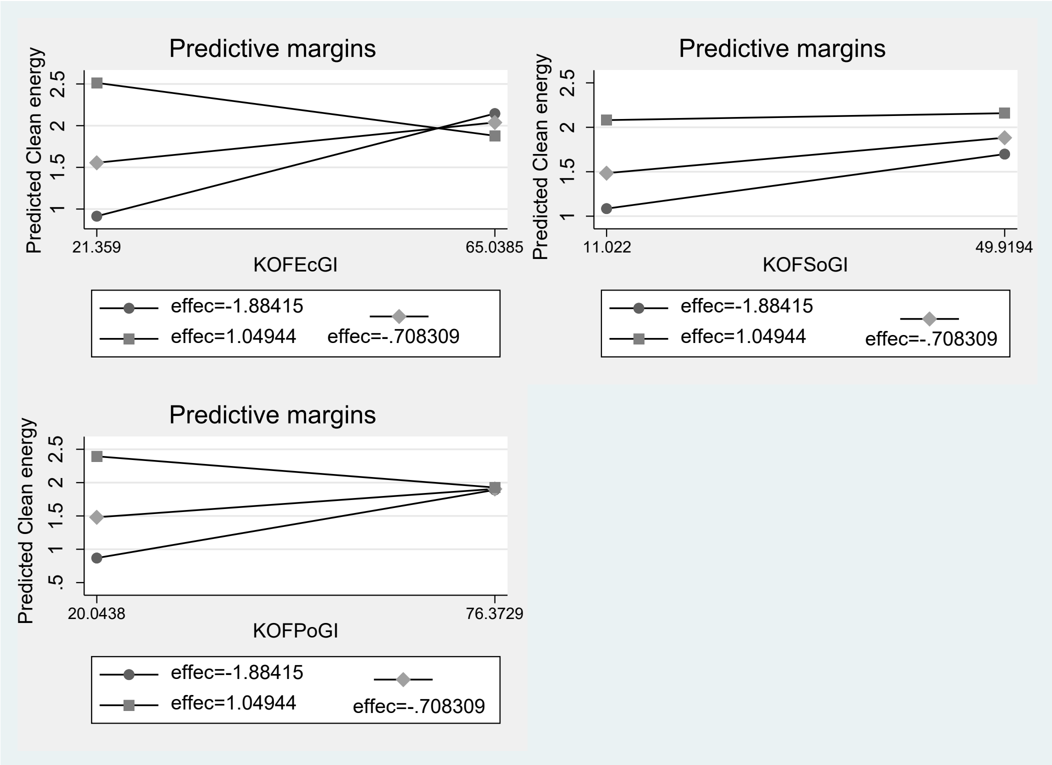


Fig. 5b: Predictive marginal effects of globalization variables conditioned by government effectiveness on clean fuels and cooking technologies

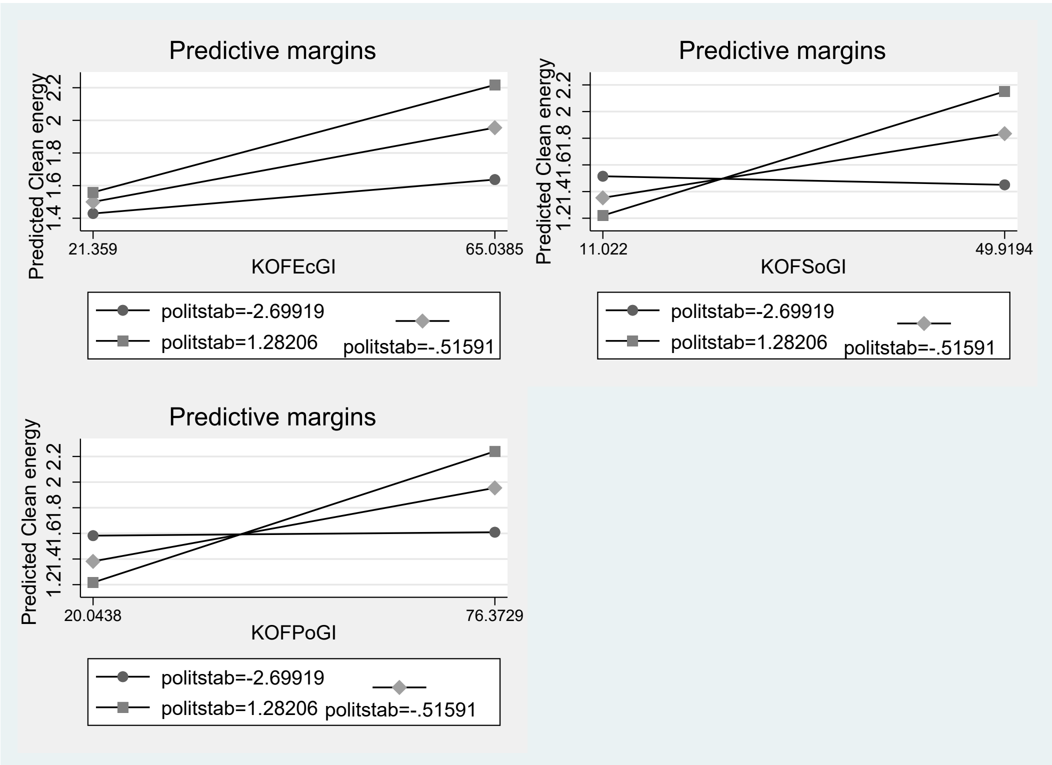


Fig. 5c: Predictive marginal effects of globalization variables conditioned by political stability on clean fuels and cooking technologies

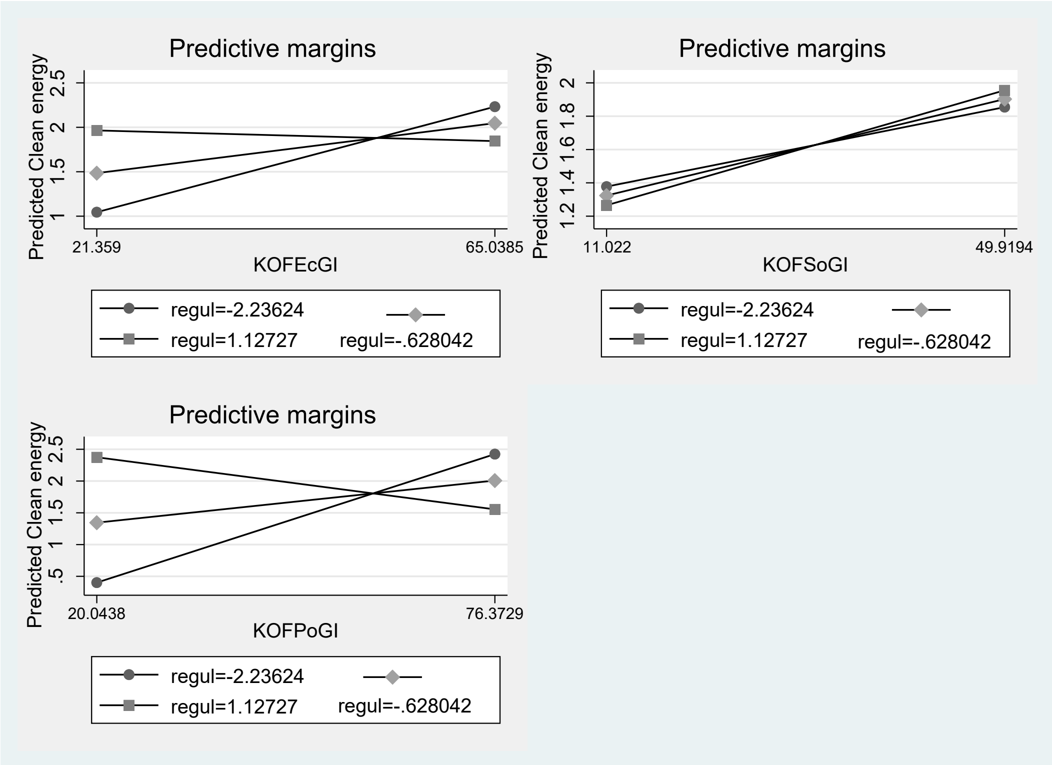


Fig. 5d: Predictive marginal effects of globalization variables conditioned by regulatory quality on clean fuels and cooking technologies

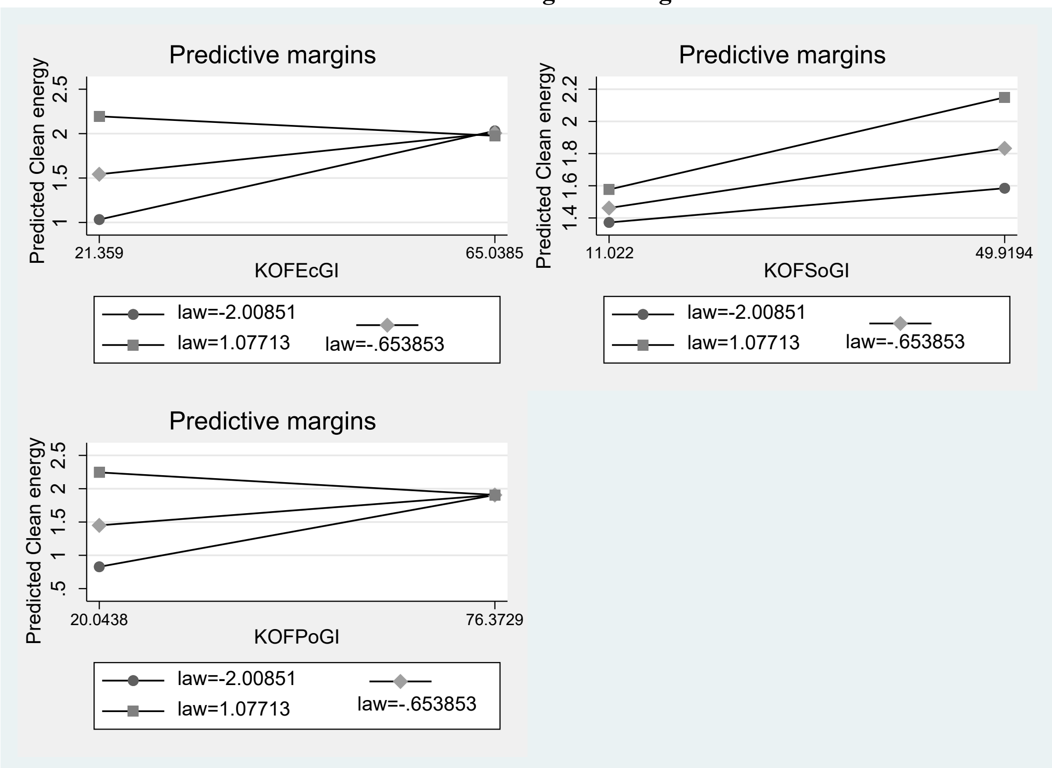


Fig. 5e: Predictive marginal effects of globalization variables conditioned by the rule of law on clean fuels and cooking technologies

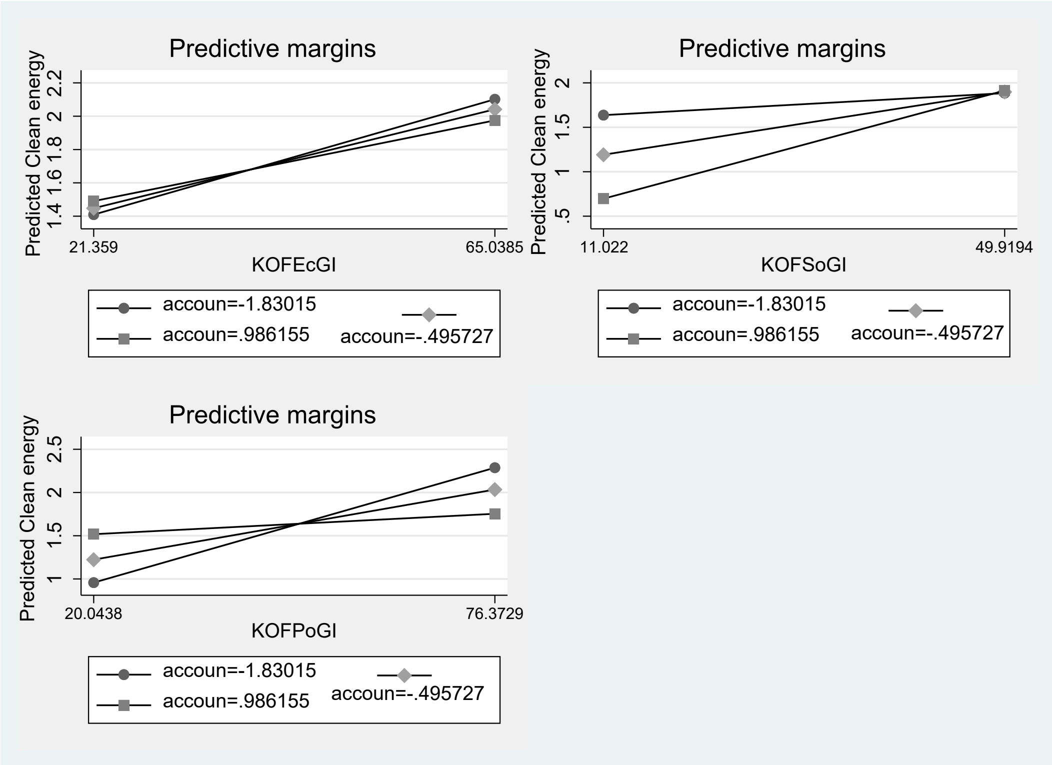


Fig. 5f: Predictive marginal effects of globalization variables conditioned by voice and accountability on clean fuels and cooking technologies

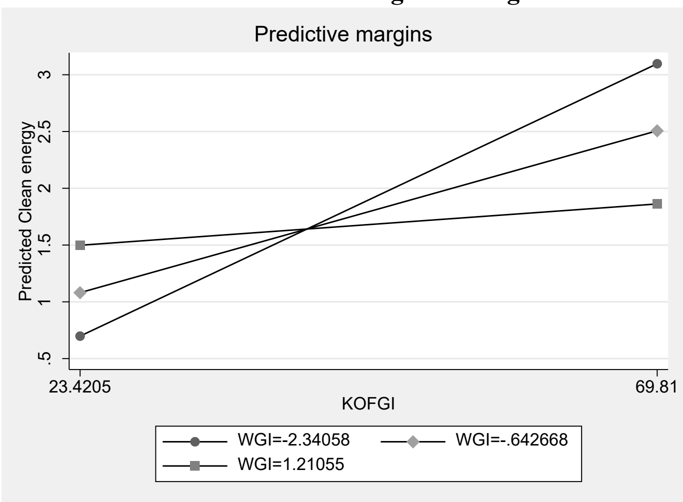


Fig. 5g: Predictive marginal effects of composite globalization index conditioned by composite governance index on clean fuels and cooking technologies

4.4 ***Further analysis using the de facto and de jure measures of globalization and accounting for political ideologies***

In this section, we attempt to disentangle the respective effect of de facto and de jure measures of globalization on the adoption of clean cooking fuels and technologies, and the results are presented in Tables 12 and 13. The de facto globalization indicators measure actual international flows and activities, while de jure globalization measures policies and conditions that, in principle, enable, facilitate, and foster flows and activities (Gygli et al., 2019). From Table 12, the estimates show that de facto economic, political, and social globalization, as well as the de facto composite globalization index, have a positive and statistically significant effect on the adoption of clean cooking fuels and technologies. On the other hand, Table 13 shows that de jure economic globalization has a significant negative effect on the adoption of clean cooking fuels and technologies, while de jure social and political globalization, as well as the de jure composite globalization index, have a statistically insignificant effect on the adoption of clean cooking energy and technologies. The take-home message is that the de facto and de jure dimensions of globalization, respectively, have a different effect on the adoption of clean cooking fuels and technologies for cooking and that the de facto dimensions play a significant role in increasing access to clean cooking fuels and technologies while the de jure indicators either limit or play an insignificant role in the adoption.

The results for the interactive effect between de facto globalization and governance indicators are presented in Appendix Table 3. From Appendix Table 3, the interaction terms of de facto political globalization and governance variables (control of corruption, regulatory quality, and the rule of law) are negative and statistically significant. Also, the interaction terms of de facto social globalization and voice and accountability are positive and statistically significant. Also, results for the interactive effect between de jure globalization and governance indicators are presented in Appendix Table 4. Appendix Table 4 also shows that the interaction terms of de jure economic globalization and governance variables (control of corruption, government effectiveness, regulatory quality, and the rule of law) are negative and statistically significant. Also, the interaction terms of de jure social globalization and governance variables (political stability, voice, and accountability) are positive and statistically significant. Finally, the interaction term of de jure political globalization and government effectiveness is negative and statistically significant, while the interaction term of de jure political globalization and political stability is positive and statistically significant. The policy implication of these interactive results is that enhancing the efficacy of domestic governance is important in enabling globalization to enhance the adoption and access to clean cooking fuels and technologies in SSA.

The literature review highlighted that political ideologies play a vital role in clean and renewable energy production and consumption. In Table 14, we control political ideologies in the model. We observe from Table 14 that the right-wing political leaders dummy variable has a positive effect on the adoption of clean fuels and technologies for cooking and is statistically significant at a 5% or better. Also, the coefficients of the left-wing political leaders and center-wing political leaders dummy variables are positive and negative, respectfully, but statistically insignificant. These findings highlight those political ideologies matter in the adoption of clean energy. Our results indicate that right-wing political leaders have contributed significantly to developing and using clean cooking fuels and technologies in SSA. These results contradict the claim that right-wing political parties and individuals are more likely to relegate issues of environmental protection (to, for instance, tackle climate change) and favor policies that protect free market opportunities for businesses by lessening environmental regulations (Gromet, Kunreuther & Larrick, 2013). The significant positive role of right-wing political leaders stimulating the adoption of clean cooking fuels and technologies could be due to their free market policies, which encourage private investors to enter the energy market to manufacture and sells clean cooking fuels and technologies in SSA.

Table 12: IV-GMM results for aggregated sample using de facto globalization indicators

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	1.264***	1.220***	1.318***	1.226***	1.181***	1.287***	1.289***	1.230***	1.341***	1.281***	1.231***	1.341***	1.252***	1.215***	1.308***	1.304***	1.242***	1.358***	1.215***
	(0.060)	(0.075)	(0.055)	(0.062)	(0.077)	(0.060)	(0.056)	(0.073)	(0.051)	(0.062)	(0.075)	(0.058)	(0.059)	(0.074)	(0.055)	(0.057)	(0.073)	(0.050)	(0.065)
lndcpf	-0.132***	-0.127***	-0.115***	-0.136***	-0.131***	-0.116***	-0.128***	-0.126***	-0.112***	-0.128***	-0.124***	-0.112***	-0.137***	-0.131***	-0.119***	-0.125***	-0.123***	-0.110***	-0.156***
	(0.024)	(0.025)	(0.025)	(0.024)	(0.025)	(0.025)	(0.024)	(0.025)	(0.025)	(0.025)	(0.026)	(0.025)	(0.024)	(0.025)	(0.025)	(0.025)	(0.026)	(0.026)	(0.026)
lnruralpop	-0.129**	-0.174***	-0.260***	-0.159***	-0.204***	-0.281***	-0.108*	-0.147**	-0.246***	-0.140**	-0.178***	-0.270***	-0.148**	-0.195***	-0.273***	-0.121**	-0.162**	-0.278***	-0.124*
	(0.058)	(0.065)	(0.060)	(0.057)	(0.065)	(0.059)	(0.060)	(0.066)	(0.061)	(0.059)	(0.067)	(0.060)	(0.057)	(0.065)	(0.059)	(0.059)	(0.065)	(0.059)	(0.064)
lnurbpop	0.211***	0.268***	0.223***	0.223***	0.282***	0.246***	0.191***	0.249***	0.202***	0.199***	0.255***	0.199***	0.224***	0.281***	0.242***	0.184***	0.245***	0.186***	0.077
	(0.052)	(0.055)	(0.064)	(0.052)	(0.055)	(0.064)	(0.054)	(0.057)	(0.063)	(0.053)	(0.056)	(0.068)	(0.053)	(0.056)	(0.067)	(0.055)	(0.057)	(0.065)	(0.063)
kofecgidf	0.016***			0.016***			0.016***			0.016***			0.016***			0.017***			
	(0.003)			(0.003)			(0.003)			(0.003)			(0.003)			(0.003)			
kofsogidf		0.014**			0.014**			0.016***			0.016**			0.013**			0.017***		
		(0.006)			(0.006)			(0.006)			(0.006)			(0.006)			(0.006)		
kofpogidf			0.007**			0.006			0.008**			0.008**			0.006*			0.010***	
			(0.003)			(0.004)			(0.003)			(0.004)			(0.004)			(0.003)	
corrup	0.173**	0.158*	0.151*																
	(0.083)	(0.084)	(0.089)																
effec				0.225***	0.220***	0.201**													
				(0.075)	(0.077)	(0.087)													
politstab							0.095*	0.096**	0.073										
							(0.049)	(0.049)	(0.052)										
regul										0.099	0.073	0.048							
										(0.088)	(0.087)	(0.099)							
law													0.193***	0.183**	0.174**				
													(0.071)	(0.072)	(0.080)				
accoun																0.026	-0.005	-0.041	
																(0.054)	(0.055)	(0.060)	
kofgidf																			0.038***
																			(0.007)
WGI																			-0.070
																			(0.084)
Constant	-8.456***	-8.032***	-6.621***	-7.840***	-7.414***	-6.304***	-8.716***	-8.322***	-6.777***	-8.287***	-7.951***	-6.410***	-8.221***	-7.789***	-6.558***	-8.584***	-8.214***	-6.345***	-7.176***
	(0.629)	(0.669)	(0.759)	(0.697)	(0.741)	(0.782)	(0.605)	(0.634)	(0.718)	(0.722)	(0.768)	(0.783)	(0.643)	(0.687)	(0.762)	(0.637)	(0.675)	(0.762)	(0.771)
Observations	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636
r2	0.726	0.717	0.716	0.728	0.719	0.717	0.726	0.717	0.715	0.725	0.716	0.714	0.727	0.718	0.717	0.724	0.715	0.714	0.727
No. of Instruments	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of countries	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
Hansen J	0.758	0.544	0.514	0.820	0.509	0.550	0.683	0.497	0.496	0.711	0.569	0.465	0.786	0.531	0.557	0.662	0.588	0.413	0.535
F-statistics	2454.260	3189.291	969.294	2463.826	3415.991	784.912	2439.147	3555.886	930.727	2472.598	3201.367	774.675	2464.522	3057.064	861.878	2431.056	3217.688	939.356	1323.477
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13: IV-GMM results for aggregated sample using de jure globalization indicators

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	1.424***	1.304***	1.324***	1.383***	1.277***	1.283***	1.452***	1.319***	1.351***	1.435***	1.314***	1.344***	1.420***	1.310***	1.313***	1.452***	1.300***	1.369***	1.352***
	(0.051)	(0.056)	(0.054)	(0.054)	(0.059)	(0.058)	(0.048)	(0.054)	(0.050)	(0.052)	(0.057)	(0.057)	(0.050)	(0.055)	(0.054)	(0.049)	(0.055)	(0.049)	(0.051)
lndcpf	-0.114***	-0.110***	-0.111***	-0.119***	-0.113***	-0.114***	-0.110***	-0.107***	-0.107***	-0.110***	-0.107***	-0.107***	-0.125***	-0.115***	-0.114***	-0.107***	-0.104***	-0.105***	-0.106***
	(0.024)	(0.024)	(0.026)	(0.023)	(0.024)	(0.026)	(0.023)	(0.024)	(0.027)	(0.024)	(0.025)	(0.027)	(0.023)	(0.025)	(0.026)	(0.024)	(0.025)	(0.027)	(0.025)
lnruralpop	-0.169***	-0.215***	-0.236***	-0.207***	-0.255***	-0.267***	-0.135**	-0.193***	-0.212***	-0.189***	-0.207***	-0.248***	-0.187***	-0.247***	-0.253***	-0.162***	-0.200***	-0.234***	-0.247***
	(0.057)	(0.061)	(0.060)	(0.055)	(0.063)	(0.059)	(0.057)	(0.061)	(0.060)	(0.057)	(0.068)	(0.061)	(0.055)	(0.065)	(0.059)	(0.056)	(0.062)	(0.059)	(0.063)
lnurbpop	0.203***	0.275***	0.264***	0.227***	0.295***	0.284***	0.174***	0.255***	0.240***	0.192***	0.255***	0.251***	0.223***	0.296***	0.289***	0.167***	0.254***	0.226***	0.274***
	(0.051)	(0.055)	(0.058)	(0.050)	(0.055)	(0.058)	(0.053)	(0.056)	(0.058)	(0.052)	(0.057)	(0.059)	(0.051)	(0.058)	(0.059)	(0.053)	(0.056)	(0.059)	(0.058)
kofecgidj	-0.011***			-0.013***			-0.011***			-0.010**			-0.015***			-0.008**			
	(0.004)			(0.004)			(0.004)			(0.004)			(0.004)			(0.004)			
kofsogidj		0.005			0.003			0.006			0.008			0.001			0.014**		
		(0.005)			(0.005)			(0.004)			(0.005)			(0.006)			(0.006)		
kofpogidj			0.004			0.003			0.004			0.004			0.001			0.006	
			(0.005)			(0.005)			(0.005)			(0.005)			(0.005)			(0.005)	
corrup	0.219**	0.149	0.188**																
	(0.091)	(0.101)	(0.086)																
effec				0.304***	0.229**	0.247***													
				(0.101)	(0.098)	(0.081)													
politstab							0.145***	0.077	0.104**										
							(0.055)	(0.056)	(0.051)										
regul										0.137	0.034	0.105							
										(0.109)	(0.116)	(0.093)							
law													0.301***	0.205**	0.216***				
													(0.086)	(0.103)	(0.075)				
accoun																0.062	-0.093	0.006	
																(0.058)	(0.078)	(0.056)	
kofgidj																			-0.002
																			(0.007)
WGI																			0.142
																			(0.114)
Constant	-7.633***	-7.881***	-7.538***	-6.928***	-7.175***	-6.915***	-7.976***	-8.134***	-7.829***	-7.332***	-7.978***	-7.363***	-7.384***	-7.524***	-7.365***	-7.631***	-8.280***	-7.608***	-7.405***
	(0.623)	(0.703)	(0.648)	(0.713)	(0.838)	(0.721)	(0.574)	(0.653)	(0.608)	(0.734)	(0.899)	(0.744)	(0.629)	(0.770)	(0.661)	(0.639)	(0.713)	(0.650)	(0.821)
Observations	620	636	636	620	636	636	620	636	636	620	636	636	620	636	636	620	636	636	636
r2	0.729	0.715	0.715	0.730	0.717	0.717	0.729	0.715	0.714	0.727	0.714	0.713	0.732	0.716	0.716	0.726	0.714	0.712	0.713
Hansen J	0.429	0.269	0.458	0.469	0.226	0.347	0.539	0.293	0.419	0.465	0.313	0.498	0.572	0.233	0.401	0.429	0.373	0.558	0.102
No. of Instruments	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
No. of countries	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
F-statistics	2409.692	9600.227	7492.711	2062.542	8496.217	7273.849	2530.800	9423.228	7328.428	2141.750	7409.386	6539.392	2149.456	6232.854	6801.170	2616.710	7560.607	7056.111	4859.365
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: IV-GMM results for aggregated sample, accounting for political ideology variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	1.256***	1.270***	1.315***	1.260***	1.263***	1.314***	1.276***	1.281***	1.346***	1.304***	1.283***	1.375***	1.269***	1.278***	1.327***	1.284***	1.267***	1.361***	1.255***
	(0.057)	(0.064)	(0.052)	(0.058)	(0.065)	(0.056)	(0.055)	(0.064)	(0.048)	(0.057)	(0.064)	(0.056)	(0.055)	(0.063)	(0.052)	(0.055)	(0.064)	(0.047)	(0.058)
lndcpf	-0.031	-0.030	-0.023	-0.029	-0.033	-0.025	-0.020	-0.023	-0.011	-0.006	-0.020	-0.008	-0.025	-0.028	-0.022	-0.010	-0.018	-0.006	-0.051
	(0.049)	(0.054)	(0.052)	(0.051)	(0.055)	(0.053)	(0.047)	(0.054)	(0.052)	(0.050)	(0.054)	(0.053)	(0.050)	(0.054)	(0.053)	(0.051)	(0.054)	(0.054)	(0.052)
lnruralpop	-0.242***	-0.235***	-0.271***	-0.247***	-0.243***	-0.285***	-0.229***	-0.211***	-0.253***	-0.209***	-0.189***	-0.262***	-0.241***	-0.235***	-0.276***	-0.238***	-0.214***	-0.279***	-0.190***
	(0.062)	(0.063)	(0.060)	(0.061)	(0.065)	(0.060)	(0.065)	(0.065)	(0.064)	(0.062)	(0.067)	(0.061)	(0.062)	(0.065)	(0.060)	(0.063)	(0.065)	(0.060)	(0.064)
lnurbpop	0.269***	0.287***	0.262***	0.261***	0.282***	0.255***	0.249***	0.264***	0.228***	0.224***	0.245***	0.191***	0.258***	0.279***	0.255***	0.249***	0.265***	0.208***	0.127**
	(0.056)	(0.056)	(0.068)	(0.054)	(0.055)	(0.067)	(0.057)	(0.058)	(0.067)	(0.056)	(0.057)	(0.073)	(0.056)	(0.057)	(0.071)	(0.058)	(0.058)	(0.070)	(0.062)
leader_right	0.513***	0.500***	0.484***	0.498***	0.481***	0.455**	0.507***	0.493***	0.462**	0.523***	0.521***	0.466**	0.504***	0.486***	0.459**	0.526***	0.532***	0.476***	0.490**
	(0.188)	(0.183)	(0.183)	(0.189)	(0.185)	(0.181)	(0.190)	(0.185)	(0.182)	(0.189)	(0.185)	(0.184)	(0.188)	(0.185)	(0.182)	(0.186)	(0.182)	(0.182)	(0.196)
leader_left	0.149	0.141	0.128	0.145	0.138	0.117	0.149	0.145	0.118	0.150	0.164	0.120	0.148	0.140	0.119	0.172	0.195	0.144	0.146
	(0.186)	(0.183)	(0.182)	(0.184)	(0.182)	(0.179)	(0.186)	(0.184)	(0.180)	(0.186)	(0.184)	(0.183)	(0.185)	(0.183)	(0.180)	(0.184)	(0.183)	(0.181)	(0.195)
leader_center	-0.350	-0.319	-0.329	-0.342	-0.305	-0.315	-0.348	-0.310	-0.327	-0.382	-0.322	-0.354	-0.350	-0.316	-0.329	-0.333	-0.271	-0.316	-0.421
	(0.309)	(0.297)	(0.295)	(0.310)	(0.296)	(0.294)	(0.310)	(0.296)	(0.294)	(0.321)	(0.302)	(0.299)	(0.310)	(0.296)	(0.294)	(0.310)	(0.295)	(0.295)	(0.311)
kofecgi	0.014***			0.015***			0.015***			0.019***			0.015***			0.017***			
	(0.004)			(0.005)			(0.005)			(0.005)			(0.005)			(0.004)			
kofsogi		0.008			0.009			0.010			0.015**			0.009			0.015**		
		(0.006)			(0.007)			(0.006)			(0.007)			(0.007)			(0.007)		
kofpogi			0.005			0.005			0.006			0.010*			0.005			0.009*	
			(0.005)			(0.005)			(0.005)			(0.006)			(0.005)			(0.005)	
corrup	0.110	0.138	0.158*																
	(0.089)	(0.090)	(0.090)																
effec				0.066	0.102	0.123													
				(0.088)	(0.093)	(0.092)													
politstab							0.023	0.040	0.051										
							(0.053)	(0.054)	(0.053)										
regul										-0.130	-0.108	-0.080							
										(0.104)	(0.102)	(0.105)							
law													0.044	0.076	0.103				
													(0.083)	(0.087)	(0.084)				
accoun																-0.053	-0.084	-0.057	
																(0.059)	(0.066)	(0.064)	
kofgi																			0.039***
																			(0.009)
WGI																			-0.272***
																			(0.105)
Constant	-7.919***	-8.058***	-7.417***	-7.786***	-7.838***	-7.086***	-8.083***	-8.321***	-7.557***	-8.490***	-8.719***	-7.373***	-7.951***	-8.064***	-7.338***	-8.153***	-8.505***	-7.256***	-7.966***
	(0.672)	(0.705)	(0.763)	(0.794)	(0.874)	(0.832)	(0.649)	(0.664)	(0.747)	(0.768)	(0.855)	(0.795)	(0.698)	(0.764)	(0.770)	(0.680)	(0.734)	(0.768)	(0.777)
Observations	605	605	605	605	605	605	605	605	605	605	605	605	605	605	605	605	605	605	605
r2	0.716	0.712	0.712	0.715	0.711	0.711	0.715	0.711	0.710	0.716	0.711	0.710	0.715	0.711	0.711	0.715	0.711	0.710	0.718
jp	0.928	0.461	0.841	0.945	0.468	0.792	0.985	0.508	0.808	0.995	0.620	0.776	0.967	0.495	0.828	0.977	0.599	0.778	0.770
No. of instruments	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
No. of countries	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
F-statistics	2420.196	8738.639	1730.947	2317.144	8816.109	1581.083	2389.692	9232.060	1678.496	2234.408	7857.378	1346.865	2310.792	6869.031	1511.124	2547.672	7923.787	1646.853	2289.890
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Kleibergen-Paap/Cragg-Donald F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Kleibergen-Paap/Cragg-Donald F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusion and policy implications

In this study, we examine the contributions of globalization and governance to the adoption of clean cooking fuels and technologies in SSA using panel data for the period 2000 to 2017. Regarding analytical approaches, we deploy econometric techniques such as Driscoll-Kraay and instrumental variable generalized method of moment methods to control econometric issues such as autocorrelation, heteroskedasticity, cross-sectional dependence, and endogeneity. Our findings indicate that globalization (economic, social, and political) and governance (government effectiveness, control of corruption, political stability, and the rule of law) drive the adoption of clean cooking fuels and technologies in SSA. The results further revealed that right-wing political leaders contribute significantly to adopting clean cooking fuels and technologies in SSA, while left-wing and center-wing political leaders do not. These findings were observed to vary among the subregions in SSA. For instance, globalization improves access to clean cooking fuels and technologies in West, Central, and Southern Africa, not East Africa. Also, governance (control of corruption, government effectiveness, political stability, regulatory quality, and the rule of law) spurs adoption of clean cooking fuels and technologies in West and Central Africa and not East and Southern Africa.

These findings have major implications for the last climate change conference (COP26) held in Glasgow and for SSA's policymakers. The COP26 is a major communal effort to hasten the energy transition agenda. The COP26 discussions stress the importance of transitioning towards clean energy in achieving the Paris Agreement and net zero emissions by 2050. Transitioning towards clean energy would provide opportunities for employment, sustainable economic growth, and gender empowerment and further help achieve energy efficiency and security. At COP26, many countries focused on the strategies and the assistance needed to speed up the energy transition agenda. While much attention has been focused on funding mobilization, Pedersen, Winckler Andersen & Renkens (2021) argue that energy transition is more than that. The authors emphasized that politics and international cooperation play significant roles in the energy transition. The issue of governance hence becomes critical. At COP26, the countries jointly agreed to work to lessen the gap between prevailing emission diminution plans and what is necessary to cut emissions so that the increase in the world-wide average temperature can be restricted to 1.5 degrees Celsius. At the conference, governments were encouraged to increase their funding of clean energy and stop financing fossil fuels abroad. Forty-six countries signed a pact to stop coal investments and do away with coal in the 2030s in major economies and other economies by the 2040s. These agreements and policy statements require enormous political will, and good governance becomes imperative. Good governance will ensure that governments remain loyal to their climate pledges and enforce climate policies on the private sector and industry with no comprise. In many countries, especially developing countries that are natural resource dependent, climate change mitigation policies may result in disputes and conflicts as the livelihoods of many from these countries depend on natural resource exploitation. Governance becomes key in equitably governing and managing consequential disputes arising from climate policies.

Globalization, one of the major variables studied in the paper, remains essential for attaining and advancing the goals reached by COP26. Climate action requires concerted global efforts. This is something the United Nations has drummed repeatedly. The lackadaisical nature of a country can jeopardize the attainment of climate goals. Globalization makes concerted global efforts possible by enhancing integration among countries and transferring the best climate practices and technologies from one country to the other. Clean and renewable energy technologies can move from one country to the other and ensure global adoption of these technologies to reduce reliance on fossil fuels. A perfect example is many countries' adoption of electric vehicles and the continuous expansion to other places globally.

For SSA policymakers, it is well established that SSA remains the only developing region with the least access to clean cooking fuels and technologies. The data suggest that approximately 18% of the SSA population had access to clean cooking fuels and technologies in 2020. Our findings suggest that policies that would strengthen SSA's economic, political, and social integration with the rest of the world would improve the adoption and access to clean cooking fuels and technologies. SSA's integration with the global economy would enable the easy flow of technologies into the region, including clean cooking fuels and technologies. The production and supply of clean cooking fuels and technologies in SSA are currently limited. Therefore, anti-globalization policies such as tariffs and non-tariff policies (embargos and quotas) would damage the region's technology transfer. In addition, our results indicate that increasing access to clean cooking fuels and technologies in SSA would require the improvement of the efficacy of the domestic governance system. Ensuring political stability and government effectiveness, curtailing corruption, improving regulatory quality and accountability, enforcing contracts, and protecting property rights would provide a conducive environment for investors to invest in clean cooking technologies in the region. Also, improving the governance system would suppress the bottlenecks associated with the production and supply of clean cooking technologies. It is argued that policy outcomes are reflections of institution/governance (Acemoglu et al., 2003); therefore, an effective governance system would enable the region's energy transitioning policy to deliver its objective of enhancing the adoption of clean fuels and cooking technologies. Furthermore, our interactive and marginal effect analyses suggest that improving the effectiveness of the domestic governance system would provide fertile ground for the transfer and diffusion of clean cooking fuels and technologies to SSA through economic, social, and political integration.

This study provides some avenues for future research. While our research focuses on sub-Saharan African countries, future studies can extend this study to other developing regions such as South Asia, Latin America, and the Caribbean to explore how their governance and globalization integration is shaping their transition towards clean technologies and fuels for cooking. Such a study's outcome would help policymakers understand how governance and globalization influence energy transition agenda in developing countries. Also, policy discussions on net-zero and energy transition have been focusing on financing, with less attention given to the role of domestic culture in energy transition and net zero agenda. Also, our study has focused on the importance of formal institutions (governance) in the transition toward a clean energy economy. We, therefore, recommend future studies explore the role of culture and informal institutions in achieving net zero and energy transition policies.

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Declaration of Conflict of Interest: The authors declare no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Appendix Table 1

Angola; Benin; Botswana; Burkina Faso; Burundi; Cabo Verde; Cameroon; Central African Republic; Chad; Comoros; Congo, Dem. Rep.; Congo, Rep.; Cote d'Ivoire; Eswatini; Ethiopia; Gambia, The; Ghana; Guinea; Guinea Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; South Africa; Sudan; Tanzania; Togo; Uganda; Zambia; Zimbabwe.

Appendix Table 2: Fixed effect results for Aggregated sample

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	0.206	-0.009	0.232	0.226	-0.003	0.247	0.237	0.010	0.268	0.216	-0.001	0.237	0.149	-0.058	0.194	0.154	-0.054	0.185	0.132
	(0.284)	(0.296)	(0.274)	(0.271)	(0.276)	(0.262)	(0.272)	(0.279)	(0.254)	(0.268)	(0.280)	(0.260)	(0.261)	(0.277)	(0.246)	(0.272)	(0.285)	(0.260)	(0.299)
lndcpf	0.009	0.010	0.012	0.007	0.009	0.010	0.007	0.008	0.010	0.008	0.009	0.011	0.008	0.011	0.012	0.016	0.018	0.020	0.014
	(0.036)	(0.035)	(0.039)	(0.035)	(0.035)	(0.038)	(0.035)	(0.034)	(0.038)	(0.035)	(0.034)	(0.038)	(0.036)	(0.036)	(0.039)	(0.036)	(0.036)	(0.040)	(0.036)
lnruralpop	0.764	0.613	0.808	0.776	0.617	0.816	0.784	0.628	0.832	0.763	0.619	0.803	0.626	0.510	0.706	0.730	0.594	0.774	0.615
	(0.643)	(0.575)	(0.630)	(0.674)	(0.601)	(0.667)	(0.642)	(0.574)	(0.634)	(0.646)	(0.581)	(0.634)	(0.628)	(0.567)	(0.627)	(0.605)	(0.547)	(0.598)	(0.607)
lnurbpop	0.430	-0.153	0.409	0.418	-0.161	0.401	0.404	-0.184	0.376	0.424	-0.165	0.408	0.493	-0.088	0.459	0.408	-0.137	0.370	0.242
	(0.330)	(0.370)	(0.344)	(0.361)	(0.423)	(0.379)	(0.325)	(0.371)	(0.334)	(0.327)	(0.372)	(0.342)	(0.316)	(0.370)	(0.332)	(0.302)	(0.351)	(0.312)	(0.353)
corrup	0.064	0.023	0.068																
	(0.109)	(0.103)	(0.108)																
kofecgi	0.005			0.005			0.005			0.004			0.006			0.006			
	(0.006)			(0.006)			(0.006)			(0.006)			(0.006)			(0.006)			
kofsogi		0.028***			0.028**			0.028***			0.028**			0.027**			0.026**		
		(0.010)			(0.011)			(0.010)			(0.010)			(0.010)			(0.010)		
kofpogi			0.000			0.000			0.000			0.000			0.000			0.001	
			(0.006)			(0.006)			(0.005)			(0.006)			(0.005)			(0.005)	
effec				0.029	0.009	0.041													
				(0.152)	(0.145)	(0.152)													
politstab							0.000	-0.020	-0.006										
							(0.064)	(0.061)	(0.061)										
regul										0.052	0.003	0.064							
										(0.125)	(0.115)	(0.126)							
law													0.191	0.150	0.170				
													(0.125)	(0.132)	(0.126)				
accoun																0.271*	0.238*	0.262*	
																(0.137)	(0.135)	(0.136)	
WGI																			0.027
																			(0.117)
kofgi																			0.018
																			(0.013)
Constant	-17.960**	-6.442	-18.323**	-18.111**	-6.421	-18.453**	-18.138**	-6.368	-18.498**	-17.908**	-6.411	-18.268**	-16.347**	-5.390	-17.161**	-16.735**	-5.939	-16.914**	-13.043*
	(7.083)	(6.271)	(7.081)	(7.214)	(6.225)	(7.230)	(7.097)	(6.307)	(7.139)	(7.171)	(6.281)	(7.125)	(6.926)	(6.112)	(6.990)	(6.445)	(5.914)	(6.498)	(6.611)
Observations	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636
r2	0.365	0.400	0.361	0.364	0.400	0.360	0.363	0.401	0.360	0.364	0.400	0.361	0.374	0.407	0.368	0.392	0.422	0.386	0.374

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 3: Interactive effect results for the aggregated sample using de facto globalization measures

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	1.269***	1.238***	1.311***	1.242***	1.200***	1.288***	1.291***	1.205***	1.359***	1.276***	1.230***	1.337***	1.258***	1.210***	1.295***	1.300***	1.230***	1.369***	1.236***
	(0.057)	(0.076)	(0.053)	(0.060)	(0.077)	(0.061)	(0.054)	(0.075)	(0.048)	(0.060)	(0.075)	(0.059)	(0.057)	(0.074)	(0.054)	(0.056)	(0.073)	(0.053)	(0.069)
lndcpf	-0.131***	-0.124***	-0.113***	-0.132***	-0.123***	-0.114***	-0.128***	-0.130***	-0.119***	-0.129***	-0.125***	-0.107***	-0.136***	-0.132***	-0.118***	-0.127***	-0.127***	-0.105***	-0.149***
	(0.026)	(0.026)	(0.025)	(0.025)	(0.026)	(0.024)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.026)	(0.026)	(0.024)	(0.026)	(0.025)	(0.025)	(0.027)
lnruralpop	-0.128**	-0.176***	-0.258***	-0.153***	-0.204***	-0.278***	-0.108*	-0.148**	-0.249***	-0.143**	-0.179***	-0.280***	-0.146**	-0.195***	-0.272***	-0.123**	-0.160**	-0.260***	-0.122*
	(0.058)	(0.064)	(0.060)	(0.057)	(0.064)	(0.059)	(0.059)	(0.066)	(0.061)	(0.059)	(0.067)	(0.059)	(0.057)	(0.065)	(0.059)	(0.059)	(0.065)	(0.062)	(0.063)
lnurbpop	0.207***	0.265***	0.224***	0.210***	0.277***	0.242***	0.190***	0.262***	0.198***	0.204***	0.255***	0.204***	0.219***	0.282***	0.242***	0.189***	0.244***	0.176***	0.077
	(0.056)	(0.057)	(0.063)	(0.054)	(0.055)	(0.062)	(0.058)	(0.059)	(0.065)	(0.054)	(0.057)	(0.064)	(0.055)	(0.057)	(0.065)	(0.055)	(0.057)	(0.065)	(0.063)
corrup	0.233	0.305	0.317**																
	(0.273)	(0.204)	(0.149)																
kofecgidf	0.015***			0.013***			0.016***			0.017***			0.015***			0.017***			
	(0.004)			(0.004)			(0.003)			(0.004)			(0.004)			(0.004)			
corrup # kofecgidf	-0.001																		
	(0.005)																		
kofsogidf		0.012*			0.011*			0.018***			0.016***			0.014**			0.019***		
		(0.006)			(0.006)			(0.006)			(0.006)			(0.006)			(0.006)		
corrup # kofsogidf		-0.004																	
		(0.005)																	
kofpogidf			0.005			0.002			0.009**			0.003			0.003			0.009**	
			(0.004)			(0.004)			(0.004)			(0.004)			(0.004)			(0.003)	
corrup # kofpogidf			-0.004																
			(0.003)																
effec				0.390*	0.446***	0.462***													
				(0.219)	(0.169)	(0.121)													
effec # kofecgidf				-0.003															
				(0.004)															
effec # kofsogidf					-0.006														
					(0.004)														
effec # kofpogidf						-0.006**													
						(0.002)													
politstab							0.103	-0.006	-0.063										
							(0.153)	(0.101)	(0.137)										
politstab # kofecgidf							-0.000												
							(0.003)												
politstab # kofsogidf								0.004											
								(0.003)											
politstab # kofpogidf									0.003										
									(0.003)										
regul										0.020	0.043	0.548***							
										(0.230)	(0.173)	(0.134)							
regul # kofecgidf										0.002									
										(0.004)									
regul # kofsogidf											0.001								
											(0.004)								
regul # kofpogidf												-0.011***							
												(0.003)							

law													0.264	0.140	0.464***				
													(0.210)	(0.151)	(0.136)				
law # kofecgidf													-0.001						
													(0.004)						
law # kofsogidf														0.001					
														(0.004)					
law # kofpogidf															-0.006**				
															(0.003)				
accoun																-0.065	-0.185	0.149	
																(0.181)	(0.126)	(0.129)	
accoun # kofecgidf																0.002			
																(0.003)			
accoun # kofsogidf																	0.005*		
																	(0.003)		
accoun # kofpogidf																		-0.004	
																		(0.003)	
kofgidf																			0.032***
																			(0.008)
WGI																			0.262
																			(0.263)
WGI # kofgidf																			-0.007
																			(0.005)
Constant	-8.417***	-7.966***	-6.562***	-7.703***	-7.336***	-6.159***	-8.722***	-8.390***	-6.848***	-8.339***	-7.948***	-6.048***	-8.167***	-7.803***	-6.334***	-8.640***	-8.234***	-6.498***	-7.077***
	(0.709)	(0.685)	(0.751)	(0.757)	(0.741)	(0.778)	(0.618)	(0.641)	(0.688)	(0.755)	(0.768)	(0.783)	(0.706)	(0.691)	(0.749)	(0.662)	(0.673)	(0.814)	(0.769)
Observations	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636	636
r2	0.726	0.717	0.717	0.728	0.720	0.720	0.726	0.718	0.716	0.725	0.716	0.722	0.727	0.718	0.720	0.724	0.716	0.716	0.729
Hansen J	0.745	0.519	0.543	0.765	0.457	0.545	0.677	0.500	0.473	0.735	0.575	0.483	0.759	0.540	0.549	0.693	0.629	0.396	0.576
No. of Instruments	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of countries	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
F-statistics	745.980	2025.188	585.044	536.917	2548.170	501.184	1896.868	3186.023	640.836	565.387	2676.555	466.689	697.374	2332.412	494.482	1344.338	3061.202	732.633	580.188
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Cragg-Donald/Kleibergen-Paap F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Cragg-Donald/Kleibergen-Paap F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table 4: Interactive effect results for the aggregated sample using de jure globalization measures

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
lnrgdpc	1.463***	1.286***	1.324***	1.411***	1.290***	1.277***	1.449***	1.278***	1.373***	1.443***	1.307***	1.341***	1.437***	1.292***	1.308***	1.456***	1.243***	1.374***	1.361***
	(0.056)	(0.058)	(0.052)	(0.055)	(0.061)	(0.058)	(0.048)	(0.055)	(0.045)	(0.052)	(0.058)	(0.057)	(0.052)	(0.057)	(0.053)	(0.052)	(0.058)	(0.050)	(0.052)
lndcpf	-0.105***	-0.113***	-0.112***	-0.102***	-0.109***	-0.108***	-0.119***	-0.117***	-0.120***	-0.101***	-0.109***	-0.100***	-0.116***	-0.120***	-0.111***	-0.106***	-0.112***	-0.092***	-0.099***
	(0.023)	(0.025)	(0.026)	(0.023)	(0.025)	(0.025)	(0.023)	(0.024)	(0.027)	(0.023)	(0.025)	(0.026)	(0.023)	(0.025)	(0.025)	(0.024)	(0.024)	(0.026)	(0.025)
lnruralpop	-0.169***	-0.206***	-0.236***	-0.205***	-0.258***	-0.272***	-0.131**	-0.183***	-0.215***	-0.187***	-0.207***	-0.257***	-0.184***	-0.242***	-0.255***	-0.160***	-0.195***	-0.217***	-0.247***
	(0.055)	(0.061)	(0.060)	(0.053)	(0.062)	(0.058)	(0.057)	(0.062)	(0.061)	(0.056)	(0.068)	(0.059)	(0.054)	(0.065)	(0.058)	(0.056)	(0.062)	(0.060)	(0.063)
lnurbpop	0.183***	0.271***	0.264***	0.206***	0.295***	0.285***	0.189***	0.273***	0.246***	0.185***	0.254***	0.251***	0.207***	0.296***	0.287***	0.165***	0.254***	0.210***	0.271***
	(0.051)	(0.055)	(0.058)	(0.049)	(0.055)	(0.056)	(0.053)	(0.057)	(0.059)	(0.052)	(0.057)	(0.058)	(0.052)	(0.058)	(0.058)	(0.054)	(0.057)	(0.059)	(0.058)
corrup	0.774***	-0.044	0.155																
	(0.181)	(0.236)	(0.412)																
kofecgidj	-0.018***			-0.020***			-0.009***			-0.014***			-0.018***			-0.009**			
	(0.004)			(0.004)			(0.003)			(0.004)			(0.004)			(0.003)			
corrup # kofecgidj	-0.014***																		
	(0.005)																		
kofsogidj		0.008			0.000			0.010**			0.010*			0.004			0.020***		
		(0.005)			(0.005)			(0.004)			(0.005)			(0.006)			(0.006)		
corrup # kofsogidj		0.004																	
		(0.004)																	
kofpogidj			0.004			-0.004			0.007			-0.002			-0.001			0.004	
			(0.005)			(0.005)			(0.005)			(0.005)			(0.005)			(0.005)	
corrup # kofpogidj			0.001																
			(0.007)																
effec				0.888***	0.385*	0.985***													
				(0.168)	(0.199)	(0.313)													
effec # kofecgidj				-0.015***															
				(0.004)															
effec # kofsogidj					-0.003														
					(0.004)														
effec # kofpogidj						-0.012**													
						(0.005)													
politstab							-0.056	-0.253**	-0.305										
							(0.121)	(0.118)	(0.286)										
politstab # kofecgidj							0.006												
							(0.003)												
politstab # kofsogidj								0.009***											
								(0.003)											
politstab # kofpogidj									0.006										
									(0.004)										
regul										0.509**	-0.061	0.878**							
										(0.212)	(0.207)	(0.399)							
regul # kofecgidj										-0.009**									
										(0.004)									
regul # kofsogidj											0.002								
											(0.003)								
regul # kofpogidj												-0.012**							
												(0.006)							

law													0.583***	0.020	0.565				
													(0.149)	(0.180)	(0.349)				
law # kofecgidj													-0.008**						
													(0.004)						
law # kofsogidj														0.004					
														(0.003)					
law # kofpogidj															-0.006				
															(0.006)				
accoun																0.113	-0.641***	0.672**	
																(0.150)	(0.175)	(0.335)	
accoun # kofecgidj																-0.001			
																(0.004)			
accoun # kofsogidj																	0.012***		
																	(0.003)		
accoun # kofpogidj																		-0.010**	
																		(0.005)	
kofgidj																			-0.005
																			(0.007)
WGI																			0.534**
																			(0.263)
WGI # kofgidj																			-0.008*
																			(0.005)
Constant	-7.283***	-7.983***	-7.555***	-6.532***	-7.095***	-6.392***	-8.314***	-8.414***	-8.139***	-7.141***	-7.989***	-6.830***	-7.180***	-7.609***	-7.114***	-7.631***	-8.304***	-7.515***	-7.249***
	(0.591)	(0.713)	(0.552)	(0.691)	(0.835)	(0.660)	(0.532)	(0.651)	(0.532)	(0.725)	(0.896)	(0.702)	(0.602)	(0.767)	(0.579)	(0.635)	(0.694)	(0.641)	(0.806)
Observations	620	636	636	620	636	636	620	636	636	620	636	636	620	636	636	620	636	636	636
r2	0.732	0.715	0.715	0.736	0.717	0.719	0.730	0.718	0.715	0.728	0.714	0.715	0.733	0.716	0.717	0.726	0.719	0.714	0.714
Hansen J	0.549	0.269	0.459	0.567	0.226	0.299	0.507	0.241	0.464	0.492	0.313	0.433	0.627	0.225	0.381	0.435	0.346	0.505	0.107
No. of Instruments	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
No. of countries	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43
F-statistics	1194.837	6126.487	6379.946	1258.974	6109.105	5718.845	2122.564	9019.721	7142.260	1413.027	6222.074	5234.222	1409.025	4962.010	5912.611	1778.960	6459.738	7216.509	3990.357
Stock-Yogo Weak ID test Critical values																			
10%	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93
15%	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20%	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25%	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25

Heteroscedasticity robust standard errors in parentheses. The p-values are reported for the Hansen J statistic. F-statistics is the Cragg-Donald/Kleibergen-Paap F-statistics for weak instrument identification. The probability value for the Hansen J-statistics suggests that instruments are not over-identified. The Cragg-Donald/Kleibergen-Paap F-statistics also suggest the instrument is not weak since the values are greater than the Stock-Yogo weak ID test critical values. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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