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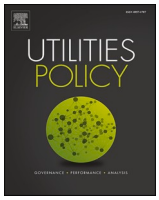

Full-length article

Promoting energy inclusiveness: Is rural energy poverty a political failure?

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ABSTRACT

We examine the impact of democracy and governance on rural electrification and rural access to clean fuels and technologies for cooking using comprehensive panel data of 34 countries from Latin America and the Caribbean between 2000 and 2020. Evidence from heteroskedasticity-based instrumental variable regression revealed that governance improves rural electrification and rural access to clean cooking fuels and technologies, while democracy of different forms limits rural electrification and rural access to clean cooking fuels and technologies. We suggest that better governance ensures justice in providing and allocating essential public services such as electricity and clean cooking solutions, not democracy.

1. Introduction

It is well-established in the literature that energy plays a significant role in driving economic growth and improving quality of life (Nguyen and Su, 2021; Oum, 2019; Pan et al., 2021). Therefore, the lack of or inability to access reliable, affordable, and adequate energy services, called energy poverty, may negatively impact people's daily life and economic growth, especially in rural areas where most inhabitants have inadequate access to clean and modern energy. Energy poverty is commonly seen as a huge challenge confronting almost all governments and countries worldwide (Rodriguez-Alvarez et al., 2021). Therefore, energy poverty reduction is vital to achieving sustainable development goals (SDGs). While energy poverty is believed to have harmful effects on various aspects of the economy and people's well-being, it is not unreasonable to expect these effects to be more pronounced in rural areas compared with urban areas, as the former may lack the necessary conditions to overcome challenges posed by energy poverty. In addition, the rural population has less access to energy relative to the urban population, thus worsening rural energy poverty. Globally, 97% of urban people have access to electricity in 2020 compared to 87% of the rural population over the same time (IEA, IRENA et al., 2020). In addition, 83% of the global urban population has access to clean cooking fuels, while only 34% of the global rural population has access to clean cooking fuels and technologies (Falchetta and Tagliapietra, 2022).

Can rural energy poverty be attributed to political failure? Electricity is sometimes regarded as a public good (Abbott, 2001; Ahlborg et al., 2015), but infrastructure services can also be understood as social goods based on public and private features (Beecher, 2021; Frischmann, 2009; Macário, 2014). Energy and other essential services are not always accessible or affordable (Macário, 2014). In addition, the provision of electricity poses the feature of a natural monopoly (Best and Burke, 2017). These suggest that the public sector's (government) involvement in producing and supplying electricity is fundamental to improving access to energy (Best and Burke, 2017). Ahlborg et al. (2015) argue that providing and extending the national grid to rural and distant communities is costly. This has made improvement in rural electrification possible through special national intervention programmes. Therefore, providing energy access to rural communities is politically driven,

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making the role of political institutions important. In the literature, the impact of political institutions such as governance and democracy in ensuring access to clean and modern energy (access to electricity and clean fuels and technologies for cooking) has been discussed (Acheampong, 2023; Acheampong et al., 2022; Ahlborg et al., 2015; Best and Burke, 2017; Rehman et al., 2012; Trotter, 2016).

The literature indicates that a better governance system that prioritizes the needs of the rural population would support rural electrification projects and programs that enhance rural access to clean cooking fuels and technologies (Best and Burke, 2017; Bhattacharyya, 2012). Additionally, better governance can help overcome poor organizational structures and corrupt activities that impede access to energy by the rural population (Acheampong et al., 2022a,b; Ahlborg et al., 2015; Ahlborg & Hammar, 2014). Likewise, democracy is argued to support rural access to energy since democratic governments support the provision of public services and want to fulfil the electorate's expectations to re-seek election (Ahlborg et al., 2015; Best and Burke, 2017; Trotter, 2016).

Although the role of political institutions in the provision of energy, in general, has been acknowledged in the empirical literature, limited empirical studies have primarily examined either the effect of governance or democracy on per capita household electricity consumption and rural electrification and these studies are primarily concentrated on sub-Saharan Africa (SSA) (see, for instance, Ahlborg et al., 2015; Ahlborg & Hammar, 2014; Trotter, 2016). In addition, a critical review of the existing studies revealed the impact of governance and democratic institutions on rural access to clean fuels and technologies for cooking had not been investigated. However, an empirical understanding of the role of governance and democracy in rural access to clean cooking fuels and technologies would help policymakers to design the appropriate intervention to scale the adoption of the technologies. Additionally, none of the empirical studies has either examined the effect of governance or democracy on rural energy poverty reduction in Latin America and the Caribbean region despite its political history and the massive inequality that exists between rural and urban access to electricity and clean cooking fuels and technologies (see Fig. 1) in the region. If any, studies on energy poverty in Latin America and the Caribbean only pay attention to the country level (Mohsin et al., 2022) or the urban areas (World Energy Council, 2006), ignoring rural areas where energy poverty is severe. These knowledge gaps motivate this study. This study, therefore, contributes to the literature by examining the impact of political institutions variables on rural electrification and rural access to clean cooking fuel and technologies using a panel of 34 countries from Latin America and the Caribbean region from 2000 to 2020. Specifically, this study seeks to answer the following research questions:

1. Does governance increase or limit rural electrification and rural access to clean cooking fuels and technologies?
2. What role does democracy play in rural electrification and rural access to clean cooking fuels and technologies?

This study is motivated to focus on Latin America and the Caribbean region for the following reasons. The region has distinct political institutions and history, providing a natural experiment for studying the impact of political variables on energy poverty reduction. First, countries in this region share political similarities (most of them going from military dictatorship in the early 1800s to democratic governments in the 1930s (Lowy et al., 1985). However, on the other hand, they have employed different approaches to dealing with economic problems. While some countries prefer the liberalization approach (which gives rise to private entities), others emphasize populist policies, leading to nationalizing some key areas, such as the energy/electricity sector (Bushnell et al., 2023). Also, from the 1800s till the early 1980s, most Latin American countries experienced wars/conflicts (civil and inter-state alike) and were even ruled by military dictatorships (the presence of praetorianism) intermittently, especially after World War II. However, since the late 1990s, all these countries have put in place their democracies with leaders of the countries elected through elections, thus improving governance quality in these countries (Lowy et al., 1985).

Nonetheless, there appears to be a lack of stability in these Latin American countries (Bolle, 2022a, 2022b), with major countries experiencing political turmoil since the 2000s, with left-wing political parties rising to power in the early 2000s (the Pink tide). However, the influence of these populist leaders appears to fade away and has been replaced by right-wing political leaders (the Conservative wave) since the mid-2010s. Furthermore, corruption seems to be an endemic problem in Latin America, with leaders from major economies being convicted. The prevalence of corruption, in turn, makes ordinary citizens feel discontented as economic gains are not distributed equally among people and political systems are rigged to serve the privileged few (Financial Times, 2022). Also, according to the Financial Times (2022), despite being well-positioned to reap huge benefits from abundant fuel, food, renewable energy, and material resources, Latin America and the Caribbean may need comprehensive structural reforms to improve their

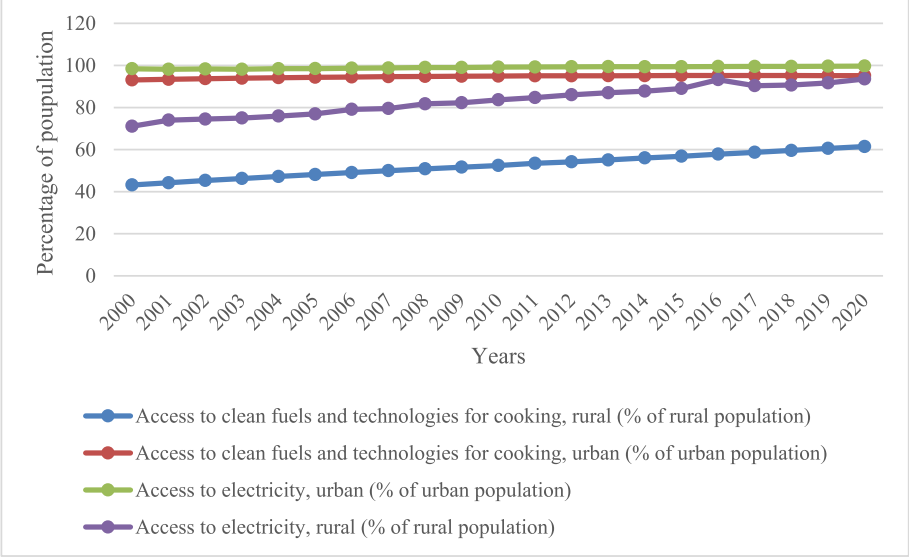

Fig. 1. Trends of rural and urban energy access in Latin America and the Caribbean.

governance quality and democratic practices.

Besides the nature of the region's political institutions, Latin America and the Caribbean show contrasting performances in electrification and access to clean cooking fuels and technologies. While these countries have made significant progress in their electrification process (with more than 98% of the population having access to electricity), access to clean cooking fuels and technologies is a different story. According to a joint report by the WB, World Bank, the International Energy Agency, the International Renewable Energy Agency, the United Nations, and the World Health Organization (2022 Tracking SDG7 The energy progress report 2022), progress in boosting access to clean cooking fuels and technologies remain stagnated in Latin American and the Caribbean countries with the access rate to clean fuels and technologies still fluctuating around 85%–91% of their population with a meagre increase of 0.1%–0.3%.

Despite the significant progress in improving access to electricity and clean fuels, and technologies for cooking at the national level, there is a disparity in rural and urban access to energy. As presented in Fig. 1, the number of urban populations with access to electricity and clean fuels and technologies outweighs the number of rural population with access to electricity and clean fuels and technologies. The Agenda 2030 makes it a priority for countries not to leave anyone behind. To meet their energy needs, policymakers should prioritize investment and support in vulnerable communities such as rural areas (UN, 2021). In other words, increasing the pace of rural electrification and rural access to clean cooking solutions could contribute significantly to rural energy poverty alleviation and play a decisive role in rural economic development and sustainable development (Obermaier et al., 2012; Riva et al., 2018).

This study's uniqueness, novelty, and contributions are discussed as follows: First, unlike Trotter (2016), who considered only government effectiveness in rural electrification in and Ahlborg et al. (2015), who examined the effect of control of corruption and rule of law on rural electrification in SSA, this study provides new knowledge by using six (6) comprehensive indicators of governance quality— Voice and accountability; political stability and absence of violence/terrorism; government effectiveness; regulatory quality; rule of law; and control of corruption to examine their respective effect on rural electrification and rural access to clean cooking fuels and technologies in Latin America and the Caribbean region. Given that what constitutes good governance is complex and multidimensional, using these multiple indicators would provide a comprehensive understanding of governances' role in eradicating rural energy poverty.

Second, we differentiate our study from the previous studies by using five (5) newly developed indicators of democracy to examine their effect on rural energy poverty reduction. Previous studies such as Ahlborg et al. (2015) and Trotter (2016) used the Freedom House/Polity IV to investigate the impact of rural electrification. However, these democracy measures have been criticized for their aggregation, precision, coding, coverage, validity, and reliability (Coppedge et al., 2011). Additionally, Coppedge et al. (2011) argue that the Polity, Freedom House, and their counterparts are overstretched and are inadequate for measuring small changes and differences in the quality of democracy. In addition, democracy is a multidimensional concept; however, the Freedom House/Polity score Freedom House democracy and their counterparts only conceived democracy as an electoral process while neglecting other important facets of democracy (Coppedge et al., 2011). To contribute and distinguish our study from the prior literature, five high-level democracy indices, namely, participatory, egalitarian, deliberative, liberal, and electoral democracies, developed by (Coppedge et al., 2011, 2018), are used in this study.[1] These high-level democracy indices consider the complexity and multidimensionality of democracy and provide a broad-based approach to measure what democracy is rather than the narrow definition of democracy as a "free and fair election."

Third, to the best of the authors' knowledge, this is the first-ever study to provide empirical evidence on the impact of governance and democracy on rural access to clean cooking fuels and technologies in addition to rural electrification focusing on Latin America and the Caribbean region. As indicated earlier, the prior empirical studies only examined the effect of governance and democracy on rural electrification in SSA (see, for instance, Ahlborg et al., 2015; Ahlborg & Hammar, 2014; Trotter, 2016). In addition, some emerging empirical studies have examined the impact of governance on clean cooking fuels and technologies in SSA (Acheampong, 2023; Acheampong et al., 2023) but did not consider rural access to clean cooking fuels and technologies in their analysis.

Finally, our study is timely and policy-relevant since it aligns with the Agenda 2030 call for countries to prioritize not leaving anyone behind in having access to clean and modern energy. In addition, by shedding light on the impact of political institutions on rural energy poverty reduction, the econometric results from this study would contribute to well-informing decision-making concerning policies and strategies for enhancing energy inclusiveness in the region.

The remainder of the paper is structured as follows: Section 2 reviews related studies in the literature; Section 3 discusses model specification, estimation methods, and data description; Section 4 presents econometric results; Section 5 focuses on the discussion of the results and Section 6 concludes and provides policy recommendations/ implications.

2. Review of related literature and hypothesis development

This study draws on the neo-institutional economic theory to examine the linkage between political institutions and rural energy poverty reduction. The neo-institutional economics theory defines institutions as formal and informal rules that shape human interactions (North, 1989, 2008; North et al., 2000). This indicates that institutions shape a countries' development trajectories and policy outcomes. Acemoglu et al. (2003) found that policy outcomes reflect institutions such that bad outcomes would be symptoms of weak institutions and vice versa. Political institutions are relevant to this study since decisions to provide and extend energy infrastructure to rural and distant communities are determined by policies and politics. For instance, Acemoglu et al. (2005) assert that political institutions allocate de jure political power and shape economic institutions that distribute resources. The literature has documented that political institutions play a significant role in providing public services and economic growth (Acemoglu and Johnson, 2005; Acemoglu et al., 2002, 2005; Acemoglu et al., 2008; Olken, 2010; Zhang et al., 2004).

In the proceeding sub-sections, we discuss the relationship between political institutions (democracy and governance) and rural energy poverty reduction (rural electrification and rural access to clean cooking fuels and technologies) and generate the hypotheses tested in this study.

2.1. Democracy and rural energy poverty reduction

The debate of whether democratic or autocratic governments do a better job of providing public services and these services always occupies a central place in the political science and economics literature (Ahlborg et al., 2015). The provision and allocation of public services heavily depend on a country's political apparatus (Deacon, 2003). In a democratic society, political leaders are elected and replaced by elections and, therefore, can be held responsible, accountable, and even liable to ordinary people for their acts (Winslow, 2005). Thus, political leaders are usually incentivized to fulfil voters' expectations and satisfy people's basic needs, especially demands for public services such as

[1] See Appendix Table 2 on what constitute each of the democracy variables. Also, for detailed discussion on participatory, egalitarian, deliberative, liberal, and electoral democracies from V-DEM kindly see (Coppedge et al., 2011; Coppedge et al., 2018).

electricity (Acemoglu and Robinson, 2006; Ahlborg et al., 2015; Schmitter and Karl, 1991). Comparatively, Deacon (2003) showed that democratic governments provide public services far above autocratic governments. As a result, it is natural to expect electrification to be guaranteed in democratic societies (Ahlborg et al., 2015; Lake and Baum, 2001; McGuire and Olson, 1996). From the environmental politics perspective, countries' democratic institutions play a significant role in environmental performance. For instance, Sinha et al. (2023) showed that democratic countries have lower per-capita carbon emissions than autocratic countries. Contrarily, Acheampong et al. (2022a. 2022b), using different democracy variables such as liberal, electoral, participatory, deliberative and egalitarian democracies, indicated these forms of democracy increase environmental degradation. The lessons from the environmental politics literature can also be extended to understand the political economy of energy poverty.

While democracy ensures the provision of public services, it also affects their allocation and distribution. Similarly, Acemoglu et al. (2015) argue that democracy can drive even distribution of resources and bridge inequality; however, when democracy favours and caters to the elite and opens up disequalizing opportunities, it can lead to uneven distribution of resources and widens inequality. From this argument, we argue that democracy could lead to uneven distribution and access to clean and modern energy between rural and urban areas. Naturally, the urban population is elite with more political power than rural populations.

Given the political power of urban elites and the fact that the median voter decides the outcome of political elections, governments in democratic societies tend to gravitate toward and over-concentrate public services in urban areas at the expense of rural areas in other to seek re-election (Acheampong et al., 2022a,b; Lipton, 1977). Urban elites have the political power to lobby and attract more energy infrastructure facilities and services than the rural population, making urban areas have higher access to energy than the rural population. In other words, the less political influence of the rural population in determining electoral outcomes and in influencing decisions regarding the allocation of public services in democratic countries makes them have poor access to energy infrastructure and service, thereby rendering them energy-poor. The implication is that by favouring urban areas, democracy renders rural areas energy-poor.

Empirically, Ahlborg et al. (2015), using 44 SSA countries, documented that democracy, measured with Freedom House/Polity IV, increases per capita household electricity consumption. Similarly, using Polity IV, Trotter (2016) showed that democracy increases rural electrification in SSA. Kroth et al. (2016) also confirm that democracy in the form of enfranchisement is associated with an increase in electrification in South Africa. Further, Min (2008), applying satellite data, showed that democracy increases electrification. Boräng et al. (2021) supported Min's (2008) findings by indicating that democracy expands electrification, especially in countries with lower corruptive practices. In another study, Boräng et al. (2016) found that democracy increases per capita household electricity consumption in 34 small island developing states, especially when corruption is low. Contrary to Ahlborg et al. (2015), Best and Burke (2017), using Polity2, found that democracy significantly negatively affects per capita electricity consumption and quality. Also, Aklin et al. (2018) found that democracy has no significant effect on total electrification while significantly reducing rural electrification.

From the literature review, there is a limited study on the effect of democracy on rural electrification. In addition, none of the empirical studies considers the effect of democracy on rural access to clean cooking fuels and technologies. We differentiate and close the existing knowledge gaps by investigating the effect of five high-level democracy indices, namely, participatory, egalitarian, deliberative, liberal, and electoral democracies, on rural electrification and rural access to clean cooking technologies in Latin America and the Caribbean. Following the theoretical argument on democracy and the distribution of public services, we test the hypothesis formulated below:

Hypothesis 1. Institutionalized democracy negatively impacts rural electrification and rural access to clean cooking fuels and technologies.

2.2. Governance and rural energy poverty reduction

An effective and well-functioning governance system is essential for enhancing access to energy (Ahlborg et al., 2015). Like democracy, governance also determines the provision and allocation of public services. Therefore, good governance could enhance electrification and access to clean cooking technologies through the design and implementation of energy policies (Acheampong, 2023; Acheampong et al., 2022a,b; Ahlborg et al., 2015). Since policies are outcome institutions (Acemoglu et al., 2003), weak governance in the inform of corruption, inadequate regulatory and legal framework, political instability, poor accountability, and transparency could render energy policies ineffective and impede any efforts to accelerate access to electricity and clean cooking technologies (Agency, 2014). Also, weak governance could misappropriate financial resources for investing in electrification and clean cooking technologies. Global Alliance for Clean Cookstove (2011) indicates that a governance system that promotes effective coordination among actors such as governments, cooking technologies manufacturers, consumers, and non-governmental organizations could provide opportunities to achieve the economies of scale associated with the production of clean cooking technologies. To improve access to clean and modern energy, a stable economic and political environment is needed for the private sector to invest in clean cooking solutions and off-grid technologies. Therefore, a governance system that enforces contracts and property rights protection could increase investment in energy solutions to enhance energy access, especially in rural and distant communities (Acheampong, 2023).

Empirical studies have shown that governance plays a significant role in electrification and access to clean cooking fuels and technologies. Regarding electrification, Ahlborg et al. (2015), for instance, showed that institutional quality, an average of the rule of law and control of corruption, increases per capita household electricity consumption in SSA while political stability reduces it. Also, Trotter (2016) showed that government effectiveness is associated with increased rural electrification in SSA. Best and Burke (2017) confirmed Trotter's (2016) findings by showing that government effectiveness is positively related to electricity capacity per capita, household per capita electricity consumption, final consumption of per capita electricity, and electricity quality while having a negative relationship with access to electricity and electricity transmission and distribution loss in low and middle-income countries. Boräng et al. (2016) also showed that control of corruption has an insignificant negative relationship with household electricity consumption in 34 small island developing states. Using data from 43 SSA countries, Acheampong et al. (2022a,b) showed that governance variables have an insignificant effect on electrification. Sarkodie and Adams (2020) showed that governance has an insignificant effect on electrification in SSA. Regarding access to clean cooking fuels and technologies, Acheampong et al. (2023) used static econometric techniques and showed that governance increases the adoption of clean cooking fuels and technologies in SSA. Contrarily, Acheampong (2023), using a dynamic econometric method, showed that governance significantly reduces access to clean cooking fuels and technologies in SSA.

From the above discussions, limited studies exist on the effect of governance on rural electrification. At the same time, none of the empirical studies considers the effect of governance on rural access to clean cooking fuels and technologies. It is also apparent from the literature review that no empirical study has focused on Latin America and the Caribbean region regarding rural electrification and rural access to clean cooking fuels and technologies. We, therefore, contribute to the literature by investigating the effect of governance variables on rural electrification and rural access to clean cooking technologies in Latin

America and the Caribbean. Following the literature, we test the hypothesis formulated below:

Hypothesis 2. Governance has a positive relationship with rural electrification and rural access to clean cooking fuels and technologies.

3. Methods and data

3.1. Empirical model and estimation approach

Following Acheampong (2023), Ahlborg et al. (2015), and Trotter (2016), the empirical model for estimating the impact of political institutions variables (democracy and governance) on rural energy poverty reduction is given in equation (1):

$$lnrpov_{i,t} = \alpha_0 + \beta_1 Politics_{i,t} + \delta_j lnX_{i,t} + \varepsilon_{it} \quad (1)$$

where $lnrpov_{i,t}$ is the log of rural energy poverty reduction variables of country i at year t. $politics_{i,t}$ the political institutions' variables of country i at year t. $X_{i,t}$ is a set of control covariates included in the specification to avoid variable omission bias. $\varepsilon_{i,t}$ is the disturbance error term. α_0, β_1, and δ_j are the unknown coefficients to be estimated.

We modelled the above equation using the Lewbel (2012) two-stage least squares technique. The Lewbel (2012) estimator has numerous advantages. First, the Lewbel two-stage least squares technique, an instrumental variable estimator, can address the endogeneity problem. Thus, it can address identification problems, especially when appropriate external instruments are not available or weak for identifying structural parameters in the regression models with endogenous or mismeasured regressors (Lewbel, 2012). Second, the Lewbel two-stage least squares estimator generates its internal heteroskedasticity-based instruments from the residuals of the auxiliary equation, which is multiplied by each of the included exogenous variables in mean-centred form as an instrument for correcting endogeneity (Lewbel, 2012). Also, unlike the standard IV-techniques, the Lewbel two-stage least squares estimator technique does not rely on satisfying standard exclusion restrictions (Lewbel, 2012). The application of Lewbel's two-stage least squares estimator to address endogeneity concerns is consistent with previous literature (Acheampong et al., 2021; Mishra and Smyth, 2015). We also use the instrumental variable generalized method of moment approach of Lewbel's estimator to test for the robustness of Lewbel's two-stage least squares estimate.

3.2. Data

Based on data availability, this study samples a panel of 34 countries from Latin America and the Caribbean region to examine the effect of governance and democracy on rural energy poverty reduction from 2000 to 2020. The period starts from 2000 because the availability of energy poverty reduction variables (rural electrification and rural access to clean cooking fuels and technologies) starts from 2000. All the variables' proxies, sources, and descriptive statistics are presented in Table 1. Except for governance and democracy variables, the log-transformed values of the remaining variables were used for the modelling and to obtain meaningful coefficients.

For the dependent variable, rural electrification and rural access to clean technologies for cooking are used to measure rural energy poverty reduction. These variables measure the proportion of the rural population with access to electricity and clean fuels and technologies for cooking. An increase in rural electrification and rural access to clean technologies for cooking implies rural energy poverty reduction and vice versa. The rural energy poverty variable is sourced from World Development Indicators (WDI).

For the key independent variables, we used governance and democracy indicators to represent political institutions broadly. The governance indicators used for this study include rural law, control of corruption, government effectiveness, political stability, regulatory quality, the rule of law, and voice and accountability. These governance variables used in this study are in their standard normal units, ranging from approximately −2.5 to 2.5, with higher values corresponding to better outcomes (Kaufmann et al., 2011). The World Governance Indicators (WGI) served as the main sources of governance variables. Also, five (5) indices, including electoral, liberal, participatory, deliberative, and egalitarian democracies variables, are used in this study to capture the multidimensionality of what democracy is about. Appendix Table 2 provides a detailed definition of each of the governance and democracy variables. The democracy variables were retrieved from the Variety of Democracy (V-DEM) database.

Consistent with previous studies such as Acheampong et al. (2022a, b), Ahlborg et al. (2015), Trotter (2016), Onyeji (2010), and Acheampong (2023), GDP per capita, education, urbanization, government expenditure, foreign direct investment, access to credit, and domestic savings were included in the specification to prevent variable omission bias. All the control variables were retrieved from WDI.

Figs. 2-5 display the bivariate relationship between governance,

Table 1
Variables description, statistics, and sources.

Variable	Indicators	Mean	Std. Dev.	Min	Max	Sources
Rural access to clean cooking technologies	Access to clean fuels and technologies for cooking, rural (% of rural population)	3.937	0.990	−0.357	4.605	WDI
Rural electrification	Rural access to electricity (% of rural population)	4.376	0.525	0.789	4.605	
GDP per capita	GDP per capita (constant 2015 US$)	8.997	0.864	7.144	11.423	
Education	School enrollment, secondary (% gross)	4.461	0.216	3.414	4.956	
Urbanization	Urban population	14.094	2.553	9.578	19.036	
Government expenditure	General government final consumption expenditure (constant 2015 US$)	22.649	1.712	18.564	26.614	
Foreign direct investment	Foreign direct investment, net inflows (% of GDP)	1.426	1.181	−3.323	7.444	
Access to domestic credit	Domestic credit to private sector by banks (% of GDP)	3.607	0.566	1.987	4.561	
Domestic savings	Gross domestic savings (% of GDP)	2.681	0.895	−2.724	3.971	
Electoral democracy	Electoral democracy index	0.646	0.183	0.117	0.912	V-DEM
Liberal democracy	Liberal democracy index	0.483	0.208	0.057	0.861	
Participatory democracy	Participatory democracy index	0.426	0.147	0.093	0.776	
Deliberative democracy	Deliberative democracy index	0.499	0.203	0.032	0.868	
Egalitarian democracy	Egalitarian democracy index	0.434	0.190	0.085	0.828	
Control of corruption	Control of corruption index	0.053	0.801	−1.722	1.725	WGI
Government effectiveness	Government effectiveness index	0.030	0.715	−2.078	1.972	
Political stability	Political Stability and Absence of Violence index	0.128	0.746	−2.374	1.492	
Regulatory quality	Regulatory quality index	0.070	0.728	−2.363	1.539	
Rule of law	Rule of law index	−0.078	0.805	−2.346	1.555	
Voice and accountability	Voice and accountability index	0.349	0.669	−1.887	1.591	

Note: WDI: World Development Indicators; V-DEM: Variety of democracy database; WGI: World governance indicators.

Table 2
Governance and rural access to clean cooking technologies (Lewbel two-stages least squares estimate).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GDP per capita	−0.012	−0.413**	0.079	−0.020	−0.289	−0.122
	(0.157)	(0.208)	(0.135)	(0.236)	(0.201)	(0.154)
Education	0.543***	0.439**	0.607***	0.633***	0.461**	0.172
	(0.189)	(0.195)	(0.180)	(0.182)	(0.200)	(0.258)
Urbanization	−0.706***	−0.870***	−0.668***	−0.785***	−0.810***	−0.397***
	(0.176)	(0.201)	(0.173)	(0.242)	(0.197)	(0.147)
Government expenditure	0.687***	0.828***	0.650***	0.753***	0.797***	0.416***
	(0.185)	(0.210)	(0.177)	(0.239)	(0.206)	(0.154)
Foreign direct investment	−0.116**	−0.180***	−0.093**	−0.120*	−0.183***	−0.247***
	(0.047)	(0.058)	(0.046)	(0.071)	(0.063)	(0.071)
Access to domestic credit	0.043	−0.091	0.087	0.041	−0.086	−0.046
	(0.058)	(0.070)	(0.056)	(0.101)	(0.086)	(0.064)
Domestic savings	0.186***	0.205***	0.178***	0.183***	0.196***	0.181***
	(0.051)	(0.050)	(0.051)	(0.053)	(0.049)	(0.047)
Control of corruption	0.160**					
	(0.065)					
Government effectiveness		0.637***				
		(0.145)				
Political stability			0.063			
			(0.103)			
Regulatory quality				0.110		
				(0.170)		
Rule of law					0.464***	
					(0.150)	
Voice and accountability						1.073***
						(0.314)
Constant	−3.561***	0.321	−4.583***	−4.165***	−1.016	0.539
	(0.886)	(1.342)	(0.841)	(1.208)	(1.346)	(1.614)
Observations	278	278	278	278	278	278
R2	0.627	0.574	0.651	0.621	0.592	0.599
Cragg-Donald Wald F statistic	30.218	10.643	18.216	10.834	10.838	6.450

Heteroscedasticity robust standard errors in parentheses. The Cragg-Donald Wald F-statistics test for weak instrument identification. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

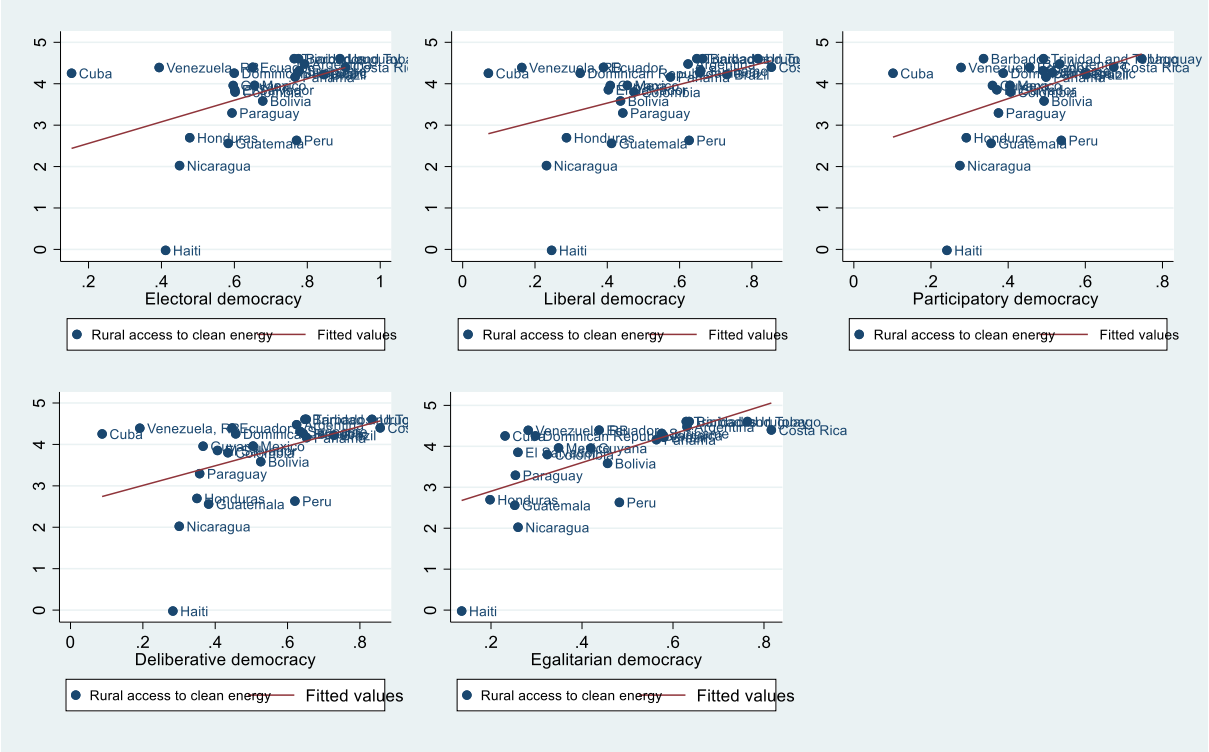

Fig. 2. Relationship between democracy variables and rural access to clean cooking fuels and technologies.

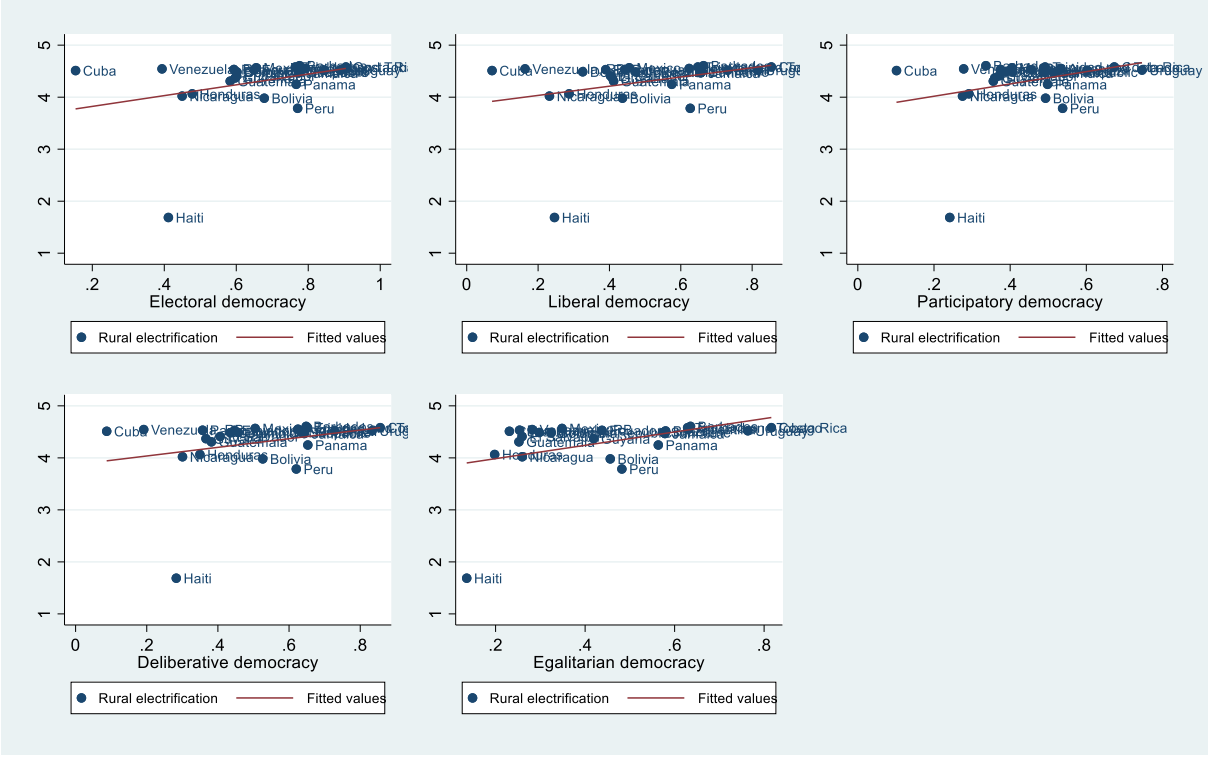

Fig. 3. Relationship between democracy variables and rural electrification.

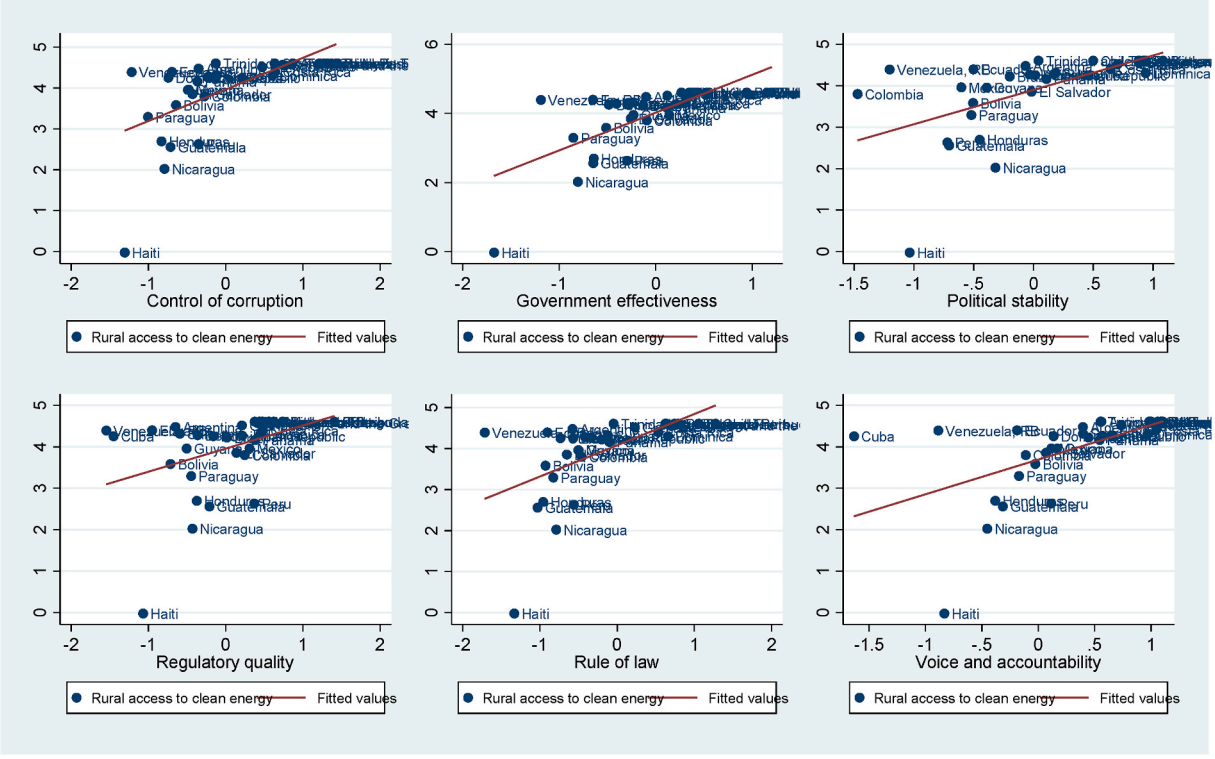

Fig. 4. Relationship between governance variables and rural access to clean cooking fuels and technologies.

democracy, and rural energy poverty reduction variables. Figs. 2 and 3 show that the democracy variables positively correlate with rural access to clean technologies for cooking and rural electrification, respectively. Similarly, Figs. 4 and 5 suggest that governance variables positively correlate with rural access to clean technologies for cooking and rural electrification, respectively. The bivariate correlation relationship among the variables provides some preliminary results; however, it is not robust or reliable to inform policy. We, therefore, modelled the impact of democracy, governance, and other control covariates on rural energy poverty reduction using robust and advanced econometric

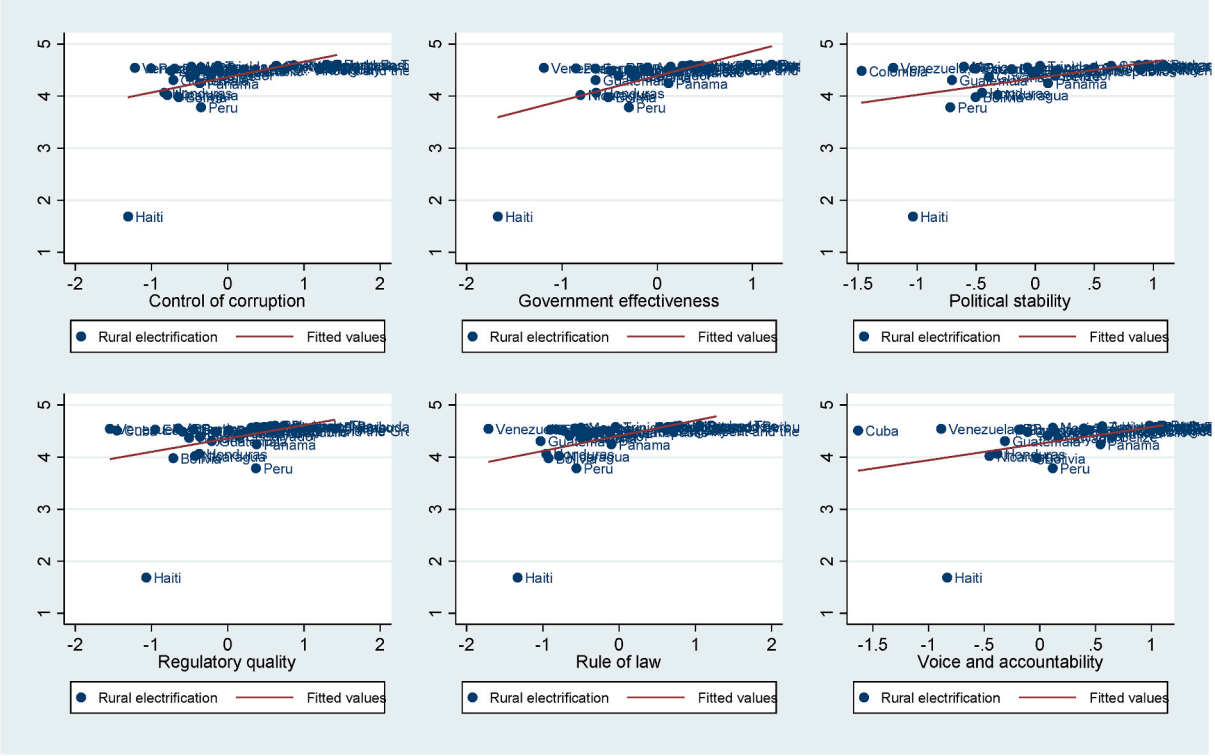

Fig. 5. Relationship between governance variables and rural electrification.

Table 3
Governance and rural electrification (Lewbel two-stages least squares estimate).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
GDP per capita	0.023	−0.170*	0.117*	−0.080	−0.042	−0.003
	(0.070)	(0.102)	(0.062)	(0.107)	(0.098)	(0.089)
Education	−0.119	−0.157	−0.039	−0.050	−0.112	−0.264*
	(0.082)	(0.097)	(0.077)	(0.083)	(0.091)	(0.153)
Urbanization	−0.272***	−0.354***	−0.291***	−0.399***	−0.303***	−0.122
	(0.087)	(0.101)	(0.089)	(0.122)	(0.095)	(0.086)
Government expenditure	0.294***	0.363***	0.300***	0.407***	0.324***	0.159*
	(0.092)	(0.106)	(0.091)	(0.123)	(0.100)	(0.088)
Foreign direct investment	−0.106***	−0.137***	−0.086***	−0.135***	−0.125***	−0.164***
	(0.019)	(0.024)	(0.019)	(0.029)	(0.027)	(0.043)
Access to domestic credit	−0.045	−0.108***	−0.002	−0.091**	−0.077**	−0.077**
	(0.031)	(0.037)	(0.027)	(0.044)	(0.032)	(0.034)
Domestic savings	−0.027	−0.021	−0.044**	−0.022	−0.033*	−0.037*
	(0.017)	(0.019)	(0.018)	(0.017)	(0.017)	(0.022)
Control of corruption	0.105***					
	(0.031)					
Government effectiveness		0.332***				
		(0.076)				
Political stability			−0.068			
			(0.050)			
Regulatory quality				0.165**		
				(0.067)		
Rule of law					0.170**	
					(0.069)	
Voice and accountability						0.500**
						(0.209)
Constant	2.636***	4.473***	1.470***	2.818***	3.159***	4.267***
	(0.393)	(0.687)	(0.348)	(0.483)	(0.599)	(1.091)
Observations	277	277	277	277	277	277
R2	0.349	0.225	0.393	0.312	0.331	0.202
Cragg-Donald Wald F statistic	29.284	10.038	17.031	12.283	11.616	6.146

Heteroscedasticity robust standard errors in parentheses. The Cragg-Donald Wald F-statistics test for weak instrument identification * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

techniques. The results from the econometric analytical methods are presented and discussed in the proceeding sections.

4. Empirical findings

In this section, we present and discuss the findings from the econometric analysis. We interpret the coefficients of governance and democracy variables using their standardized coefficients. The standardized coefficients are used because the governance and democracy variables are indexes, and their coefficients cannot be interpreted in percentages.

4.1. Governance and rural energy poverty reduction

The results on the impact of governance variables on rural access to clean cooking fuels and technologies and rural electrification are presented in Tables 2 and 3, respectively. From Table 2, the estimates show that political stability and regulatory quality have an insignificant positive effect on rural access to clean cooking fuels and technologies. However, it is observed from Table 2 that control of corruption, government effectiveness, rule of law, and voice and accountability have a significant positive effect on rural access to clean cooking fuels and technologies. The estimates suggest that a 1 standard deviation increases control of corruption, government effectiveness, rule of law, and voice, and accountability increases rural access to clean cooking fuels and technologies by 0.129, 0.460, 0.377, and 0.725 standard deviations, respectively.

GDP per capita, as a measure of economic growth, has a negative effect on rural access to clean cooking fuels and technologies but is only significant in Model 2. Education, a proxy of human capital, has a statistically significant positive effect on rural access to clean cooking fuels and technologies. The estimated coefficient on education shows that rural access to clean cooking fuels and technologies would increase between 0.439% and 0.633% when there is a 1% improvement in education. Urbanization is observed to have a statistically significant negative effect on rural access to clean cooking fuels and technologies. The estimated elasticity shows that a 1% increase in urbanization reduces rural access to clean cooking fuels and technologies between 0.397% and 0.870%. The estimated coefficients on government expenditure are positive and statistically significant at 1%. Thus, a 1% increase in government spending is associated with a 0.416%–0.828% increase in rural access to clean cooking fuels and technologies. Foreign direct investment has a statistically significant negative effect on rural access to clean cooking fuels and technologies. The estimated elasticity shows that a 1% increase in foreign direct investment inflows reduces rural access to clean cooking fuels and technologies between 0.093% and 0.247%. As a proxy of financial development, access to credit has an insignificant effect on rural access to clean cooking fuels and technologies. The estimated coefficients on domestic savings are positive and statistically significant at 1%. Thus, a 1% increase in domestic savings is associated with a 0.181%–0.205% increase in rural access to clean cooking fuels and technologies.

From Table 3, the estimates show that political stability has an insignificant positive effect on rural electrification. However, other governance variables such as that control of corruption, government effectiveness, regulatory quality, rule of law, and voice and accountability have a significant positive effect on rural electrification. The estimates suggest that one standard deviation (SD) increase in control of corruption, government effectiveness, the rule of law, and voice and accountability increases rural electrification by 0.160, 0.452, 0.236, 0.261, and 0.637 SD, respectively. For the control variables, GDP per capita has a non-robust effect on rural electrification. Education negatively affects rural electrification but is only significant in Model 6. Urbanization is observed to have a statistically significant negative effect on rural electrification. The estimated elasticity shows that a 1% increase in urbanization reduces rural electrification between 0.397% and 0.870%. The estimated coefficients on government expenditure are positive and statistically significant at 1%. Thus, a 1% increase in government spending is associated with a 0.159%–0.407% increase in rural electrification. Foreign direct investment has a statistically significant negative effect on rural electrification. The estimated elasticity shows that a 1% increase in foreign direct investment inflows reduces rural electrification between 0.106% and 0.137%. Access to credit significantly negatively affects rural access to clean cooking fuels and technologies. Also, domestic savings has a significant negative impact on rural electrification.

4.2. Democracy and rural energy poverty reduction

The results on the impact of democracy variables on rural access to clean cooking fuels and technologies and rural electrification are presented in Tables 4 and 5, respectively. From Table 4, the estimates show that participatory and egalitarian democracy has an insignificant effect on rural access to clean cooking fuels and technologies. However, other democracy indices such as electoral, liberal, and deliberative democracy significantly negatively affect rural access to clean cooking fuels and technologies. The estimates suggest that electoral, liberal, and deliberative democracy reduces rural access to clean cooking fuels and technologies by 0.727, 0.617, and 0.385 standard deviations, respectively. Consistently education, domestic savings, and government expenditure have a statistically significant positive effect on rural access to clean cooking fuels and technologies. Also, urbanization and foreign direct investment consistently negatively affect rural access to clean cooking fuels and technologies. Other variables, such as GDP per capita and access to credit, have an insignificant effect on rural access to clean cooking fuels and technologies.

In Table 5, the estimates show that participatory and egalitarian democracy have an insignificant positive effect on rural electrification. However, electoral, liberal, and deliberative democracy have significant positive and negative effects on rural electrification. The estimates show that rural electrification declines by 0.926, 0.613, and 0.380 standard deviations when estimates suggest that a 1 standard deviation increase in electoral, liberal, and deliberative democracy reduces, respectively. From Table 5, government expenditure consistently has a statistically significant positive effect on rural electrification. Urbanization and foreign direct investment consistently have statistically significant negative effects on rural electrification. Other variables, such as GDP per capita, education, access to credit, and domestic savings, have an insignificant effect on rural electrification.

4.3. Robustness check

In this section, we conduct robustness using the instrumental variable generalized method of moment approach of Lewbel's technique. These robustness check results are consistent with the previous Lewbel two-stages least squares results. The results on the impact of governance variables on rural access to clean cooking fuels and technologies and rural electrification are presented in Table 6, while results for the impact of democracy variables on rural access to clean cooking fuels and technologies and rural electrification are presented in Table 7.

Evidence from Models 1–6 of Table 6 shows that political stability and regulatory quality have an insignificant positive effect on rural access to clean cooking fuels and technologies; however, control of corruption, government effectiveness, rule of law, and voice and accountability have a significant positive effect on rural access to clean cooking fuels and technologies. The estimated coefficients show that rural access to clean cooking fuels and technologies rises by 0.222, 0.414, 0.407, and 0.427 standard deviations when control of corruption, government effectiveness, rule of law, and voice and accountability rise. Also, in Models 7–12, the estimates show that political stability has a significant negative effect on rural electrification, while control of corruption, government effectiveness, regulatory quality, rule of law, and

Table 4
Democracy and rural access to clean cooking technologies (Lewbel two-stages least squares estimate).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
GDP per capita	0.065	−0.016	0.169	0.137	0.437*
	(0.197)	(0.198)	(0.310)	(0.182)	(0.237)
Education	0.726***	0.684***	0.737*	0.698***	0.377
	(0.216)	(0.219)	(0.379)	(0.213)	(0.304)
Urbanization	−1.362***	−1.485***	−0.999*	−1.112***	−0.514
	(0.278)	(0.314)	(0.522)	(0.257)	(0.422)
Government expenditure	1.315***	1.457***	0.947*	1.057***	0.472
	(0.273)	(0.300)	(0.499)	(0.248)	(0.394)
Foreign direct investment	−0.027	−0.012	−0.098	−0.022	−0.143**
	(0.060)	(0.054)	(0.067)	(0.062)	(0.063)
Access to domestic credit	0.053	0.065	0.089	0.061	0.087
	(0.063)	(0.060)	(0.055)	(0.058)	(0.069)
Domestic savings	0.277***	0.223***	0.233**	0.217***	0.147**
	(0.083)	(0.059)	(0.098)	(0.063)	(0.067)
Electoral democracy	−3.932***				
	(1.174)				
Liberal democracy		−2.936***			
		(0.642)			
Participatory democracy			−2.393		
			(2.407)		
Deliberative democracy				−1.876***	
				(0.587)	
Egalitarian democracy					0.280
					(1.011)
Constant	−6.726***	−8.235***	−6.512***	−6.841***	−5.046***
	(0.857)	(0.956)	(1.356)	(0.887)	(1.200)
Observations	239	239	239	239	239
R2	0.595	0.686	0.623	0.659	0.638
Cragg-Donald Wald F statistic	8.770	10.444	5.412	8.504	3.279

Heteroscedasticity robust standard errors in parentheses. The Cragg-Donald Wald F-statistics test for weak instrument identification. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 5
Democracy and rural electrification (Lewbel two-stages least squares estimate).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
GDP per capita	0.016	0.020	0.160	0.102	0.111
	(0.094)	(0.095)	(0.103)	(0.078)	(0.141)
Education	0.070	0.005	−0.023	0.012	0.038
	(0.108)	(0.106)	(0.125)	(0.081)	(0.178)
Urbanization	−0.723***	−0.678***	−0.349**	−0.480***	−0.479*
	(0.151)	(0.164)	(0.170)	(0.130)	(0.287)
Government expenditure	0.732***	0.696***	0.355**	0.484***	0.466*
	(0.148)	(0.161)	(0.164)	(0.127)	(0.265)
Foreign direct investment	−0.043*	−0.051**	−0.103***	−0.057***	−0.092***
	(0.024)	(0.026)	(0.023)	(0.020)	(0.030)
Access to domestic credit	−0.038	−0.028	−0.018	−0.030	−0.046
	(0.035)	(0.037)	(0.030)	(0.030)	(0.040)
Domestic savings	0.028	−0.018	−0.027	−0.021	−0.029
	(0.031)	(0.021)	(0.025)	(0.018)	(0.025)
Electoral democracy	−2.653***				
	(0.654)				
Liberal democracy		−1.547***			
		(0.361)			
Participatory democracy			−0.803		
			(0.685)		
Deliberative democracy				−0.981***	
				(0.291)	
Egalitarian democracy					−0.697
					(0.652)
Constant	0.558	−0.032	1.103**	0.709**	0.790
	(0.390)	(0.491)	(0.433)	(0.351)	(0.721)
Observations	239	239	239	239	239
R2	0.399	0.415	0.455	0.523	0.514
Cragg-Donald Wald F statistic	8.770	10.444	5.412	8.504	3.279

Heteroscedasticity robust standard errors in parentheses. The Cragg-Donald Wald F-statistics test for weak instrument identification * $p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

voice and accountability have a significant positive effect on rural electrification. Thus, political stability reduces rural electrification by 0.149 standard deviations, while rural electrification by 0.212, 0.373, 0.216, 0.342, and 0.546 SD, respectively, when control of corruption, government effectiveness, regulatory quality, rule of law, and voice and accountability increase.

Table 6
Governance and rural energy poverty reduction (Lewbel two-step GMM estimates).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
	Rural access to clean fuels and technologies for cooking						Rural electrification					
GDP per capita	−0.122	−0.297	0.135	−0.065	−0.350*	0.020	0.043	−0.116	0.154***	−0.021	−0.101	−0.031
	(0.124)	(0.197)	(0.111)	(0.194)	(0.188)	(0.141)	(0.063)	(0.093)	(0.051)	(0.086)	(0.073)	(0.075)
Education	0.487***	0.542***	0.766***	0.935***	0.461**	0.562**	−0.059	−0.113	0.059	0.051	−0.065	−0.129
	(0.171)	(0.187)	(0.155)	(0.164)	(0.196)	(0.233)	(0.071)	(0.085)	(0.062)	(0.071)	(0.072)	(0.126)
Urbanization	−0.712***	−0.779***	−0.634***	−0.708***	−0.878***	−0.319**	−0.162**	−0.282***	−0.210***	−0.265***	−0.264***	−0.072
	(0.142)	(0.195)	(0.145)	(0.205)	(0.192)	(0.131)	(0.065)	(0.086)	(0.064)	(0.089)	(0.072)	(0.085)
Government expenditure	0.694***	0.732***	0.594***	0.637***	0.850***	0.322**	0.178***	0.290***	0.209***	0.264***	0.284***	0.108
	(0.150)	(0.203)	(0.147)	(0.207)	(0.200)	(0.140)	(0.069)	(0.091)	(0.065)	(0.090)	(0.076)	(0.087)
Foreign direct investment	−0.113**	−0.202***	−0.058	−0.182***	−0.217***	−0.114*	−0.116***	−0.141***	−0.063***	−0.150***	−0.148***	−0.128***
	(0.045)	(0.053)	(0.044)	(0.063)	(0.056)	(0.060)	(0.018)	(0.023)	(0.017)	(0.024)	(0.021)	(0.035)
Access to domestic credit	−0.024	−0.030	0.087	−0.052	−0.162**	−0.016	−0.072***	−0.065**	−0.016	−0.080**	−0.072***	−0.076**
	(0.053)	(0.066)	(0.053)	(0.068)	(0.077)	(0.060)	(0.026)	(0.033)	(0.024)	(0.035)	(0.028)	(0.032)
Domestic savings	0.231***	0.198***	0.164***	0.213***	0.212***	0.133***	−0.007	−0.011	−0.030*	−0.011	−0.021	−0.020
	(0.047)	(0.049)	(0.049)	(0.047)	(0.047)	(0.046)	(0.016)	(0.019)	(0.018)	(0.016)	(0.017)	(0.021)
Control of corruption	0.274***						0.139***					
	(0.055)						(0.023)					
Government effectiveness		0.574***						0.274***				
		(0.132)						(0.071)				
Political stability			−0.050						−0.105**			
			(0.092)						(0.049)			
Regulatory quality				0.199						0.156***		
				(0.128)						(0.052)		
Rule of law					0.501***						0.223***	
					(0.116)						(0.047)	
Voice and accountability						0.632**						0.428**
						(0.245)						(0.167)
Constant	−2.269***	−0.549	−5.030***	−3.290***	−0.332	−1.497	3.196***	4.187***	1.522***	3.001***	3.806***	4.255***
	(0.765)	(1.274)	(0.785)	(0.896)	(1.184)	(1.363)	(0.326)	(0.667)	(0.335)	(0.420)	(0.468)	(0.917)
Observations	278	278	278	278	278	278	277	277	277	277	277	277
R2	0.603	0.585	0.636	0.582	0.579	0.628	0.301	0.261	0.363	0.291	0.277	0.213
Cragg-Donald Wald F statistic	30.218	10.643	18.216	10.834	10.838	6.450	29.284	10.038	17.031	12.283	11.616	6.146

Heteroscedasticity robust standard errors in parentheses. The Cragg-Donald Wald F-statistics test for weak instrument identification * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7
Democracy and rural energy poverty reduction (Lewbel two-step GMM estimates).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
	Rural access to clean fuels and technologies for cooking					Rural electrification				
GDP per capita	−0.069	−0.210	−0.088	0.137	0.389**	0.048	0.035	0.155*	0.149**	0.145
	(0.183)	(0.159)	(0.233)	(0.165)	(0.196)	(0.090)	(0.085)	(0.082)	(0.065)	(0.101)
Education	0.566***	0.633***	0.995***	0.386**	0.532*	0.092	0.063	0.121	0.037	0.082
	(0.198)	(0.199)	(0.241)	(0.183)	(0.278)	(0.095)	(0.099)	(0.089)	(0.069)	(0.110)
Urbanization	−1.410***	−1.839***	−1.400***	−0.972***	−0.306	−0.628***	−0.610***	−0.287**	−0.279***	−0.281
	(0.248)	(0.216)	(0.353)	(0.201)	(0.368)	(0.141)	(0.142)	(0.125)	(0.098)	(0.199)
Government expenditure	1.360***	1.790***	1.321***	0.924***	0.293	0.627***	0.614***	0.288**	0.282***	0.276
	(0.251)	(0.215)	(0.347)	(0.204)	(0.341)	(0.139)	(0.141)	(0.123)	(0.097)	(0.187)
Foreign direct investment	0.012	0.003	−0.030	−0.050	−0.150**	−0.037*	−0.029	−0.066***	−0.053***	−0.071***
	(0.057)	(0.045)	(0.055)	(0.056)	(0.059)	(0.023)	(0.024)	(0.019)	(0.019)	(0.021)
Access to domestic credit	0.026	0.006	0.057	0.025	0.118*	−0.070**	−0.056*	−0.037	−0.059**	−0.064**
	(0.058)	(0.054)	(0.053)	(0.053)	(0.063)	(0.032)	(0.033)	(0.027)	(0.027)	(0.032)
Domestic savings	0.258***	0.254***	0.297***	0.243***	0.144***	0.015	−0.011	−0.008	−0.038**	−0.030
	(0.079)	(0.057)	(0.088)	(0.061)	(0.053)	(0.026)	(0.020)	(0.022)	(0.017)	(0.020)
Electoral democracy	−3.018***					−2.179***				
	(1.134)					(0.528)				
Liberal democracy		−3.272***					−1.363***			
		(0.524)					(0.319)			
Participatory democracy			−3.781**					−1.099**		
			(1.696)					(0.508)		
Deliberative democracy				−0.917*					−0.331	
				(0.492)					(0.214)	
Egalitarian democracy					0.852					−0.350
					(0.929)					(0.426)
Constant	−5.660***	−8.040***	−7.104***	−5.076***	−4.881***	0.905***	0.362	1.205***	1.434***	1.435***
	(0.837)	(0.874)	(0.979)	(0.781)	(1.122)	(0.331)	(0.429)	(0.345)	(0.294)	(0.500)
Observations	239	239	239	239	239	239	239	239	239	239
R2	0.632	0.661	0.551	0.665	0.605	0.458	0.433	0.427	0.457	0.453
Cragg-Donald Wald F statistic	8.770	10.444	5.412	8.504	3.279	8.770	10.444	5.412	8.504	3.279

Heteroscedasticity robust standard errors in parentheses. The Cragg-Donald Wald F-statistics test for weak instrument identification * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

As displayed in Table 7, Models 1–5 show that electoral, liberal, participatory, and deliberative democracy have a significant negative effect on rural access to clean cooking fuels, while egalitarian democracy has an insignificant. The estimated coefficients suggest that rural access to clean cooking fuels and technologies decreases by 0.558, 0.687, 0.560, and 0.1881 standard deviations, respectively, when electoral, liberal, participatory, and deliberative democracies rise. Also, in Models 6–10, electoral, liberal, and deliberative democracy have a significant negative effect on rural electrification, while participatory and egalitarian democracy have an insignificant negative effect on rural electrification. From the estimated coefficients, rural electrification declines by 0.760, 0.540, and 0.307 standard deviations when electoral, liberal, and deliberative democracies increase.

Tables 6 and 7 show that education, domestic savings, and government expenditure consistently have a statistically significant positive effect on rural access to clean cooking fuels and technologies. Also, urbanization and foreign direct investment consistently negatively affect rural access to clean cooking fuels and technologies. Other variables, such as GDP per capita and access to credit, have an insignificant effect on rural access to clean cooking fuels and technologies. For rural electrification models [see Models 7–12 in Table 6 and Models 6–10 in Table 7], it is observed that government expenditure consistently has a statistically significant positive effect on rural electrification. Urbanization and foreign direct investment consistently have a statistically significant negative effect on rural electrification. Other variables, such as GDP per capita, education and access to credit, and domestic savings, have an insignificant effect on rural electrification.

5. Discussion

This study determines whether political factors such as democracy and governance contribute to rural energy poverty reduction in Latin America and the Caribbean. This study addresses two key research and policy questions: (1) *Does democracy contribute to rural electrification and rural access to clean cooking fuels and technologies*? (2) *Does governance contribute to rural electrification and rural access to clean cooking fuels and technologies*? In answering these important questions, we deployed the heteroskedasticity-based instrumental variable, capable of handling endogeneity, as our analytical tool. Generally, the findings show that governance and democracy uniquely affect rural energy poverty alleviation. These findings and their policy implications are discussed as follows:

First, the findings reveal that, generally, governance contributes to rural energy poverty reduction. Control of corruption, government effectiveness, the rule of law, regulatory quality, and voice and accountability were positively related to rural electrification and rural access to clean cooking fuels and technologies. This indicates that a better governance system is essential in the fight against rural energy poverty. Better governance systems devoid of corruption, better regulation, enforcement of the rule of law, political leaders being accountable, and press freedom to contribute significantly to a fair share of the national cake. Thus, with a better governance system, political leaders overlook their parochial political and selfish interests and make decisions that benefit the society's marginalized population. Our findings lend support to previous evidence that: institutional quality, an average of the rule of law and control of corruption, increases per capita household electricity consumption in SSA (Ahlborg et al., 2015); governance expands access to clean cooking fuels and technologies in SSA (Acheampong et al., 2023) and electrification in low and middle-income countries (Best and Burke, 2017). On the other hand, our results contradict previous results that: political stability is inversely related to per capita household electricity consumption in SSA (Ahlborg et al., 2015), governance plays an insignificant role in electrification in SSA (Acheampong et al., 2022a,b), and governance reduces clean cooking fuels and technologies in SSA (Acheampong, 2023).

Second, this study shows that, generally, democracy is associated with rural energy poverty. Participatory, deliberative, liberal, and electoral democracies were found to increase rural energy poverty by

reducing rural electrification and rural access to clean cooking fuels and technologies. This finding essentially confirms the urban bias theory conjecture that in democratic countries, the rural population benefits less from allocating public services, including energy infrastructure and services (Acheampong et al., 2022a,b; Lipton, 1977). It is widely acknowledged that in a democratic regime, political leaders provide public services that benefit electorates because they intend to seek re-election (Harding and Stasavage, 2014; Trotter, 2016). However, in democratic regimes, political leaders always have a large share of their electoral votes from urban electorates relative to rural electorates. Based on this power-centred rule, the urban population decides who wins a political election and, therefore, plays a significant role in allocating public services. On the contrary, given the less influence of the rural population in determining electoral outcomes in democratic countries, they play a negligible role in influencing decisions regarding resource allocations and, therefore, are always at a disadvantage when political leaders decide where to concentrate public services, including electricity and clean technologies for cooking. Our result differs from Ahlborg et al. (2015) and Trotter (2016), who found that democracy improves rural electrification in SSA.

Apart from the political economy variables, other socio-economic variables were found to play a significant role in rural energy poverty reduction. For instance, education contributed significantly to rural energy poverty alleviation by increasing rural electrification and rural access to clean cooking fuels and technologies. The implication is that education is vital for providing access to reliable electricity as well as modern and clean cooking technologies since it provides the needed skills or the human capital for the operation and management of energy infrastructure and related technologies (Shi et al., 2016; Zhang et al., 2019). In addition, our findings suggest that increasing government expenditure increases rural electrification and rural access to clean cooking technologies. This indicates that government spending on rural energy projects is critical to improving rural energy poverty. In addition, through fiscal policy, the government can support rural population access to clean cooking fuels and technologies through rebate and subsidization policies.

The study further indicates that urbanization increases rural energy poverty by reducing rural electrification and rural access to clean cooking fuels and technologies. This evidence suggests that as the urban population rises, more energy infrastructure will be allocated in urban areas while less will be concentrated in rural areas. Thus, relative to the rural population, the urban population has adequate access to electricity and clean cooking technologies, and this can be attributed to the fact that it is technically and financially efficient to connect urban households to the national grid because of the higher concentration of the population, industries, and among others (Goldemberg, 2000). On the other hand, the inverse relationship between urbanization and rural population access to modern and clean energy (electricity and clean cooking technologies) could be attributed to urban-bias policies. Thus, urban bias policies have been contributing to the over-concentration of energy infrastructures in urban areas at the expense of rural areas, thereby making the rural population energy-poor (Khennas, 2012).

The importance of foreign direct investment and access to credit in alleviating energy poverty cannot be underestimated (Acheampong, 2023; Said and Acheampong, 2023; Zhang et al., 2019). However, our results reveal that foreign direct investment and access to credit do not contribute to rural energy poverty reduction. These results could be attributed to the first weak financial system in Latin America and the Caribbean (De la Torre et al., 2011). In a weak financial system, it is costly for an individual to have access to credit, making it difficult for people to access modern, clean, and reliable energy which is relatively expensive (Acheampong, 2023). Also, entrepreneurs do not have easy access to credit and sometimes borrow at a very high-interest rate. This limits their ability to produce sufficient clean cooking technologies at affordable prices for rural populations. Second, it could be that foreign direct investments to Latin America and the Caribbean are primarily concentrated in urban areas, thereby exacerbating urban bias and making the rural population energy poor. Our result is similar to Acheampong's (2023) and Acheampong et al. (2023) findings that access to credit has an inverse relationship with access to clean cooking fuels and technologies in SSA.

Theoretically, Zhang et al. (2019) argue that any attempt to improve access to electricity without robust economic growth lacks foundation. Contrary to argument and expectation, real GDP per capita was found not to be a significant determinant of rural electrification and rural access to clean cooking technologies. This suggests that rural economic growth has not been inclusive in enabling the rural population to improve their access to energy. Finally, the impact of domestic savings on rural energy poverty is ambiguous. For instance, domestic savings did not favour rural access to clean cooking technologies; however, consistent with Onyeji (2010), our result reveals that domestic savings increase rural electrification. Gross domestic savings is a major source of funding for electrification projects in developing countries (Onyeji, 2010).

6. Conclusion and policy implications

In this study, we augment the energy justice literature by providing empirical evidence on the impact of democracy and governance variables on rural electrification and rural dwellers' access to clean fuels and technologies for cooking using comprehensive panel data from 34 countries from Latin America and Caribbean region. Our application of heteroskedasticity-based instrumental variable regression to control endogeneity reveals that governance improves rural electrification and rural access to clean cooking fuels and technologies, while democracy does not favour rural electrification and rural access to clean cooking fuels and technologies. Theoretically, our study contributes to knowledge by demonstrating that better governance and democracy are not intertwined and that governance and democracy may not have the same effect on the provision and allocation of public services. Our findings also demonstrate that it is a better governance system, not democracy, that ensures justice in the provision and allocation of essential public services. While democracy can foster better governance, our findings highlight that rural law, control of corruption, government effectiveness, political stability, regulatory quality, the rule of law, and voice and accountability play more favourable roles in enhancing rural population access to electricity and clean cooking technologies than electoral, liberal, participatory, deliberative, and egalitarian democracies.

Significant policy implications can be drawn from the findings of this study. Governance matters in rural energy poverty alleviation. A better governance system characterized by sound regulation, a stable political environment, enforcement of the rule of law, independence of public and civil organizations, accountability and transparency, freedom, and minimizes corruption could provide a foundation for enhancing rural electrification and access to clean cooking technologies. Governments in developing countries are known for having technical and financial challenges that hinder their efforts in the expansion of electricity and clean cooking solutions to rural areas. In the face of these challenges, donors and the private sector can play a substantial role in efforts to improve rural electrification and rural access to clean cooking solutions. However, the decision of donors and the private sector supports are conditional upon institutional quality. Therefore, having a better governance system could increase investors' confidence and creates an enabling environment for the private sector and donor countries to support rural electrification and access to clean cooking solutions. Additionally, ensuring a better governance system would enhance the effectiveness of energy policies to accelerate rural electrification and access to clean cooking solutions.

The negative effect of democracy on rural electrification and rural access to clean cooking fuels and technologies has significant implications for policies regarding the allocation of public services such as electricity and clean cooking solutions. The rural population is mostly

not favoured by democracy regarding infrastructure endowment. Since the urban population are the median voters and, thus, decides the outcome of an election, political leaders in democratic countries concentrate on major infrastructural facilities and services in the urban areas at the expense of rural areas. From our analysis, the adverse effect of democracy on rural electrification and rural access to clean cooking solutions is very substantial. This study, therefore, calls for reforming democratic principles and practices in the region to ensure fair and equitable distribution of energy infrastructure between rural and urban areas. We also pray to political leaders to overlook their gains and uphold the principle of fairness and equity in the distribution of energy infrastructures. We finally recommend that policymakers engage the rural population when designing and implementing energy policies, which could contribute to energy democracy in the region.

The findings and their policy implications may apply to regions with similar political and structural characteristics as the Latin America and Caribbean regions considered in this study. Although this study has contributed to the literature, this study has some limitations that offer direction for further research. First, our study focused only on rural energy poverty but did not consider holistic indicators that could capture the rural-urban energy divide. Therefore, we suggest that future studies can examine political factors' role in holistic indicators that measure the rural-urban energy divide. Second, future research can extend our analysis to examine if the impact of political forces on rural energy poverty is conditioned by urbanization.

Given that our study focuses on Latin America and Caribbean regions, with relatively better energy access to other regions, such as sub-Saharan Africa and South Asia, further research is needed to identify the role of political institutions in rural energy poverty and the rural-urban energy divide in these energy-poor regions. Also, while this study focused on political institutions, future studies will contribute significantly to knowledge if these studies examine the role of economic institutions on rural energy poverty and the rural-urban energy divide. Finally, further investigation of the potential mediating channels through which political factors influence rural energy poverty is needed.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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Appendix A

Table 1
Latin America & Caribbean countries included in the analysis.

Antigua and Barbuda, Argentina, Bahamas, The, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela, RB

Table 2
Explanation of democracy and governance variables

Variable	Definitions	Sources
Electoral democracy	Measures core value of political rulers being responsible toward citizens through sporadic elections	Coppedge et al. (2011)
Liberal democracy	Captures the intrinsic value of protecting individual and minority rights against potential domination by the majority and state tyranny generally	
Participatory democracy	Represents the values of direct rule and active participation by citizens in all political procedures	
Deliberative democracy	Measures the value that political decisions that go into the activities of public interest	
Egalitarian democracy	Measures the ideal of power disseminated evenly among all citizens irrespective of class, ethnicity, and orientation of any form or other social group	
Control of corruption	Captures the views on how public power is exercised for private gain.	Kaufmann et al. (2011)
Government effectiveness	Measures the perception of quality and degree independence of public and civil services as well as the quality of policy formulation, implementation, and credibility of government policies	
Political stability	Measures the perception about the probability of government being destabilized or overthrown by unconstitutional means	
Regulatory quality	Measures the ability of government to formulate and implement sound regulatory policies that ensure private sector development	
Rule of law	Measures the perception about the extent to which agents have confidence and obey the rule of law and the quality of contract enforcement and property right protection.	
Voice and accountability	Capture the views about the perception to which citizens can participate in selecting their government and freedom of association and free media.	

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