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Abstract

This study employs macro-level data from 33 African countries to examine the impact of energy consumption (disaggregated into renewable and non-renewable sources) on income inequality. It further investigates the moderating role of five distinct democracy typologies – liberal, electoral, deliberative, participatory, and egalitarian – within the energy-inequality nexus. Employing the dynamic GMM estimator, the analysis accounts for the persistence of income inequality and mitigates endogeneity concerns. The findings reveal that energy consumption plays a significant role in reducing income inequality across Africa. The interactive analysis also demonstrates that the income-equalising effect of non-renewable energy is particularly pronounced. Moreover, while all democracy typologies amplify the inequality-reducing effect of non-renewable energy, only participatory and egalitarian democracies enhance the impact of renewable energy. These results underscore the nuanced and asymmetric influence of energy types on income distribution in Africa, with non-renewable energy exhibiting more substantial direct and conditional effects. The study concludes by outlining key policy implications to foster equitable growth.

Keywords: Africa, Democracy, Energy consumption, Renewable energy consumption, Non-renewable energy consumption, Income inequality.

JEL Codes: D63, H11, O43, O55, Q01, Q43

1. Introduction

Income inequality (hereafter: *inequality*) remains a significant socioeconomic challenge, particularly across the developing world (Chancel et al., 2023; Odusola, 2017). Chancel et al. (2023) highlight Africa as a striking example of extreme inequality, where the top 10% control 55% of total income, while the bottom 50% account for less than 10%. This disparity translates into the top decile earning at least 30 times more than the poorest half of the population. Of greater concern is the growing empirical evidence that inequality hinders economic growth and undermines health and educational outcomes (Halter et al., 2014). Inequality also exacerbates societal issues, including crime, suicide, conflict, and environmental degradation (McGee & Greiner, 2018). Against this backdrop, inequality has been recognised as a key barrier to achieving the Sustainable Development Goals (SDGs) and fostering harmonious societies (Batuo et al., 2022).

This paper undertakes a nuanced examination of energy consumption as a potential mechanism for addressing Africa's inequality challenge. The development economics literature highlights the critical role of affordable and reliable energy in driving economic growth (Stern, 2011; Apergis & Payne, 2009). For developing economies, particularly those in Africa, SDG 7 stresses the transformative potential of renewable energy in alleviating energy insecurity and fostering resilient and sustainable growth (IEA et al., 2023). Reliable and affordable energy access can spur industrialisation, generate employment, and promote social mobility. Moreover, lower energy costs can stimulate entrepreneurship and innovation. Access to modern energy can also improve education and healthcare outcomes, which are essential for human capital development and upward mobility.

However, Africa's energy sector faces profound challenges that hinder its capacity to drive equitable income redistribution. While energy is critical to economic growth, job creation, and livelihoods (IEA et al., 2023), it remains a contested resource. Fossil fuel extraction, a major economic driver for many African nations, generates significant export revenue, yet local communities often remain impoverished and lack access to essential energy services (Sovacool, 2012). Moreover, the shift towards renewable energy in Africa is constrained by challenges such as high installation costs, limited technological capabilities, and a tight fiscal space (Burke & Stephens, 2018; AfDB, 2023). These complexities reflect broader power asymmetries within energy production, distribution, and consumption. In Africa, where energy infrastructure and institutions are still developing, expanding energy access must not only address coverage but also mitigate inequality.

The literature shows that Africa's energy system challenges are as much political as they are economic (Chen et al., 2021; Uzar, 2020). For example, Chen et al. (2021) emphasise the critical role of democratic institutions in shaping renewable energy policies. Similarly, Uzar (2020) demonstrates the impact of institutional quality on renewable energy consumption. We build on these by examining the role of democracy in the energy consumption-inequality nexus. Two key theoretical frameworks underpin our contribution. First, institutional theory pinpoints the influence of governance structures on resource allocation and economic outcomes (Acemoglu & Robinson, 2012; North, 1990). In this context, democracy emerges as an essential mechanism for equitable energy distribution. For instance, liberal democracies, through checks and balances, can prevent the monopolisation of energy resources. Likewise, participatory democracy can foster grassroots engagement in shaping energy policies, including the involvement of marginalised groups such as women (Rodrik et al., 2004). Second, this study draws on energy justice theory, which emphasises fairness, accountability, and the provision of safety nets within energy systems (Sovacool & Dworkin, 2015). Democracy, with its inclusive ethos, can, in this sense, become indispensable in promoting equitable energy access and income.

While previous studies have explored the link between renewable energy consumption and income inequality in developing nations (Asongu & Odhiambo, 2021; Uzar, 2020; Sharma & Rajpurohit, 2022), they do not assess the moderating role of democracy. This study fills that gap by investigating how various dimensions of democracy – electoral, participatory, liberal, deliberative, and egalitarian – influence the relationship between energy consumption and inequality. Additionally, we perform sensitivity analysis by assessing whether the contingency effects of these democracy indicators differ across the renewable and non-renewable domains of energy consumption.

We use country-level data from 33 African countries for the analysis. To address potential endogeneity, we apply the two-step system GMM estimator developed by Blundell and Bond (1998) to the data. The evidence shows that energy consumption significantly reduces inequality. The sensitivity analysis also demonstrates that the inequality-reducing effect of non-renewable energy consumption is particularly striking. Additionally, all democracy indicators – liberal, electoral, deliberative, participatory, and egalitarian – enhance the effectiveness of both renewable and non-renewable energy consumption in mitigating inequality. However, the evidence indicates that the conditional effect of non-renewable energy consumption on reducing inequality is notable. The study has far-reaching implications, especially in the remit of enhancing democratic governance and inclusive growth in Africa.

The rest of the study is organised as follows: Section 2 reviews the literature on energy consumption, democracy, and income inequality, whilst Section 3 describes the data and methods employed for the analysis. The results and the policy recommendations are also presented in Sections 4 and 5, respectively.

2. Literature Review and hypothesis formation

2.1 Energy consumption and income inequality

Energy is an essential driver of sustainable development outcomes (IEA et al., 2023). While the income growth effects of energy consumption have garnered significant empirical attention (e.g., Gozgor et al., 2018; Wang et al., 2024), its implications for income redistribution remain underexplored. Thus, a specific question remains as to whether the income gains from energy-driven growth are equitably distributed across all socioeconomic strata. Studies such as those of Stern (2011) uncover a positive impact of energy consumption on economic growth and job creation, all of which are prerequisites for income distribution. Similarly, Apergis and Payne (2014) assert that energy consumption can stimulate industrialisation and economic growth.

However, research also suggests that energy consumption and inequality can reinforce each other. On one hand, energy consumption affects income distribution by influencing costs, affordability, and environmental quality. On the other hand, inequality can also affect energy consumption patterns. Sonora (2022), for example, finds a robust negative relationship between energy consumption and inequality in 145 countries, while Xu and Zhong (2023) reveal that inequality increases energy consumption. On the other hand, unequal access may reduce or deepen income disparities, as limited energy access restricts opportunities for education, employment, and entrepreneurship, creating a feedback loop of economic inclusion (IEA et al., 2023). Huang and Yao (2023) also provide evidence that energy transmission can worsen income inequality between urban and rural China.

Affordability is a key determinant of how energy consumption relates to income inequality. The inability to access affordable energy disproportionately weighs on poor populations, especially in energy-deprived regions like Sub-Saharan Africa (SSA). Wealthier households, on the other hand, consume more energy, driven by their ability to purchase modern appliances, occupy larger living spaces, and use private transportation. This aligns with the energy ladder hypothesis, which suggests that as households become wealthier, they shift to cleaner and more efficient energy sources, whereas poorer households continue to rely on expensive, inefficient, and environmentally harmful fuels like biomass or kerosene. (Perera et al., 2024). Moreover, Bhuiyan et al. (2022) adduce evidence to show that increases in energy costs disproportionately affect poorer households, amplifying economic inequalities and hindering their ability to climb the energy ladder. These perspectives suggest that the impact of total/primary energy consumption on inequality is hard to predict.

2.1.1 Renewable energy consumption and income inequality

The transition from fossil fuel to renewable energy can affect the dynamics of income distribution either in support of or in opposition to the energy justice concept. According to Carley and Konisky (2020), switching to clean energy will inevitably create winners and losers. On the one hand, several studies suggest that countries rich in renewable resources, such as hydropower or solar energy, may achieve more inclusive economic growth by promoting job creation (see, e.g., Çetin & Eğrican, 2011; Lehr et al., 2012). A case in point is Morocco, where the expansion of solar energy projects has contributed to improved access and reduced income inequality (IEA, 2019). Topcu and Tugcu (2020) also show that renewable energy leads to a decrease in income inequality in 23 developed countries for the period 1990-2014. Similarly, Fraser et al. (2023) demonstrate that renewable energy adoption triggers improvements in social equity for 99 countries over the period 1990-2015.

On the contrary, the high investment cost associated with renewable energy production and consumption can worsen the income gap between the rich and the poor (Priesmann et al., 2022). A strand of the literature also contends that the shift from fossil fuel to renewable energy consumption triggers income inequality by stifling the economic activities of communities that are predominantly dependent on fossil fuel-related employment (McGee & Greiner, 2019; Apergis, 2015; Pereira et al., 2019; Huang et al., 2020; Cai et al., 2014). For instance, Apergis (2015) found that renewable has a significant positive effect on inequality for a panel of OECD countries over the period 1998-2013. In a related study of Germany over the period 2003-2018 based on 40,000 households, Priesmann et al. (2022) find that indiscriminate renewable energy support levies on electricity consumption do increase income inequality and energy poverty. This is supported by Haar (2020), who reported that the burden of the transition to renewables falls disproportionately on poor households in the EU. These studies suggest that the effects of replacing fossil energy with renewables on income redistribution are complex. Accordingly, we seek to answer the question:

Question 1: Does renewable energy consumption lessen income inequality?

2.1.2 Non-renewable energy and income inequality

The relationship between energy consumption and inequality extends beyond renewable energy sources to include non-renewable energy, particularly fossil fuels. Previous contributions suggest that relying heavily on non-renewable energy increases inequality, especially in low-income countries (see, e.g., Solarin, 2022; Couharde & Mouhoud, 2020). One notable reason is the structure of fossil fuel subsidies, which tend to benefit wealthier households disproportionately. This is often the situation in many developing countries where wealthier individuals consume more energy, leading them to receive a larger share of these subsidies. For instance, Couharde and Mouhoud (2020) recently showed that in developing countries, the richest 20% of the population capture approximately 43% of the benefits from fuel subsidies, while the poorest 20% receive only about 7%. This regressive distribution not only deepens existing income disparities but also diverts essential public funds from critical sectors such as education and healthcare, which are more beneficial to lower-income groups.

Further, non-renewable energy consumption can entrench inequality by concentrating wealth in the hands of those who control fossil fuel resources while imposing disproportionate environmental and health burdens on marginalised populations. This situation deepens economic disparities, as traditionally marginalised communities bear the costs of pollution and climate risks associated with fossil fuel use (Rauner et al., 2024). Similarly, Çatık (2024) finds evidence indicating that non-renewable energy decreases equitable income redistribution through its effect on pollution. The findings of Xu et al. (2023) reiterate the detrimental impact of fossil fuel consumption on sustainable development, particularly in regions with high inequality. We examine the African context of this relationship by asking the question:

Question 2: Does non-renewable energy consumption worsen income inequality?

2.2 Democracy and income inequality

The dynamics of political power and, for that matter, democracy significantly determine economic outcomes. Amendola et al. (2013) note that inclusive societies with large middle classes are not the natural outcome of market forces but rather the creation of institutions – the laws, policies, and practices. Theoretically, the effect of democracy on income inequality is indeterminate, a priori (Nikoloski, 2015). Some theoretical antecedent highlights the potential of democracy to reduce income inequality. One foundational theory is the median voter theorem (Meltzer & Richard, 1981). Meltzer and Richard (1981) present a model that emphasises the role of majority rule in driving redistributive policies to reduce inequality. In other words, politicians are likely to support policies that 'take from the rich and give to the poor' to remain in political power. Amendola al. (2013) argue that democracies reduce inequality by promoting transparency, accountability, citizen participation, and promoting policies (i.e., social spending, education, and health) that benefit a broader segment of society. However, some scholars submit that the effect of democracy on income inequality may be compromised in specific contexts due to corruption, coup d' états and capital flight (see, e.g., Acemoglu et al., 2015).

On the empirical front, studies have shown that democracy can reduce economic inequality. For example, Trinugroho et al. (2023) demonstrate that democracy mitigates inequality by granting marginalised groups greater access to education, which raises their income prospects. Also, Adegboye et al. (2023) find a significant negative effect of democracy on inequality in SSA. Similarly, Al-Majali (2023) employed fixed and random effects models to establish a downward impact of democracy on inequality, drawing on data from a sample of 114 countries. Recent evidence from Ofori (2024) also reveals that democracy, particularly electoral and participatory forms, plays a crucial role in reducing inequality in Africa. Using macro data from 1990–2018 for 38 SSA countries, Gossel (2024) employ instrumental variable regression analysis and find that democracy reduces inequality in both the short and long run. The study further highlights democracy's role in shaping foreign investment to mitigate inequality, provided a moderate level of democracy is attained.

However, there is the view that democracy can lead to increased inequality under certain conditions, particularly when wealthier segments of the population capture the political system (see Acemoglu et al., 2015; Wong, 2021; Kang & Seo, 2023). For instance, Wong (2021) examines the impact of electoral and participatory democracy on inequality using data from 135 countries and instrumental variable regressions. The findings reveal that while electoral democracy reduces inequality, participatory democracy (without elections) exacerbates it. Bahamonde and Trasberg (2021) use fixed effects analysis on a panel of 126 countries, revealing that while democracy reduces inequality in high-state-capacity contexts, it may exacerbate inequality over time. This occurs because such environments attract more foreign direct investment and foster financial sector development, both of which can disproportionately benefit the wealthy. Acemoglu et al. (2015) have also shown that democracy heightens inequality, particularly in countries that have undergone significant structural transformation, where the income gap between the poor and middle class is narrow, and where land ownership remains highly unequal. Kang and Seo (2023), for example, relied on a sample of 164 countries and concluded that the effectiveness of democracy in equalising income is curtailed in societies where political influence is dominated by the wealthy (elites) or neoliberal policies. This finding is confirmed by Zuazu (2022), who employed the system-GMM estimator on 85 countries to show that democracy does not significantly mitigate income inequality; instead, political equality and electoral systems play a crucial role in shaping income distribution outcomes.

2.2.1 The role of democracy in the energy consumption-income inequality nexus

The political economy scholarship emphasises the effectiveness of democratisation in public service delivery, opportunities, and economic development. (Acemoglu et al., 2015) For example, liberal democracy, characterised by the protection of individual rights and free-market principles, can enhance access to critical resource resources such as energy. However, Heffron and McCauley (2014) argue that policy gaps in redistribution within such systems may inadvertently exacerbate inequalities. This suggests that the emphasis on market-driven mechanisms in democracy might leave marginalised communities at a disadvantage, for instance, in energy access.

Similarly, by prioritising public discourse on national development, deliberative democracy can ensure that the voices of marginalised groups are heard. This can contribute to more equitable energy access and economic outcomes (Sovacool & Dworkin, 2015). Participatory democracy can also drive inclusive energy governance and promote equitable outcomes by engaging citizens directly and shaping policies that address diverse economic challenges (see Heffron & McCauley, 2014). With its strong emphasis on promoting equity in the access to social overhead capital, opportunities and safety nets, egalitarian democracy can promote fairness in energy access and, consequently, economic outcomes. However, empirical evidence on the role democracy plays in the energy consumption-income inequality nexus in the context of Africa is lacking. We fill this gap in the literature by answering the question:

Question 3: Does democracy moderate energy consumption to reduce inequality?

Thus far, we have established through the literature review that country- and regional-specific factors, including the political systems, are critical in explaining income inequality. We also gather that previous studies focus much on the drivers of energy consumption, with the impact of income inequality and institutions featuring prominently (see, e.g., Uzar 2020; Apergis & Pinar, 2021; Asongu & Odhiambo, 2021; Chen et al., 2021; Xu, & Zhong 2023). However, how (non-) renewable energy consumption affects inequality in Africa is hard to find. Moreover, we find that studies have not explored how the five typologies of democracy moderate the impact of (non-) renewable energy consumption on inequality in Africa. This study fills these gaps in the extant scholarship. The following sections describe the research methods employed for the data analysis.

3. Methods and Data

3.1 Data

To empirically examine the effect of energy consumption on income inequality, as well as the moderating effect of democracy in the relationship, the study employs data from a panel of 33 African countries for the analysis (see the list of countries in Table A.1). The study period is 2010-2020. We focus on these countries and the study period because of data issues. Data for the Palma ratio is missing/scanty for the Democratic Republic of Congo, Comoros, Cape Verde, Djibouti, Eritrea, Mauritania, Madagascar, Somalia, South Sudan, and Zimbabwe.

The dependent variable in this study is income inequality, which is proxied by the Palma ratio. According to Ofori et al. (2022), the Palma ratio is important for income inequality analysis because it provides a clear picture of the growth in incomes of the wealthiest 10% of the population relative to that of the bottom 40%. To assess the robustness of the estimates, this study employs the Gini index as an alternative outcome variable. We consider this approach to be more appropriate because (i) institutional quality variables are not suitable substitutes for democracy indicators, and (ii) the democracy measures from the Polity Project and Freedom House lack critical dimensions such as deliberativism and egalitarianism. The Gini coefficient measures the extent to which the distribution of income among individuals or households within an economy deviates from perfect equality. The Gini index ranges from 0 (perfect income equality) to 1 (perfect income inequality) in a given population. The study collects the Palma ratio and Gini index series from the World Income Inequality Database [WIID] (UNU-WIDER, 2023).

The primary predictor variable in this study is energy consumption. As aptly articulated in Sections 1 and 2, the type of energy consumption – renewable or non-renewable – can have a profound impact on income distribution. In this study, energy consumption is measured as total primary energy consumption in quadrillion British thermal units (Quand BTU). To allow for targeted policy recommendations, this study further disaggregates total primary energy consumption into renewable energy (proxied by total renewable energy consumption in BTU) and non-renewable energy (proxied by total fossil fuel energy consumption in BTU). Data for energy consumption dynamics are retrieved from the Energy Information Administration (2023).

The moderating variable in this study is democracy. As already explained in the introductory section, stronger democracies can moderate energy consumption to promote equitable income distribution. Following Coppedge et al. (2016), we use a more holistic measure of democracy instead of narrow and restrictive democracy indicators such as those developed by the Polity Project and Freedom House on the grounds of accuracy, coverage, and reliability. Democracy variables put forward by these sources have been criticised over issues related to their definitions, accuracy, scope, aggregation methods, and reliability (Coppedge et al., 2019). In particular, the Polity Project and Freedom House democracy indicators lack data on non-electoral dimensions such as liberalism and egalitarianism. Thus, employing these sources would restrict a comprehensive understanding of how democracy influences income inequality. Accordingly, this study employs the widely disaggregated and comprehensive democracy indicators developed by (Coppedge et al., 2019) for the analysis. These indexes have been used in recent empirical works such as Adegboye et al. (2023). According to Coppedge et al. (2016), electoral democracy emphasises political authorities' responsiveness to citizens through periodic elections. Participatory democracy also values direct citizen involvement in all political processes. Liberal democracy focuses on safeguarding individual and minority rights against potential majority and state tyranny. Egalitarian democracy aims for equal power distribution among citizens regardless of class, ethnicity, or social group orientation. Deliberative democracy advocates decisions based on respectful and rational discourse in addition to fair distribution of national resources and opportunities to all segments of the population for the common good. Thus, these variables capture the underlying principles and processes of democracy, such as citizen involvement, debate, individual freedoms, and social equality. These concepts emphasise how power is distributed and exercised in a democratic system, focusing on values like representation, inclusivity, and rights protection. Accordingly, the democratic variables used in this study deviate from governance indicators such as the rule of law, political stability, government effectiveness, and corruption control, which focus on the quality and functionality of public institutions, the enforcement of laws, and the overall stability of political systems. In other words, democracy reflects normative and procedural aspects of a political system, while governance indicators assess the capacity and performance of institutions. Data for these democracy variables are sourced from Coppedge et al. (2023). All the democracy indices range from 0 to 1, where 0 represents the lowest attainable level of democracy (e.g., a fully authoritarian or politically repressive system), and 1 signifies the highest level of democracy (e.g., a fully democratic or politically inclusive system).

Consistent with the theoretical and empirical literature, the study controls for credit access (Meniago & Asongu, 2018), human capital (Nunoo et al., 2024; Adeleye, 2024), internet access (Adams & Akobeng, 2021), corruption control (Adams & Klobodu, 2016; Ofori et al., 2023) and remittances (Ofori et al., 2022; Song et al., 2021) to mitigate omitted variables bias and take into account the role of financial access, the digital economy, institutions, and education and training on income inequality.

Table 1: Description of variables and data sources

Variables	Symbols	Description	Sources
Outcome variables			
Palma ratio	*Palma*	The ratio of the share of all income held by the 10% of people with the highest disposable income to that held by 40% of the people in the population with the lowest disposable income.	UNU-WIDER (2023)
Gini index	*Gini*	It measures the extent to which the distribution of income among individuals or households within an economy deviates from perfect equality.	UNU-WIDER (2023)
Main predictors			
Energy consumption	*Pener*	Total primary energy consumption in quadrillion British thermal unit (Quand BTU)	EIA (2023)
Renewable energy consumption	*Rener*	Total renewable energy consumption in quadrillion British thermal unit (Quand BTU)	EIA (2023)
Fossil fuel energy consumption	*Fosfl*	Fossil fuel energy consumption in quadrillion British thermal units (Quand BTU)	EIA (2023)
Moderators			
Electoral democracy	*Elede*	Electoral democracy index	Coppedge et al. (2023)
Liberal democracy	*Libde*	Liberal democracy index	Coppedge et al. (2023)
Participatory democracy	*Parde*	Participatory democracy index	Coppedge et al. (2023)
Deliberative democracy	*Delde*	Deliberative democracy index	Coppedge et al. (2023)
Egalitarian democracy	*Egalde*	Egalitarian democracy index	Coppedge et al. (2023)
Control variables			
Financial access	*Fidev*	Domestic credit to private sector (% of GDP)	World Bank (2023)
Remittances	*Remit*	Personal remittances received as a percentage of gross domestic product	World Bank (2023)
Internet access	*Intnet*	Individuals using the internet (% of the population)	World Bank (2023)
Human capital	*Hcap*	Number of years and returns to education	Feenstra et al. (2015)
Corruption control	*Corrupt*	Captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	World Bank (2023)

Note: EIA is the United States Energy Information Administration

3.2 Model specifications

This study follows the dynamic model specifications of Adeleye (2024) and Nunoo et al. (2024) by modelling income inequality as primarily driven by energy consumption, democracy, and the set of control variables.

$$Ineq_{it} = \alpha_0 + \alpha_1 Ineq_{it-1} + \beta_1 Fidev_{it} + \beta_2 Remit_{it} + \beta_3 Intnet_{it} + \beta_4 Hcap_{it} + \beta_5 Corrupt_{it} + \beta_6 Energy_{it} + \beta_7 Democ_{it} + v_i + \vartheta_t + \varepsilon_{it} \quad (1)$$

where $Ineq_{it}$ is the level of income inequality – proxied by the Gini coefficient and the Palma ratio – in country i time t. Also, $Ineq_{it-1}$ is the lag of income inequality, which we introduce to capture the persistence of income inequality in Africa. Similarly, $Energy$ is a vector of energy consumption variables, namely, primary energy consumption (*Pener*), renewable energy consumption (*Rener*) and non-renewable energy consumption (*Fosfl*). Moreover, $Remit$ is remittances, $Fidev$ is financial access, $Hcap$ is human capital, and $Intnet$ is internet access.

Also, consistent with Objective 2 of the study, we introduce an interaction between energy consumption and democracy such that Equation 1 is modified to obtain Equation 2.

$$Ineq_{it} = \alpha_0 + \alpha_1 Ineq_{it-1} + \beta_1 Fidev_{it} + \beta_2 Remit_{it} + \beta_3 Intnet_{it} + \beta_4 Hcap_{it} + \beta_5 Corrupt_{it} + \beta_6 Energy_{it} + \beta_7 Democ_{it} + \beta_8 (Energy_{it} \times Democ_{it}) + v_i + \vartheta_t + \varepsilon_{it} \quad (2)$$

where $Energy \times Democ$ is the interaction term for energy consumption and democracy, v_i is the country-fixed effect, ϑ_t is the time effect, ε_{it} is the residual term and all the other symbols are as earlier defined. It is imperative to note that $Democ$ is a vector of five democracy dynamics, namely, Electoral democracy ($Elede$), Liberal democracy ($Libde$), Participatory democracy ($Parde$), Deliberative democracy ($Delde$), and Egalitarian democracy ($Egalde$), which we stepwisely in Equations 3 and 4.

To ascertain whether these democratic dispensations are statistically significant in moderating energy consumption to affect income inequality, we evaluate the attendant total effects based on Equation 5.

$$\frac{\partial(Ineq_{it})}{\partial(Energy_{it})} = \beta_6 + \beta_8 (\overline{Democ_{it}}) \quad (5)$$

We evaluate the conditional effects of energy consumption dynamics on income inequality at the means of the democracy variables. These indirect effects capture the interplay between energy consumption and democracy in influencing inequality.

Consistent with the questions, we expect non-renewable (renewable) energy consumption to increase (reduce) income inequality. Similarly, the study expects all the democracy variables to promote income equality.

3.3 Estimation strategy

Inherent in most shared growth models is the issue of endogeneity, caused by measurement error, omitted variables bias or reverse causality. In this study, endogeneity is at least apparent since we have introduced the lag of the dependent variables (i.e., income inequality). Estimating Equations 1 and 2 via the standard pooled least squares or the fixed effect regression will cause an upward bias in the estimates, rendering inferences flawed. To circumvent this, we apply the Blundell and Bond (1998) two-step system generalised method of moments (GMM) to estimate the models.

Although in principle, both the first difference GMM of Arellano and Bond (1991) and the two-step system-GMM of Blundell and Bond (1998) can be applied to estimate the results, the former will fail to address the endogeneity problem if the sampled countries (N) exceed the time (T). In this study, N=33>T=11, making the Blundell and Bond (1998) approach appropriate for the regression. Also, according to Roodman (2009), the Blundell and Bond technique is efficient in addressing instrument proliferation, overfitting, and cross-sectional dependence. The estimator accounts for cross-sectional dependence (see Table A.3) by eliminating the time-effects in the first difference estimation. More importantly, the Blundell and Bond approach accounts for endogeneity by using the first differencing approach, which eliminates the unobserved country-specific effects and time effects in Equations 1 and 2 to obtain Equations 3 and 4:

$$Ineq_{i,t} - Ineq_{i,t-1} = \alpha_0\left(Ineq_{i,t-1} - Ineq_{i,t-2}\right) + \beta_1\left(Fidev_{i,t} - Fidev_{i,t-1}\right) + \beta_2\left(Remit_{i,t} - Remit_{i,t-1}\right) + \beta_3\left(Intnet_{i,t} - Intnet_{i,t-1}\right) + \beta_4\left(Ecostr_{i,t} - Ecostr_{i,t-1}\right) + \beta_5\left(Gpcgr_{i,t} - Gpcgr_{i,t-1}\right) + \beta_6\left(Energy_{i,t} - Energy_{i,t-1}\right) + \beta_7\left(Democ_{i,t} - Democ_{i,t-1}\right) + \left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right) \quad (3)$$

$$Ineq_{i,t} - Ineq_{i,t-1} = \alpha_0(Ineq_{i,t-1} - Ineq_{i,t-2}) + \beta_1(Fidev_{i,t} - Fidev_{i,t-1}) + \beta_2(Remit_{i,t} - Remit_{i,t-1}) + \beta_3(Intnet_{i,t} - Intnet_{i,t-1}) + \beta_4(Ecostr_{i,t} - Ecostr_{i,t-1}) + \beta_5(Gpcgr_{i,t} - Gpcgr_{i,t-1}) + \beta_6(Energy_{i,t} - Energy_{i,t-1}) + \beta_7(Democ_{i,t} - Democ_{i,t-1}) + \beta_8[(Energy_{i,t} \times Democ_{i,t}) - (Energy_{i,t-1} \times Democ_{i,t-1})] + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \quad (4)$$

The Blundell and Bond estimator uses the internal instrumentation approach such that the lagged differences of the predictors and the outcome variable become instruments for equations in levels and first difference. To ascertain the appropriateness of these instruments and, by extension, the estimates, the study tests for the validity of the over-identification restriction and instrument proliferation. The latter is assessed by checking whether the number of instruments is less than or equal to the number of countries, whereas the former is evaluated by invoking the Hansen (1982) test of identification restriction. We also evaluate additional post-estimation tests to determine whether: (i) the energy-democracy interaction terms are statistically significant, (ii) there is no second-order serial correlation in the residuals as given by AR (2) statistics, and (iii) the models are jointly significant. Accordingly, the estimated results are considered robust/reliable if the number of instruments is less than or equal to the number of countries, the Hansen p-values are statistically insignificant at either the 1%, 5% or 10% level, the interaction terms are statistically significant, and all the models are jointly significant as given by the Wald Chi-square statistics.

4. Results and discussion

4.1 Exploratory data analysis

Table A.2 and Table 2 report the summary statistics and correlation matrix of the variables. The average primary energy consumption is 0.471 BTU, which is high in the context of developing countries. We also report average values of 0.032 and 0.185 Quand BTU for renewable energy and fossil fuel consumption, respectively. This gives an indication that fossil consumption in Africa is at least five times higher than renewable consumption. The data show mean values of 1.88, 3.14%, and 20.56% for human capital, remittances, and internet access, respectively. This information also suggests that: (i) the number of years and returns to education in Africa is high, (ii) remittances inflow to Africa is quite high, and (iii) at least 78% of Africa's population does not have access to reliable internet.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Palma ratio	330	5.093	2.262	1.255	15.137
Gini index	330	55.388	8.022	31.877	72.877
Financial access	330	27.709	26.698	4.769	128.838
Human capital	330	1.885	0.474	1.166	2.939
Internet access	352	20.562	18.097	0.580	84.12
Corruption control	363	-0.510	0.535	-1.544	1.003
Remittances	363	3.149	4.516	0.000	27.302
Primary energy consumption	363	0.471	1.171	0.003	5.810
Renewable energy consumption	363	0.032	0.042	0.000	0.184
Fossil fuel consumption	363	0.185	0.364	0.002	1.782
Electoral democracy	363	0.449	0.184	0.125	0.773
Liberal democracy	363	0.324	0.178	0.043	0.680
Participatory democracy	363	0.272	0.123	0.053	0.516
Deliberative democracy	363	0.353	0.175	0.040	0.721
Egalitarian democracy	363	0.310	0.145	0.070	0.642

Note: Obs is observations, Std. Dev. is standard deviation, Min is Minimum, and Max is Maximum.

For income inequality (Palma ratio), we note a mean value of 5.093, which suggests that the share of income of the top 10% of the wealthiest people in Africa is at least five times that of the income of the bottom 40%. Detailed information concerning the level of income inequality in the sampled countries is presented in Figure 1. The figure shows that the top six most unequal countries in Africa are South Africa, Zambia, Central African Republic, Eswatini, Namibia, and Lesotho. Figure 2 illustrates how these countries perform across various democratic indicators. Strikingly, we observe that only 7 (Ghana, Senegal, Namibia, South Africa, Niger, Kenya, and Sierra Leane) out of the 33 countries sampled have shown notable progress across all dimensions of democracy over the period 2010-2020. Similarly, Egypt, Congo, Algeria, Angola, and Cameroon report low performance across these democracy dynamics.

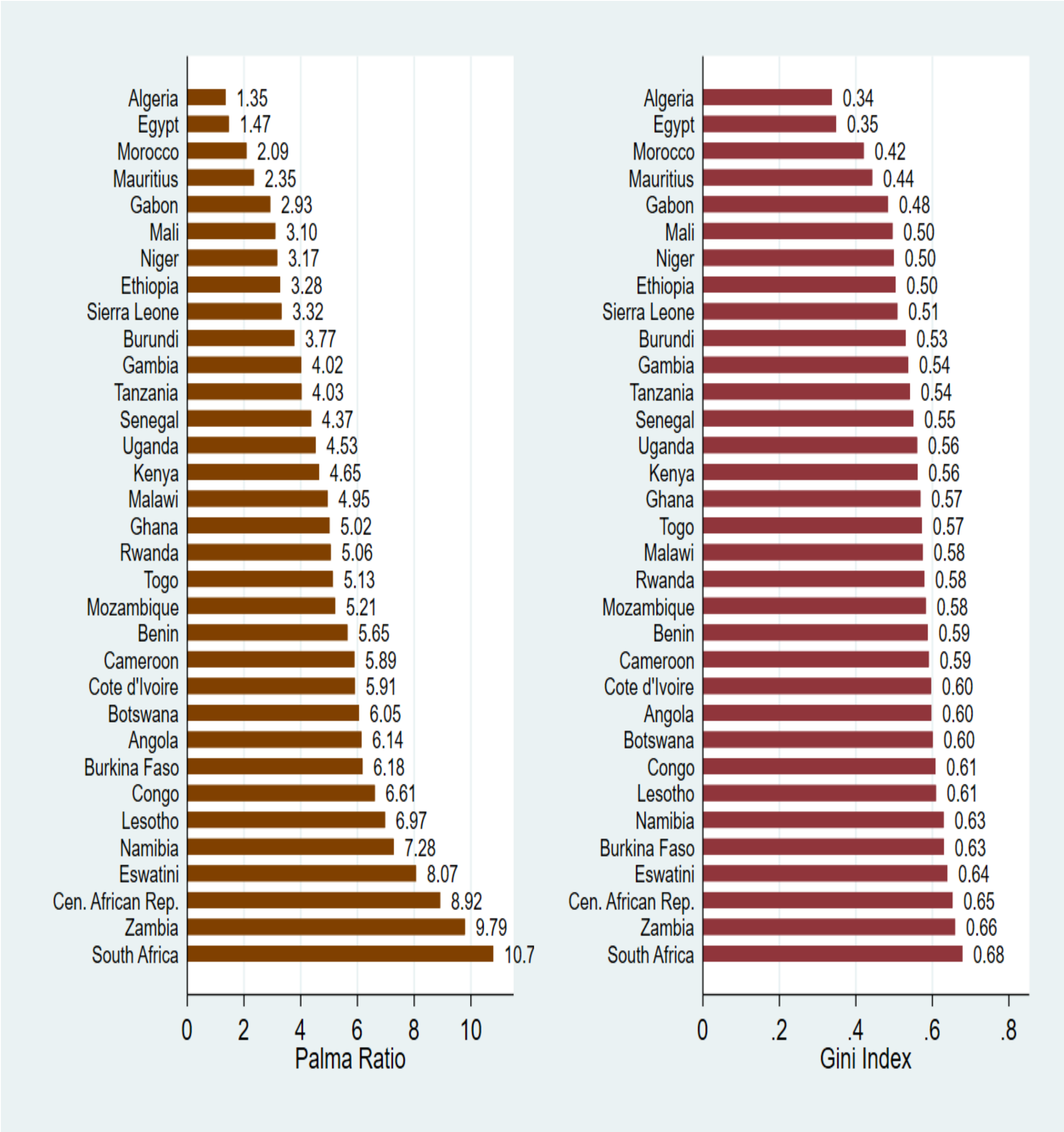

Figure 1: Income Inequality in African Countries (Average), 2010-2020

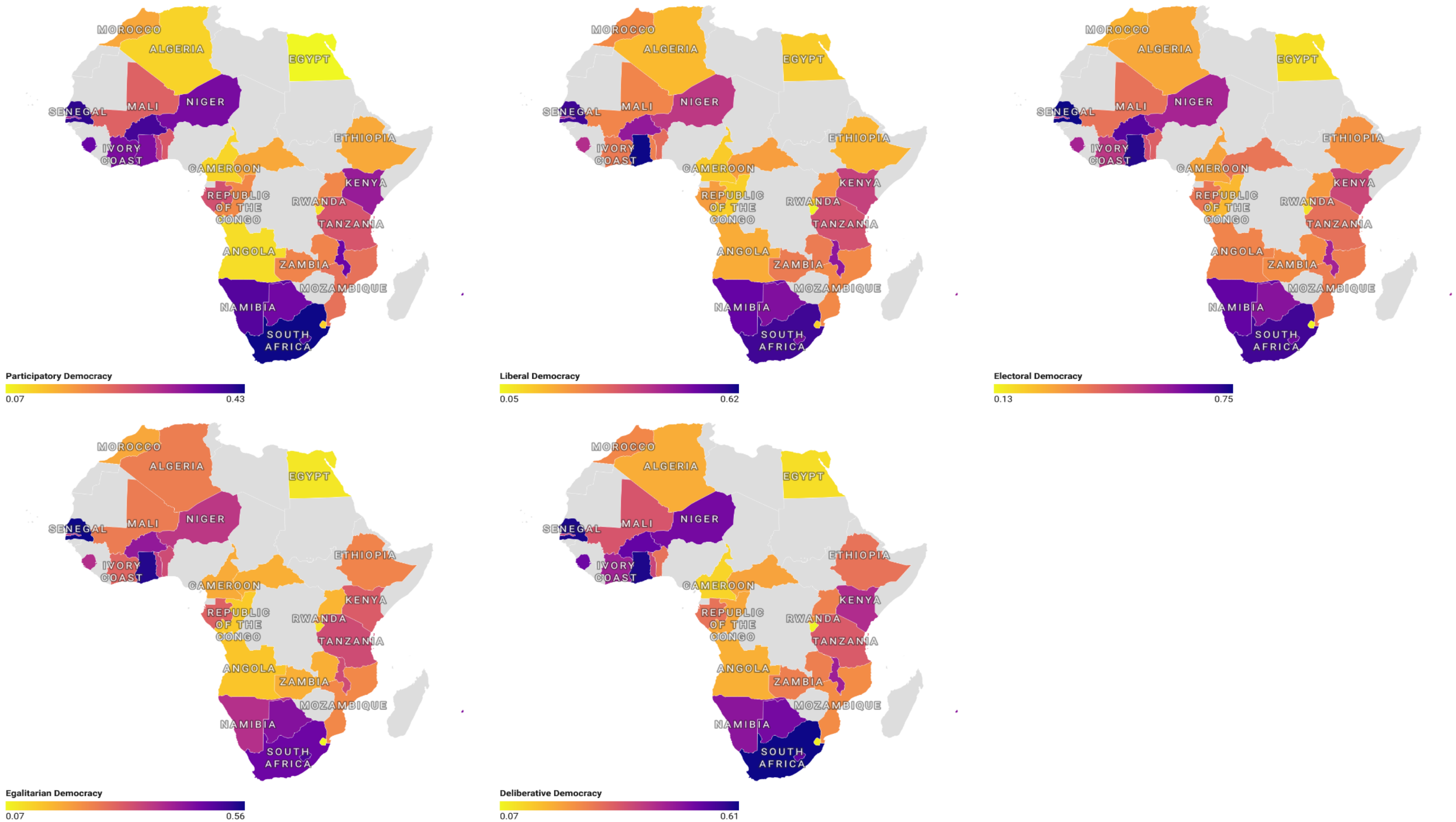

Figure 2: In-country performance across various democracy indicators, 2010-2020.

4.2 Effects of energy consumption and democracy on income inequality

Table 3 presents the findings for the estimated effects of primary energy consumption and democracy on income inequality. The table is organised into twelve columns, with Columns 1 through 6 reporting estimates for the Palma ratio while Columns 7-12 display the results for our robustness checks (i.e., the Gini index as an alternative outcome variable).

We find robust evidence that income inequality persists in Africa. This is indicated by the positive and statistically significant coefficients of the lag of inequality. The results further indicate that primary energy consumption reduces inequality. We find that a unit increase in primary energy consumption reduces inequality by 0.05 points. This evidence is consistent with existing literature in energy economics (see, e.g., Apergis, 2015; Stern, 2011). A crucial pathway through which an increase in energy consumption can promote redistribution is through job creation. For instance, reliable energy access can promote economic growth by enabling small-scale enterprises, agricultural processing, and light manufacturing industries to operate efficiently. This can stimulate job creation, helping bridge the income divide. Another critical pathway through which energy consumption promotes equitable income distribution is by unlocking opportunities for extended study hours and digital learning, particularly among disadvantaged groups. Access to reliable energy transforms education by enabling the use of technology and fostering skill development, equipping individuals with the capabilities needed to compete for higher-paying jobs. This not only narrows income gaps but also drives upward social mobility (Nunoo et al., 2024).

Further, we assess the effects of the various democracy indicators on inequality. The findings reveal that only electoral, liberal, and egalitarian democracies have statistically significant impacts on inequality. The magnitude of the estimated coefficients indicates that electoral, liberal, and egalitarian democracy increase income inequality by 0.08, 0.07 and 0.06 points, respectively. These unexpected findings may stem from the nascent nature of democratic dispensations in Africa. Notably, low levels of electoral, liberal, and egalitarian democracies can perpetuate income inequality in developing countries by undermining accountability, institutional fairness, and social inclusion. For instance, weak electoral democracies often allow elites to capture states, leading to policies that favour narrow interests and neglect marginalised populations (Coppedge et al., 2016).

Table 3: Effects of energy consumption and democracy on income inequality in Africa

	Main results: Palma ratio estimates						Robustness check: Gini index estimates					
Variables	1	2	3	4	5	6	7	8	9	10	11	12
L.lpalma	0.9035***	0.9080***	0.9094***	0.9063***	0.9079***	0.9067***	–	–	–	–	–	–
	(0.008)	(0.022)	(0.022)	(0.019)	(0.017)	(0.018)	–	–	–	–	–	–
L.ggini	–	–	–	–	–	–	0.9173***	0.9341***	0.9385***	0.9370***	0.9300***	0.9411***
	–	–	–	–	–	–	(0.007)	(0.025)	(0.027)	(0.022)	(0.019)	(0.020)
Findev	-0.0005***	-0.0005**	-0.0004*	-0.0004	-0.0003	-0.0005*	-0.0001***	-0.0001	-0.0001	-0.0001	-0.0001	-0.0001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hcap	0.0156	0.0136	0.0170	0.0183	0.0237*	0.0186	0.0021	0.0018	0.0021	0.0023	0.0022	0.0020
	(0.010)	(0.010)	(0.012)	(0.013)	(0.013)	(0.012)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Intnet	0.0004***	0.0006***	0.0006***	0.0005***	0.0005***	0.0005***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Corrupt	-0.0133	-0.0307**	-0.0280**	-0.0190	-0.0200*	-0.0255*	-0.0014	-0.0030	-0.0027	-0.0009	-0.0006	-0.0021
	(0.009)	(0.012)	(0.012)	(0.012)	(0.010)	(0.013)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Remit	-0.0034**	-0.0041**	-0.0041***	-0.0037**	-0.0040***	-0.0039***	-0.0006***	-0.0005**	-0.0005**	-0.0004*	-0.0005**	-0.0005**
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pener	-0.0523***	-0.0410***	-0.0494***	-0.0491***	-0.0511***	-0.0430***	-0.0069***	-0.0053*	-0.0060**	-0.0067***	-0.0067***	-0.0050**
	(0.006)	(0.013)	(0.012)	(0.012)	(0.009)	(0.011)	(0.001)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Elede		0.0822**						0.0053				
		(0.035)						(0.006)				
Pener x Elede		-0.0082						-0.0034				
		(0.023)						(0.005)				
Libde			0.0719**						0.0030			
			(0.034)						(0.006)			
Pener x Libde			-0.0083						-0.0038			
			(0.027)						(0.005)			
Parde				0.0414						-0.0074		
				(0.055)						(0.009)		
Pener x Parde				-0.0097						-0.0036		
				(0.033)						(0.006)		
Delde					0.0394						-0.0043	
					(0.033)						(0.005)	
Pener x Delde					-0.0098						-0.0020	
					(0.023)						(0.004)	
Egalde						0.0698*						0.0017
						(0.038)						(0.007)
Pener x Egalde						-0.0160						-0.0066
						(0.029)						(0.005)
Total effects	na	-0.0445***	-0.0520***	-0.0517***	-0.0545***	-0.0479***	na	-0.0067	-0.0072***	-0.0076***	-0.0073***	-0.0070***
	na	(0.0057)	(0.0057)	(0.0057)	(0.0057)	(0.0057)	na	(0.0011)	(0.0010)	(0.0010)	(0.0009)	(0.0010)
Constant	0.1441***	0.0878	0.0963	0.1180*	0.1016*	0.1025*	0.0469***	0.0331*	0.0314	0.0361**	0.0407***	0.0307*
	(0.034)	(0.065)	(0.062)	(0.061)	(0.059)	(0.057)	(0.006)	(0.019)	(0.019)	(0.017)	(0.015)	(0.016)
Observations	268	268	268	268	268	268	268	268	268	268	268	268
Countries/Instruments	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31
Fisher Statistic	1073689.3***	35977.9***	43146.2***	788480.2***	336307.9***	259587.8***	5446404.4***	2468363.5***	4686584.4***	2914361.7***	2849636.1***	4672264.5***
AR (1)	0.1565	0.1350	0.1359	0.1571	0.1184	0.1631	0.1577	0.1582	0.1676	0.2022	0.1679	0.1803
AR (2)	0.2626	0.2236	0.2146	0.2631	0.2239	0.2604	0.3023	0.2879	0.2921	0.3003	0.2987	0.2948
Hansen p-value	0.9071	0.7905	0.8486	0.8479	0.8785	0.8554	0.7343	0.6337	0.7193	0.8127	0.7244	0.7409

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Similarly, limited liberal democracy, characterised by fragile institutions and poor rule of law, fosters corruption, and weakens protections for property and labour rights, exacerbating wealth concentration (Coppedge et al., 2011). Finally, low levels of egalitarian democracy fail to address structural inequalities by excluding disadvantaged groups from policymaking and neglecting redistributive policies like progressive taxation and universal access to education and healthcare, thereby perpetuating systemic inequities (Balcázar, 2016).

We now focus on the interactive effect of energy consumption and democracy on inequality. The estimated coefficients of all the interaction terms are negative, suggesting that democracy interacts with energy consumption to reduce inequality. This evidence is robust across both the Gini index and Palma ratio. That said, we proceed to calculate the total effects arising from these interactions. For the interaction term between energy consumption and electoral democracy, we report a total effect of 0.044 points. Similarly, the total effects of the interactions between energy consumption and liberal democracy and energy consumption and egalitarian democracy are 0.052 and 0.047 points, respectively. Several reasons can account for these results in the African context. First, electoral democracy fosters pro-poor energy policies through elected leadership, which can prioritise rural electrification, implement targeted subsidies, and ensure accountability in energy infrastructure. Similarly, liberal democracy can promote market efficiency and legal frameworks that protect consumers, incentivise private sector investment, and regulate energy prices to make energy more affordable. Likewise, deliberative democracy can foster inclusive decision-making by ensuring that energy policies address the specific needs of marginalised communities, promoting community-centred projects and transparent policymaking. Participatory democracy can also empower citizens to engage directly in energy governance, fostering community-owned energy systems, grassroots advocacy, and decentralised solutions like micro-grids. Finally, egalitarian democracy can promote universal energy access as a fundamental right, using progressive taxation and redistributive policies to ensure equitable energy distribution and reduce disparities in energy consumption.

Concerning the control variables, the results in Column 1 show a positive but statistically insignificant effect of human capital on income inequality. The results also reveal that remittances and financial access reduce income inequality, irrespective of model specification type. Our result corroborates that of Akobeng (2016), which shows that remittances enhance income equality in Africa. The findings also demonstrate that internet access deepens income inequality. The result contradicts Ofori et al. (2024) but is consistent with Adams and Akobeng (2021), suggesting that the huge digital divide in Africa deepens income inequality. The evidence also suggests that corruption control promotes income equality. In developing countries, effective frameworks for corruption control can mitigate income inequality by ensuring a more equitable distribution of resources and improving the efficiency of public services, including those that provide essential infrastructure and social welfare. The result aligns with Adams and Klobodu (2016).

4.4 Effects of renewable energy consumption and democracy on income inequality

Table 4 reports evidence for the impact of renewable energy consumption on inequality, including how the democracy indicators moderate the relationship. The evidence shows that renewable energy consumption has a negative relationship with inequality, but the effect is statistically insignificant. Renewable energy may be ineffective in reducing income inequality in Africa because of the following reasons. First, a shift from fossil fuel to renewable energy consumption can disproportionately burden low-income households, as it initially benefits the affluent and middle class, who are better able to invest in renewable energy technologies like solar panels and energy-efficient appliances, as noted by Fraser et al. (2023). Second, consistent with argument of McGee and Greiner (2019), the transition to renewable energy consumption in developing countries requires effective redistribution policies, like price subsidies for vulnerable consumers, but due to resource constraints, these interventions are often poorly targeted. This can exacerbate income inequality by disproportionately enhancing the income of affluent households or well-established firms compared to that of poor or small-scale enterprises.

However, when we condition the impact of renewable energy consumption on income inequality, some interesting findings emerge. We find that all the democracy variables, but electoral and participatory democracy, form synergy with renewable energy consumption to reduce inequality. The attendant total effects are also negative, albeit statistically insignificant.

Table 4: Effects of Renewable energy consumption and democracy on income inequality in Africa

	Main results: Palma ratio estimates						Robustness check: Gini index estimates					
Variables	1	2	3	4	5	6	7	8	9	10	11	12
L.lpalma	0.9177***	0.9012***	0.9098***	0.9029***	0.9099***	0.9062***	–	–	–	–	–	–
	(0.013)	(0.021)	(0.020)	(0.021)	(0.022)	(0.020)	–	–	–	–	–	–
L.ggini	–	–	–	–	–	–	0.9376***	0.9175***	0.9253***	0.9223***	0.9363***	0.9240***
	–	–	–	–	–	–	(0.012)	(0.021)	(0.020)	(0.020)	(0.021)	(0.021)
Findev	-0.0015***	-0.0016***	-0.0016***	-0.0016***	-0.0015***	-0.0016***	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hcap	-0.0156	-0.0128	-0.0161	-0.0073	-0.0102	-0.0140	-0.0030**	-0.0019	-0.0023	-0.0012	-0.0021	-0.0018
	(0.013)	(0.011)	(0.014)	(0.016)	(0.013)	(0.012)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Intnet	0.0007***	0.0007***	0.0007***	0.0006***	0.0006**	0.0007***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Corrupt	-0.0243***	-0.0473***	-0.0440***	-0.0390***	-0.0363***	-0.0553***	-0.0044***	-0.0070***	-0.0059***	-0.0046**	-0.0041**	-0.0078***
	(0.009)	(0.012)	(0.011)	(0.011)	(0.010)	(0.013)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Remit	-0.0040***	-0.0053***	-0.0045***	-0.0042***	-0.0039***	-0.0054***	-0.0005***	-0.0006***	-0.0006***	-0.0005**	-0.0005**	-0.0006***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Rener	-0.0410	-0.4891	-0.1202	-0.1660	-0.0315	-0.0456	-0.0222*	-0.0441	-0.0155	-0.0346	-0.0104	0.0024
	(0.070)	(0.377)	(0.337)	(0.373)	(0.307)	(0.408)	(0.012)	(0.071)	(0.057)	(0.058)	(0.056)	(0.066)
Elede		0.0711						0.0087				
		(0.047)						(0.008)				
Rener x Elede		0.7392						0.0289				
		(0.656)						(0.121)				
Libde			0.0759*						0.0070			
			(0.044)						(0.007)			
Rener x Libde			-0.0063						-0.0607			
			(0.774)						(0.129)			
Parde				0.0913						0.0007		
				(0.058)						(0.009)		
Rener x Parde				0.2091						-0.0138		
				(1.062)						(0.169)		
Delde					0.0418						-0.0026	
					(0.042)						(0.007)	
Rener x Delde					-0.2118						-0.0475	
					(0.581)						(0.109)	
Egalde						0.1230*						0.0148
						(0.067)						(0.010)
Rener x Egalde						-0.3409						-0.1288
						(1.232)						(0.187)
Total effect	na	-0.1637	-0.1222	-0.1095	-0.1056	-0.1512	na	-0.0313	-0.0349	-0.0383**	-0.0269	-0.0374**
	na	(0.1130)	(0.1433)	(0.1236)	(0.1303)	(0.0943)	na	(0.0208)	(0.0221)	(0.0183)	(0.0219)	(0.0165)
Constant	0.1787***	0.1631***	0.1628***	0.1615***	0.1649***	0.1473**	0.0430***	0.0486***	0.0468***	0.0495***	0.0438***	0.0436**
	(0.029)	(0.059)	(0.052)	(0.049)	(0.054)	(0.066)	(0.008)	(0.016)	(0.014)	(0.013)	(0.015)	(0.017)
Observations	268	268	268	268	268	268	268	268	268	268	268	268
Countries/Instruments	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31
Fisher Statistic	270639.3***	123107.8***	2070228.8***	550249.6***	565605.7***	24181.1***	2469467.6***	2832535.5***	1288456.8***	3411194.3***	2662994.0***	1058640.9***
AR (1)	0.2951	0.3736	0.3517	0.3163	0.3360	0.3460	0.2768	0.3740	0.3920	0.4641	0.3541	0.3971
AR (2)	0.3102	0.2645	0.2924	0.3143	0.3149	0.3060	0.3213	0.3252	0.3433	0.3483	0.3418	0.3520
Hansen p-value	0.7413	0.6716	0.6062	0.5868	0.6214	0.7165	0.5712	0.5283	0.4530	0.5166	0.5381	0.5704

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The effects of the control variables are also similar to those reported in Table 3. Our evidence suggest that remittances, financial access, and corruption control reduce income inequality, while internet access shows otherwise.

4.4 Effects of non-renewable energy consumption and democracy on income inequality

Table 5 reports the (un) conditional impact of non-renewable energy consumption on income inequality. We find robust evidence of a negative and statistically significant negative impact of non-renewable energy consumption on income inequality. The evidence in Column 1, for instance, suggests that a unit increase in non-renewable energy consumption translates into a 0.119% decline in income inequality. This finding can be attributed to the fact that fossil fuels remain the primary source of energy for domestic and commercial purposes in Africa. According to IEA (2022), at least 60% of Africa's population relies on fossil fuels for their domestic and commercial needs (e.g., for transportation, lighting, cooking, heating, and small businesses).

The interactive analysis also reveals that all the democracy dynamics condition non-renewable energy consumption to reduce income inequality in Africa. Our results demonstrate that non-renewable energy consumption interacts with electoral democracy to reduce income inequality by 0.082 points (Column 2). Similarly, the study finds that liberal democracy interacts with non-renewable energy to reduce income inequality by 0.093 points (Column 3). Also, in the presence of participatory, deliberative, and egalitarian democracy, non-renewable energy consumption reduces inequality by -0.089, -0.105, and -0.109 points, respectively. These conditional effects of non-renewable energy consumption on income inequality remain the same when the Gini index is employed as an alternative outcome variable (See Columns 7-12). In developing countries like Africa, democracy can directly moderate energy consumption to reduce income inequality through two practical channels. First, democratic governance prioritises equitable energy policies, such as subsidies or rural electrification programs, ensuring affordable and reliable energy access for poor and/or low-income earners. This can reduce the energy burden on low-income households, freeing up resources for education, health, and economic activities.

Table 5: Effects of non-renewable energy consumption and democracy on income inequality in Africa

	Main results: Palma ratio estimates						Robustness check: Gini index estimates					
Variables	1	2	3	4	5	6	7	8	9	10	11	12
L.lpalma	0.8880***	0.9071***	0.9262***	0.9270***	0.9236***	0.9122***	–	–	–	–	–	–
	(0.009)	(0.019)	(0.019)	(0.020)	(0.015)	(0.017)	–	–	–	–	–	–
L.ggini	–	–	–	–	–	–	0.9072***	0.9306***	0.9551***	0.9525***	0.9421***	0.9457***
	–	–	–	–	–	–	(0.012)	(0.021)	(0.022)	(0.022)	(0.018)	(0.017)
Findev	-0.0008***	-0.0009***	-0.0007***	-0.0006***	-0.0005**	-0.0007***	-0.0001***	-0.0001***	-0.0001***	-0.0001**	-0.0001**	-0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hcap	-0.0027	-0.0045	-0.0044	-0.0093	-0.0073	0.0026	-0.0007	-0.0006	-0.0012	-0.0013	-0.0002	-0.0005
	(0.013)	(0.007)	(0.009)	(0.009)	(0.006)	(0.011)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Intnet	0.0005***	0.0006***	0.0006***	0.0006***	0.0006***	0.0005***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Corrupt	-0.0149	-0.0246**	-0.0228**	-0.0177	-0.0172*	-0.0198	-0.0022	-0.0024	-0.0018	-0.0011	-0.0016	-0.0007
	(0.009)	(0.011)	(0.011)	(0.011)	(0.009)	(0.012)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Remit	-0.0041***	-0.0055***	-0.0048***	-0.0047***	-0.0054***	-0.0052***	-0.0006***	-0.0007***	-0.0007***	-0.0006***	-0.0006***	-0.0007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Fosfl	-0.1191***	-0.0157	-0.0087	-0.0006	-0.0179	-0.0217	-0.0153***	-0.0022	0.0016	-0.0000	-0.0026	-0.0005
	(0.016)	(0.033)	(0.028)	(0.028)	(0.021)	(0.026)	(0.003)	(0.006)	(0.005)	(0.005)	(0.005)	(0.004)
Elede		0.1318***						0.0127*				
		(0.041)						(0.007)				
Fosfl x Elede		-0.1507**						-0.0248**				
		(0.065)						(0.011)				
Libde			0.1501***						0.0144*			
			(0.042)						(0.007)			
Fosfl x Libde			-0.2648***						-0.0440***			
			(0.075)						(0.014)			
Parde				0.1861***						0.0143		
				(0.054)						(0.010)		
Fosfl x Parde				-0.3308***						-0.0518***		
				(0.096)						(0.019)		
Delde					0.1280***						0.0104*	
					(0.028)						(0.006)	
Fosfl x Delde					-0.2492***						-0.0355**	
					(0.064)						(0.013)	
Egalde						0.1376***						0.0110
						(0.047)						(0.007)
Fosfl x Egalde						-0.2836***						-0.0502***
						(0.077)						(0.013)
Total effect	na	-0.0820***	-0.0934***	-0.0898***	-0.1051***	-0.1095***	na	-0.0130***	-0.0124***	-0.0139***	-0.0150***	-0.0160***
	na	(0.0166)	(0.0141)	(0.0144)	(0.0170)	(0.0158)	na	(0.0031)	(0.0027)	(0.0029)	(0.0029)	(0.0028)
Constant	0.2096***	0.1146**	0.0921*	0.0979*	0.1056**	0.1150**	0.0578***	0.0384**	0.0262	0.0286	0.0329**	0.0325**
	(0.034)	(0.056)	(0.049)	(0.052)	(0.041)	(0.048)	(0.009)	(0.016)	(0.016)	(0.017)	(0.014)	(0.013)
Observations	268	268	268	268	268	268	268	268	268	268	268	268
Countries/Instruments	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31	32/31
Fisher Statistic	651472.6***	226441.4***	125056.1***	195604.5***	96298.7***	1025227.5***	948868.1***	1323767.6***	1377767.7***	1533448.8***	2478076.4***	5819356.0***
AR(1)	0.2171	0.1217	0.1192	0.1107	0.0941	0.1344	0.2009	0.1294	0.1270	0.1260	0.1121	0.1399
AR(2)	0.3295	0.2475	0.2717	0.3037	0.2408	0.3138	0.3329	0.3219	0.3372	0.3408	0.3244	0.3413
Hansen p-value	0.8289	0.5455	0.7212	0.5859	0.7182	0.7442	0.6468	0.3603	0.4335	0.4557	0.5386	0.5227

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Second, stronger/burgeoning democracies promote accountability and transparency, encouraging investments in sustainable energy infrastructure. These investments can promote sustainable growth and fairer income distribution by boosting entrepreneurship, productivity, and job opportunities.

Our findings are robust and sound for policy recommendations on several fronts. The AR(2) statistics confirm no second-order serial correlation in the residuals, while Hansen p-values above 0.05 ensure that the instruments satisfy the exclusion restriction. Additionally, the remarkably high F-statistics highlight that the models are well-specified and effectively explain variations in income inequality. Finally, the absence of instrument proliferation, with the number of groups exceeding the number of instruments in each model, further strengthens the validity of our results.

5. Conclusion and Policy Implications

This study addresses two critical gaps in the social progress literature, with insights that could inform energy and governance policies in Africa and other developing regions. First, the study investigates the impact of electricity consumption (disaggregated into renewable and non-renewable) on income inequality in Africa. Second, consistent with the political economy literature, this study examines how democratic governance moderates the impact of energy consumption on income inequality.

Using robust macro-level data from 33 African countries between 2010 and 2020, we study applies the Blundell and Bond (1998) two-step system GMM estimator for the estimation. The attendant findings are revealing and policy relevant. The study reveals that energy consumption (overall) reduces income inequality in Africa. However, across renewable and non-renewable sources, the study uncovers that the impact of the latter on income inequality reduction is notable compared to the former. Further, interactive analysis suggests that democracy is a crucial mechanism for conditioning energy consumption, particularly non-renewable energy consumption, to promote fairer income distribution. We conclude that although energy consumption reduces income inequality in Africa, progress in inclusive democracy is critical for amplifying the impact.

These results call for critical policy considerations. First, African governments must prioritise investments in renewable energy to address the dual challenges of energy poverty and insecurity. Scaling up electricity production through renewable sources like solar, wind, and hydropower not only aligns with the socioeconomic sustainability goal of ensuring that the energy transition is just and inclusive. To support this effort, Africa's development partners, such as the World Bank, the European Union, and the Bill and Melinda Gates Foundation, should earmark financial and technical resources. Their contributions will be instrumental in driving forward transformative energy policies that are economically beneficial for all segments of society.

This study uncovers that democratic dynamics such as participatory, liberal, deliberative, and egalitarian are significant complementary mechanisms moderating the impact of energy consumption on income inequality. We suggest that African leaders commit to strengthening democratic principles by ensuring fairness, transparency, and accountability in resource allocation and governance processes. African leaders can deepen participatory and inclusive governance by fostering active citizen engagement and empowering communities to meaningfully shape decision-making processes, ensuring policies effectively reflect and respond to the needs of all citizens.

Ensuring affordable electricity for low-income households is vital to bridging the income inequality gap and fostering economic empowerment. In line with the moderating role of democracy in the electricity-income inequality nexus, governments should introduce targeted subsidies or pricing mechanisms to make electricity access equitable. By prioritising energy affordability for disadvantaged groups, African governments can amplify the socioeconomic benefits of electrification, creating a more inclusive and sustainable development trajectory.

Although this study makes a valuable contribution to economic development scholarship and policy, a few limitations and avenues for future research deserve attention. First, our study did not decompose income inequality into specific strata, such as the top 1%, top 10%, or bottom 40% of the income distribution. Future research could explore this perspective to uncover whether the interactive effects of energy consumption and democracy differ across these income segments. Second, we did not examine whether the conditional effect of energy consumption differs across Africa's regional blocs. A deeper exploration of this dimension could complement our study to provide a more comprehensive understanding of regional disparities.

Declaration statement

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

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Table A.1: List of sampled countries

Country	Palma Average	Gini Average
Algeria	1.3494	0.3373
Angola	6.1427	0.5972
Benin	5.6498	0.5878
Botswana	6.0518	0.6007
Burkina Faso	6.1822	0.6300
Burundi	3.7740	0.5299
Cameroon	5.8929	0.5907
Central African Republic	8.9160	0.6527
Congo Republic	6.6122	0.6081
Cote d'Ivoire	5.9134	0.5965
Egypt	1.4652	0.3483
Eswatini	8.0679	0.6391
Ethiopia	3.2767	0.5038
Gabon	2.9265	0.4840
Gambia	4.0168	0.5367
Ghana	5.0172	0.5687
Kenya	4.6459	0.5612
Lesotho	6.9729	0.6092
Malawi	4.9534	0.5750
Mali	3.1050	0.4957
Mauritius	2.3525	0.4426
Morocco	2.0891	0.4204
Mozambique	5.2140	0.5828
Namibia	7.2793	0.6294
Niger	3.1721	0.4993
Rwanda	5.0585	0.5789
Senegal	4.3677	0.5502
Sierra Leone	3.3229	0.5086
South Africa	10.7903	0.6783
Tanzania	4.0297	0.5412
Togo	5.1342	0.5726
Uganda	4.5284	0.5601
Zambia	9.7908	0.6593

Note: Source: Authors' construct, 2024

Table A.2: Correlation Matrix

Variable	Palma	Gini	Fidec	Hcap	Intnet	Corrupt	Remit	Pener	Rener	Fosfl	Electo	Delde	Libde	Parde	Egalde
Palma	1														
Gini	0.909***	1													
Fidev	0.120*	-0.0479	1												
Hcap	0.0813	-0.117*	0.401***	1											
Intnet	-0.170**	-0.335***	0.632***	0.570***	1										
Corrupt	0.0999	0.0637	0.395***	0.371***	0.415***	1									
Remit	-0.110	-0.0986	-0.0526	-0.118*	0.0869	0.167**	1								
Pener	0.0996	-0.200***	0.574***	0.432***	0.456***	0.0998	-0.0432	1							
Rener	0.0375	-0.108	0.141*	0.248***	0.164**	-0.0829	-0.0510	0.405***	1						
Fosfl	-0.121*	-0.420***	0.474***	0.420***	0.489***	0.0582	0.0257	0.936***	0.507***	1					
Electo	0.172**	0.229***	0.345***	0.170**	0.128*	0.465***	0.0850	0.0270	-0.151**	-0.108	1				
Delde	0.0734	0.132*	0.392***	0.207***	0.169**	0.499***	0.0610	0.0591	-0.154**	-0.0577	0.964***	1			
Libde	0.175**	0.212***	0.422***	0.263***	0.200***	0.557***	0.0795	0.0697	-0.0740	-0.0484	0.968***	0.959***	1		
Parde	0.173**	0.255***	0.371***	0.172**	0.118*	0.509***	0.0139	-0.00591	-0.194***	-0.168**	0.932***	0.934***	0.932***	1	
Egalde	0.0731	0.132*	0.351***	0.196***	0.176**	0.565***	0.172**	-0.0123	-0.226***	-0.135*	0.958***	0.946***	0.947***	0.908***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.3: Cross-sectional dependence test

Variable	Test statistic	P-value
Palma	-1.722*	0.085
Gini	-1.742*	0.081
Pener	43.33***	0.000
Rener	10.226***	0.000
Fosfl	25.653***	0.000
Hcap	63.781***	0.000
Findev	.	.
Remit	0.402	0.688
Internet	66.233***	0.000
Corrupt	-0.266	0.790
Elede	0.257	0.798
Libde	-0.332	0.740
Parde	-0.262	0.794
Delde	0.572	0.568
Egalde	1.225	0.220

NB: Test statistics for Cps are not possible due to missing values in panels.
Null hypothesis: Panels are cross-sectionally independent.