

# Exploring the Impact of Democratic Consolidation and Women's Political Participation in Alleviating Energy Poverty

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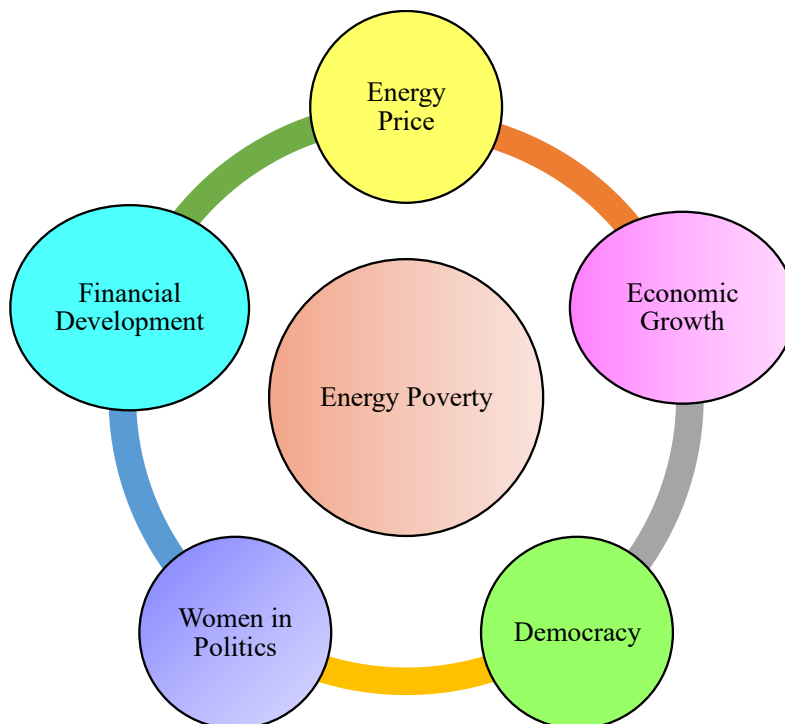
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## Abstract

Tackling energy poverty contributes to attaining Sustainable Development Goal 7, which seeks to provide universal access to cheap, dependable, eco-friendly energy by 2030. The present study examines drivers of energy poverty in South Africa using data from Q1 1997 to Q4 2021 to explore the association. The study employs nonlinear ARDL (NARDL), revealing that democracy and financial development exhibit significant positive long-run effects on energy poverty, while the short-run impacts demonstrate mixed asymmetries, with democracy showing a weaker negative effect. Economic growth and women's political representation reduce energy poverty in the long run, emphasizing their pivotal roles in promoting equitable energy access and fostering sustainable communities. Conversely, energy prices have a strong positive long-run effect, exacerbating energy poverty. Although price reductions alleviate

poverty significantly, short-run effects show smaller but consistent dynamics. In alignment with the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy) and SDG 5 (Gender Equality), policymakers should prioritize enhancing women's political representation and promoting inclusive financial development to ensure equitable energy access, reduce energy poverty and support sustainable socioeconomic development.

### Graphical Abstract



**Keywords:** Energy poverty, women in politics, energy price, democracy, financial development

**JEL Classification:** O13, O16, I32, Q48

## 1. Introduction

Women's participation in political decision-making, which is a human right, remains limited globally, and this underrepresentation hinders the achievement of equitable and inclusive policies, particularly in areas critical to sustainable development. Despite the progress in fostering gender equality, women still face substantial blockades to full participation in political leadership and decision-making processes. Although women hold around

46% of parliamentary seats in South Africa, their influence in key decision-making roles often remains constrained by societal norms and institutional barriers (Inter-Parliamentary Union, 2021). This limitation not only undermines SDG 5, which aims to achieve gender equality and empower all women and girls, but also affects the broader agenda of sustainable development, including SDG 16 on justice, peace and strong institutions and SDG 10 on reducing inequalities (Acheampong *et al.*, 2024b; Adebayo and Özkan, 2024). The underrepresentation of women in decision-making roles can result in the exclusion of gender-sensitive perspectives that are crucial for addressing issues such as health, education, poverty and climate change. In South Africa, while strides have been made towards gender parity in politics, the depth of women's involvement in high-level decision-making remains a challenge, reflecting a need for more robust policies and actions to empower women in all levels of governance.

Women are often considered to bear the most significant repercussions of energy poverty (Winther *et al.*, 2018). Women in developing countries are primarily responsible for most household duties. Compared to boys and men, girls and women have a distinct pattern in which they consume, acquire and are affected by energy (Nguyen and Su, 2021). In rural areas, gathering and searching for traditional energy sources where most people do not have access to modern energy services is the duty of women and girls (Rustagi *et al.*, 2024). To access traditional biomass for household energy, women use significant physical strength with essential tools and sometimes animals.

Given that in some societies, women often assume the responsibility of running the household, including caring for the children and preparing meals for the family, they bear a disproportionate share of the energy-related tasks inside the family. Managing the house in this manner requires much more women's time when there is a dearth of modern energy services. Rao *et al.* (2022) asserted that access to modern energy sources facilitates efficient drying, heating, refrigeration and cooking. The unequal burden placed on women compared to males in some civilizations when it comes to supplying energy for the home is considered a significant contributing factor to the disparity in women's political participation. Furthermore, women in such societies experience substantial discrimination, resulting in increased economic impoverishment and unequal opportunities for social and economic advancement.

The motivation for this study stems from the observation that women tend to be more eco-friendly than men and are disproportionately affected by energy poverty. It raises a compelling research question: How does the involvement of women in politics influence energy poverty? Addressing this question is crucial, as it examines a relatively underexplored

dimension in the literature – the role of women in politics in alleviating energy poverty. Using South Africa as a case study, this research delves into the impact of women’s political participation on energy access and affordability. Women’s involvement in governance and decision-making is pivotal for achieving the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy) and SDG 5 (Gender Equality). Their participation in shaping energy policies is critical to ensuring equitable and sustainable solutions to energy poverty. Since energy-related issues are inherently linked to governance and policy frameworks, politics is paramount in effectively addressing these challenges. Governments act as regulatory authorities for the energy sector and political commitment is essential for managing both the demand and supply sides of energy. By investigating this link, the study contributes to a deeper understanding of the intersection between governance, gender and energy equity.

The study contributes to ongoing literature in several ways. Firstly, after careful evaluation of the literature, Rustagi *et al.* (2024) is the closest to this study. Nonetheless, Rustagi *et al.* (2024) does not consider financial development as a determinant of energy poverty. Financial development, especially for the less privileged members of society, simplifies the processes involved in making financial decisions, removes obstacles to financial services and reduces energy poverty. Secondly, this is the first study to explore the role of women in politics in South Africa. Thirdly, prior studies in this line, including Opoku *et al.* (2021) and Rustagi *et al.* (2024), did not consider the nonlinear attributes of the series; thus, we employ nonlinear ARDL to explore the positive and negative effects.

The rest of the paper is organized as follows: Section 2 presents the literature review and the gap in the literature. Section 3 highlights the data sources and proposed methods. Section 4 showcases the results, and Section 5 concludes the study.

## 2. Literature Review

When individuals cannot afford or depend on modern energy services, their quality of life and ability to build their economies are impaired. This phenomenon is called energy poverty (ENP). Regarding this discourse, studies have been conducted with inconclusive results. For instance, Nguyen and Su (2021) examined 51 developing countries from 2002 to 2017 using the GMM method to explain the drivers of ENP. Their outcomes showed that reducing ENP appears to increase employment opportunities for women.

Additionally, a reduction in ENP was found to rebalance gender inequality in health indicators. Rao *et al.* (2022) studied the N11 countries using recent econometric approaches to define how ENP was affected from 2001 to 2017. Their findings revealed a significant

decline in ENP in countries such as Bangladesh (0.65) and Pakistan (0.47). Furthermore, a decrease in ENP was also observed in South Korea. Li *et al.* (2021) analysed the nexus between access to electricity and economic growth (EG) and employed yearly data from 1990 to 2017. They studied 50 developing countries and employed techniques using the GMM approach, to conclude that access to electricity intensifies economic growth.

Furthermore, Awan *et al.* (2022) inquired into how the case of Pakistan influences energy poverty. The investigators used data from 1998–2019 and discovered that the decline in ENP is attributed to the spike in economic growth. Besides, their study disclosed that the increase in ENP is attributed to a decline in education. Furthermore, Sen *et al.* (2023) used a multilevel regression model to explore determinants of ENP alleviation, with the results affirming that the surge in ENP is credited to an upsurge in financial inclusion. Based on yearly data between 2005 and 2016, Murshed and Ozturk (2023) found that improvements in energy efficiency, FD and REC lessen electricity inaccessibility in Africa, reducing ENP. On the other hand, evidence suggests that higher population growth and positive oil price shocks exacerbate ENP by increasing rates of power inaccessibility over time.

Ulussever *et al.* (2023) examined the impact of economic and energy variables in GCC countries from 2000 to 2021 monthly. The study revealed that economic growth exacerbates energy poverty by increasing energy demand disproportionately, intensifying access inequality. Conversely, higher energy prices reduce energy poverty in the long term through incentivizing energy efficiency and investments in renewable technologies. Furthermore, Kılıç Depren *et al.* (2022) explored the electricity price volatility and its impact on economic activities in Turkey's contingent and non-contingent periods. The study revealed that the economic shock experienced during the COVID-19 pandemic amplifies the unpredictability of electricity prices, increasing energy poverty among vulnerable populations due to declining affordability. These studies highlight a dual challenge of balancing short-term affordability with long-term sustainability to alleviate energy poverty.

Sen *et al.* (2023) investigated the connection between ENP and remittances. Their study, based in Bangladesh, used the GMM to find that families receiving remittances had a much lower rate of ENP. Their conclusion supports the idea that an upsurge in remittance lessens ENP. Djeunankan *et al.* (2024) looked at the link between ENP and industrialization using data from 44 African countries and employing a two-stage GMM approach. The study used a mediation approach that revealed easing ENP to help African states industrialize via FD and HC channels. Similarly, Khan *et al.* (2023) examined the BRICS countries from 2004 to 2019 using the CS-ARDL approach. Their findings revealed that ENP is most affected by energy expenditures, HC, EG and FD in these countries.

In recent times, several studies have explored the role of women in politics (WP) in relation to ENP and access to electricity. For instance, regarding the role of WP in energy poverty, Salamon (2023) explored its influence on ENP using data for 100 democracies from 1997 to 2017 using recent panel estimators for middle-income states, concluding that women's parliamentary participation is crucial in curbing ENP in the selected countries since women's parliamentary participation highlights energy consciousness. Acheampong *et al.* (2024a) inspected how energy poverty is influenced by gender equality. The study used 2000 to 2021 and a panel of 98 countries. The authors employed the GMM estimators, with the results dictating that access to clean cooking fuels and technologies is associated with an enhancement in gender parity.

Similarly, Acheampong *et al.* (2024b) also looked at the role of women in politics in relation to improved electrification inequality and access to electricity. The study used data from 2000 to 2020 and a sample of 111 countries. The research found that countries that implemented gender quotas had better rates of access to energy and more equal power accessibility compared to those that did not. Moreover, equitable access to electricity between rural and urban areas is associated with a notable rise in the number of women serving in parliament. In a recent study by Anser *et al.* (2024), WP was found to be an effective instrument in promoting access to electricity in Nigeria, using data from 1997 to 2021.

## 2.1 Literature gap

Critical research gaps persist despite the extensive literature on energy poverty (ENP) and its determinants. While previous studies have examined the roles of economic growth, financial development, remittances and energy efficiency in alleviating ENP, many have failed to account for time-varying and nonlinear relationships that could offer deeper insights into the dynamics of ENP across different contexts. For instance, although gender equality and the role of women in politics (WP) have been explored, most findings are limited to linear impacts, overlooking potential nonlinearities and asymmetries that may provide a more thorough understanding. Moreover, while methods such as GMM and CS-ARDL are frequently employed to capture cross-sectional and panel variations, there is a notable underutilization of advanced techniques such as nonlinear ARDL (NARDL), which can effectively capture the asymmetric effects of positive and negative shifts in independent variables on ENP. Additionally, the literature lacks studies focused on South Africa, a country facing unique energy challenges, underscoring the need for further investigation to address this geographical gap.

### 3. Methods

#### 3.1 Data variables

This section provides information about the selected variables. The dependent variable for this study is energy poverty, while the independent variables are democracy, economic growth, energy price, financial development and women’s participation in politics. The study covers the period from 1997 to 2022. All other data are annual except energy price data, which are available monthly. We apply the natural logarithm to all data to conform to normal distribution and reduce heteroscedasticity.

Additionally, due to limited data availability, we transform annual data into quarterly data. Consequently, we utilize data from Q1 1997 to Q4 2022 to investigate the drivers of energy poverty. Table 1 presents the symbols for variables, the measurement units and the sources of the variables studied.

**Table 1: Measurement units, sources and variables**

Symbol	Variable	Measurement unit	Source
<i>DEM</i>	Democracy	Degree to which political leaders are picked via inclusive rights to vote in free and fair elections while ensuring that freedoms of association and speech are protected. It ranges from 0 to 1 (most democratic).	Global Change Data Lab (2024)
<i>EG</i>	Economic growth	GDP per capita constant US\$ 2015	WB (2024)
<i>ENP</i>	Energy poverty	Access to electricity (% of population)	WB (2024)
<i>EP</i>	Energy price	US\$	FRED (2024)
<i>FD</i>	Financial development	Domestic credit to private sector by banks (% of GDP)	WB (2024)
<i>WP</i>	Women in politics	Proportion of seats held by women in national parliaments (%)	WB (2024)

Source: Authors’ own elaboration

#### 3.2 Methodology

To reflect the positive/negative shift of the independent variable on the dependent variable, we employ nonlinear autoregressive distributed lag (NARDL) suggested by Shin *et al.* (2014). The NARDL model captures both short-run and long-run asymmetric effects of in-

dependent variables on a dependent variable. It allows a separate estimation of the impact of positive and negative changes in the explanatory variables.

The independent variable  $x_t$  is decomposed into two components:  $x_t^+$  stands for positive changes (increases) in  $x_t$  and  $x_t^-$  for positive changes (decreases) in  $x_t$ , as follows:

$$x_t^+ = \sum_{i=1}^t \max(\Delta x_i, 0), x_t^- = \sum_{i=1}^t \min(\Delta x_i, 0) \quad (1)$$

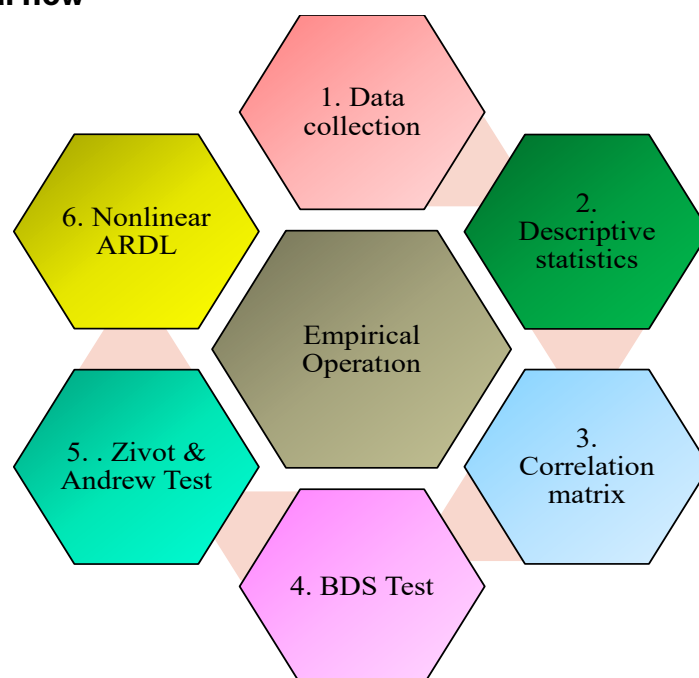
The NARDL model can then be written as:

$$y_t = \phi_0 + \phi_1 y_{t-1} + \phi_2 x_{t-1}^+ + \phi_3 x_{t-1}^- + \sum_{i=0}^p \beta_i^+ \Delta x_{t-i}^+ + \sum_{i=0}^p \beta_i^- \Delta x_{t-i}^- + \sum_{j=1}^q \gamma_j \Delta y_{t-j} + \varepsilon_t \quad (2)$$

where  $\phi_0$  is the constant term,  $\phi_1$  is the coefficient of the lagged dependent variable  $y_{t-1}$  (captures long-run effects),  $\phi_2$  is the coefficient of  $x_{t-1}^+$  (positive long-run effect),  $\phi_3$  is the coefficient of  $x_{t-1}^-$  (negative long-run effect),  $\beta_i^+$  are coefficients of lagged positive changes in  $x_t^+$  (positive short-run effects),  $\beta_i^-$  are coefficients of lagged negative changes in  $x_t^-$  (negative short-run effects),  $\gamma_j$  are the coefficients of lagged changes in  $y_t$  (short-run dynamics),  $\varepsilon_t$  is the error term, and  $p$  and  $q$  are the maximum lags of  $x_t$  and  $y_t$  respectively.

The long-run effects of  $x_t^+$  and  $x_t^-$  are given by:

- 1) Positive long-run effect:  $\frac{-\phi_2}{\phi_1}$
- 2) Negative long-run effect:  $\frac{-\phi_3}{\phi_1}$

**Figure 1: Empirical flow**

Source: Authors' own elaboration

## 4. Empirical Results and Discussion

This section discusses the empirical findings of the study. It begins with descriptive statistics and progresses to the correlation matrix, the QQ plots, the nonlinearity test and nonlinear ARDL.

**Table 2: Descriptive statistics**

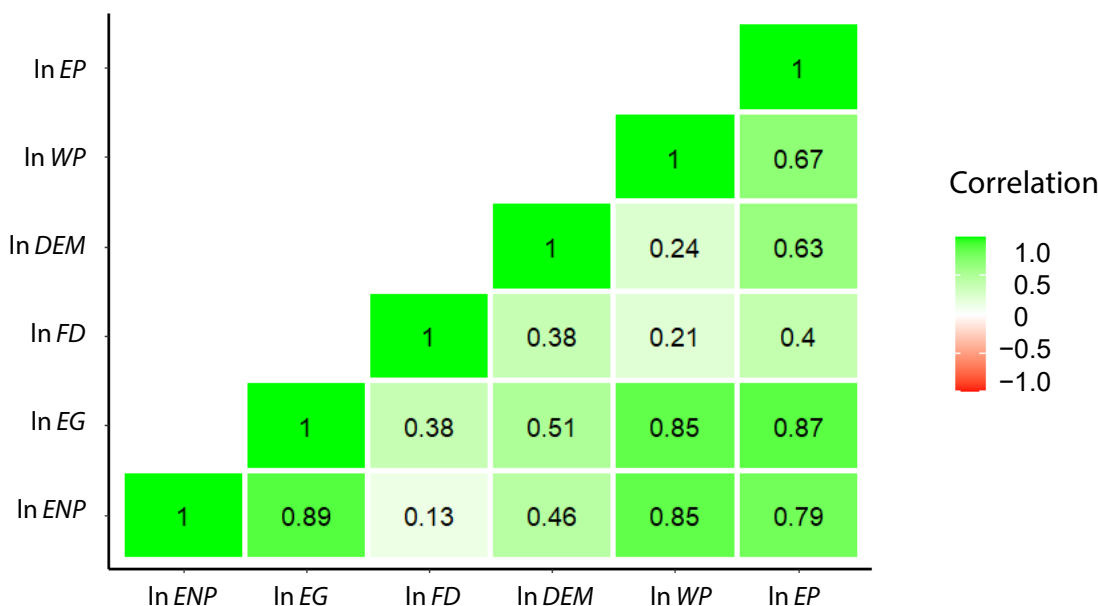
	<i>DEM</i>	<i>EG</i>	<i>ENP</i>	<i>EP</i>	<i>FD</i>	<i>WP</i>
<b>Mean</b>	0.7413	5663.27	81.052	57.3954	61.034	37.667
<b>Median</b>	0.7472	5962.03	82.695	56.5906	60.814	41.658
<b>Maximum</b>	0.7748	6271.51	90.628	123.775	70.916	46.998
<b>Minimum</b>	0.6548	4526.96	64.440	12.9337	48.382	23.046
<b>Std. dev.</b>	0.0312	614.92	6.4738	28.1244	4.5372	6.9310
<b>Skewness</b>	-1.1850	-0.7304	-0.9475	0.2897	-0.0439	-0.1861
<b>Kurtosis</b>	3.8483	1.9377	3.1577	2.0815	3.5544	1.5182
<b>Jarque-Bera</b>	27.457***	14.138***	15.670***	5.1111*	1.3653	10.115***
<b>Probability</b>	0.0000	0.0009	0.0004	0.0776	0.5053	0.0064

Note: \*\*\*, \* denote statistical significance at the 1%, and 10% levels, respectively.

Source: Authors' own calculations

Table 2 displays the statistical information on the data. The value of the mean shows that *DEM* (0.7413) has a negative trend, while *EG* (5663.27), *ENP* (81.052), *EP* (57.395), *FD* (61.034) and *WP* (37.667) have a positive trend. The skewness value shows that *DEM*, *EG*, *ENP*, *EP*, *FD* and *WP* are skewed positively, suggesting that their distributions are skewed to the right, with a longer tail on the right side. The standard deviation value shows that *EP* has the highest SD, with *DEM* having the lowest SD. It demonstrates that *EP* is highly volatile while *DEM* is less volatile. The kurtosis results indicate that *DEM*, *ENP* and *FD* exhibit leptokurtic distributions ( $> 3$ ), meaning that they have higher peaks and larger tails than a normal distribution. It suggests that these variables experience frequent extreme values or outliers, reflecting greater risk and uncertainty. On the other hand, the kurtosis values of *EG*, *FD* and *WP* are less than 3, indicating that these variables have a platykurtic distribution characterized by a flatter peak and thinner tails compared to a normal distribution. The result of the JB refutes the null hypothesis of normal distribution for all the variables except *FD*.

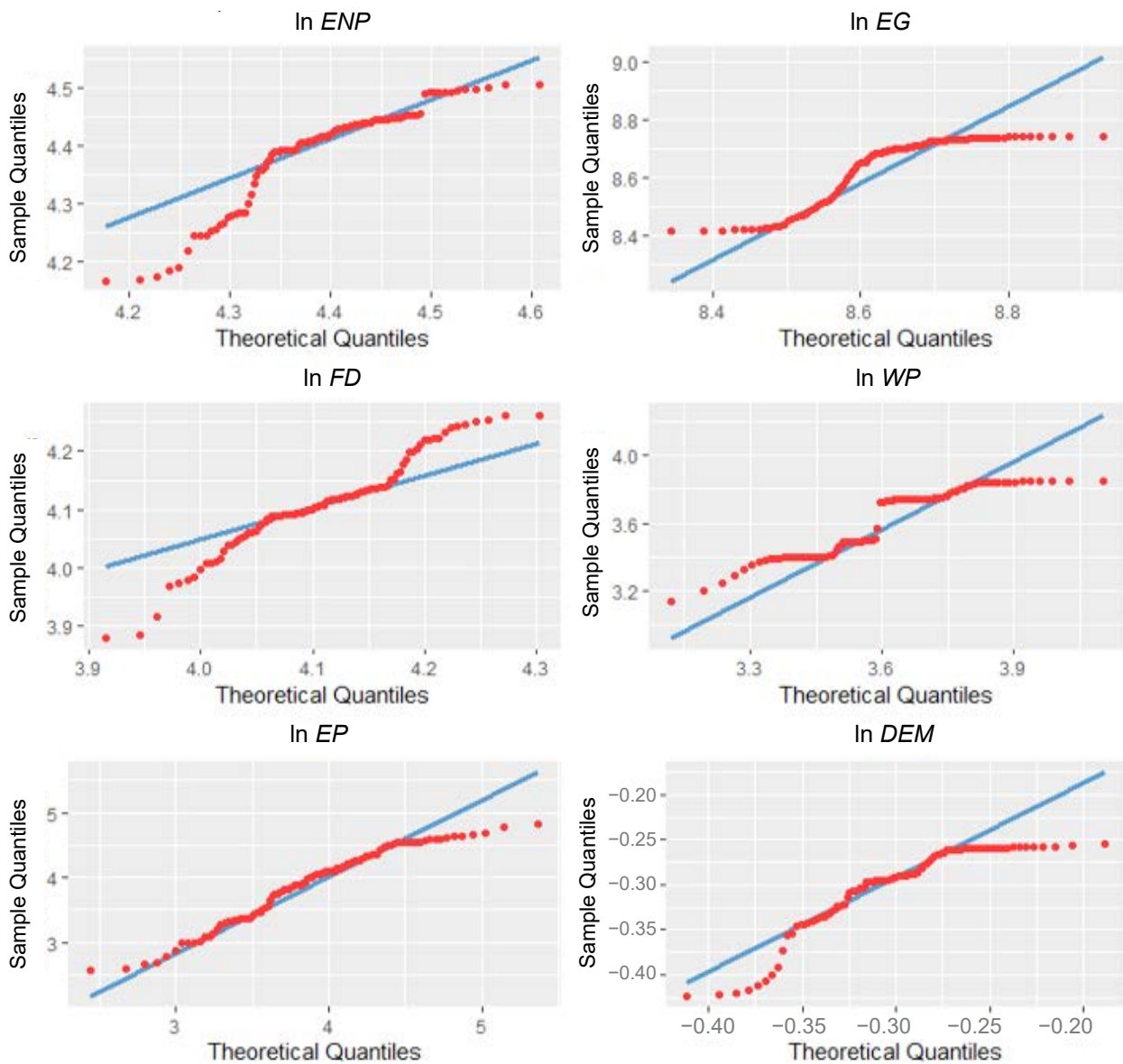
**Figure 2: Correlation matrix**



Source: Authors’ own elaboration

Figure 2 illustrates the correlation matrix. The results show that all the variables (ln *WP*, ln *EP*, ln *EG* and ln *DEM*) have a positive correlation with ln *ENP* except ln *FD*, which has a weak positive correlation.

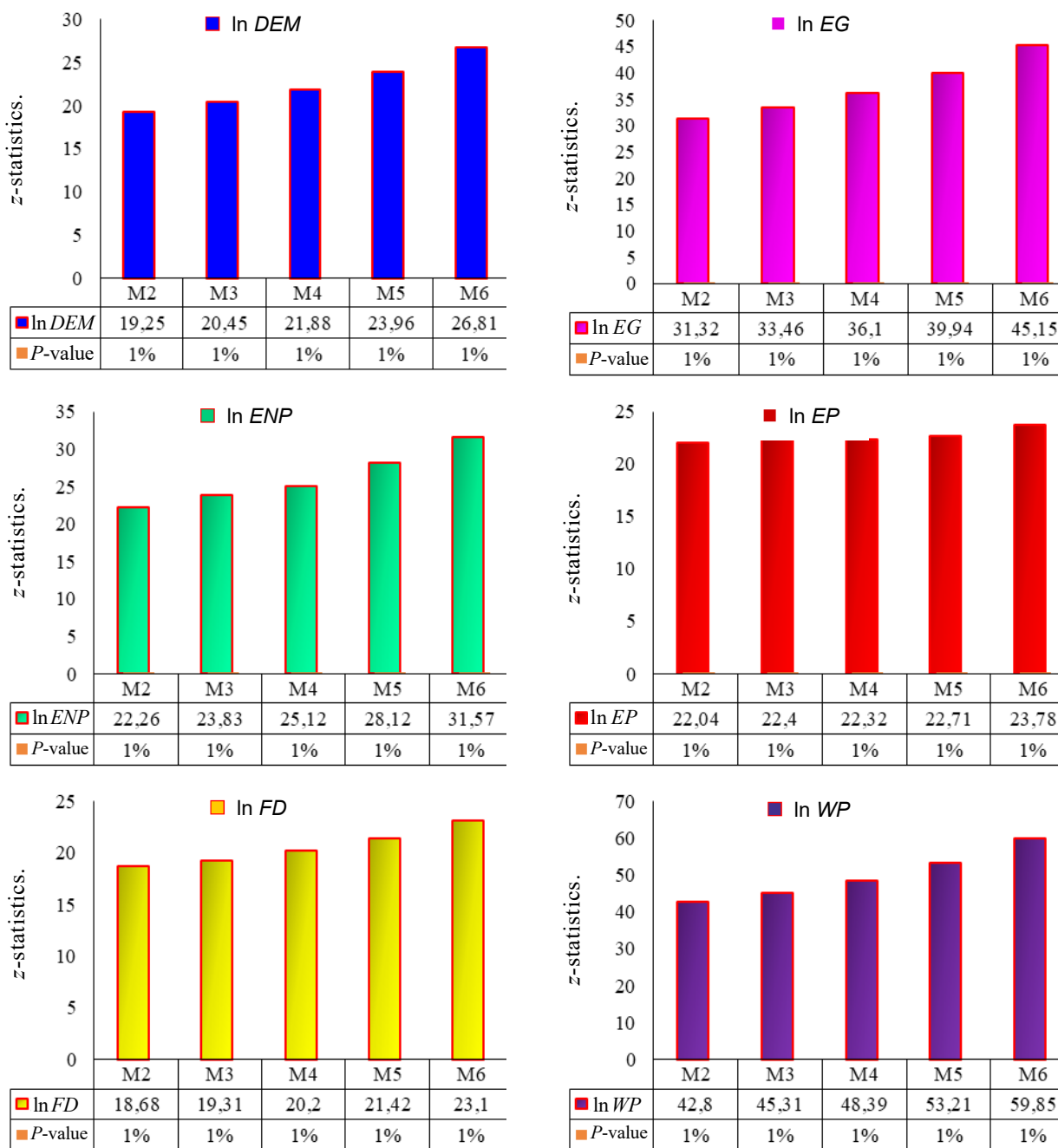
**Figure 3: QQ plot results**



Source: Authors’ own elaboration

We scrutinized the normal distribution of the studied series using a QQ plot, with the results displayed in Figure 3 above. The QQ plot reveals that none of the variables align along a straight line, confirming the non-normal distribution of the variables. These results are consistent with the kurtosis, skewness and the Jarque–Bera test findings.

**Figure 4: BDS test results**



Source: Authors' own elaboration

We began the main estimation by examining the nonlinear attributes of the series. The BDS test, proposed by Broock *et al.* (1996), was employed to evaluate the nonlinear characteristics of *DEM*, *EG*, *ENP*, *EP*, *WP* and *FD*. Figure 4 presents the findings of the BDS test. The null hypothesis of linearity is rejected at 1% for each dimension (M2–M6) for all the variables. Results of various statistical tests, including skewness, kurtosis, Jarque–Bera

and BDS, confirmed the non-normal distribution and nonlinear attributes of the variables. Consequently, using linear approaches would not be effective in this investigation. Therefore, we applied NARDL approaches for the analysis.

We also examined the stationarity properties of the series using the Zivot and Andrews (1992) test, which accounts for potential structural breaks in the data. The results (see Table 3) indicate that all the series are non-stationary at their levels but achieve stationarity after first differencing, confirming the presence of unit roots in the original data.

**Table 3: Zivot–Andrew test results**

Variable	Level t-statistic	Level break year	First difference t-statistic	First difference break year
<i>DEM</i>	−4.123	2005 Q1	−5.678***	2006 Q3
<i>EG</i>	−3.876	2008 Q3	−5.456**	2009 Q1
<i>ENP</i>	−3.945	2010 Q4	−5.789***	2011 Q2
<i>EP</i>	−4.067	2002 Q2	−5.678**	2003 Q1
<i>FD</i>	−3.789	2007 Q4	−5.345**	2008 Q2
<i>WP</i>	−3.912	2011 Q3	−5.601**	2012 Q4

Note: \*\*\*, \*\* denote statistical significance at 1% and 5% levels, respectively.

Source: Authors' own calculations

Table 4 presents the NARDL bounds test results, indicating cointegration between the dependent and independent variables, as demonstrated by the significant *F*-statistics at the 1% significance level.

**Table 4: NARDL bounds test results**

<i>F</i> -statistic	CV bounds (5%)		Decision
	Lower bound	Upper bound	
6.647***	3.79	4.87	Reject null

Note: \*\*\* denotes statistical significance at 1% level.

Source: Authors' own calculations

Table 4 presents the results of a nonlinear autoregressive distributed lag (NARDL) analysis with energy poverty as the dependent variable. The independent variables include democracy, economic growth, energy prices, financial development and women in politics. The error correction term (ECT) captures the speed of adjustment towards equilibrium in the long run. The significance levels indicate the robustness of the relationships. The analysis decomposes effects into positive and negative long-run changes and short-run dynamics.

Democracy has a significant positive long-run effect and a weaker negative effect. In the short run, positive changes increase energy poverty, while negative changes reduce it. This result suggests that while democracy can foster inclusive policies addressing energy poverty, it may also introduce inefficiencies in resource allocation due to political complexity. The dual role of democracy in addressing energy poverty reflects its complex nature. The significant positive long-run effect suggests that democratic governance promotes policies to expand energy access, often prioritizing inclusivity and equity (Acheampong *et al.*, 2022). However, the weaker negative effect and the short-run inefficiencies likely stem from political complexities and resource mismanagement inherent in democratic systems. For instance, fragmented decision-making and competing interests can delay energy reforms or lead to suboptimal allocation of resources (Acheampong *et al.*, 2024a). While democracy fosters broad-based initiatives, its implementation challenges, particularly in developing countries, often result in inefficiencies that exacerbate energy poverty in the short term.

Economic growth has a negative long-run impact, indicating that growth reduces energy poverty. However, the negative long-run effect is weaker. Short-run effects are smaller but consistent. The negative long-run impact of economic growth on energy poverty highlights the transformative role of sustained growth in improving infrastructure and energy accessibility. As economies expand, investments in modern energy infrastructure increase, reducing reliance on traditional energy sources and alleviating energy poverty (Koomson and Danquah, 2021). However, the weaker negative effect in the long run and smaller short-run impacts point to the uneven distribution of growth benefits, where marginalized communities might not experience immediate improvements (Banerjee *et al.*, 2021; Dong *et al.*, 2022). The study emphasizes that rapid economic growth often widens income inequalities, leaving vulnerable populations unable to afford modern energy services.

Energy prices exhibit a strong positive long-run effect and a significant negative effect. In the short run, positive changes increase energy poverty, while negative changes reduce it significantly. Energy prices play a crucial role, with a strong positive long-run effect and a significant negative effect in both the long and short runs. Rising energy prices increase

energy poverty by reducing affordability, disproportionately affecting low-income households. This finding aligns with Murshed and Ozturk (2023), who showed that higher energy costs exacerbate energy poverty, particularly in regions with limited subsidies. Conversely, price reductions alleviate energy poverty, as seen in the significant negative effects. However, some studies have argued that higher energy prices can drive efficiency improvements and investments in renewable energy, potentially reducing energy poverty in the long term (Awan *et al.*, 2022).

**Table 5: NARDL results**

Variable	Positive long-run	Negative long-run	Positive short-run	Negative short-run
<b>In DEM</b>	0.500***	-0.200*	0.219*	-0.150*
<b>In EG</b>	-0.353***	-0.150**	-0.120*	-0.080*
<b>In EP</b>	0.794**	-0.300**	0.300	-0.250**
<b>In FD</b>	0.400*	-0.250*	0.150*	-0.155
<b>In WP</b>	-0.250**	0.100***	-0.100	0.050***
<b>ECT</b>	-0.550***	-	-	-

Note: \*\*\*, \*\*, \* denote statistical significance at 1%, 5% and 10% levels, respectively.

Source: Authors' own calculations

Financial development positively influences energy poverty in both long and short runs. Conversely, negative financial changes have a weaker effect. The dual impact of financial development highlights its potential to enhance energy access while acknowledging its limitations. The positive effects in both the long and short runs indicate that financial systems can mobilize resources for energy infrastructure and renewable energy projects, thereby reducing energy poverty. Dong *et al.* (2022) supported this view, noting that financial inclusion enables access to credit and investment opportunities. However, the weaker negative effects suggest that financial instability or uneven development might hinder progress in certain regions. Achuo *et al.* (2024) argued that financial development often prioritizes urban or industrial energy demands, neglecting rural and marginalized populations, thereby limiting its impact on energy poverty reduction.

Women's political representation reduces energy poverty in the long run, while increases in representation affect it positively. In the short run, the positive effects and nega-

tive effects are weak. The long-run reduction in energy poverty due to women's political representation underscores the role of gender-inclusive governance in driving equitable energy policies. Women in leadership positions are more likely to advocate for policies addressing the needs of underserved communities, including energy access (Acheampong *et al.*, 2024a). However, the weaker positive effects of increased representation highlight systemic barriers, such as cultural and institutional constraints, that limit the effectiveness of these policies (Sen *et al.*, 2023). In the short run, the less pronounced effects may reflect the time required for policy implementation and the translation of political participation into tangible outcomes.

The ECT coefficient is highly significant, indicating that 55% of any disequilibrium in energy poverty is corrected within a single period. It demonstrates a rapid adjustment towards long-run equilibrium, highlighting the dynamic nature of the relationships between variables. The significant ECT aligns with the validity of the NARDL model and confirms the existence of a stable long-run relationship.

## 5. Conclusion and Policy Implications

### 5.1 Conclusion

Energy poverty is a significant global issue that affects millions of people and is characterized by the lack of reliable and affordable energy supplies. Addressing energy poverty is essential for promoting human rights, economic growth, improving living standards and ensuring environmental sustainability (Adewusi and Kocadal, 2022). Thus, the present study examined how energy prices, women in politics, democracy and financial development affected South Africa's energy poverty from Q1 1997 to Q4 2021. In doing so, the study employed nonlinear ARDL (NARDL). The NARDL results reveal that democracy and financial development exhibit significant positive long-run effects on energy poverty, while their short-run impacts demonstrate mixed asymmetries, with democracy showing a weaker negative effect (Adebayo and Özkan, 2024). Economic growth and women's political representation reduce energy poverty in the long run, highlighting their roles in driving equitable energy access. Energy prices have a strong positive long-run effect, exacerbating energy poverty, but price reductions alleviate it significantly, with short-run effects showing smaller but consistent dynamics. The ECT confirms a stable long-run equilibrium, with deviations correcting rapidly at a significant rate.

## 5.2 Policy implications

Based on the findings, South African governments and policymakers should implement targeted measures to address energy poverty across different periods.

The potential of democracy to foster inclusive energy policies can be further strengthened by improving the efficiency of governance systems, aligning with SDG 16 (Peace, Justice and Strong Institutions). Simplifying bureaucratic processes, fostering collaboration among political stakeholders and reducing resource mismanagement can optimize the benefits of democratic reforms. Policymakers should prioritize creating frameworks that promote transparency, accountability and equitable distribution of energy resources. Engaging communities in decision-making supports SDG 7 (Affordable and Clean Energy) by addressing local energy needs and ensuring that energy poverty reduction efforts reach vulnerable populations effectively.

The long-term ability of economic growth to alleviate energy poverty highlights the importance of sustained and inclusive development, which directly contributes to SDG 8 (Decent Work and Economic Growth) and SDG 10 (Reduced Inequalities). Governments should direct growth-related investments towards underserved regions to ensure equitable energy infrastructure expansion. Encouraging public-private partnerships can bridge gaps in energy access by leveraging private capital for public benefit. At the same time, targeted subsidies and financial assistance for low-income households can translate economic growth into tangible improvements in energy affordability and accessibility for marginalized communities, addressing SDG 1 (No Poverty).

Given the critical role of energy prices in shaping energy poverty, stabilizing energy markets should be a policy priority in alignment with SDG 7 (Affordable and Clean Energy). Implementing targeted interventions, such as subsidies or direct financial assistance, can protect low-income households from the adverse effects of energy price volatility. Investing in renewable energy technologies can reduce reliance on fluctuating fossil fuel prices and lower long-term energy costs, supporting SDG 13 (Climate Action). Additionally, promoting energy efficiency measures, such as subsidized energy-saving appliances and consumer education, can mitigate the impact of high energy prices on vulnerable populations.

Financial systems must be leveraged to facilitate energy access for underserved communities, contributing to SDG 9 (Industry, Innovation and Infrastructure). Expanding financial inclusion through affordable credit schemes and microfinance options can support renewable energy adoption in rural areas. Policymakers should design regulatory frameworks that ensure financial development benefits disadvantaged populations, addressing SDG 10 (Reduced Inequalities). Moreover, increasing women's political representation aligns with

SDG 5 (Gender Equality) and can lead to policies that address energy equity, particularly for marginalized groups. Supporting women leaders through capacity-building initiatives and addressing systemic barriers to their participation in governance amplifies their role in reducing energy poverty and fostering progress towards SDG 7 (Affordable and Clean Energy).

### 5.3 Limitations and future studies

Similar to other studies, this investigation is not without limitations. Firstly, it omitted key variables such as climate policy uncertainty, income inequality and political globalization, which are critical in shaping energy poverty dynamics. Future research should integrate these variables to provide a more comprehensive analysis. Secondly, this study focused solely on the positive and negative shifts of the variables using the NARDL approach, overlooking the time-varying associations between variables. Future investigations should employ advanced techniques such as wavelet or quantile-based models to capture relationships across scales and quantiles. Lastly, there are challenges with the generalizability of the policy recommendations, as they may not apply fully to varying socioeconomic and political contexts. Future studies should replicate and adapt similar analyses for both developed and developing countries to ensure broader applicability of the findings.

### List of abbreviations

ADF	Augmented Dickey–Fuller
PP	Phillip–Perron
SDG	Sustainable Development Goals
GMM	General method of moments
ENP	Energy poverty
FD	Financial development
BDT	Brock, Dechert and Scheinkman test
REC	Renewable energy consumption
QQ	Quantiles plot
DEM	Democracy
EG	Economic growth
EP	Energy price
SD	Standard deviation
BRICS	Brazil, Russia, India, China, South Africa

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