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Reducing energy poverty in developing countries: does democracy matter?

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Abstract. This study examines the effect of democracy on reducing energy poverty in developing countries, where access to clean, modern, reliable, and affordable energy remains insufficient. Drawing on neo-institutional theory, the study analyzes how political institutions influence the provision and distribution of energy services. Unlike existing studies, this study adopts a multidimensional approach to democracy by employing five indices (electoral, participatory, liberal, deliberative, and egalitarian) as well as aggregate and disaggregated indicators of energy poverty. Using panel data from 48 developing countries over the period 2006–2023, the two-stage least squares (2SLS) method was applied. The results show that democracy contributes significantly to reducing energy poverty, notably by improving access to clean fuels and increasing electricity consumption, but with differentiated effects depending on institutional dimensions. This effect is more pronounced in low-income countries. The study thus highlights the importance of strengthening democratic institutions and governance to promote inclusive energy policies and support sustainable development.

Keywords: *Democracy; Energy poverty; Developing countries; 2SLS.*

1. Introduction

Access to energy services, particularly electricity, is a key driver of human, economic, and social development. Yet, in many developing countries, a significant portion of the population remains without reliable, affordable, and sustainable access to energy. According to a recent report by the International Energy Agency (IEA, 2023), nearly 666 million people worldwide lacked reliable, affordable, and sustainable access to electricity. Despite overall improvement (nearly 92% of the world's population now has basic electricity access), the deficit remains concentrated almost exclusively in developing countries, particularly in sub-Saharan Africa (UN, 2023).

Furthermore, access to clean fuels and technologies for cooking remains insufficient. In 2023, approximately 2.1 billion people still relied on polluting fuels for cooking (IEA, 2023). This "energy poverty" is defined not only by the lack of access to electricity, but also by the absence of modern, reliable, affordable, and sustainable energy services adapted to the needs of the population. This lack of access to electricity and modern, reliable, affordable, and sustainable energy services constitutes a major obstacle to sustainable development, public health, education, and the socio-economic inclusion of populations (WHO, 2023).

Energy poverty refers to the situation in which a household or individual lacks sufficient, reliable, safe, and affordable access to the energy services necessary to meet their basic needs for a decent standard of living (Boardman, 1991; Pachauri and Spreng, 2004; IEA, 2017; Bouzarovski, 2015; Acheampong et al., 2023). This can include factors such as spending more than 10% of household income on electricity bills, lack of access to energy services like electricity and clean fuels, poor housing quality, inadequate energy infrastructure, and high energy prices (Pachauri and Spreng, 2004; Bouzarovski, 2015; Acheampong et al., 2023; Fotio et al., 2024). This can result in an inability to pay energy bills, increased exposure to energy-related health risks, and a decline in education levels, economic productivity, and other opportunities due to energy constraints.

To this end, addressing energy poverty is crucial for economic development for several reasons: first, energy poverty typically affects low-income populations, thus perpetuating poverty and inequality. Improving access to electricity can directly reduce energy poverty by enabling households to access modern energy services for cooking, heating, lighting, and productive uses, such as powering small businesses (Kanagawa and Nakata, 2008; Njiru and Letema, 2018).

Furthermore, access to reliable and affordable energy services is crucial for boosting economic productivity. Energy poverty can hinder economic activity, limit industrial growth, and stifle business and entrepreneurship development (Dinkelman, 2011; Acheampong et al., 2021; Nguea et al., 2022b; Fotio et al., 2023; Fotio et al., 2024). Reducing energy poverty in a country can unlock its economic potential and create opportunities for sustainable development. Finally, energy poverty often leads to dependence on traditional and polluting fuels, such as biomass, kerosene, and wood, which have detrimental effects on health. Indeed, indoor air pollution from these sources can cause respiratory illnesses and other health problems (WHO, 2016). Overcoming this problem of energy poverty by using clean energy services can improve household health while reducing healthcare costs, and contribute to improving the overall standard of living and productivity (Nguea and Fotio, 2023; Acheampong et al., 2023; Fotio et al., 2024).

To address this issue, several studies have been published, including : the study by Nguyen et al. (2021) which demonstrates the importance of financial development in reducing energy poverty; the study by Said and Acheampong (2023) which demonstrates the usefulness of financial inclusion in combating energy poverty; the study by Tadjeu et al. (2023) focuses on the importance of social sanctions, women's political participation, religiosity (with the work of de Ampofo and Mabefam (2021), cultural diversity (with the study by Chaudhry and Shafiullah (2021), ethnic diversity (with the study by Churchill and Smyth (2020), governance (with the study by Alhborg et al. (2015), education and health (with the work of Acheampong et al. (2021), and education, innovation and financial development (by Sun et al. (2023)). However, these existing studies use disaggregated measures of energy poverty (access to electricity, access to clean fuels). Existing studies highlight the contribution of GDP, foreign direct investment, trade openness, and oil shocks (Nchofoung, 2024; Fotio et al., 2024).

Despite the scale and urgency of these challenges, efforts to ensure universal access to energy are progressing too slowly, and significant disparities persist, particularly in rural, isolated, or impoverished areas (UN, 2023). It is in this context that the institutional dimension, especially the type of political regime, deserves greater attention. The role of political institutions in access to energy services and the reduction of energy poverty is often overlooked in the economic literature. Yet, a democratic regime could, in theory, foster: accountability of government officials, better allocation of public resources, inclusive social policies, transparency in the management of public services, and greater citizen participation. All these factors could improve the level of access to energy and reduce inequalities in this access.

The literature recognizes that democracy plays a crucial role in improving access to energy, particularly through support for electrification projects and access to clean fuels. Better governance helps overcome organizational problems and corruption, thereby facilitating the implementation of effective energy policies (Acheampong et al., 2023). Democracy can also support energy access by promoting the provision of public services and meeting electoral expectations (Acheampong et al., 2023).

Most previous studies have focused on sub-Saharan Africa (SSA), particularly on rural electrification. Furthermore, some studies have used traditional measures of democracy (such as the Polity IV case study, Freedom House), which have been criticized for their lack of precision and their neglect of different dimensions of democracy. This study stands out by using five indicators of democracy (participatory, egalitarian, deliberative, liberal, and electoral democracy), developed by Coppedge et al. (2011), to better analyze the different dimensions of democracy's impact on energy poverty, going beyond simply free and fair elections. Moreover, most studies focus on sub-Saharan Africa, while the effect of political institutions in other developing regions, such as Latin America and the Caribbean, remains largely unexplored. In this study, we will shed light on this gap by examining the effect of democracy on energy poverty in developing countries and analyzing the role of governance in this relationship.

Existing studies often adopt classic empirical methodologies such as instrumental ordinary regressions, but these can be limited by the availability of valid instruments (Lewbel, 2012; Acheampong et al., 2021). Furthermore, most studies use indicators such as Polity IV or Freedom House, which, while important, generally lack nuance regarding the multidimensional complicity of institutions (Coppedge et al., 2011). In addition, few studies have simultaneously explored the role of governance and democracy on access to electricity, access to fuels, and per capita electricity consumption in kWh in the context of developing countries. A better understanding of the developing country context could inform targeted strategies to reduce energy poverty in these vulnerable areas.

Furthermore, existing studies use disaggregated measures of energy poverty, including access to electricity, access to clean fuels, and per capita electricity consumption in kWh. This study will not only use disaggregated measures but also aggregate measures (the Energy Poverty Reduction Index and the Aggregate Democracy Index) in developing countries initially. Secondly, it will assess the effect of the Energy Poverty Reduction Index on the Aggregate Democracy Index through the governance channel (control of corruption, political stability, rule of law, voice and accountability, government effectiveness, and regulatory quality), unlike previous studies that focused on the effect of democracy and governance independently (Acheampong et al., 2023).

These studies show that democracy has not been sufficiently addressed as a machanism for reducing energy poverty in developing countries. The objective of our article is therefore to assess the effect of democracy on energy poverty in developing countries. Our study differs from others in two ways: first, our study uses a composite index of three poverty indicators on a composite index of five high-level democracy indicators. Second, this study examines the effect of democracy on each energy poverty indicator in order to identify which of these indicators' leaders can use to better reduce energy poverty in developing countries. The second is that this study uses several estimation techniques to prove that regardless of the technique used, the effect of democracy on energy poverty remains unchanged.

The rest of the article is structured around a review of the literature (section 2), data and methodologies (section 3), estimation methods (section 4), results and discussions (section 5), and finally a conclusion with policy implications (section 6).

2. Literature review

This study will draw on neo-institutional economic theory to analyze the relationship between political institutions and the reduction of energy poverty. Indeed, neo-institutional theory defines institutions as rules and informal structures that shape interactions between individuals (North, 1989, 2008; North et al., 2000). This suggests that institutions facilitate a country's development trajectories and policy outcomes. Similarly, Acemoglu et al. (2003) observed that policy outcomes reflect institutions, so poor outcomes would be symptoms of weak institutions and vice versa. In this regard, political institutions play a crucial role in this study, as decisions to provide quality energy infrastructure to individuals are determined by public policies. This theory is further supported by the study of Acemoglu et al. (2005), who argue that political institutions allocate political power and shape the political institutions that distribute resources.

The economic literature has examined the role of political institutions in the provision of public services and economic growth (Acemoglu and Johnson, 2005; Acemoglu et al., 2002, 2005, 2008; Olken, 2010; Zhang et al., 2004). In this subsection, we will examine the relationship between political institutions (democracy and governance) and the reduction of energy poverty (access to electricity, access to fuels, and energy consumption in kWh per capita). In this study, we will not only assess the effect of each democracy variable on the energy poverty sub-variables but also the effect of the democracy index on the energy poverty index.

a. The link between democracy and energy poverty

Controversies surrounding whether democratic regimes are more efficient than autocratic regimes in providing public goods and services continue to occupy a prominent place in the political science and economics literature in recent times (Ahlborg et al., 2015). The provision and distribution of public goods and services are closely linked to a country's political apparatus (Deacon, 2003). Indeed, in a democratic country, political leaders are elected and replaced by voters. As such, elected leaders are held accountable and can even be sued by ordinary citizens for their actions (Winslow, 2005). Therefore, political leaders are generally incentivized to respond to citizens' needs and satisfy the population's basic needs, particularly the provision of goods and services necessary to improve social well-being, such as electricity (Acemoglu and Robinson, 2006; Ahlborg et al., 2015; Shmitter and Karl, 1991). To support this idea, Deacon (2003) examined in his study that countries with democracies provide better public goods and services than countries with autocracies. Therefore, it is reasonable to expect that democracy will improve access to energy services in a country (Ahlborg et al., 2015; Lake and Baum, 2001; McGuire and Olson, 1996).

This theory was supported by the study of Acheampong et al. (2022a, 2022b), which focused on different forms of democracy, such as electoral, liberal, deliberative, participatory, and egalitarian democracy. They showed that these different variables influence access to energy services. Democracy guarantees not only the provision of public goods and services but also their allocation and equitable distribution. Similarly, Acemoglu et al. (2015) argue that democracy can lead to an equitable distribution of resources and reduce inequality.

Furthermore, several studies indicate that democratic regimes, by their inclusive and accountable nature, promote the implementation of public policies that benefit populations. This is confirmed by the studies of Acheampong et al. (2023), who examine the effect of democracy and good governance on rural electrification and rural access to clean fuels and cooking technologies using panel data from 34 Caribbean and Latin American countries over a period of 2000 to 2020 and find that democracy promotes access to energy services. This idea may also be motivated by the fact that the accountability of leaders, their need for re-election, and the pressure from the electorate encourage these governments to invest in social services, particularly in the energy sector. Similarly, Kwilinski et al. (2024), assess the effects of European democracy on energy poverty in EU countries using the Voice and Accountability Index (VEA), which is part of the global governance indicators compiled by the World Bank to measure the level of democracy. The results of their analysis show that democracy reduces energy poverty in European Union countries.

In contrast to the studies presented above, Best and Burke (2017), using data from Polity2, showed that democracy has a significant negative effect on per capita electricity consumption and the quality of energy services. Similarly, Aklin et al. (2018) showed that democracy has no significant effect on total electricity access, while reducing the level of electricity access in rural areas.

Based on the literature above, there is a lack of research on the effect of democracy on energy poverty in developing countries. Specifically, no study has simultaneously analyzed the effect of each energy poverty variable (access to electricity, access to fuels, and electricity consumption in kWh per capita) and the energy poverty reduction index on different forms of high-level democracy (electoral, participatory, deliberative, liberal, and egalitarian democracy) and the democracy index. We will address this existing knowledge gap by evaluating the effect of five democracy indices on energy poverty indicators in developing countries, in line with theoretical arguments on the role of democracy in the provision of public goods and services.

b. The link between governance and energy poverty

Like democracy, governance also influences the distribution and allocation of public goods and services. In this regard, three trends: first, studies showing that governance promotes access to energy services; second, studies showing that governance does not promote access to energy services; and finally, studies showing a non-significant link between governance and energy services.

According to Ahlborg et al. (2015), an effective and efficient governance system is important for promoting access to energy services (access to electricity, access to clean fuels, and electricity consumption). This argument is supported by the capacity of an effective governance system to develop and implement energy policies appropriate to a country (Acheampong, 2023; Acheampong et al., 2022; Ahlborg et al., 2015). Given that public policies are results-based (Acemoglu et al., 2003), a weak governance system characterized by high levels of corruption, an inadequate regulatory and judicial framework, political instability, and a lack of accountability and transparency among leaders in the management of public assets can render energy policies ineffective and hinder any efforts to accelerate access to energy services (Agence, 2014).

To improve access to clean and modern energy, a stable economic and political environment is needed to encourage private sector investment in clean cooking solutions and off-grid technologies. Therefore, a governance system that enforces contracts and protects property rights could increase investment in energy solutions to improve energy access, particularly in rural and remote communities (Acheampong, 2023).

Empirical studies have shown that governance plays a significant role in improving access to energy services (access to electricity and access to clean fuels and cooking technologies). This is confirmed by the studies of Ahlborg et al. (2015), who examined the link between institutional quality and energy poverty. More specifically, they investigated the link between the rule of law and corruption control on per capita electricity consumption in sub-Saharan Africa. The results of their study show that good governance promotes access to energy services and, consequently, reduces energy poverty in sub-Saharan Africa. Similarly, Trotter (2016) demonstrated in his study that government efficiency increases access to rural electricity in sub-Saharan Africa. This finding was corroborated by the study of Best and Burke (2017), which showed that government efficiency improves electricity capacity and quality.

Boräng et al. (2016) also showed that the fight against corruption has a negative effect on household electricity consumption in a sample of 34 small developing states. Using a sample of 43 sub-Saharan African countries (SSA), Acheampong et al. (2023) showed that governance variables promote access to electricity. Sarkodie and Adams (2020) examined the effect of governance on electrification in SSA. The results of their study show that governance promotes access to electricity in SSA. Regarding access to clean fuels and cooking technologies, Acheampong et al. (2023), using static econometric techniques, show that governance promotes the adoption of clean fuels and cooking technologies in SSA. In contrast to previous studies, another analysis of the link between governance and access to fuels, conducted by Acheampong et al., (2023), based on the dynamic method, showed that governance reduces the level of access to clean fuels and cooking technologies in SSA.

The uniqueness, novelty and contributions of this study are : firstly, unlike the studies by Ahlborg et al. (2015), which assessed the effect of the fight against corruption and the rule of law on access to rural electricity in SSA, the study by Trotter (2016), which focused solely on the effect of government effectiveness on access to electricity in rural areas of SSA, and Acheampong et al. (2023), which examined the effect of democracy and governance on access to electricity and clean fuels in rural areas of Latin America and the Caribbean, this study provides new knowledge by using the five (05) indices of democracy (Electoral, Liberal, Participatory, Deliberative and Egalitarian Democracy Index) developed by Coppedge et al. (2011, 2018) in order to assess their respective effect on the three indicators of energy poverty reduction (Access to electricity, Access to fuels and clean technologies for cooking, Electricity consumption in kWh per capita) in developing countries, unlike previous studies (Ahlborg et al., 2015; Trotter, 2016), which used the Freedom House/Polity IV indicator to measure democracy, despite these measures being criticized in the literature for their aggregation, accuracy, coding, coverage, validity and reliability (Coppedge et al., 2011).

In order to contribute to the existing literature and differentiate our study from previous ones, and given that good governance is a complex and multidimensional concept, we examine the role of these indicators (Corruption Control, Government Effectiveness, Political Stability, Regulatory Quality, Rule of Law, and Voice and Accountability) in the relationship between democracy and energy poverty reduction in developing countries. To our knowledge, this is the very first study to address the issue of the role of governance in the relationship between democracy and energy poverty in developing countries, as previous empirical studies have only analyzed the effect of governance and democracy on rural electrification in sub-Saharan Africa (Ahlborg et al., 2015 and Trotter, 2016) and in Latin America and the Caribbean (Acheampong, 2023; Acheampong et al., 2023).

3. Data and methodology

a. Data

In this study, we will analyze the effect of democracy on energy poverty in a sample of 48 developing countries from 2006 to 2023 across four different regions: Africa, Asia, Europe, and Latin America (see Table A1 in the appendix). The study period and sample size are primarily determined by data availability. Data on energy poverty are extracted from the World Bank database (WDI, 2023). Indicators of democracy are extracted from the Variety of Democracy

(V-Dem) database. Control variables are also drawn from the World Bank database (WDI, 2023).

b. Methodology

To construct a composite index of energy poverty and democracy, this study will use Principal Component Analysis (PCA), developed by Pearson (1901) and modified by Hotelling (1933). PCA is a simple, non-parametric method for extracting data from large datasets and effectively reduces multicollinearity in models. This method is known for its usefulness in exploring the internal correlation of variables and reducing the required data by calculating principal components. To this end, our study will perform PCA to calculate the components of several indicators (five (5) indicators of democracy and three (3) indicators of energy poverty), following the work of Agradi (2023). This approach transforms several variables into a single uncorrelated variable, which is the linear combination of the original variables, and the resulting variable is a weighted index that possesses all the properties of the original variables (Khan et al., 2020). Based on three (03) independent indicators of energy poverty (Access to electricity, Access to fuels and clean technologies for cooking, Electricity consumption in kWh per capita) and five (05) indicators of democracy (Index of electoral, liberal, participatory, deliberative and egalitarian democracy) to develop a composite index of energy poverty and democracy.

i. The dependent variable

Numerous previous studies have used several indicators to measure energy poverty in the existing literature. These measures are not only at the microeconomic level but also at the macroeconomic level. Generally, energy poverty is measured by indicators such as access to electricity and access to clean fuels and cooking technologies. These main indicators are commonly used in the literature to assess energy poverty at the national and international levels (Apergis et al., 2022; Banerjee et al., 2021; Nguyen and Nasir, 2021; Nkoa et al., 2023). In our study, we will use three (3) indicators to measure energy poverty, unlike previous studies that were limited to the approach of access to energy services. First, we will consider the proportion of the total population with access to electricity; an increase in this indicator leads to a reduction in energy poverty. Second, we will use the indicator of access to clean fuels and cooking technologies by the total population. Finally, there is the indicator of electricity consumption in kWh per capita. This approach makes it possible not only to measure the level of access to energy services but also the level of actual use by households, thus providing a more accurate picture of energy poverty.

In addition to using two approaches (access-based and effective-use-based) to energy poverty in this study, it will also assess the effect of the Energy Poverty Reduction Index (EPI) on democracy. Regarding the measurement of energy poverty, this study combines several energy poverty indicators from the literature and created a composite index to indicate energy poverty, called the "Energy Poverty Reduction Index (EPI)," which includes access to electricity, access to fuels, and energy consumption in kWh per capita, according to (Apergis et al., 2022; Sule et al., 2022). Data for the relevant variables are from the World Bank's online database (WDI, 2023).

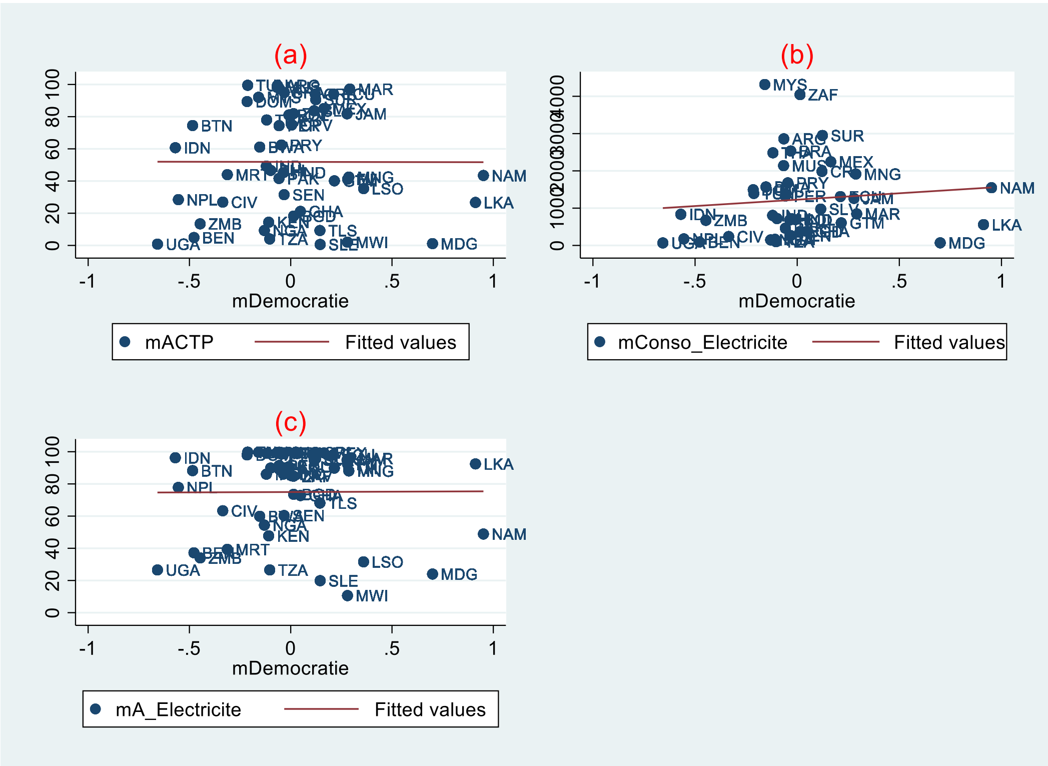
ii. The independent variable

Regarding the independent variable, this study will use the various high-level democracy indices (electoral, liberal, participatory, deliberative, and egalitarian democracy indices) developed by Coppedge et al. (2011) to better capture the multidimensionality of democracy, going beyond simple free and fair elections. The variables in these indices are expressed in their standard normal units, ranging from 0 to 1; higher values correspond to better outcomes. The data related to these indices are extracted from the Variety of Democracy (V-Dem) database.

iii. The control variables

In this study, we will select our control variables based on existing literature explaining the most recent determinants of poverty (Apergis et al., 2022; Zhang et al., 2019; Kotera and Okada, 2017; Nguea et al., 2022; Acheampong et al., 2021, 2022, 2023). In our baseline model, we will use five control variables: economic growth, in accordance with the studies by Zhang et al. (2019), Acheampong et al. (2023), and Amang et al. (2025). We predict a positive effect of economic growth on energy poverty; and public spending, following the work of Kotera and Okada (2017), Acheampong et al. (2023), and Amang et al. (2025). Increased public spending, when poorly managed, can increase the level of corruption. Conversely, if public spending is well managed and directed towards financing major development projects, we anticipate a positive effect of public spending on energy poverty. Financial development, for which Nguyen and Su (2021) and Acheampong et al. (2022) show that increased financial development leads to access to electricity, is also expected to have a positive sign. Foreign Direct Investment (FDI), according to studies by Kotera and Okada (2017) and Nguea et al. (2022), can improve access to energy services and consequently reduce energy poverty, thus also indicating a positive sign. Population density, according to the study by D'Amelio et al., is also a factor. (2016), population density can have a positive effect on access to electricity.

Figure 1 : Correlation between democracy and energy poverty indicators in developing countries



Source: authors

Figure 1 above illustrates my correlation between democracy and energy poverty indicators in developing countries. It shows an overall negative relationship between the level of democracy and energy poverty. In other words, countries with higher democratic scores tend to have lower levels of energy poverty, as measured by access to electricity (A_Electricity), per capita electricity consumption (Conso_Electricité), and the share of the population with access to clean cooking technologies (ACTP).

This trend shows that democratic regimes favor the implementation of more inclusive energy policies, enabling a better distribution of infrastructure and broader access to basic energy services. The mechanisms of transparency and political accountability inherent in democratic systems can incentivize leaders to invest more in essential public services, particularly the energy sector, to meet citizens' needs and improve their well-being.

Furthermore, the dispersion of points observed in the figure indicates that there is some heterogeneity between countries. This is reflected in the fact that countries may have a similar level of democracy, but some achieve higher energy performance than others. This variability can be explained by structural factors such as income level, quality of governance, institutional capacity, or regional differences in the availability of energy resources.

4. Methodology

This study applies the econometric approaches best suited to the data of the current study, with a large N and a small T. After specifying the model of our study, we will start by testing the cross-sectional dependence and the homogeneity of slopes, then we will perform a unit root analysis and cointegration tests before estimating the long-term parameters and causal dimensions of the modeled variables.

a. Specification of the econometric model of our study

Our objective is to assess the effect of democracy on energy poverty in developing countries. Given that the level of democracy can affect the level of energy poverty, as justified in the empirical literature, we opt for the linear model in accordance with recent studies by : Alhborg et al. (2015), Trotter (2016), Acheampong et al. (2021), Acheampong (2023), Acheampong et al. (2023).

$$PE_{i,t} = \beta_0 + \beta_1 Demo_{i,t} + \beta_2 EVC_{i,t} + \varepsilon_{i,t} \quad (1)$$ With i = 1.... 49 and t = 2006 ... 2023

In detail, our model will have the following models:

Model 1 : Estimates the effect of democracy on access to clean cooking fuels and technologies

$$Accès\_Combustible_{i,t} = \beta_0 + \beta_1 Demo_{i,t} + \beta_2 PIB_{i,t} + \beta_3 DP_{i,t} + \beta_4 OUV_{i,t} + \beta_5 Educ_{i,t} + \beta_6 Urb_{i,t} + \beta_7 Créd_{i,t} + \varepsilon_{i,t} \quad (2)$$

Model 2 : Estimates the effect of democracy on access to electricity :

$$Accès\_Électricité_{i,t} = \beta_0 + \beta_1 Demo_{i,t} + \beta_2 PIB_{i,t} + \beta_3 DP_{i,t} + \beta_4 OUV_{i,t} + \beta_5 Educ_{i,t} + \beta_6 Urb_{i,t} + \beta_7 Créd_{i,t} + \varepsilon_{i,t} \quad (3)$$

Model 3 : Estimates the effect of democracy on electricity consumption :

$$Con\_Electricité_{i,t} = \beta_0 + \beta_1 Demo_{i,t} + \beta_2 PIB_{i,t} + \beta_3 DP_{i,t} + \beta_4 OUV_{i,t} + \beta_5 Educ_{i,t} + \beta_6 Urb_{i,t} + \beta_7 Créd_{i,t} + \varepsilon_{i,t} \quad (4)$$

b. Estimation method

To address potential endogeneity issues between democracy indices and energy poverty indicators, this study employs two-stage least squares (2SLS) analysis. Democracy can be endogenous due to reverse causality, as improved access to electricity, modern energy services, and per capita electricity consumption can strengthen political participation, government accountability, and democratic consolidation. Furthermore, this study also utilizes the heteroscedasticity-based instrumentation method proposed by Lewbel (2012) (see Table A3 in the appendix), which, like the previous method, helps resolve endogeneity problems when appropriate external instruments are unavailable or insufficient to identify structural parameters in regression models of endogenous or poorly measured regressors (Lewbel, 2012). Next, this method generates its internal instruments based on heteroscedasticity from the residuals of the auxiliary equation, which is multiplied by each of the included exogenous variables in mean-centered form as an endogeneity correction instrument (Lewbel, 2012). Finally, this method does not rely on adherence to standard exclusion restrictions (Lewbel, 2012). The application of this estimation method to address the endogeneity problem is consistent with previous literature (Acheampong et al., 2021; 2023; Mishra and Smyth, 2015).

c. Preliminary analyses and tests

An examination of Table 1 shows that the average rate of access to clean cooking technologies (CCT) is 51.89%, with a relatively large dispersion (standard deviation of 33.75), reflecting significant inequalities among developing countries in access to fuels and clean cooking technologies. The average rate of access to electricity (A_Electricity) is 74.96%, indicating that although progress has been made, a significant portion of the population remains excluded from basic energy services. Per capita electricity consumption averages 1224 kWh, but its very high standard deviation (1081) highlights the significant heterogeneity among countries based on their level of economic development and energy infrastructure.

Table 1 : Descriptive statistics of the variables

Variable	Obs	Mean	Std. Dev.	Min	Max
ACTP	864	51,894	33,756	.3	99.9
Electricity	864	74,966	28.083	3.7	100
Electricity Consumption	720	1224.471	1081.236	33.062	5111.968
Polyarchy	864	.159	.205	-.309	1.206
Delibdem	864	.448	1.17	-2.249	5.217
Partipdem	864	.09	.132	-.339	.838
Libdem	864	.156	.155	-.489	.835
Egaldem	864	.459	1.271	-2.566	5.311
PIBh	864	2061291.5	7919591.1	464.667	74299839
Inflation	843	6.34	6.313	-16.86	59.12
Schooling	758	59,787	22,226	12.137	174,322
CPOP	864	1.556	.91	-2.8	3.567
Credit	432	71.048	50,973	-29,776	251.522
FBCF	828	24.186	15.67	-145,582	70.335
EFP	864	-.316	.529	-1.332	1.238
SP	864	-.304	.748	-2.81	1.265
QR	864	-.284	.479	-1.633	1.197
ED	864	-.367	.498	-1.472	1.024
VR	864	-.034	.495	-1.416	1.152
CC	864	-.371	.537	-1.443	1.618

Source : authors

In relation to institutional variables, the average score for electoral democracy (Polyarchy) is 0.159, while the other dimensions of democracy, such as deliberative, liberal, egalitarian, and participatory (Delibdem, Libdem, Egaldem, and Partidem), also show relatively low scores (0.448, 0.156, 0.459, and 0.09, respectively), reflecting a still fragile level of democracy in most of the countries in the sample. This reflects the political reality of developing countries, where democratic institutions often remain incomplete or unstable.

Economic variables also exhibit significant heterogeneity. Average GDP per capita (GDPh) is 2,061,291, with marked dispersion (standard deviation of 7,919,591), confirming the coexistence of low-income and emerging economies in our sample. The average inflation rate is 6.34%, while average school enrollment reaches nearly 60%, reflecting a moderate but improving level of education. Population growth (PCG) varies considerably between -2.8% and 3.56%, reflecting contrasting demographic trajectories. Finally, financial and investment variables indicate high variability : domestic credit represents on average 71% of GDP, and gross fixed capital formation (GFCF) approximately 24%, reflecting uneven economic dynamism across countries.

Overall, these descriptive statistics highlight the structural diversity of the countries studied, in economic, institutional, and energy terms. This heterogeneity justifies the use of econometric methods adapted to panel data, allowing for the control of country- and period-specific effects.

Table 2: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) IPE	1,000							
(2) Democracy	0.003 (0.946)	1,000						
(3) PIBh	0.091* (0.014)	-0.067 (0.051)	1,000					
(4) Inflation	-0.135* (0.000)	-0.002 (0.947)	-0.052 (0.133)	1,000				
(5) Schooling	0.598* (0.000)	-0.035 (0.341)	0.172* (0.000)	-0.058 (0.114)	1,000			
(6) CPOP	-0.712* (0.000)	-0.011 (0.749)	-0.074* (0.029)	0.141* (0.000)	-0.531* (0.000)	1,000		
(7) Credit	0.503* (0.000)	-0.045 (0.355)	-0.098* (0.041)	-0.323* (0.000)	0.224* (0.000)	-0.573* (0.000)	1,000	
(8) FBCF	-0.223* (0.000)	-0.010 (0.784)	0.064 (0.066)	-0.406* (0.000)	-0.075* (0.041)	0.073* (0.035)	-0.074 (0.132)	1,000
***p<0.01, **p<0.05, *p<0.1								

Source : authors

To examine the nature and direction of the relationships between the different variables in the study, the table below presents the correlation coefficients between the Energy Poverty Index (EPI), democracy, and economic and institutional variables. This exploratory step allows us to identify potential relationships between the variables, while also highlighting the potential presence of multicollinearity before econometric estimations.

Analysis of Table 2 above shows, firstly, that the correlation between democracy and the energy poverty reduction index (r=0.003) is positive but very weak and not significant. This suggests that, at first glance, the relationship between these two variables is not immediately apparent in the raw data. However, this descriptive result does not rule out the possibility of a causal effect, which may be masked by other economic or institutional factors and will be verified through subsequent econometric estimations.

In contrast, several control variables showed statistically significant correlations with the Energy Poverty Reduction Index (EPI). For example, GDP per capita (r=0.091, p<0.05) was positively correlated with energy poverty reduction. This indicates that a higher level of economic development is associated with better access to energy. Conversely, inflation (r=-0.135, p<0.01) was negatively correlated with the Energy Poverty Reduction Index (EPI). This suggests that macroeconomic instability tends to exacerbate energy poverty.

The school enrollment rate shows a strong positive correlation with the energy poverty reduction index (r=0.091, p<0.01), reflecting the key role of education in the dissemination of modern energy technologies and in households' ability to adopt clean energy solutions. Population growth (CPOP) shows a high negative correlation (r=-0.712, p<0.01), confirming that rapid population growth puts negative pressure on existing energy infrastructure.

Furthermore, domestic credit (r=0.503, p<0.01) is positively associated with the energy poverty reduction index. This indicates that the development of the financial sector promotes investment in energy access. Gross fixed capital formation (GFCF), on the other hand, shows a moderate negative correlation (r=-0.223, p<0.01), which may reflect the fact that overall investment is not systematically directed towards the energy sector.

In summary, the observed correlations are economically consistent and do not indicate excessive multicollinearity between the explanatory variables. These preliminary results justify further econometric estimations to determine the nature and strength of the causal effect of democracy on energy poverty.

Before proceeding with the econometric estimation itself, it is important to ensure the statistical reliability of the data used. Diagnostic tests allow us to verify the main assumptions of panel data regression models, including the absence of autocorrelation of errors, homoscedasticity of variances, and non-multicollinearity between explanatory variables. Furthermore, stationarity tests allow us to determine the degree of integration of the series and avoid spurious regressions.

- **Wooldridge's autocorrelation test**

Wooldridge test for autocorrelation in panel data H0:

no first order autocorrelation

F (1, 17) = 27.983 Prob > F = 0.0001

The Wooldridge test applied to the panel data rejects the null hypothesis of the absence of first-order autocorrelation (F (1,17) = 27.983; p-value = 0.0001). This result indicates the presence of autocorrelation in the errors, meaning that the disturbances are not independent over time. To correct for this problem, subsequent estimates were performed using robust standard deviations (corrected for autocorrelation and heteroscedasticity) and estimation methods such as generalized methods of squares (GMS) and the two-squaring method (2SLS).

- **The Breusch-Pagan heteroscedasticity test**

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity Ho: Constant variance

Variables: fitted values of IPE

chi2(1) = 0.06

Prob > chi2 = 0.8027

The Breusch-Pagan test ($\chi^2 = 0.06$; p = 0.8027) does not allow us to reject the null hypothesis of homoscedasticity. We can therefore conclude that there is no heteroscedasticity in the data. However, to ensure the robustness of the estimates, robust White standard deviations were also used in the regressions to neutralize any residual effect of variance heterogeneity.

Table 3: The multicollinearity test

Variables	LIVELY	1/VIF
CPOP	1.445	.692
Inflation	1.307	.765
lnCredit	1.265	.791
FBCF	1.144	.874
lnPIBh	1.089	.918
Schooling	1.053	.95
Democracy	1.043	.959
Mean VIF	1.192	.

Source : authors

Table 3 presents the results of the multicollinearity test between the explanatory variables. The variance factor analysis (VFI) shows that all the values obtained are less than 5, with a mean of 1.192. These results indicate the absence of multicollinearity among the explanatory variables. In other words, the variables included in the model are not strongly correlated with each other, which ensures the stability and reliability of the estimated coefficients.

- **First and second generation tests were used to verify the stationarity of the series.**

The Maddala and Wu (1999) test, which assumes independence between cross-sections, shows that most variables, including democracy, inflation, schooling and Gross Fixed Capital Formation, are stationary at the 5% level (p<0.05), while other variables such as the Energy Poverty Reduction Index (EPI) and GDP per capita (GDPh) exhibit characteristics close to first-order integration (I (1)) depending on the number of lags retained.

The Pesaran test (2007), which takes into account the dependence between sections, generally confirms these results : the Zt statistics associated with democracy (-7.845; p = 0.000) and inflation (-4.875; p = 0.000) are significant, indicating the stationarity of these variables, while some such as the energy poverty reduction index (EPI) may be weakly non-stationary in the absence of a trend but become stationary when a trend is introduced.

These findings show that the variables are mostly stationary or integrated of order one, which justifies the use of dynamic models on panel data such as the generalized methods of moments (GCM and 2SLS), capable of correcting the endogeneity problem and dealing with time dependence.

5. Results

a. Main results : Two-Stage Least Squares (2SLS) method

The estimates obtained using the Two-Stage Least Squares method aim to identify the causal effect of democracy on energy poverty by addressing the problem of the potential endogeneity of democracy. The three specifications considered use the following as dependent variables, respectively : the logarithm of the proportion of the population with access to clean cooking technologies (ln_ACTP), the logarithm of per capita electricity consumption (lnConso_Électricité), and the logarithm of access to electricity (lnA_Électricité).

The logarithm of the proportion of the population with access to clean cooking technologies (ln_ACTP) shows that the coefficient associated with the democracy index is 0.3213 (significant at the 5% level, adjusted standard deviation of 0.1332). This result indicates that every one-unit increase in the democracy index leads to a 0.32-unit increase in the level of access to clean cooking fuels and technologies, all other things being equal. This result indicates a substantial economic effect : the improvement in the level of democracy is accompanied by a significant increase in household ownership of clean cooking technologies, reducing energy poverty at home.

The logarithm of electricity consumption per capita (lnConso_Électricité) has a democracy coefficient of 0.3260 (significant at the 5% level and a standard deviation of 0.1321). This means that every one-unit increase in the democracy index leads to a 0.32-unit increase in the level of electricity consumption in kWh per capita. This suggests that democracy not only promotes access to energy but also intensifies its use, likely through more extensive infrastructure and greater household purchasing power.

The logarithm of access to electricity (lnA_Electricity) shows that the associated coefficient is positive but not significant (0.0367). Here, the effect on the general electricity access indicator is not statistically distinct from zero at conventional levels : the effect of democracy on aggregate electricity coverage is less clear than on consumption and/or access to clean cooking technologies.

Table 4 : Main results of the effect of democracy on energy poverty in developing countries

	(1)	(2)	(3)
	2SLS		
VARIABLES	ln_ACTP	lnConso_Electricite	lnA_Electricity
Democracy	0.3213**	0.3260**	0.0367
	(0.1332)	(0.1321)	(0.0360)
lnPIBh	-0.0644***	-0.0280	-0.0016
	(0.0246)	(0.0209)	(0.0070)
Inflation	-0.0153	0.0277	-0.0169**
	(0.0195)	(0.0169)	(0.0070)
Schooling	0.0068***	0.0128***	0.0007
	(0.0025)	(0.0026)	(0.0009)
CPOP	-0.7429***	-0.5106***	-0.2859***
	(0.0948)	(0.0872)	(0.0213)
lnCredit	0.1148	0.2044*	0.0611***
	(0.0737)	(0.1227)	(0.0201)
FBCF	0.0072*	-0.0060	-0.0013
	(0.0039)	(0.0084)	(0.0012)
Constant	4.6482***	6.3509***	4.6070***
	(0.4769)	(0.6589)	(0.1260)
Observations	320	288	320
R-squared	0.3527	0.1986	0.5764
Hansen (p)	0.391	0.412	0.927
Cragg-Donald Wald F statistic	7.455	8.177	7.455
Kleibergen-Paap rk Wald F statistic	6.785	6.961	6.785
Fisher	19.83***	19.35***	40.88***

** P<0.10; ** P < 0.05; *** P < 0.01.*

Source: author based on data from WDI and V-Dem using Stata software.

b. Analysis of the sensitivity of the results by decomposing the democracy index

In this subsection, we will test the sensitivity of the results by analyzing the effect of different dimensions of democracy on energy poverty. The results presented in Table 4 above generally converge on a central conclusion : democracy contributes significantly and robustly to reducing energy poverty, and this through several of its components. This section offers a detailed interpretation of the main constants.

Table 5: Disaggregated effect of democracy on energy poverty in Sustainable Development Countries

	(1)	(2)	(3)	(4)	(5)
2SLS					
VARIABLES	IPE	IPE	IPE	IPE	IPE
Partipdem	5.6287**				
	(2.3475)				
Polyarchy		2.9466***			
		(1.1237)			
Delibdem			-0.0170		
			(0.0222)		
Libdem				3.3176**	
				(1.4015)	
Egaldem					-0.0295
					(0.0200)
lnPIBh	0.0091	0.0024	-0.0077	0.0091	-0.0053
	(0.0222)	(0.0198)	(0.0171)	(0.0200)	(0.0173)
Inflation	-0.0034	-0.0049	-0.0159	-0.0078	-0.0166
	(0.0173)	(0.0154)	(0.0130)	(0.0141)	(0.0129)
Schooling	0.7200***	0.8004***	0.7622***	0.7754***	0.7665***
	(0.2209)	(0.2092)	(0.1724)	(0.1976)	(0.1708)
CPOP	-1.0344***	-1.0170***	-0.9970***	-1.0316***	-0.9929***
	(0.0716)	(0.0682)	(0.0574)	(0.0647)	(0.0573)
lnCredit	0.2907***	0.3137***	0.3212***	0.2932***	0.3179***
	(0.0856)	(0.0831)	(0.0668)	(0.0793)	(0.0660)
FBCF	-0.0231***	-0.0234***	-0.0210***	-0.0188**	-0.0211***
	(0.0085)	(0.0078)	(0.0058)	(0.0073)	(0.0058)
Constant	-2.2971**	-2.6198**	-1.9759**	-2.6790***	-2.0005**
	(1.1072)	(1.0630)	(0.8354)	(1.0348)	(0.8267)
Observations	288	288	288	288	288
R-squared	0.5059	0.6016	0.7567	0.6455	0.7573
Hansen(p)	0.943	0.312	0.606	0.242	0.804
Cragg-Donald Wald F statistic	4,576	7,552	4446	6,599	5093
Kleibergen-Paap rk Wald F statistic	4.779	5,792	10847	5.636	14480
Fisher	78.38***	93.56***	162.0***	108.9***	162.0***

. * P<0.10; ** P < 0.05; *** P < 0.01.

Source : authors

The results from the decomposition of the overall democracy index presented in Table 5 highlight that certain dimensions of democracy strongly influence energy poverty, while others appear less significant. Three dimensions stand out: Participatory democracy, Electoral democracy, and Liberal democracy.

These components exhibit positive and statistically significant coefficients, indicating that increased political participation, electoral competition, and the protection of civil liberties contribute to reducing energy poverty. These results can be explained by the fact that a more inclusive and transparent political climate improves the quality of public policies, strengthens the accountability of decision-makers, and limits predatory behaviors that undermine investments in the energy sector.

In contrast, the deliberative and egalitarian dimensions do not show a significant effect on energy poverty. This result may reflect the fact that these dimensions operate over longer time horizons or through more diffuse institutional channels, so the direct effect on energy performance is less immediately observable.

c. Analyzing the results according to a country's income level

The analysis by income level reveals significant heterogeneity in the effect of democracy. This effectis: Strong and significant in low-income countries; Weak and not significant in lower-middle-income countries; Not significant in upper-middle-income countries.

The results presented in the table highlight that democracy plays a particularly crucial role in the most vulnerable economies, where public institutions are fragile and access to energy is highly dependent on the quality of public policies. In more advanced countries, technical capacity, existing energy infrastructure, and the relative quality of institutions mitigate the marginal role of democracy in reducing energy poverty.

When indicators of specific institutional quality (political stability, regulatory quality, government effectiveness, rule of law, and control of corruption) are introduced into the models, the results show that democracy remains consistently significant in reducing energy poverty in developing countries over the period of our study. None of the added institutional quality variables become significant, suggesting a strong collinearity between these institutional dimensions and democracy itself. This result suggests that democracy has an all-encompassing effect, integrating several institutional components in its influence on energy performance. In other words, democracy appears to be a comprehensive institutional vector through which mechanisms such as transparency, political accountability, rent-seeking behavior, and good energy governance operate.

Table 6 : Analysis of results according to a country's income level

	(1)	(2)	(3)
	2SLS		
	Low-income countries	**Low-middle-income countries**	**High-middle-income countries**
VARIABLES	IPE	IPE	IPE
Democracy	0.0359***	0.0595	0.1661
	(0.0090)	(0.0563)	(0.1085)
lnPIBh	-0.4613***	-0.4045***	0.0490**
	(0.0683)	(0.0301)	(0.0198)
Inflation	-0.0011	-0.0036	-0.0003
	(0.0030)	(0.0079)	(0.0198)
Schooling	0.0749***	-0.0089***	0.0183***
	(0.0036)	(0.0014)	(0.0033)
CPOP	-0.1892***	-1.1343***	-0.5529***
	(0.0549)	(0.0896)	(0.0857)
lnCredit	-1.2418***	0.6358***	0.1736***
	(0.1960)	(0.1149)	(0.0620)
FBCF	0.0013	-0.0126***	-0.0335***
	(0.0041)	(0.0030)	(0.0105)
Constant	4.2540***	4.3773***	-0.3263
	(0.5480)	(0.7352)	(0.3630)
Observations	16	96	176
R-squared	0.9863	0.9825	0.4624
Hansen (p)	0.115	0.693	0.595
Cragg-Donald Wald F statistic	3.915	1,600	4.058
Kleibergen-Paap rk Wald F statistic	2.432	1.613	3.645
Fisher	306.2***	1080***	36.99***

* P<0.10; ** P < 0.05; *** P < 0.01.

Source : authors

6. Conclusion and recommendations for economic policies

This study examines the effect of democracy (electoral, liberal, participatory, deliberative, and egalitarian dimensions) on energy poverty in developing countries. The study employs the Two-Stage Least Squares (2SLS) method to correct for potential biases. The results show that democracy reduces energy poverty in developing countries between 2006 and 2023. In other words, improvements in democratic quality contribute significantly to access to clean fuels and cooking technologies, access to electricity, and increased per capita electricity consumption (kWh), with effects varying according to institutional dimensions. These results remained unchanged regardless of the estimation technique used, such as generalized least squares (GLS) and Discrall-Kraay (see Table A2 in the appendix).

The results suggest that developing countries should strengthen their democratic institutions to improve the effectiveness of energy policies, promote citizen participation in energy access projects, and reduce inequalities through targeted support mechanisms. Transparent and stable governance is also essential for attracting investment in the energy sector and addressing energy poverty.

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Appendices

Table A1 : List of countries

Argentina	Bangladesh	Benign	Bhutan
Bolivia	Botswana	Brazil	Cape Verde
Costa Rica	Ivory Coast	Dominican Republic	Ecuador
El Salvador	Fiji	Ghana	Guatemala
Honduras	India	Indonesia	Jamaica
Kenya	Lesotho	Madagascar	Malawi
Malaysia	Mauritania	Mauritius	Mexico
Mongolia	Morocco	Namibia	Nepal
Nigeria	Pakistan	Paraguay	Peru
Philippines	Senegal	Sierra Leone	South Africa
Sri Lanka	Suriname	Tanzania	Thailand
Timor-Leste	Tunisia	Uganda	Zambia

Source : authors

Table A2 : The effects of the democracy index on energy poverty in developing countries

	(1)	(2)	(3)	(4)	(5)	(6)
	MCG			Discrall-Kraay		
VARIABLES	ln_ACTP	lnConso_Electricite	A_Electricity	ln_ACTP	lnConso_Electricite	lnA_Electricity
Democracy	0.0545**	0.0547***	0.3207	0.0545***	0.0547*	0.0076
	(0.0241)	(0.0208)	(0.4114)	(0.0183)	(0.0266)	(0.0082)
lnPIBh	-0.0840***	-0.0491***	0.5150*	-0.0840***	-0.0491***	-0.0019
	(0.0177)	(0.0152)	(0.3015)	(0.0055)	(0.0070)	(0.0022)
Inflation	-0.0179	0.0156	-0.8335***	-0.0179	0.0156	-0.0158**
	(0.0142)	(0.0120)	(0.2419)	(0.0156)	(0.0148)	(0.0066)
Schooling	0.0057***	0.0124***	-0.0039	0.0057***	0.0124***	0.0006**
	(0.0021)	(0.0017)	(0.0351)	(0.0014)	(0.0021)	(0.0002)
CPOP	-0.7351***	-0.5442***	-17.0240***	-0.7351***	-0.5442***	-0.2926***
	(0.0566)	(0.0486)	(0.9644)	(0.0482)	(0.0383)	(0.0299)
lnCredit	0.1221**	0.1340***	3.9896***	0.1221***	0.1340	0.0831***
	(0.0479)	(0.0396)	(0.8157)	(0.0239)	(0.0829)	(0.0165)
FBCF	0.0065	-0.0017	-0.1222	0.0065**	-0.0017	-0.0013
	(0.0047)	(0.0064)	(0.0796)	(0.0026)	(0.0084)	(0.0008)
Constant	4.9061***	6.8770***	92.8791***	4.9061***	6.8770***	4.5170***
	(0.3489)	(0.3008)	(5.9456)	(0.2015)	(0.3128)	(0.0744)
Observations	360	324	360	360	324	360
R-squared				0.5094***	0.4993***	0.5842***
chi2	373.7	323.1	704.8			
Fisher				1451***	2506***	36.83***

Source : authors

Table A3 : Robustness of results when changing instrumentation method

	(1)	(2)	(3)	(4)
2SLS by Lewbel (2012)				
VARIABLES	ln_ACTP	lnConso_Electricite	lnA_Electricity	IPE
Democracy	0.2414**	0.2443**	0.0272	0.2676**
	(0.1132)	(0.1073)	(0.0294)	(0.1050)
lnPIBh	-0.0696***	-0.0340*	-0.0022	0.0076
	(0.0230)	(0.0173)	(0.0069)	(0.0173)
Inflation	-0.0165	0.0259*	-0.0170**	-0.0144
	(0.0192)	(0.0156)	(0.0071)	(0.0135)
Schooling	0.0066***	0.0127***	0.0006	0.0149***
	(0.0023)	(0.0024)	(0.0009)	(0.0024)
CPOP	-0.7383***	-0.5081***	-0.2854***	-0.9968***
	(0.0948)	(0.0851)	(0.0214)	(0.0612)
lnCredit	0.1218*	0.2131*	0.0619***	0.2816***
	(0.0698)	(0.1182)	(0.0206)	(0.0749)
FBCF	0.0067**	-0.0055	-0.0013	-0.0201***
	(0.0033)	(0.0077)	(0.0012)	(0.0072)
Constant	4.6935***	6.3794***	4.6123***	0.1676
	(0.4397)	(0.6325)	(0.1239)	(0.4711)
Observations	320	288	320	288
R-squared	0.4352	0.3474	0.5843	0.6903
Hansen (p)	0.703	0.822	0.268	0.822
Cragg-Donald Wald F statistic	2.965	2.686	2.965	2.686
Kleibergen-Paap rk Wald F statistic	2.328	2.378	2.328	2.378
Fisher	21.81***	23.22***	41.79***	127.9***

Source : authors