BLACK SHADOW: EFFECT OF ENERGY POVERTY ON THE INFORMAL ECONOMY IN DEVELOPING COUNTRIES

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Introduction

The informal economy is thriving in the developing world, due to a number of factors, including energy poverty. The majority of the world's working population is employed informally, totaling 2 billion workers. Informal employment

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accounts for 90% of employment in low-income countries, 67% in middle-income countries, and 18% in high-income countries (ILO, 2019).[1] In terms of gender, 92% of women compared to 87% of men are employed in the informal sector in developing countries. In addition, more women than men work in the informal sector in India and Pakistan and some other South Asian countries (ILO, 2019).[2] According to International Labour Organisation (ILO) statistics, 80% of rural jobs, compared with 44% of urban jobs, are informal worldwide. Employment in the developing world is therefore dominated by the informal economy.

The term "informal economy" was coined by Keith Hart in 1971. The presence and growth of the informal sector raises fundamental questions, including the nature and formation of markets and the role of governments in regulating their economies (Andreas, 2004).[3] The causes and consequences of the proliferation of informality are still the subject of much debate, particularly in developing countries. Finding ways to control this phenomenon has therefore become a crucial issue (Bhattacharya, 2019; Rangaswamy, 2019).[4]

In this context, a new consensus has emerged recognizing that the informal economy negatively affects inclusive and sustainable development, and the transition from informality to formality now features prominently in the Sustainable Development Goals (SDGs) (Kiaga and Leung, 2020).[5] Over the last few decades, the ILO has proposed several solutions to this end. It recommends that countries implement a variety of policies, mainly based on increasing productivity, improving the regulatory environment and innovation, providing incentives and improving enforcement systems. In a similar vein, Basbay et al. (2016) show that at the aggregate level, energy intensity is related to the size of the informal sector, providing real empirical evidence of the presence of high labor intensity and low capital intensity in the informal economy.[6] Ningaye and Ketu (2023) find that the development of infrastructure, particularly electricity, reduces the relative size of the

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informal economy in African countries.[7] In this study, we aim to examine the effect of energy poverty on the informal economy in developing countries.

To better understand the potential links between these two phenomena, we empirically assess the effect of energy poverty on the informal sector in 95 developing countries for the years 1993 to 2017. Drawing on existing theories and approaches from multiple bodies of literature, we postulate that energy poverty directly affects the growth of the shadow economy, as it limits the opportunities available to workers in the formal sector and encourages behavior that seeks to reduce additional burdens outside the formal economy. Our results confirm the existence of a significant link between greater energy poverty and the growth of the informal economy.

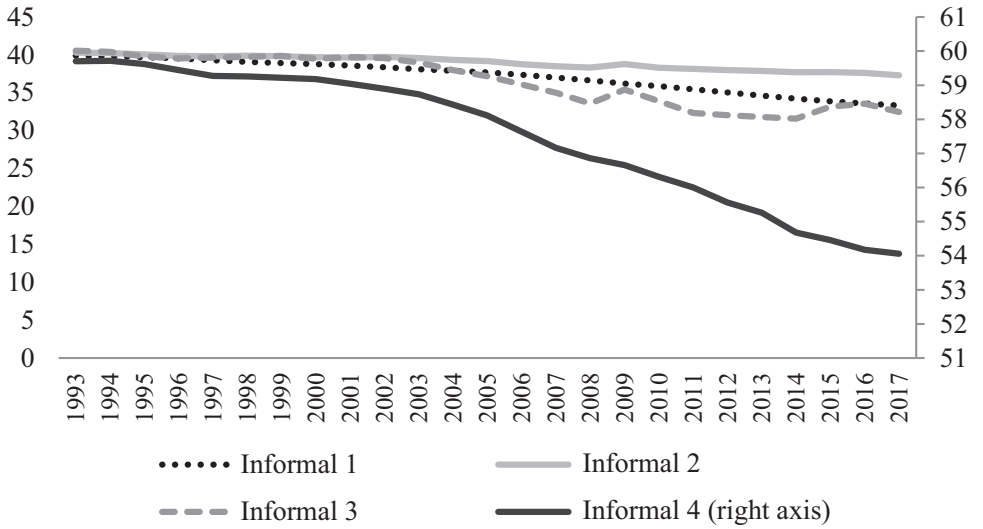
Developing countries are particularly affected by the persistence of two phenomena: energy poverty and informality. The literature presenting the issues of energy poverty is limited, which is one of the contributions of this work. The contribution of this work is threefold. Firstly, this study is the first of its kind to include energy poverty as a relevant and modern factor and indicator of informality. To the best of our knowledge, the existing literature has focused more on analyzing the effects of infrastructure, ICTs, and natural resources as relevant determinants of informality (Ndoya et al., 2023; Ningaye and Ketu, 2023; Blanton and Peksen, 2021).[8] Second, we consider a broad sample of developing countries. Developing countries are particularly affected by the emergence of these two phenomena. Finally, it shows its polysemic nature, which can be grasped in all its complexity by taking into account disaggregated indices and alternative measures of informality and energy poverty. It also considers the specific characteristics of developing countries. As a result, relevant and targeted economic policy recommendations can be made. The aim of this article, which constitutes its originality, is therefore to examine the effect of energy poverty on the informal economy in developing countries.

Following this introduction, the rest of the article is organized into four additional sections. The first presents a summary of the state of energy poverty and informality. The second presents the methodological strategy. The third presents the results and discussion. We conclude with suggestions for policy recommendations in the fourth section.

1. Energy Poverty and Informality in Developing Countries: An Overview

The Level of Informality Has Fallen in Developing Countries: Figure 1 shows that the level of informality in developing countries has fallen slightly on average since 1993, from 40% or 60% to 35% or 50%, respectively, of the overall economy in 2017. This decline has been between 5% and 10%, depending on the measure used. The reasons for this decline are to be found in the empirical literature, but also in the fact that fuel poverty has not been taken seriously as a relevant

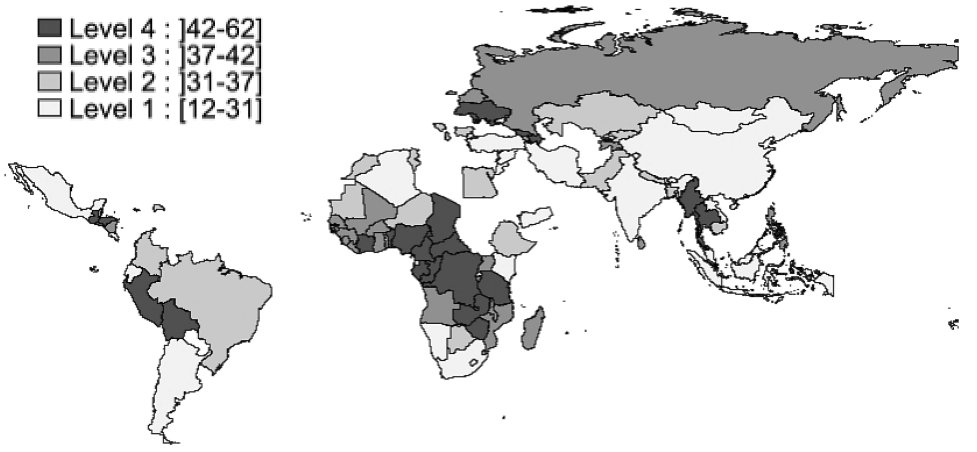
Figure 1
INFORMALITY TRENDS IN DEVELOPING COUNTRIES



Source: Authors' construction.

determinant of informality in these countries. Figure 2 shows the distribution of informality in our sample of developing countries. Informality is concentrated in every continent in our sample. There are also countries with very low levels of informality.

Figure 2
LOCATION OF INFORMALITY IN DEVELOPING COUNTRIES



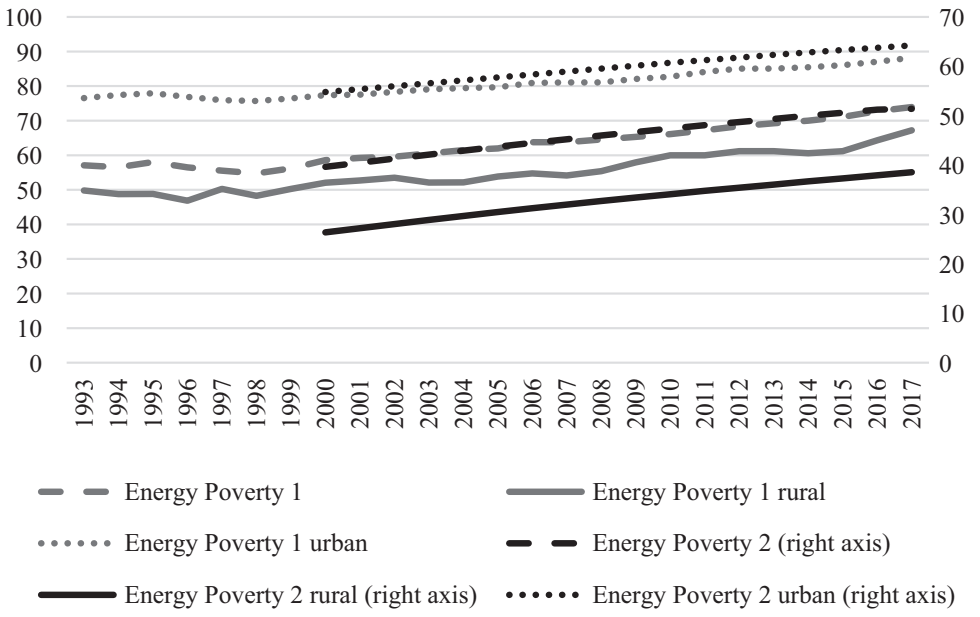
Source: Authors' construction.

Energy Poverty Falls: Electricity, cooking energy, and clean technologies, all fell over the study period. The reduction in energy poverty is slight, rising from 52% or 26% in 2000 to 67% or 39% of the population. This increase was mainly due to the introduction of policies aimed at improving access to clean energy, which is also included in the United Nations' Sustainable Development Goals for 2030. Figure 3 depicts energy poverty trends in developing countries.

Figure 4 shows that energy poverty is no longer a reality for most European countries, although some are still lagging behind. The countries of Africa are largely affected by this phenomenon, which is still a reality for most of these economies, which have so far been unable to provide access to electricity for most of their populations. With the staggering demographic expansion that African countries are undergoing, there is a risk that this objective will not be achieved if the authorities do not take matters into their own hands as soon as possible.

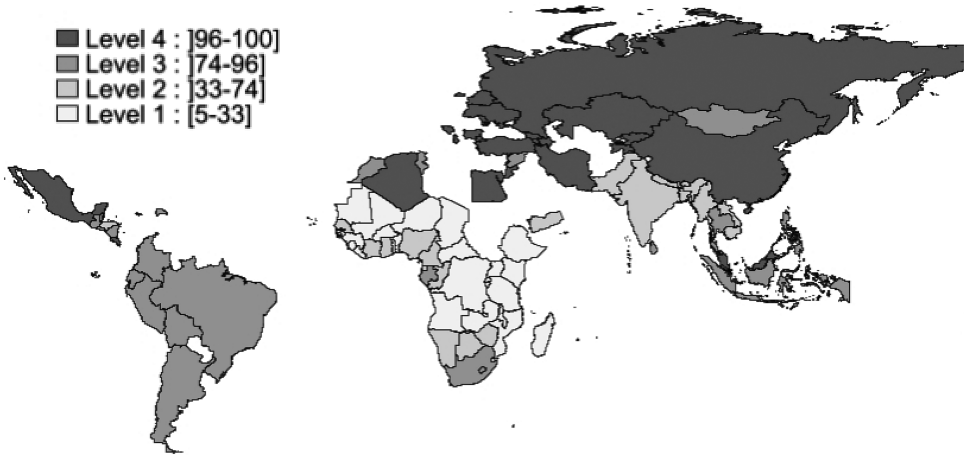
Energy Poverty Increases the Size of the Informal Economy: The graphical correlation presented in Figure 5 suggests that energy poverty increases all measures of informality; in other words, access to electricity reduces the degree of informality in developing countries.

Figure 3
ENERGY POVERTY TRENDS IN DEVELOPING COUNTRIES



Source: Authors' construction.

Figure 4
GEOGRAPHY OF ENERGY POVERTY

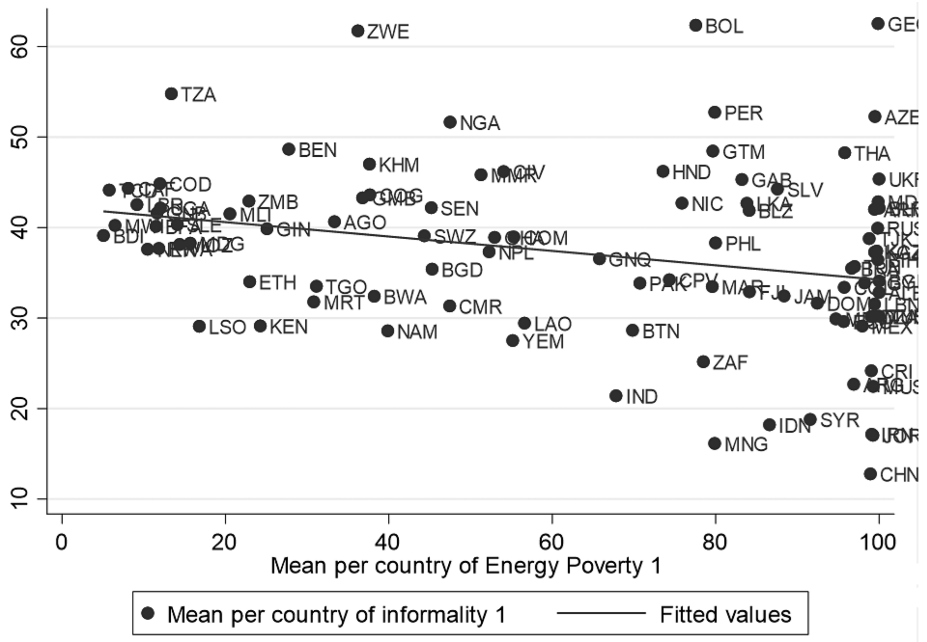


Source: Authors' construction.

2. Literature Review

The informal economy is characterized by a labor-intensive, rather than a capital-intensive, sector with no access to the technological frontier of production (Matthews, 1983).[9] The theoretical literature on the informal economy falls into two main groups. On the one hand, it has been shown that the size of the informal economy is a function of a wide range of factors. The growth of the informal sector is based on the increasing burden of taxes and security contributions (Lippert and Walker, 1997; Schneider, 2000).[10] However, it has also been noted that it is not only the rise in tax rates per se that is responsible for the increase in the size of the underground economy, but also the inefficient and discretionary application of the tax system and regulations by governments (Johnson et al., 1989).[11] On the other hand, the strengthening of regulatory activities, the shortcomings of the institutional system, particularly in providing access to an energy source for the entire population, and tax pressure explain the growth in the income share of the underground economy (Schneider, 2000; Johnson et al., 1998, 1999).[12] However, recent literature also highlights the primordial role of corruption and its complementarity with informality in developing and transition countries (Dreher and Schneider, 2006; Cule and Fulton, 2005).[13] In addition, there are other reasons for the emergence and growth of the underground economy, such as the lack of development of public sector services, which reduces the quality of governance and fiscal morality, and the willingness of agents to engage in the informal economy (Schneider and Klinglmair, 2004), not to mention energy poverty, which increases production costs.[14]

Figure 5
CORRELATION BETWEEN FUEL POVERTY AND INFORMALITY



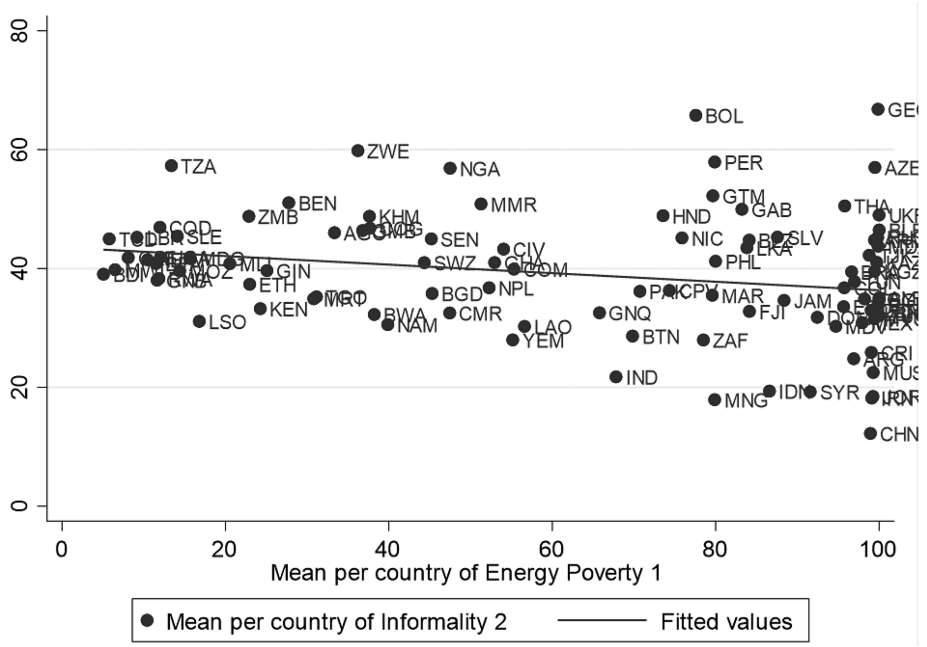
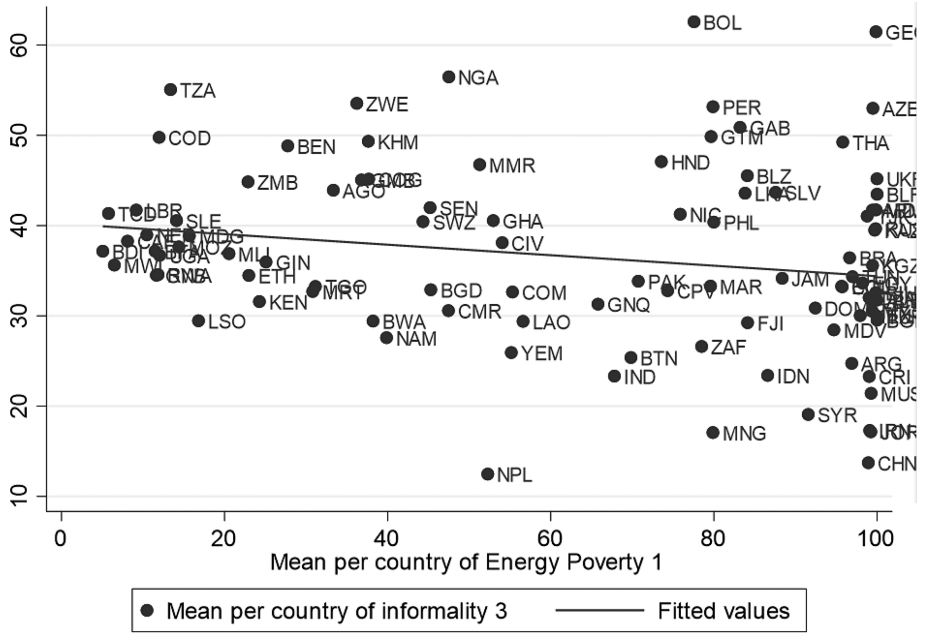
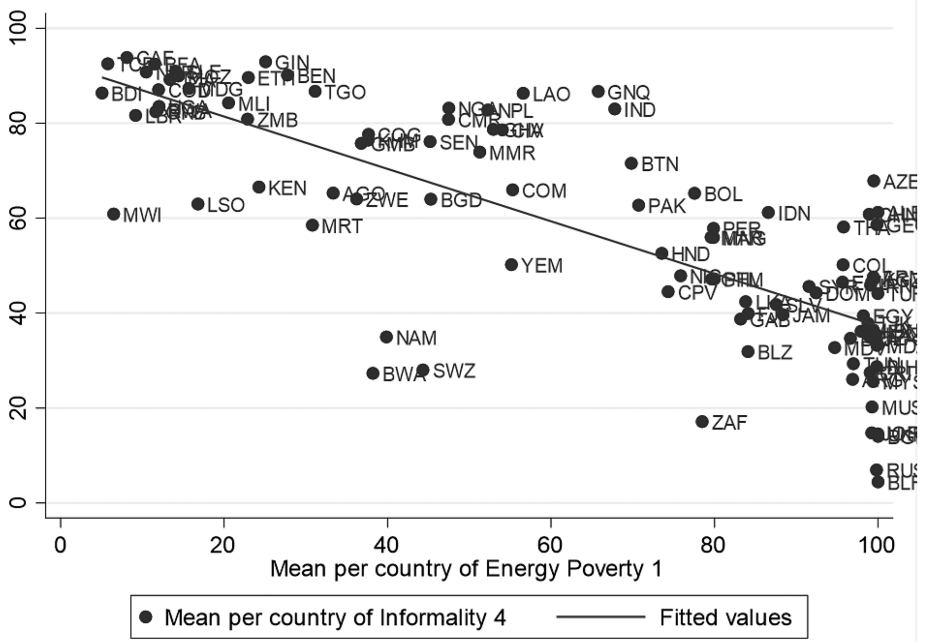


Figure 5 (continued)
CORRELATION BETWEEN FUEL POVERTY AND INFORMALITY





The literature suggests that the provision of public goods, particularly energy, is at the heart of the social contract between citizens and their respective governments (Timmons and Garfias, 2015).[15] Consequently, the provision of public goods, particularly energy, can, on the one hand, induce positive attitudes among citizens towards meeting their tax obligations, while the government, on the other hand, uses the tax revenues raised to finance future expenditure. The supply of public goods, particularly energy, is therefore positively correlated with government tax revenues. Thus, less tax revenue means a reduction in both the quality of regulation and the supply of public and energy goods (Schneider and Klinglmair, 2004).[16] Tax revenues alone make it possible to improve the quality of governance and increase the supply of public and energy goods, thereby reducing the size of the underground economy (Friedman et al., 2000).[17]

The debate on the importance of electricity supply and access to electricity for business performance remains mixed. On the one hand, access to electricity is a basic ingredient for business performance; on the other hand, electricity is a crucial factor that frees microenterprises from low-capital-intensity, low-productivity, low-income, and low-technology activities (Basbay et al., 2016; Little, 1987; Fakira, 1994).[18] Access to electricity encourages the modernization of businesses but has only a modest stimulating effect on income growth because of the constraints facing microenterprises in developing countries, such as limited infrastructure and rising energy prices. Electrification therefore plays a central role in complementary telecommunications and transport services. These services are essential to deter informality (Motta and Reiche, 2001).[19] Electrification in rural areas modifies the sectoral composition of economic activities (Neelsen and Peters, 2011).[20] Electrification seems to have a negative effect on the underground economy by reducing the time and cost of setting up formal businesses. Electricity users in developing countries are aware of its economic potential. Businesses connected to the electricity grid work longer hours (Peter-Cookey and Janyam, 2017).[21] Ndoya et al. (2023) find that the use of information and communication technologies reduces the spread of the informal economy in Africa.[22]

Barriers, connection fees, time to connect to a network, and the inability to pay regularly are the most relevant and direct consequences of the informality of settlements. People cannot enter into formal agreements and cannot pay a regular bill because of irregular income (Butera et al., 2019; Smith, 2004).[23] This mechanism leads, on the one hand, to utilities experiencing high rates of insolvency as well as technical and non-technical losses; on the other hand, residents (both formal and informal) suffer from power cuts due to the irregular load produced by energy losses and illegal connections (Butera et al., 2019).[24] Ningaye and Ketu (2023), using data from 42 African countries over the period 2003-2018, find that infrastructure development reduces the relative size of the underground economy in African countries.[25]

From the non-exhaustive summary of the literature review, three observations emerge. Firstly, to the best of our knowledge, no study has attempted to demonstrate the effect of energy poverty on the informal economy. Secondly, no study has looked at a panel of developing countries from a macroeconomic point of view. Finally, the vagueness of the empirical work justifies new investigations with a view to reducing the underground economy.

3. Empirical Methodology and Data

Empirical Model and Estimation Technique: The aim of this study is to assess the effect of fuel poverty on the informal economy in developing countries. Our empirical approach is divided into two steps to achieve this objective. First, we assume that energy poverty increases the spread of the informal economy. For this hypothesis, we first estimate the effect of energy poverty on the informal economy using robust ordinary least squares (Robust-OLS) regression to check the sign of the relationship, as shown in the equation (1):

$$Informal_{i,t} = \alpha_0 + \alpha_1 EnergyPov_{i,t} + \alpha_2 X_{i,t} + \varphi_i + \gamma_t + v_{i,t} \quad (1)$$

Due to the limitations of Robust-OLS, notably the sensitivity of this method to the problem of endogeneity and the persistence of the informal economy over time, we switch to a dynamic approach. To do this, we apply the Generalized Moment Method (GMM), proposed by Arellano and Bond (1991) and developed by Arellano and Bover (1995) and Blundell and Bond (1998).[26] First, we take advantage of the structure of our panel data: the sample comprises 95 economies and 25 years for each country. With an individual dimension more than three times larger than the time dimension, our sample meets the main requirements for using GMM. Secondly, this method solves the endogeneity problems currently observed in panel data regression. In this study, endogeneity can arise from measurement errors, omitted variables, and reverse causality. With regard to measurement errors, the variables relating to the informal economy and energy poverty are known to be associated with measurement errors. This is because there is no consensus measure of these variables in the literature. Thirdly, informality is considered to be a persistent phenomenon, as the correlation between this variable and its first lag is greater than 0.9.

With regard to omitted variables, there are main variables that can be omitted from the model. Although there are important determinants of the informal economy, these omitted variables may be correlated with the other variables in the model and are therefore not included. Finally, the reverse causality problem can be explained by the fact that while fuel poverty affects the informal economy, reverse causality is also possible because the proliferation of informal activities is

generally associated with informal jobs that sometimes require access to energy. For all these reasons, the GMM is the most appropriate method for our study. Although GMM is available in two versions: difference GMM and system GMM, Bond et al. (2001) recommend system GMM (sGMM) as the most robust.[27]

The consistency of the sGMM estimator depends on two elements: the validity of the assumption that the error term is not serially correlated (ar2) and the validity of the instruments (Hansen test). Too many instruments can seriously weaken and bias Hansen's test of identification restrictions, so the rule of thumb is that the number of instruments should be less than the number of countries (Roodman, 2009).[28]

In doing so, we specify the following dynamic panel model in equation (2):

$$Informal_{i,t} = \alpha + \beta_1 Informal_{i,t-1} + \beta_2 EnergyPov_{i,t} + \beta_3 X_{i,t} + \lambda_i + \mu_t + \varepsilon_{i,t} \quad (2)$$

Where $Informal_{i,t}$ is the level of the informal economy in country i at date t. $EnergyPov_{i,t}$ is the energy poverty indicator. $X_{i,t}$ is the vector of control variables, λ_i the unobserved country fixed effects, μ_t the time fixed effects, and $\varepsilon_{i,t}$ the error term.

Before estimating the sGMM, it is worth briefly discussing certain fundamental principles. These are identification, simultaneity and exclusion restrictions. Identification concerns variables that are suspected to be endogenous or predetermined. In the recent literature (Ningaye and Ketu, 2023; Ndoya et al., 2023), it has been shown that all explanatory variables are assumed to be predetermined (or assumed to be endogenous), while only time-invariant variables (or time-invariant variables) are assumed to be endogenous in first difference.[29] As a result, the time-invariant variables (years) influence the dependent variable (*informal economy*) only through the assumed endogenous variable (*EnergPov*). Furthermore, to assess the validity of the exclusion restriction for instrument exogeneity, we rely on the Hansen test. For simultaneity, lagged explanatory variables are used as instruments for difference indicators.

Data: This study covers a sample of 95 developing countries according to the World Bank classification over the period 1993-2017, with data extracted from various sources. The choice of sample and study period was dictated by data availability.

Dependent Variable: One of the main challenges of empirical studies on our dependent variable, the informal economy, is the lack of precision in its measurement. Most cross-country studies have used indirect approaches, which focus on macroeconomic indicators to obtain information on the informal economy (Elbahnasawy et al., 2016).[30] These approaches typically obtain estimates by taking the differences between estimates of indicators that include both formal and informal economic activity and indicators that include only formal economic activity. These

approaches include, for example, differences between national income and national expenditure, official and real participation rates, total money demand and money demand for transactions in the formal economy, electricity consumption and GDP. All these approaches must be based on strong assumptions, such as the assumption that all differences between national income and national expenditure result from the informal economy, the assumption that all differences in activity rates are due to work in the informal economy, the assumption that the velocity of money is the same in the formal and informal sectors, and the assumption that informal production uses electricity as intensively as in the formal sector, among other assumptions. Our dependent variable, the informal economy, is taken from Elgin et al. (2021), who applied the Dynamic general equilibrium model-based (DGE) modeling approach to estimate the size of the informal economy as a percentage of GDP.[31]

Independent Variables: Three indicator groups are used to measure the independent variable. The first group of measures is the proportion of the total population with access to electricity (energy poverty 1) from national grids. Access to electricity is considered at three levels: total, urban (Energy poverty 1 urban), and rural (Energy poverty 1 rural). The second group of indicators is the proportion of the total population with access to clean fuels and technologies for cooking (Energy poverty 2). Access to clean cooking fuels and technologies is considered at three levels: total, urban (Energy poverty 2 urban), and rural (Energy poverty 2 rural). Electricity production by energy source is based on five measures, namely, oil (Elecpro oil), nuclear (Elecpro nuclear), natural gas (Elecpro natgas), hydro (Elecpro hydro), and coal (Elecpro coal). In addition, we have two groups of sources, renewable energy excluding hydro (Elecpro renew) and energy from oil, gas, and coal (Elecpro oil gas coal).

We obtained these variables from the World Bank (2022). We use these measures because they represent the proportion of the total population, urban and rural, with access to electricity, clean fuels, and technologies and different energy sources. These indicators therefore have a comparative advantage over other standard measures, as they provide information on the effectiveness of government policies in providing electricity and clean fuels and technologies to the population according to geographical location (urban and rural populations). And they consider the different energy resources involved in electricity production.

Drawing on the literature on the determinants of the informal economy (Elgin and Erturk, 2019; Blanton and Peksen, 2021; Ndoya et al., 2023),[32] we use as control variables: (i) GDP per capita; (ii) inflation; (iii) trade openness, and (iv) ICT. These variables are taken from the World Bank's World Development Indicators (WDI). The list of countries sampled, the definition and sources of the variables, and the correlation matrix are given in Table Appendix 1, Table Appendix 2, and Table Appendix 3, respectively, in the Appendix. Table 1 presents the descriptive statistics of the variables used.

Table 1
DESCRIPTIVE STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
Informality 1	2425	37.157	10.205	8.721	66.451
Informality 2	2425	38.969	10.354	11.298	69.346
Informality 3	2425	36.538	10.662	9.4	70.5
Informality 4	2425	57.497	24.07	1.406	95.392
Informality 4 male	2425	54.509	22.124	1.912	93.676
Informality 4 female	2425	61.285	27.583	.847	99.233
Energy Poverty1	2130	63.756	34.168	.534	100
Energy Poverty1 rural	1974	56.022	37.978	.523	100
Energy Poverty1 urban	2136	81.194	24.268	3.43	100
Energy Poverty2	1727	46.077	36.8	.1	99.9
Energy Poverty2 rural	1710	32.834	35.73	0	99.9
Energy Poverty2 urban	1710	59.713	38.039	.2	100
Elecpro oil	1647	21.334	28.813	0	100
Elecpro nuclear	1577	2.18	8.105	0	48.572
Elecpro natgas	1647	21.675	29.445	0	99.039
Elecpro hydro	1647	37.384	35.127	0	100
Elecpro coal	1647	14.534	26.376	0	100
Elecpro renew	1647	2.571	6.098	0	48.275
Elecpro oil gas coal	1647	57.542	34.903	0	100
Inflation	2408	49.654	671.64	−31.566	26765.858
ICT	2418	39.791	45.464	0	190.525
Trade	2258	71.839	32.916	11.855	220.407
GDPpc	2413	2878.904	2683.067	190.234	14222.549
Dependency ratio	2425	72.055	19.265	36.03	116.766
Political Stability	1843	−.517	.805	−2.974	1.284
CO2emissions	2413	.588	.598	0	5.175
Maternal death	1746	1.428	1.805	.002	10.314
Ln(Labor)	2425	15.29	1.693	11.052	20.476
FD	1952	29.349	28.411	0	158.505
Cost procedures	1334	74.98	144.349	.2	1540.2
Time start a business	1334	37.782	34.193	2	260.5
Time get electricity	831	115.381	81.922	31	602

Source: Authors' compilation.

Results and Discussion

Basic Results: We first establish the link between energy poverty and the informal economy by estimating equation (1) using the Robust-OLS estimator. The results reported in Table 2 first present a bivariate regression between energy poverty and the informal economy, as seen in column (1), i.e., an equation specification without control variables. In columns (2) to (6), all baseline control

Table 2
BASIC ANALYSIS: ENERGY POVERTY AND INFORMALITY[a]

	Dependent variable: Informality 1					
Technical Estimate		**Robust POLS**		**LSDV**	**Robust POLS**	**LSDV**
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Energy Poverty1	−0.085***	−0.071***	−0.044***	−0.125***	−0.049***	−0.055***
	(0.005)	(0.007)	(0.009)	(0.008)	(0.009)	(0.009)
Inflation		0.003***	0.004***	0.000	0.003**	0.000
		(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
ICT		−0.083***	0.053***	−0.034***	0.173***	0.043***
		(0.014)	(0.015)	(0.005)	(0.020)	(0.008)
Trade		0.011	0.012*	−0.037***	0.013*	−0.034***
		(0.007)	(0.007)	(0.005)	(0.007)	(0.004)
GDPpc			−0.001***	−0.000***	−0.001***	−0.001***
			(0.000)	(0.000)	(0.000)	(0.000)
FD			−0.090***	−0.031***	−0.098***	−0.027***
			(0.011)	(0.006)	(0.012)	(0.006)
Constant	42.325***	41.835***	42.835***	49.105***	45.816***	49.620***
	(0.339)	(0.514)	(0.530)	(0.507)	(1.872)	(0.689)
Country Effect	No	No	No	Yes	No	Yes
Time Effect	No	No	No	No	Yes	Yes
Observations	2,130	1,995	1,631	1,631	1,631	1,631
R-squared	0.084	0.109	0.217	0.971	0.243	0.975
F-stat	250.3	82.05	96.53	5003	21.16	2739

[a]Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors.

variables are added to the model. We also take into account country and/or time effects in columns (4) to (6).

Overall, in line with Figure 3, the results show a negative and significant effect of access to electricity on the informal economy, both without and with control variables. Indeed, a one-point increase in access to electricity reduces the size of the informal sector by between 0.04 and 0.12 points. As already mentioned, estimating the equation using the Robust-OLS method raises several problems, some of which are specific to dynamic models. Firstly, the explanatory variables are not necessarily all exogenous, even if this is assumed *a priori*, and the causality between them and the variable being explained could be twofold. Secondly, specific individual effects, among others, may be correlated with the explanatory variables. In addition, the presence of one or more lags of the dependent variable among the explanatory variables introduces a risk of autocorrelation of the error terms. In order to overcome these difficulties, we apply the generalized method of moments (GMM) to estimate equation (2) and repeat the same series of regressions as in Table 2.

The results are reported in Table 3 and, as before, we present the results in columns (1) and (3). As can be seen from Table 3, the regressions all satisfy the specification tests (ar1, ar2, and Hansen test). The number of instruments used is much lower than the number of countries in the sample. Indeed, in order to limit the proliferation of instruments in the implementation of the GMM estimator, Roodman (2009) recommends specifying the model so that the number of instruments does not exceed the number of countries.[33] Next, Arellano and Bond's (1991) autocorrelation test is used to deduce the presence of residual autocorrelation to order 1 and the absence of serial autocorrelation to order 2.[34] Finally, the regressions pass Hansen's test and confirm the validity of the instruments.

Overall, the results in Table 3 confirm a negative relationship between access to electricity and the size of the informal sector. In other words, as the percentage of the population with access to electricity increases, the extent of informality decreases. The findings remain consistent when alternative measures of informality are considered. Public access to electricity lowers business costs and encourages entrepreneurs operating informally to shift towards formal structures that align with recognized standards in developing countries. Compliance with these standards allows businesses to take advantage of benefits like government subsidies. These results align with existing literature, which suggests that access to and use of energy provides opportunities for entrepreneurs, particularly in food production and preservation. Moreover, access to efficient energy sources reduces production costs and boosts productivity, making businesses more competitive. This competitiveness incentivizes formalization, allowing businesses to benefit from state support and further develop. Our results are therefore consistent with those of Pondie et al. (2023) and Ningaye and Ketu (2023).[35]

Table 3
SGMM ESTIMATES: ENERGY POVERTY AND INFORMALITY[a]

	(1)	(2)	(3)
		Technical estimate: sGMM	
Variables	**Informal 1**	**Informal 2**	**Informal 3**
L.informal 1	0.937***		
	(0.017)		
L.informal 2		0.986***	
		(0.009)	
L.informal 3			0.999***
			(0.002)
Energy poverty1	−0.010***	−0.014**	−0.004*
	(0.003)	(0.007)	(0.002)
Inflation	0.000	0.007***	0.000
	(0.001)	(0.002)	(0.001)
ICT	−0.004***	−0.003	−0.004***
	(0.001)	(0.002)	(0.001)
Trade	−0.000	−0.005*	−0.001
	(0.002)	(0.003)	(0.001)
GDPpc	−0.000**	−0.000**	−0.000***
	(0.000)	(0.000)	(0.000)
Constant	2.390***	0.681*	−0.016
	(0.688)	(0.402)	(0.110)
Observations	1,973	1,886	1,886
Number of countries	95	95	95
Number of instruments	25	22	24
ar1p	0.007	0.000	0.000
ar2p	0.222	0.134	0.0792
Hansenp	0.464	0.492	0.531

[a]Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors.

Regarding the determinants of the informal sector, all control variables considered have the anticipated signs and align with expectations from the literature. The inflation variable is significantly and positively correlated with informal economic activity, suggesting that higher inflation drives more individuals into informal work. Similarly, increased taxation provides a strong incentive for individuals to shift to informal activities (Medina and Schneider, 2018; Blanton and Peksen, 2021).[36] Information and communication technologies (ICTs) are significantly and negatively associated with informality, as their inclusion encourages operators in the informal sector to transition toward structures that comply with government-recognized standards.

This compliance allows them to benefit from advantages such as government subsidies (Ndoya et al., 2023).[37] Trade liberalization significantly reduces informality by offering entrepreneurs access to products at lower costs. While GDP per capita shows a negative but insignificant coefficient, this finding, consistent with Ndoya (2021) and Elgin and Erturk (2019), suggests that the initial stages of development may not immediately reduce informal activities.[38] It is only in later phases of development that a noticeable decline in informality occurs.

Robustness Analysis: In this section, we carry out a series of sensitivity analyses and robustness checks. In doing so, we extend our baseline specification by modifying the measure of fuel poverty and the informal economy and use alternative measures.

Finally, we test the robustness of our results using an alternative measure of the informal economy. In the previous section, we measured the informal economy by the size of the informal sector as a percentage of GDP. For this robustness analysis, we follow Nguimkeu and Okou (2021) and Ndoya et al. (2023) in using informal employment as an alternative measure of informality.[39] The results are presented in Table 4 and corroborate our basic results. Access to electricity contributes more to reducing informal employment for women than for men. In many developing countries, electricity is often scarce or unavailable in rural areas where women often work in agriculture and informal enterprises. Women working in informal businesses, such as cottage industries, food processing, sewing or hairdressing, often need electricity to operate efficiently and to compete with formal businesses. By providing reliable access to electricity, women can be better able to develop their businesses, provide high-quality products and services, reach new customers, and create jobs for other women.

Table 5 presents the results using alternative measures of energy poverty (*Energy poverty 2*), in particular the percentage of the population with access to clean cooking fuels and technologies according to geographical location. We note that rural energy poverty contributes more strongly to the expansion of informality. The results remain robust to the change in variable, and the control variables retain the sign of the basic results.

In Table 6, we introduce the measure of energy production by source. The control variables retain their sign as agreed in the basic results. Energy production from different sources contributes to the reduction of informality. The energy sources that contribute most to reducing informality are nuclear energy, followed by energy from natural gas, columns (4) and (5), respectively. The energy sources that contribute least are oil and coal, columns (3) and (7), respectively. Renewable energies, excluding hydropower, make a greater contribution than coal, oil, and gas to reducing informality.

Energy Poverty and Informality—Mediation Analysis: This subsection conducts a mediation analysis using four main mediators: Time (business and electricity), Cost, Financial development, CO_2 emissions, Labor (ln), Dependency ratio, Maternal death, and Political stability. Our method, presented in Figure 6, is

Table 4
GENDER APPROACH: ENERGY POVERTY AND INFORMALITY[a]

	(1)	(2) sGMM	(3)
Variables	**Informality 4**	**Informality 4 male**	**Informality 4 female**
L. Informality 4	0.962***		
	(0.012)		
L. Informality 4 male		0.931***	
		(0.017)	
L. Informality 4 female			0.799***
			(0.016)
Energy poverty 1	−0.027**	−0.047***	−0.144***
	(0.011)	(0.014)	(0.018)
Inflation	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
ICT	0.003**	0.005**	0.020***
	(0.002)	(0.002)	(0.004)
Trade	−0.004***	−0.005**	−0.015***
	(0.001)	(0.003)	(0.004)
GDPpc	−0.000*	−0.000	−0.001***
	(0.000)	(0.000)	(0.000)
Constant	4.043***	6.908***	22.972***
	(1.456)	(1.838)	(2.031)
Observations	1,868	1,868	1,868
Number of countries	95	95	95
Number of instruments	34	31	48
ar1p	0.000	0.000	0.000
ar2p	0.295	0.755	0.740
Hansenp	0.1888	0.129	0.172

[a]Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors.

based on Ang (2013), which was also used by Ndoya et al. (2023).[40] This approach involves the estimation of two regression equations subsequently, as described below:

$$\text{Model 1: } Med_i = \alpha_1 + b_1 EnergyPov_i + \acute{c}_1 X_i + \mu_i \quad (3)$$

$$\text{Model 2: } Informality_i = \alpha_2 + b_2 EnergyPov_i + b_3 Med_i + \acute{c}_2 X_i + v_i \quad (4)$$

Where Med_i represents the mediation variables (Time [business and electricity], Cost, Financial development, CO_2 emissions, Labor (ln), Dependency ratio,

Table 5
LOCATION AND ALTERNATIVE MEASURES: ENERGY POVERTY AND INFORMALITY[a]

	Dependent Variable: Informality 1 sGMM					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
L.informality 1	0.937***	0.938***	0.930***	0.963***	0.963***	0.962***
	(0.017)	(0.015)	(0.017)	(0.011)	(0.011)	(0.012)
Energy Poverty1	−0.010***					
	(0.003)					
Energy Poverty1 urban		−0.012***				
		(0.003)				
Energy Poverty1 rural			−0.012***			
			(0.004)			
Energy Poverty 2				−0.010*		
				(0.005)		
Energy Poverty 2 urban					−0.008**	
					(0.003)	
Energy Poverty 2 rural						−0.014**
						(0.006)
Inflation	0.000	0.000	0.000	0.001	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ICT	−0.004***	−0.003***	−0.004***	−0.003***	−0.003***	−0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Trade	−0.000	0.000	0.001	0.001	0.001	−0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
GDPpc	0.000**	0.000**	0.000**	0.000*	0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	2.390***	2.811***	2.433***	1.060**	1.175***	0.967**
	(0.688)	(0.709)	(0.672)	(0.440)	(0.426)	(0.468)
Obs.	1,973	1,972	1,838	1,620	1,605	1,605
Number of countries	95	95	95	94	93	93
Number of instruments	25	25	25	25	25	23
ar2	1.222	1.129	1.289	0.675	0.655	0.579
ar1p	0.007	0.006	0.009	0.021	0.021	0.023
ar2p	0.222	0.259	0.197	0.499	0.512	0.563
Hansenp	0.464	0.530	0.416	0.227	0.227	0.211

[a]Obs. = Observations. Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors.

Table 6
BY ENERGY SOURCE: ENERGY POVERTY AND INFORMALITY[a]

	Dependent Variable: Informality 1						
	sGMM						
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
L.informality 1	0.829***	0.820***	0.842***	1.237***	0.984***	1.070***	0.976***
	(0.010)	(0.010)	(0.011)	(0.016)	(0.013)	(0.017)	(0.009)
Elecpro oil			−0.004***				
			(0.001)				
Elecpro nuclear				−0.027***			
				(0.007)			
Elecpro natgas					−0.014***		
					(0.002)		
Elecpro hydro						−0.005***	
						(0.001)	
Elecpro coal							−0.003**
							(0.002)
Elecpro renewn hydro	−0.014***						
	(0.002)						
Elecpro oilgascoal		−0.011***					
		(0.002)					
Inflation	0.002***	0.001***	0.001***	0.000***	0.001***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ICT	−0.013***	−0.012***	−0.013***	0.001	−0.007***	−0.003***	−0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Trade	0.003***	0.003*	0.003	−0.003**	−0.001	−0.003**	0.000
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
GDPpc	0.000***	0.000	0.000*	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	5.662***	6.849***	5.435***	−9.274***	0.282	−2.634***	0.469
	(0.544)	(0.532)	(0.508)	(0.728)	(0.509)	(0.684)	(0.442)

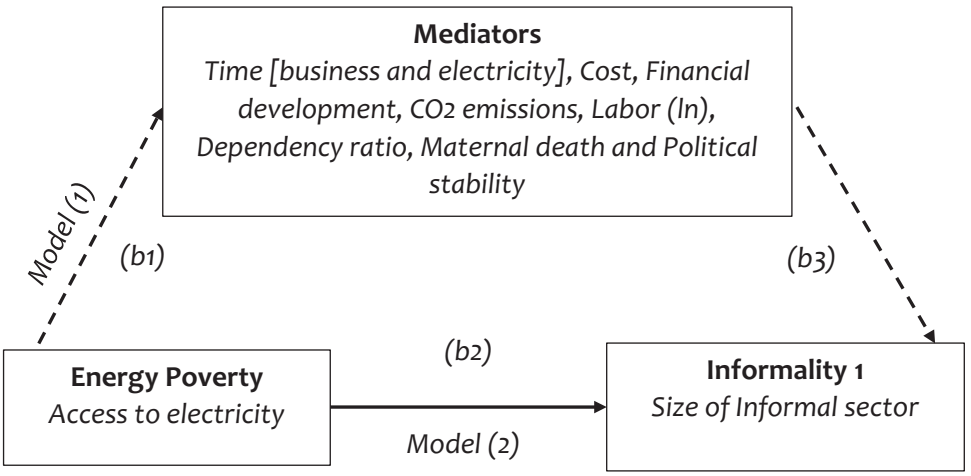
(continued)

Table 6 (continued)
BY ENERGY SOURCE: ENERGY POVERTY AND INFORMALITY[a]

	Dependent Variable: Informality 1						
	sGMM						
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Observations	1,511	1,511	1,511	1,373	1,442	1,442	1,511
Number of countries	72	72	72	72	72	72	72
Number of instruments	54	54	54	52	52	52	45
ar1p	0.031	0.018	0.023	0.019	0.012	0.012	0.011
ar2p	0.242	0.186	0.235	0.201	0.382	0.363	0.358
hansenp	0.162	0.179	0.156	0.432	0.271	0.517	0.181

[a]Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Authors.

Figure 6
MODELING THE MEDIATION EFFECT OF ENERGY POVERTY ON INFORMALITY



Source: Authors, from Ang (2013).

Maternal death, and Political stability). The composition effect follows from the above models as follows:

Indirect effect: $b_1 \times b_3$; direct effect: b_2; and total effect: $(b_1 \times b_3) + b_2$

In the first step, we estimate model (1), which is the effect of energy poverty on the mediators (Time [business and electricity], Cost, Financial development, CO_2 emissions, Labor (ln), Dependency ratio, Maternal death and Political stability); *b1* is the parameter describing this effect. The second step is to estimate model (2), in which we regress fuel poverty on informality while controlling for mediators. The magnitude of this effect is provided by the energy poverty coefficient (*b2*). The indirect effect is therefore obtained by the product of *b1* and *b3*, where *b3* measures the strength of the correlation between energy poverty and the mediators in model (2). This term also reflects the size of the mediation, which essentially depends on the extent to which fuel poverty affects the mediators (*b1*) and the extent to which the mediators influence the informal economy (*b3*). The results are presented in Tables 7 to 9 using access to electricity as a measure of fuel poverty. Columns (1a), (2a), and (3a) of each table present the estimates of model (1), using, respectively, Time [business and electricity], Cost, Financial development, CO_2 emissions, Labor (ln), Dependency ratio, Maternal death and Political stability as mediators. The estimates of model (2) using the mediators as controls are reported in columns (1b), (2b), and (3b) accordingly.

Overall, the results suggest that: (i) fuel poverty affects all nine mediators, and the effects are statistically significant at the 1% level (columns 1a, 2a and 3a in

Table 7
ANALYSIS OF MEDIATION 1[a]

	(i) Mediator: Time GE		(ii) Mediator: Time SB		(iii) Mediator: Cost Pro.	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Dep. variable =	**Time GE**	**Informal1**	**Time SB**	**Informal1**	**Cost Pro**	**Informal1**
Energy Pov 1	−0.5015***	−0.0326**	−0.1798***	−0.0063**	−1.9414***	0.0147**
	(0.100)	(0.015)	(0.036)	(0.011)	(0.158)	(0.011)
Time GE		0.0064*				
		(0.004)				
Time SB				0.0212**		
				(0.009)		
Cost Pro.						0.0163***
						(0.003)
Constant	145.325***	36.505***	50.0777***	39.2476***	201.7627***	36.9254***
	(8.289)	(1.108)	(3.052)	(0.729)	(13.875)	(0.860)
Controls V	No	Yes	No	Yes	No	Yes
Bootstrap	500	500	500	500	500	500
Obs.	797	797	1,265	1,265	1,265	1,265

	Mediating of Time GE			Mediating of Time SB			Mediating of Cost Pro.		
	Coeff.	**Std. err**	**p-value**	**Coeff.**	**Std. err**	**p-value**	**Coeff.**	**Std. err**	**p-value**
(A) Mediators tests									
Delta	−0.003	0.002	0.096	−0.004	0.002	0.034	−0.032	0.004	0.000
Sobel	−0.003	0.002	0.112	−0.004	0.002	0.027	−0.032	0.006	0.000
Monte Carlo	−0.003	0.002	0.121	−0.004	0.002	0.030	−0.031	0.006	0.000
(B) Composition of the effect									
Indirect effect (Sobel)	0.003			0.004			0.032		
Direct effect	0.033			0.006			0.015		
Total effect	0.036			0.010			0.047		
% of the Total effect mediated	**9 %**			**37 %**			**68 %**		

[a]Source: Authors. Note: Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8
ANALYSIS OF MEDIATION 2[a]

	(i) Mediator: FD		(ii) Mediator: CO2 emissions		(iii) Mediator: Labor	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Dep. var. =	**FD**	**Informal1**	**CO2**	**Informal1**	**Labor**	**Informal1**
Energy Pov 1	0.4803***	−0.0447***	0.0079***	−0.0235**	0.0052***	−0.0295***
	(0.016)	(0.010)	(0.000)	(0.010)	(0.001)	(0.008)
FD		−0.0843***				
		(0.010)				
CO2				−1.3670**		
				(0.558)		
Labor						−0.7092***
						(0.147)
Constant	1.1373*	42.6449***	0.0650***	41.9529***	201.7627***	36.9254***
	(0.636)	(0.536)	(0.011)	(0.541)	(13.875)	(0.860)
Controls V	No	Yes	No	Yes	No	Yes
Bootstrap	500	500	500	500	500	500
Obs.	1,643	1,643	2,012	2,012	1,265	1,265

	Mediating of FD			Mediating of CO2			Mediating of Labor		
	Coeff.	**Std. err**	**p-value**	**Coeff.**	**Std. err**	**p-value**	**Coeff.**	**Std. err**	**p-value**
(A) Mediators tests									
Delta	−0.040	0.005	0.000	−0.011	0.004	0.011	−0.004	0.001	0.001
Sobel	−0.040	0.005	0.000	−0.011	0.004	0.015	−0.004	0.001	0.000
Monte Carlo	−0.041	0.005	0.000	−0.011	0.004	0.014	−0.004	0.001	0.000
(B) Composition of the effect									
Indirect effect (Sobel)	0.040			0.011			0.004		
Direct effect	0.045			0.024			0.030		
Total effect	0.085			0.034			0.033		
% of the Total effect mediated	**48 %**			**31 %**			**11 %**		

[a]Source: Authors. Note: Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 9
ANALYSIS OF MEDIATION 3[a]

	(i) Mediator: LRMD		(ii) Mediator: ADRW		(iii) Mediator: Po. Stab.	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Dep. var. =	**LRMD**	**Informal1**	**ADRW**	**Informal1**	**Po. Stab.**	**Informal1**
Energy Pov 1	−0.0440***	0.0228*	−0.4826***	0.0250*	0.0035***	−0.0398***
	(0.001)	(0.013)	(0.006)	(0.013)	(0.001)	(0.009)
LRMD		1.3950***				
		(0.166)				
ADRW				0.1524***		
				(0.024)		
Po. Stab.						−1.0153***
						(0.294)
Constant	0.0650***	41.9529***	101.5723***	26.1236***	−0.7323***	39.8499***
	(0.011)	(0.541)	(0.439)	(2.666)	(0.046)	(0.629)
Controls V	No	Yes	No	Yes	No	Yes
Bootstrap	500	500	500	500	500	500
Obs.	1,639	1,639	2,012	2,012	1,669	1,669

	Mediating of LRMD			Mediating of ADRW			Mediating of Po. Stab.		
	Coeff.	**Std. err**	**p-value**	**Coeff.**	**Std. err**	**p-value**	**Coeff.**	**Std. err**	**p-value**
(A) Mediators tests									
Delta	−0.061	0.007	0.000	−0.074	0.012	0.000	−0.004	0.001	0.005
Sobel	−0.061	0.007	0.000	−0.074	0.012	0.000	−0.004	0.001	0.003
Monte Carlo	−0.061	0.007	0.000	−0.073	0.012	0.000	−0.004	0.001	0.003
(B) Composition of the effect									
Indirect effect (Sobel)	0.011			0.074			0.004		
Direct effect	0.024			0.025			0.040		
Total effect	0.034			0.099			0.043		
% of the Total effect mediated	**32 %**			**74 %**			**9 %**		

[a]Source: Authors. Note: Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

tables 7 to 9). (ii) The nine mediators have a significant separate effect on the informal economy (columns 1b, 2b, and 3b in tables 7 to 8). (iii) The estimated coefficient of energy poverty on the informal economy decreases when a mediator is included in the model (columns 1b, 2b, and 3b in Tables 7 to 9, compared to column 1 in Table 2). Taken together, the results suggest that mediation may have occurred when some of the influences of energy poverty on the informal economy are driven by Time [business and electricity], Cost, Financial development, CO_2 emissions, Labor (ln), Dependency ratio, Maternal death, and Political stability.

Tables 7 to 9 present a formal evaluation of the mediation effects using several statistical approaches. Several mediation tests are considered to analyze whether the indirect effect of energy poverty on the informal economy through the influence of Time [business and electricity], Cost, Financial development, CO_2 emissions, Labor (ln), Dependency ratio, Maternal death and Political stability is statistically different from zero. If we consider the mediation effect of financial development, for example, the Sobel test statistic is estimated at 0.040 for access to electricity. The P-value is less than 1% in Table 8, suggesting that the null hypothesis of no mediation is rejected. The results are similar when using other mediation tests (Delta and Monte Carlo). It was also pointed out that the use of bootstrap confidence intervals does not alter the results. Indeed, the evidence presented implies that the mediation effect of financial development is significant with around 48% of the total effect of fuel poverty on the informal economy, for access to electricity. Tables 7 to 9 also show clear evidence of the mediating effect of Time [business and electricity], Cost, Financial development, CO_2 emissions, Labor (ln), Dependency ratio, Maternal death and Political stability.

4. Conclusion and Policy Implications

The objective of this paper is therefore to fill the gap in the literature on the effects of energy poverty on the informal economy in developing countries. Using a sample of 95 developing countries for the period 1993-2017 and applying the generalized method of moments, we empirically test two hypotheses. First, energy poverty increases informality and second, the effect of energy poverty on the informal economy is mediated through certain channels.

Overall, our results show that energy poverty (access to electricity, access to clean cooking fuels and technologies) increases the spread of the informal economy, corroborating modernization theory, which suggests that developing the energy sector helps governments put in place strong policies that would reduce corruption and help individuals move from the informal to the formal sector. Our results withstand a battery of robustness checks, including alternative measures of energy poverty and the informal economy. Finally, we carry out an analysis of the transmission channels and, without being exhaustive, we find that Time [business

and electricity], Cost, Financial development, CO_2 emissions, Labor (ln), Dependency ratio, Maternal death, and Political stability are the channels through which energy poverty influences the informal economy.

From a political perspective, considering that the informal economy plays a significant role in the development of many developing countries, providing opportunities for the unemployed and fostering the growth of entrepreneurial ventures, it is not always seen as entirely negative. We recommend a quantitative and qualitative strengthening of energy infrastructures to sustainably curb the rise of the informal sector in these regions.

This study also opens up avenues for future research, particularly in exploring the bidirectional causality between fuel poverty and informality. The increase in fuel poverty could, in turn, be influenced by the expansion of informal activities. Additionally, investigating the threshold effects in the relationship between fuel poverty and the informal economy could yield valuable insights.

NOTES

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APPENDIX

Appendix Table 1
LIST OF COUNTRIES

Albania	Colombia	Ivory Coast	Nicaragua
Algeria	Comoros	Jamaica	Niger
Angola	Congo Dem. Rep.	Jordan	Nigeria
Argentina	Congo Rep.	Kazakhstan	Pakistan
Armenia	Costa Rica	Kenya	Peru
Azerbaijan	Dominican Republic	Kyrgyz Rep.	Philippines
Bangladesh	Ecuador	Lao PDR	Russian Federation
Belarus	Egypt	Lebanon	Rwanda
Belize	El Salvador	Lesotho	Senegal
Benin	Equatorial Guinea	Liberia	Sierra Leone
Bhutan	Eswatini	Madagascar	South Africa
Bolivia	Ethiopia	Malawi	Sri Lanka
Bosnia and Herzegovina	Fiji	Malaysia	Syrian Arab Rep.
Botswana	Gabon	Maldives	Tajikistan
Brazil	Georgia	Mali	Tanzania
Bulgaria	Ghana	Mauritania	Thailand
Burkina Faso	Guatemala	Mauritius	Togo
Burundi	Guinea	Mexico	Tunisia
Cabo Verde	Gambia, The	Moldova	Turkiye
Cambodia	Guinea-Bissau	Mongolia	Uganda
Cameroon	Honduras	Morocco	Ukraine
Central African Rep.	Indonesia	Mozambique	Yemen Rep.
Chad	India	Myanmar	Zambia
China	Iran, Islamic Rep	Nepal	Zimbabwe

Source: Authors' construction.

Appendix Table 2
DESCRIPTION OF VARIABLES

Variable	Description	Source
Informal 1	Dynamic general equilibrium model-based (DGE) estimates of informal output (% of official GDP)	Elgin et al (2021)
Informal 2	Multiple indicators multiple causes model-based (MIMIC) estimates of informal output (% of official GDP)	Elgin et al (2021)
Informal 3	Size and development of the shadow economy	Medina and Schneider (2017)
Informal 4	Self-employed. total (% of total employment)	World Bank (2021)
Informal 4 male	Self-employed. male (% of male employment)	World Bank (2021)
Informal 4 female	Self-employed. female (% of female employment)	World Bank (2021)
Energy Poverty1	Access to electricity (% of population)	World Bank (2021)
Energy Poverty1 rural	Access to electricity. rural (% of rural population)	World Bank (2021)
Energy Poverty1 urban	Access to electricity. urban (% of urban population)	World Bank (2021)
Energy Poverty2	Access to clean fuels and technologies for cooking (% of population)	World Bank (2021)
Energy Poverty2 rural	Access to clean fuels and technologies for cooking. rural (% of rural population)	World Bank (2021)
Energy Poverty2 urban	Access to clean fuels and technologies for cooking. rural (% of urban population)	World Bank (2021)
Elecpro renew	Electricity production from renewable sources. excluding hydroelectric (% of total)	World Bank (2021)
Elecpro oil gas coal	Electricity production from oil, gas and coal sources (% of total)	World Bank (2021)

(continued)

Appendix Table 2 (continued)
DESCRIPTION OF VARIABLES

Variable	Description	Source
Elecpro oil	Electricity production from oil sources (% of total)	World Bank (2021)
Elecpro nuclear	Electricity production from nuclear sources (% of total)	World Bank (2021)
Elecpro natgas	Electricity production from natural gas sources (% of total)	World Bank (2021)
Elecpro hydro	Electricity production from hydroelectric sources (% of total)	World Bank (2021)
Elecpro coal	Electricity production from coal sources (% of total)	World Bank (2021)
Inflation	Inflation. GDP deflator (annual %)	World Bank (2021)
ICT	Mobile cellular subscriptions (per 100 people)	World Bank (2021)
Trade	Trade (% of GDP)	World Bank (2021)
GDPpc	GDP per capita (constant 2015 US$)	World Bank (2021)
Dependency ratio	Age dependency ratio (% of working-age population)	World Bank (2021)
Political Stability	Political Stability and Absence of Violence/ Terrorism: Estimate	World Bank (2021)
CO2emissions	CO_2 emissions (kg per 2015 US$ of GDP)	World Bank (2021)
Maternal death	Lifetime risk of maternal death (%)	World Bank (2021)
Ln(Labor)	Logarithm of Labor force. total	World Bank (2021)
FD	Domestic credit to private sector (% of GDP)	World Bank (2021)
Cost procedures	Cost of business start-up procedures (% of GNI per capita)	World Bank (2021)
Time start a business	Time required to start a business (days)	World Bank (2021)
Time get electricity	Time required to get electricity (days)	World Bank (2021)

Source: Authors' construction.

Appendix Table 3
MATRIX OF CORRELATION

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Informal 1	1.00															
(2) Informal 2	0.96	1.00														
(3) Informal 3	0.90	0.93	1.00													
(4) Informal 4	0.25	0.25	0.19	1.00												
(5) Informal 4 male	0.22	0.22	0.17	0.99	1.00											
(6) Informal 4 female	0.28	0.28	0.21	0.98	0.94	1.00										
(7) Energy Poverty1	−0.25	−0.23	−0.20	−0.74	−0.70	−0.75	1.00									
(8) Energy Poverty1 rural	−0.28	−0.27	−0.24	−0.73	−0.68	−0.76	0.95	1.00								
(9) Energy Poverty1 urban	−0.24	−0.21	−0.19	−0.61	−0.58	−0.61	0.91	0.82	1.00							
(10) Energy Poverty2	−0.23	−0.22	−0.18	−0.82	−0.78	−0.83	0.84	0.83	0.69	1.00						
(11) Energy Poverty2 rural	−0.29	−0.28	−0.24	−0.75	−0.71	−0.78	0.76	0.80	0.59	0.94	1.00					
(12) Energy Poverty2 urban	−0.18	−0.17	−0.14	−0.80	−0.78	−0.79	0.83	0.79	0.74	0.94	0.81	1.00				
(13) Inflation	−0.00	0.01	0.03	−0.06	−0.08	−0.06	−0.01	0.00	−0.03	0.05	0.05	0.05	1.00			
(14) ICT	−0.17	−0.10	−0.22	−0.41	−0.41	−0.40	0.45	0.43	0.38	0.43	0.40	0.38	−0.10	1.00		
(15) Trade	0.01	0.01	0.03	−0.32	−0.34	−0.32	0.19	0.16	0.15	0.21	0.20	0.26	0.10	0.10	1.00	
(16) GDPpc	−0.31	−0.28	−0.24	−0.64	−0.61	−0.64	0.59	0.54	0.47	0.66	0.60	0.57	0.00	0.45	0.11	1.00

Source: Authors' construction.