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Renewable Energy, Electricity Access, and Oil-Shock Resilience in Africa: Evidence of Complex Resilience Effects from the Iran War Shock

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Abstract

This study examines the relationship between renewable-energy share, electricity access, and domestic oil-shock resilience in Africa using a monthly panel of 20 countries. Building on earlier evidence that the Iran war shock increased domestic fuel-price and inflation stress while higher renewable-energy shares reduced vulnerability, the analysis tests whether electricity access conditions the resilience effect of renewable energy. The results show that the Iran war shock significantly increased both fuel-price and inflation stress across the sample. Renewable-energy share and electricity access each display shock-buffering effects, although the electricity-access effect is stronger and more robust, especially in the inflation models. However, the findings do not support the expectation that electricity access strengthens the resilience effect of renewable-energy share. Instead, the interaction estimates indicate that the negative effect of renewable share weakens as electricity access rises. Conditional-effect analysis confirms that renewable share exerts its strongest protective effect at lower levels of access, with the effect fading at higher levels. The findings therefore suggest that renewable energy and electricity access function as complementary but non-reinforcing resilience channels. These patterns remain broadly consistent in the dynamic fixed-effects and system GMM robustness checks for the inflation equation. The study contributes to the African energy-security literature by showing that the relationship between renewable penetration, access, and shock resilience is more complex than a simple amplification framework would suggest.

Keywords: Renewable energy; electricity access; oil-shock resilience; Africa; fuel-price stress; inflation stress; panel data; energy security

1. Introduction

Africa's continued exposure to external oil disruptions remains a major source of domestic macroeconomic stress. Geopolitical shocks in international energy markets do not remain external for long; they are quickly transmitted into domestic fuel prices, inflationary pressure, fiscal strain, and broader welfare losses across many African economies. This vulnerability is especially important in countries where petroleum dependence remains structurally high and where domestic resilience mechanisms are still limited.

Recent evidence already shows that the Iran war shock significantly increased domestic fuel-price and inflation stress across African countries, while the severity of the pass-through was shaped by structural energy conditions. In particular, Nyang et al. (2026) show that countries with greater net energy import dependence were more exposed to the shock, whereas countries with higher renewable-energy shares experienced weaker domestic stress. While Nyang et al. (2026) established that renewable-energy share reduced the domestic severity of the Iran war shock, the question of whether this resilience depends on electricity access remains unexplored. That contribution established the importance of renewable energy as a resilience factor, but it also opened a further question that is even more relevant for current policy: does renewable energy provide stronger domestic protection when electricity access is broader?

This question is timely because African energy policy is no longer focused only on expanding generation capacity. It is increasingly concerned with access, affordability, resilience, and economic transformation. In this context, renewable-energy share may reflect the potential for domestic resilience, but electricity access may determine the extent to which that resilience is actually transmitted to households, firms, and productive sectors. The present study therefore extends Nyang et al. (2026) by moving beyond the question of whether renewable energy matters for resilience and examining whether its protective effect depends on the breadth of electricity access across African economies.

This changing policy context also alters how renewable energy should be understood. A growing body of recent work argues that renewable energy can reduce energy insecurity by lowering dependence on imported fossil fuels and by diversifying domestic energy systems. At the same time, this literature increasingly emphasizes that renewable deployment does not automatically translate into broad-based protection unless it is linked to actual electricity delivery and system integration. Nchofoung (2024) shows that oil-price shocks adversely affect Africa's energy transition, underscoring how external petroleum dependence can disrupt structural energy progress. Obi et al. (2025) similarly argue that decentralized renewable systems are important not only for sustainability, but also for equitable access and resilience in sub-Saharan Africa. Lemaire (2025) further shows that expanding renewable electricity in sub-Saharan Africa could support growth and development, while IRENA (2025) notes that renewable investment in Africa has been highly concentrated in countries where electricity access was already relatively stronger. Taken together, these studies suggest that renewable-energy potential and renewable-energy protection are not the same thing.

This distinction is analytically important. A country may have a relatively high renewable-electricity share in its national energy mix, but if a large portion of households, firms, farms, and public services remain outside the electricity system, then the macroeconomic protection offered by that renewable base may be limited. Put differently, renewable energy may provide potential resilience, while electricity access determines the extent to which that resilience is transmitted into the wider economy. This is the key proposition of the present study. In a shock environment, renewable energy is likely to dampen domestic stress more effectively where electricity access is broader, because more of the economy can rely on domestic power systems

rather than imported petroleum-based energy use. Recent policy and market developments reinforce this logic. The IEA notes that distributed solar and off-grid applications are becoming increasingly important for expanding electricity access, particularly where grids are weak, while Mission 300 places strong emphasis on both grid and off-grid solutions as part of Africa's electrification strategy (IEA, 2025; World Bank, 2026a).

Against this background, the present study examines whether electricity access conditions the resilience effect of renewable energy in African economies during the Iran war shock. Using the monthly panel dataset from April 2023 to March 2026, the study investigates whether countries with stronger renewable-energy shares were better protected from fuel-price and inflation stress, and whether that protective effect was stronger in countries with wider electricity access. This approach retains the original shock framework but opens the black box of renewable resilience by asking whether renewable-energy presence alone is sufficient, or whether access is the mechanism that converts renewable capacity into broader domestic protection.

The study makes three contributions. First, it extends the earlier oil-shock resilience analysis by moving from the question of whether renewables matter to the more policy-relevant question of when they matter most. Second, it contributes to the African energy-security literature by treating electricity access not merely as a development outcome, but as a structural condition that shapes the domestic pass-through of external energy shocks. Third, it contributes to current policy debates by linking renewable energy, electricity access, and macroeconomic resilience in a way that speaks directly to Mission 300, decentralized renewable deployment, and the broader challenge of insulating African economies from imported fossil-fuel volatility (World Bank, 2025, 2026a, 2026b; Obi et al., 2025; IRENA, 2025).

The central question of the paper is whether renewable energy provides stronger oil-shock resilience where electricity access is broader. Rather than assuming that this relationship is straightforward, the study tests whether renewable-energy share and electricity access operate as reinforcing or more complex resilience channels in African economies during the Iran war shock.

2. Literature Review

2.1 External Oil Shocks and Domestic Energy Vulnerability

The literature on energy security increasingly treats vulnerability as a multidimensional issue involving not only energy availability, but also affordability, reliability, diversification, and exposure to external political and price shocks. In this perspective, countries that depend heavily on imported fossil fuels are structurally more exposed to international energy disruptions than countries with more diversified or domestically anchored energy systems. Recent work on sub-Saharan Africa reinforces this point. Cai et al. (2024), in an IMF Staff Climate Note, argue that the region's electricity gap and continued reliance on traditional and imported energy sources create major economic vulnerabilities and constrain broader development. Nchofoung (2024) similarly shows that oil price shocks adversely affect Africa's energy transition, suggesting that external petroleum volatility is not only a short-run macroeconomic problem, but also a structural barrier to long-run energy transformation. Recent global evidence likewise indicates that geopolitical tensions and energy insecurity have stronger negative economic effects in emerging and developing economies, especially where external dependence is high (Cai et al., 2024; Nchofoung, 2024).

This broader framework is directly relevant to African oil-shock transmission. In the study Nyang et al. (2026) demonstrated that the Iran war shock significantly increased domestic fuel-price and inflation stress across African economies and that countries with greater net energy import

dependence were more adversely affected. This study builds on that result by asking whether the domestic transmission of such shocks depends not only on fossil-fuel exposure, but also on the extent to which alternative domestic electricity systems are accessible to the wider economy. On this basis, the first hypothesis remains a baseline expectation for the paper:

H1: The Iran war shock increased domestic fuel-price and inflation stress across African countries.

2.2 Renewable Energy as a Resilience Mechanism

A growing recent literature argues that renewable energy should be understood not only as a decarbonisation pathway, but also as a resilience mechanism. In the African context, this argument is especially important because renewable expansion can reduce dependence on imported petroleum, improve diversification, and lower exposure to international oil-market volatility. IRENA (2024) emphasizes that Africa's renewable-energy potential is large enough to support major reductions in fossil-fuel imports while also generating development, health, and industrial benefits. Cai et al. (2024) similarly show that accelerated renewable-electricity investment in sub-Saharan Africa can raise power generation and GDP, especially when paired with reforms and climate finance. Panja (2025) further argues that Africa's renewable transition should be evaluated not only through the lens of climate goals, but also through sustainable development and resilience. Villar-Roldán et al. (2025) also show that geopolitical and economic conditions shape renewable-energy development in sub-Saharan Africa, reinforcing the idea that renewable energy is tied to broader structural resilience rather than environmental policy alone. This reasoning implies that countries with higher renewable-electricity shares should be less vulnerable to external oil shocks because a larger part of their domestic energy system is not directly tied to internationally priced fossil fuels. The paper Nyang et al. (2026) already found evidence consistent with this claim: the interaction between the shock and renewable-energy share was negative and significant in both the fuel-price and inflation models. This paper extends that insight by asking whether the resilience effect of renewables depends on the breadth of electricity access.

This leads to the second hypothesis:

H2: The adverse effects of the Iran war shock were weaker in countries with higher renewable-energy shares.

2.3 Electricity Access and the Transmission of Energy Resilience

Although renewable-energy share may indicate a country's domestic energy mix, it does not automatically tell us how much of the economy actually benefits from that energy base. This is where electricity access becomes crucial. A country may generate a meaningful share of electricity from renewable sources and yet still have large populations, firms, farms, and informal enterprises outside the effective electricity system. In such a case, the existence of renewable generation does not fully translate into broad-based macroeconomic protection. Recent policy and scholarly work increasingly support this distinction. The World Bank's *Energy Progress Report 2025* shows that access gains have continued globally but remain deeply uneven, with sub-Saharan Africa accounting for the overwhelming share of people still lacking electricity access. The IEA (2025) further estimates that achieving universal electricity access in Africa requires a major scaling up of investment in both grid and decentralized systems, emphasizing that electricity access is central to inclusive economic transformation. Obi et al. (2025) likewise argue that decentralized renewable energy systems are critical for equitable and sustainable transitions in sub-Saharan Africa because they link renewable deployment to actual access and local resilience.

This literature suggests that electricity access should be treated not only as a welfare outcome, but as a structural condition that determines whether renewable energy becomes economically meaningful at scale. If more households and productive sectors are connected to the electricity system, then domestic renewable generation should have a wider ability to reduce exposure to imported fuel costs. By contrast, where access remains weak, the resilience benefits of renewable energy may remain narrow and unevenly distributed. This interpretation is especially relevant in the context of Mission 300, which aims to connect 300 million Africans to electricity by 2030 and is backed by major commitments from the World Bank Group, the African Development Bank, and other financial institutions. Mission 300 is built around the idea that energy access is central to jobs, productivity, and economic resilience, not only to social inclusion (World Bank, 2025, 2026a, 2026b).

This leads to the third hypothesis:

H3: The adverse effects of the Iran war shock were weaker in countries with higher electricity access.

2.4 Research Gap and Hypotheses Development

Despite important advances in the literature, a clear gap remains. First, studies of African energy vulnerability often focus on oil-price shocks, structural energy insecurity, or renewable transition separately, rather than integrating them in a single shock-resilience framework. Second, the recent renewable-resilience literature increasingly argues that renewable energy supports economic security, but it says less about whether this protection depends on the extent of electricity access. Third, major current policy initiatives in Africa, including Mission 300, are built on the premise that **access** is what turns energy investment into inclusive development outcomes, yet this access channel has rarely been tested explicitly in the context of external oil shocks. In other words, the literature has established that renewables may reduce vulnerability, but it has not adequately tested whether electricity access determines how effectively renewable-energy presence translates into real domestic protection (Cai et al., 2024; Nchofoung, 2024; Obi et al., 2025; World Bank, 2025, 2026a, 2026b).

The study addresses that gap by extending the monthly African panel used and testing whether electricity access conditions the resilience effect of renewable-energy share during the Iran war shock. On that basis, the study proposes a fourth and central hypothesis:

H4: The resilience effect of renewable-energy share was stronger in countries with higher electricity access.

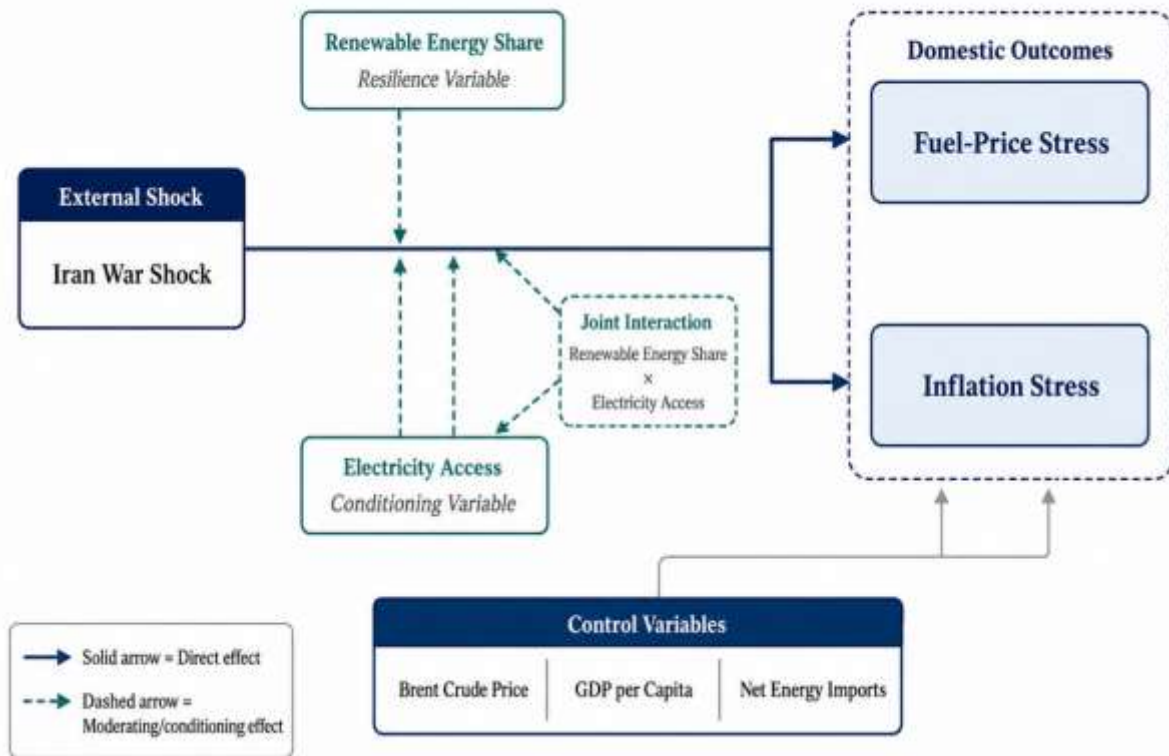
2.5 Conceptual Framework

The conceptual framework of the study is built around three linked channels: a shock channel, a renewable-resilience channel, and an access-conditioning channel. The first channel captures the direct effect of the Iran war shock on domestic fuel-price and inflation stress. The second channel captures the proposition that countries with higher renewable-energy shares are less exposed to imported oil volatility and therefore experience weaker domestic pass-through. The third channel introduces electricity access as the key condition that determines whether renewable presence translates into broad-based economic protection.

In this framework, renewable energy provides potential resilience, but electricity access determines the extent to which that resilience is economically transmitted. Where access is wider, more households, firms, and productive sectors can rely on domestic electricity systems, making renewable-energy penetration more meaningful as a buffer against fossil-fuel shocks. Where access is weaker, the macroeconomic protection offered by renewables is likely to be more limited. The conceptual framework therefore treats renewable-energy share as a potential resilience factor and electricity access as a conditioning factor, while recognizing that the

empirical relationship between the two may be reinforcing, offsetting, or otherwise more complex than the initial amplification hypothesis suggests.

Conceptual Framework



3. Methodology

3.1 Research Design

This study adopts a quantitative country–month panel-data design to examine whether electricity access conditions the resilience effect of renewable energy during the Iran war shock. The design is appropriate because the research question concerns both the time-varying impact of an external oil shock and the cross-country structural differences that shape domestic pass-through. A panel framework makes it possible to control for unobserved country-specific characteristics such as geography, inherited infrastructure, institutional quality, and long-run policy differences that may otherwise bias simpler cross-sectional estimates. In applied panel econometrics, fixed-effects and random-effects models are standard starting points for this kind of setting, while dynamic panel estimators are appropriate where persistence and endogeneity are plausible concerns (Hausman, 1978; Arellano & Bond, 1991; Blundell & Bond, 1998; Roodman, 2009).

The empirical design treats the Iran war shock as a common external disturbance that was transmitted into African economies through higher global oil prices and tighter petroleum-market conditions. The study then asks whether countries with higher renewable-energy shares, stronger electricity access, or a combination of both experienced weaker domestic fuel-price and inflation pass-through. This approach allows the analysis to move beyond average shock effects and examine the structural conditions under which renewable energy becomes more economically protective.

3.2 Data and Sample

The study uses a monthly balanced panel of 20 African countries covering the period April 2023 to March 2026. The countries included are Algeria, Botswana, Côte d'Ivoire, Egypt, Ethiopia, The Gambia, Ghana, Kenya, Malawi, Mali, Mauritania, Morocco, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Tunisia, Uganda, and Zambia. The sample provides variation across West, East, Southern, and North Africa and includes countries with differing levels of renewable-energy penetration, electricity access, and external energy dependence.

Observed fuel-price data are compiled from Global Petrol Prices, which provides monthly retail gasoline and diesel prices. Structural energy variables are drawn from the World Bank's World Development Indicators (WDI), including renewable electricity output (% of total electricity output), access to electricity (% of population), GDP per capita, and net energy imports (% of energy use). Renewable-energy capacity data from IRENA are available for auxiliary and robustness analysis, but the main resilience variable in this paper is renewable electricity share, since it is more directly tied to the domestic electricity mix. Brent crude oil prices are included as an external control to capture global oil-market conditions.

3.3 Variable Measurement

Dependent Variables

The study uses two dependent variables.

The first is fuel-price stress, measured as the average of retail gasoline and diesel prices (fuel_price_avg). This is the most direct domestic manifestation of an external oil shock because it reflects the immediate pass-through of global oil-market disruption into domestic fuel costs. The second is inflation stress, measured using the monthly inflation rate (cpi_inflation). Inflation is included because oil shocks affect African economies not only through fuel markets, but also through transport costs, food prices, exchange-rate pressure, and fiscal adjustment. These two dependent variables allow the study to assess both direct energy-market stress and broader macroeconomic transmission.

Main Explanatory Variable

The core explanatory variable is the Iran war shock dummy (shock_dummy), coded 1 from March 2026 onward and 0 before March 2026. This timing captures the period in which the geopolitical disruption became materially relevant to domestic African energy markets. The shock dummy serves as the common external stress event in the present analysis.

Resilience Variable

The principal resilience variable is renewable-energy share (renewable_share_pct), measured as renewable electricity output (% of total electricity output). Higher values indicate a larger role for renewable generation in the domestic electricity mix. In this paper, renewable share captures the extent to which a country's electricity system is less directly tied to imported fossil fuels.

Conditioning Variable

The key conditioning variable is electricity access (electricity_access_pct), measured as access to electricity (% of population). Electricity access is introduced to test whether renewable-energy share becomes more protective when a larger share of households and firms are actually connected to the electricity system. In this sense, electricity access is not treated merely as a development indicator, but as the structural channel through which renewable-energy resilience is transmitted into the wider economy.

Control Variables

The study includes the following controls:

- Brent crude oil price (brent_price_usd_bbl), capturing global oil-market conditions;

- GDP per capita (*gdp_pc_usd*), capturing differences in income level, economic structure, and fiscal capacity;
- where appropriate, net energy imports (% of energy use) may be retained as an auxiliary structural control to account for external fossil-fuel dependence.

These controls are included because the domestic effects of an external oil shock may depend not only on energy-system structure, but also on the broader global oil-price environment and countries’ economic capacity to absorb shocks.

Table 1. Variable Measurement

Variable	Symbol	Measurement	Role	Expected Sign
Fuel-price stress	<i>fuel_price_avg</i>	Average of retail gasoline and diesel prices	Main dependent variable	—
Inflation stress	<i>cpi_inflation</i>	Monthly inflation rate	Secondary dependent variable	—
Iran war shock	<i>shock_dummy</i>	1 from March 2026 onward, 0 otherwise	Main explanatory variable	+
Renewable-energy share	<i>renewable_share_pct</i>	Renewable electricity output (% of total electricity output)	Resilience variable	–
Electricity access	<i>electricity_access_pct</i>	Access to electricity (% of population)	Conditioning variable	–
Brent crude price	<i>brent_price_usd_bbl</i>	Global oil-price benchmark	Control	+
GDP per capita	<i>gdp_pc_usd</i>	GDP per capita (current US\$)	Control	±
Net energy imports	<i>net_energy_imports_pct</i>	Net energy imports (% of energy use)	Auxiliary structural control	+

3.4 Model Specification

The empirical strategy begins with a baseline shock model:

$$Y_{it} = \alpha + \beta_1 Shock_t + \beta_2 Brent_t + \beta_3 GDPpc_{it} + \mu_i + \varepsilon_{it}$$

where Y_{it} represents either fuel-price stress or inflation stress in country i at month t , $Shock_t$ is the Iran war shock dummy, $Brent_t$ is Brent crude price, $GDPpc_{it}$ is GDP per capita, μ_i captures country fixed effects, and ε_{it} is the idiosyncratic error term.

To test the direct resilience effect of renewable energy, the study estimates:

$$Y_{it} = \alpha + \beta_1 Shock_t + \beta_2 (Shock_t \times Renew_i) + \beta_3 Brent_t + \beta_4 GDPpc_{it} + \mu_i + \varepsilon_{it}$$

where $Renew_i$ denotes renewable-energy share.

To test the role of electricity access, the study estimates:

$$Y_{it} = \alpha + \beta_1 Shock_t + \beta_2 (Shock_t \times Access_i) + \beta_3 Brent_t + \beta_4 GDPpc_{it} + \mu_i + \varepsilon_{it}$$

where $Access_i$ denotes electricity access.

The main full model combines both channels:

$$Y_{it} = \alpha + \beta_1 Shock_t + \beta_2 (Shock_t \times Renew_i) + \beta_3 (Shock_t \times Access_i) + \beta_4 (Shock_t \times Renew_i \times Access_i) + \gamma X_{it} + \mu_i + \varepsilon_{it}$$

where X_{it} includes Brent crude prices, GDP per capita, and additional controls where appropriate.

The coefficient of greatest interest is the three-way interaction term ($Shock_t \times Renew_i \times Access_i$). A negative and statistically significant coefficient would indicate that renewable-energy share becomes more protective against the shock in countries where electricity access is broader.

3.5 Estimation Strategy

The analysis proceeds in stages.

First, the study presents descriptive statistics and correlation analysis to summarize the distribution of the variables and provide initial evidence on the relationships among shock exposure, renewable-energy share, electricity access, and domestic stress outcomes.

Second, the study estimates baseline fixed-effects (FE) and random-effects (RE) panel models. The FE estimator is especially important because it controls for time-invariant country-specific characteristics that may be correlated with the explanatory variables. The RE model is estimated for comparison, and the Hausman specification test is used to guide model choice (Hausman, 1978).

Third, because inflation stress may exhibit persistence over time, the analysis extends the baseline panel models using a dynamic fixed-effects specification that includes a lagged dependent variable. To further address potential dynamic panel bias and endogeneity concerns, the study also estimates a two-step system GMM model for the inflation equation. The GMM specification treats the lagged dependent variable as endogenous and instruments it using collapsed lag structures, while the shock and interaction terms are entered as standard instruments. This approach is appropriate in a short panel setting where persistence, unobserved country effects, and potential endogeneity may coexist (Arellano & Bond, 1991; Blundell & Bond, 1998; Roodman, 2009).

Standard errors are clustered at the country level to account for heteroskedasticity and serial correlation within countries. Additional diagnostics include the modified Wald test for groupwise heteroskedasticity and variance inflation factors (VIFs) in pooled specifications.

3.6 Expected Signs

The study's expectations follow directly from the hypotheses.

The coefficient on the shock dummy is expected to be positive:

$$\beta_1 > 0$$

indicating that the Iran war shock increased domestic fuel-price and inflation stress.

The interaction between the shock and renewable-energy share is expected to be negative:

$$\beta_2 < 0$$

indicating that renewable energy reduced the domestic pass-through of the shock.

The interaction between the shock and electricity access is also expected to be negative:

$$\beta_3 < 0$$

indicating that countries with broader access were better able to absorb the shock.

Most importantly, the three-way interaction is expected to be negative:

$$\beta_4 < 0$$

indicating that the resilience effect of renewable-energy share becomes stronger where electricity access is broader.

These expectations are theory-driven and provide the basis for hypothesis testing. However, the final empirical interpretation depends on the estimated sign and significance of the interaction terms. In particular, the three-way interaction may reveal a more complex relationship than the original amplification hypothesis anticipates.

3.7 Methodological Summary

In sum, this study uses the same monthly African panel employed in the first article to examine a more specific resilience question: whether renewable-energy share becomes more protective when electricity access is wider. The empirical design treats the Iran war shock as an external stress event and tests whether the domestic pass-through of that shock is dampened by renewable-energy penetration, electricity access, and their joint interaction. By combining observed monthly fuel-price data, structural energy indicators from WDI, renewable-energy information from IRENA, and dynamic panel estimators, the methodology is designed to capture both the immediate domestic impact of the shock and the structural conditions under which renewable energy translates into broader economic protection.

4. Results and Discussion

4.1 Descriptive Statistics

Table 2 presents the descriptive statistics for the study variables. The panel contains 720 country-month observations. Average fuel-price stress is 1.3673, with a standard deviation of 0.2596, indicating substantial variation in domestic fuel-price conditions across countries and over time. Average gasoline and diesel prices are 1.3228 and 1.4118, respectively. Mean inflation is 6.8978%, while Brent crude averages 88.3403 USD per barrel over the sample. The structural variables also show meaningful heterogeneity: mean net energy imports are 20.9% of energy use, average renewable-electricity share is 34.15%, renewable capacity per capita averages 35.45, electricity access averages 70.5%, and GDP per capita averages USD 3,695.55. These patterns confirm that the sample contains sufficient cross-country variation in both vulnerability and resilience conditions to support the interaction analysis.

Table 2. Descriptive Statistics

Variable	N	Mean	SD	Min	Median	Max
Fuel price average	720	1.3673	0.2596	0.9241	1.3256	2.2148
Gasoline price	720	1.3228	0.2469	0.9058	1.2969	2.1736
Diesel price	720	1.4118	0.2741	0.9244	1.3680	2.3103
CPI inflation	720	6.8978	4.0012	2.2053	5.0136	18.0826
Brent crude price	720	88.3403	9.8495	77.0500	85.2150	119.0700
Net energy imports (%)	720	20.9000	11.8442	-18.0000	22.5000	36.0000
Renewable share (%)	720	34.1500	22.5551	2.0000	30.0000	89.0000
Renewable capacity per capita	720	35.4500	19.7861	1.0000	39.5000	68.0000
Electricity access (%)	720	70.5000	20.9681	19.0000	72.5000	100.0000
GDP per capita (USD)	720	3695.5460	1848.0560	854.1000	3616.9900	6971.7900

4.2 Summary by Shock Period

Table 3 compares the pre-shock and shock periods. The results show a clear deterioration in domestic energy and macroeconomic conditions during the Iran war shock. Average fuel-price stress rises from 1.2654 before the shock to 1.6322 during the shock period. Gasoline prices increase from 1.2280 to 1.5694, while diesel prices rise from 1.3029 to 1.6950. Inflation also increases sharply, from 4.6151% in the pre-shock period to 12.8328% during the shock. Brent crude prices rise from 83.0881 to 101.9960 USD per barrel. These raw comparisons already suggest that the shock was associated with substantial domestic pass-through.

Table 3. Summary by Shock Period

Variable	Pre-shock mean	Shock-period mean
Fuel price average	1.2654	1.6322
Gasoline price	1.2280	1.5694
Diesel price	1.3029	1.6950
CPI inflation	4.6151	12.8328
Brent crude price	83.0881	101.9960

4.3 Correlation Analysis and Multicollinearity Diagnostics

Table 4 reports the pairwise correlations. Fuel-price stress is strongly and positively correlated with inflation stress ($r = 0.7050$) and the shock dummy ($r = 0.6333$), confirming that the shock period coincided with a marked deterioration in domestic conditions. Fuel-price stress is negatively correlated with renewable share ($r = -0.2696$), suggesting that countries with higher renewable penetration tended to face lower stress. Electricity access has only a weak positive bivariate correlation with fuel-price stress ($r = 0.0838$), which indicates that its role is better evaluated in the multivariate framework. GDP per capita is positively correlated with fuel-price stress ($r = 0.2211$). Net energy imports show a weak positive association with fuel-price stress ($r = 0.0391$) but a stronger positive correlation with inflation ($r = 0.1379$). Renewable share is moderately negatively correlated with electricity access ($r = -0.5127$) and positively correlated with net energy imports ($r = 0.4276$), suggesting that the structural relationships across countries are not straightforward.

Multicollinearity is not a serious concern. The variance inflation factor results show a mean VIF of 2.27, with no individual VIF high enough to threaten coefficient stability. This indicates that the interaction structure can be estimated without severe collinearity problems.

Table 4. Selected Correlation Matrix

Variable	1	2	3	4	5	6	7	8
1. Fuel price average	1.0000							
2. CPI inflation	0.7050	1.0000						
3. Shock dummy	0.6333	0.9206	1.0000					
4. Renewable share (centered)	-0.2696	-0.0462	-0.0000	1.0000				
5. Electricity access (centered)	0.0838	-0.0566	-0.0000	-0.5127	1.0000			
6. Net energy imports (centered)	0.0391	0.1379	0.0000	0.4276	-0.5548	1.0000		
7. Brent crude price	0.6600	0.8017	0.8604	-0.0000	0.0000	0.0000	1.0000	

Variable	1	2	3	4	5	6	7	8
8. GDP per capita	0.2211	0.0054	-0.0000	0.0832	0.1456	-0.0838	0.0000	1.0000

Multicollinearity diagnostic: Mean VIF = 2.27

4.4 Baseline Fixed-Effects Results

The baseline fixed-effects models confirm that the Iran war shock significantly increased domestic energy and macroeconomic stress. In the fuel-price model, the shock dummy is positive and highly significant ($\beta = 0.1459, p < 0.001$), indicating that the shock raised fuel-price stress by about 0.146 units. Brent crude oil is also positive and highly significant ($\beta = 0.01168, p < 0.001$), confirming the direct transmission of global oil-market conditions into domestic fuel prices. GDP per capita is omitted in the fixed-effects specification because of collinearity with country fixed effects.

In the inflation model, the shock dummy remains strongly positive and highly significant ($\beta = 7.9318, p < 0.001$), showing that the Iran war shock substantially increased inflation stress across the sample. Brent crude is positive but only marginally significant ($\beta = 0.0151, p = 0.100$). These results provide strong support for the baseline hypothesis that the shock materially worsened domestic economic conditions.

Table 5. Baseline Fixed-Effects Results

Variable	Fuel-price stress	SE	p-value	Inflation stress	SE	p-value
Shock dummy	0.1458941	0.0117355	0.000	7.931828	0.4842034	0.000
Brent crude price	0.0116800	0.0004036	0.000	0.0151173	0.0087326	0.100
GDP per capita	omitted			omitted		
Constant	0.2949669	0.0373380	0.000	3.359033	0.7014156	0.000
Observations	720			720		
Countries	20			20		
Within R ²	0.9538			0.8873		

4.5 Main Interaction Results

Table 6 presents the core interaction results. In the clustered fixed-effects fuel-price model, the interaction between the shock and renewable share is negative but only weakly significant ($\beta = -0.0012906, p = 0.110$). The interaction between the shock and electricity access is also negative and marginally significant ($\beta = -0.0011797, p = 0.093$). This suggests that both renewable penetration and electricity access may help dampen fuel-price pass-through, but the evidence is modest in the fuel-price equation.

In the inflation model, the pattern is stronger. The interaction between the shock and renewable share is negative and weakly significant ($\beta = -0.031907, p = 0.095$), while the interaction between the shock and electricity access is negative and statistically significant ($\beta = -0.043832, p = 0.009$). This indicates that broader electricity access more clearly reduced the inflationary transmission of the shock than renewable share alone.

The most important finding concerns the three-way interaction among the shock, renewable share, and electricity access. In both the fuel-price and inflation models, this coefficient is positive rather than negative. This means that the negative resilience effect of renewable share becomes weaker, not stronger, as electricity access rises. Accordingly, the evidence does not support the original hypothesis that electricity access strengthens the protective role of renewable-energy share. Instead, the results suggest that renewable share and electricity access

each matter for resilience, but their joint relationship is more complex than the original theory predicted.

Table 6. Main Fixed-Effects Interaction Results

Variable	Fuel-price stress	SE	p-value	Inflation stress	SE	p-value
Shock dummy	0.1583143	0.0151955	0.000	8.310029	0.4633405	0.000
Shock × renewable share	-0.0012906	0.0007700	0.110	-0.0319070	0.0181403	0.095
Shock × electricity access	-0.0011797	0.0006675	0.093	-0.0438320	0.0150301	0.009
Shock × renewable share × electricity access	0.0000513	0.0000291	0.094	0.0015620	0.0007511	0.051
Brent crude price	0.0116800	0.0004045	0.000	0.0151173	0.0087509	0.100
GDP per capita	omitted			omitted		
Constant	0.2949669	0.0366008	0.000	3.359033	0.7134551	0.000
Observations	720			720		
Countries	20			20		
Within R ²	0.9624			0.9037		

4.6 Conditional Effects of Renewable Share at Different Levels of Electricity Access

To clarify the interaction pattern, conditional effects of renewable share during the shock were estimated at different levels of electricity access. For fuel-price stress, the effect of renewable share is most negative at low access and becomes progressively weaker as access rises. At $c_access = -20$, the conditional renewable effect is -0.0023165 ($p = 0.065$). At -10 , it is -0.0018035 ($p = 0.074$). At the centered mean (0), the effect is -0.0012906 ($p = 0.110$). At 10, it declines to -0.0007776 ($p = 0.259$), and at 20, it becomes -0.0002646 ($p = 0.703$). This shows that the negative fuel-price resilience effect of renewable share weakens markedly at higher access levels.

For inflation stress, the same pattern is even clearer. At $c_access = -20$, the conditional renewable effect is -0.0631471 ($p = 0.032$). At -10 , it is -0.0475271 ($p = 0.043$). At the centered mean, it is -0.0319070 ($p = 0.095$). At 10, it becomes -0.0162869 ($p = 0.350$), and at 20, it is effectively zero at -0.0006669 ($p = 0.972$). These conditional estimates reinforce the conclusion that the negative resilience effect of renewable share fades as electricity access rises.

Table 7. Conditional Effect of Renewable Share During the Shock

Centered electricity access level	Fuel-price stress effect	p-value	Inflation stress effect	p-value
-20	-0.0023165	0.065	-0.0631471	0.032
-10	-0.0018035	0.074	-0.0475271	0.043
0	-0.0012906	0.110	-0.0319070	0.095
10	-0.0007776	0.259	-0.0162869	0.350
20	-0.0002646	0.703	-0.0006669	0.972

4.7 Model Selection and Additional Robustness

Country effects are clearly important in this dataset. The joint test that all country effects are zero is strongly rejected in both equations. In the pooled regression with country dummies, the country effects are jointly significant ($F = 937.38, p < 0.001$). In the fixed-effects models, the tests

of all country-specific effects are likewise strongly significant for both fuel-price stress and inflation stress. This supports the use of panel estimators that account for unobserved country heterogeneity.

The Hausman tests do not reject the null that coefficient differences between fixed and random effects are not systematic:

- fuel-price model: $\chi^2 = 2.70$, $p = 0.4403$
- inflation model: $\chi^2 = 1.15$, $p = 0.7656$.

This indicates that the random-effects specification is statistically acceptable. However, the substantive results are almost identical across fixed and random effects, and the paper retains fixed effects in the main text as a conservative within-country specification for analyzing shock transmission.

An additional dynamic robustness analysis was conducted for the inflation equation using both dynamic fixed effects and two-step system GMM. In the dynamic fixed-effects model, the lagged dependent variable is positive and highly significant ($\beta = 0.6104$, $p < 0.001$), confirming persistence in inflation dynamics. The shock dummy remains positive and highly significant ($\beta = 2.0288$, $p < 0.001$), while the interaction between the shock and electricity access remains negative and significant ($\beta = -0.0186$, $p = 0.024$). The interaction between the shock and renewable share remains negative but statistically insignificant ($\beta = -0.0137$, $p = 0.118$), and the three-way interaction remains positive and marginally significant ($\beta = 0.000721$, $p = 0.064$). Brent crude becomes strongly positive and highly significant ($\beta = 0.0984$, $p < 0.001$).

The two-step system GMM results reinforce this pattern. The lagged dependent variable remains positive and highly significant ($\beta = 0.5978$, $p < 0.001$), confirming dynamic persistence in inflation stress. The shock dummy remains positive and highly significant ($\beta = 2.2622$, $p < 0.001$). The interaction between the shock and electricity access remains negative and significant ($\beta = -0.0213$, $p = 0.017$), while the shock–renewable interaction remains negative but only weakly significant ($\beta = -0.0152$, $p = 0.097$). The three-way interaction remains positive and statistically significant ($\beta = 0.0008673$, $p = 0.022$). Brent crude also remains strongly positive and highly significant ($\beta = 0.0933$, $p < 0.001$). Diagnostic tests support the validity of the GMM specification: the AR(1) test is significant, the AR(2) test is not significant ($p = 0.413$), the Hansen test does not reject the validity of the instruments ($p = 0.670$), and the instrument count remains low at 9. Overall, the dynamic FE and GMM results confirm that electricity access is the more robust resilience channel, while the joint renewable-access effect remains more complex than originally expected.

Table 8. Hausman, Dynamic FE, and System GMM Robustness

Test / Variable	Result
Hausman test (fuel-price model)	$\chi^2 = 2.70$, $p = 0.4403$
Hausman test (inflation model)	$\chi^2 = 1.15$, $p = 0.7656$
Dynamic FE inflation: L.inflation	0.6104298***
Dynamic FE inflation: Shock dummy	2.0288200***
Dynamic FE inflation: Shock × renewable share	-0.0137021
Dynamic FE inflation: Shock × electricity access	-0.0185518**
Dynamic FE inflation: Shock × renewable share × electricity access	0.0007210*
Dynamic FE inflation: Brent crude	0.0983789***
System GMM inflation: L.inflation	0.5978411***
System GMM inflation: Shock dummy	2.2621960***

Test / Variable	Result
System GMM inflation: Shock × renewable share	-0.0151861*
System GMM inflation: Shock × electricity access	-0.0212639**
System GMM inflation: Shock × renewable share × electricity access	0.0008673**
System GMM inflation: Brent crude	0.0933154***
AR(1)	p = 0.000
AR(2)	p = 0.413
Sargan test	p = 0.452
Hansen test	p = 0.670
Number of instruments	9

Notes: * p < 0.10, ** p < 0.05, *** p < 0.01.

4.8 Discussion of Findings

The findings support three main conclusions. First, the Iran war shock significantly increased both fuel-price and inflation stress across African countries. This is evident in the descriptive comparisons, the baseline fixed-effects models, and the consistently positive shock coefficients across the main specifications. The shock therefore translated directly from international oil-market disruption into domestic economic stress.

Second, both renewable share and electricity access matter for resilience, but they do so with different levels of strength. Renewable share has a negative effect on shock transmission, but the evidence is only weak or marginal in the main clustered fixed-effects models. Electricity access, by contrast, plays a more robust buffering role, particularly in the inflation equation. This suggests that electricity access may be the more immediate resilience channel when the concern is broader macroeconomic pass-through rather than fuel prices alone.

Third, the joint renewable-access mechanism does not behave as originally hypothesized. Instead of strengthening the protective effect of renewable share, higher electricity access appears to attenuate it. The conditional-effect estimates show that renewable share exerts its strongest negative effect at lower levels of access and becomes much weaker as access rises. This implies that renewable-energy resilience and electricity-access resilience are not simply additive in a reinforcing manner. Rather, they appear to operate through partly distinct channels, or electricity access may be capturing broader structural conditions that alter the way renewable penetration affects domestic stress.

Taken together, the evidence suggests a more complex resilience story than initially expected. Renewable share and electricity access both matters, but their interaction does not support a simple amplification hypothesis. The results therefore favor a more cautious conclusion: renewable energy and electricity access are complementary but non-reinforcing resilience factors in the context of external oil shocks.

4.9 Hypothesis Evaluation

Table 9. Hypothesis Decision Table

Hypothesis	Statement	Decision
H1	The Iran war shock increased domestic fuel-price and inflation stress across African countries	Supported
H2	The adverse effects of the Iran war shock were weaker in countries with higher renewable-energy shares	Weak / marginal support
H3	The adverse effects of the Iran war shock were weaker in countries with higher electricity access	Supported, especially for inflation
H4	The resilience effect of renewable-energy share was stronger in countries with higher electricity access	Not supported

The hypothesis evaluation confirms that H1 is clearly supported. H2 receives only weak support because the shock–renewable interaction is negative but only marginally significant in the main models. H3 is supported, especially in the inflation equation where electricity access has a statistically significant buffering effect. H4 is not supported because the three-way interaction is positive rather than negative, indicating that the protective role of renewable share weakens rather than strengthens as electricity access rises.

5. Policy Implications, Conclusion, Limitations, and Future Research

5.1 Policy Implications

The findings offer several policy implications for African energy planning and shock resilience. First, the results confirm that external geopolitical oil shocks can transmit rapidly into domestic fuel prices and inflation. This means that African policymakers cannot treat energy security as a narrow supply issue; it is also a macroeconomic stability issue. The strong positive effect of the Iran war shock on both fuel-price stress and inflation stress highlights the continued vulnerability of African economies to externally driven fossil-fuel disruptions.

Second, the results suggest that both renewable-energy penetration and electricity access can play resilience roles, but not with the same degree of robustness. Renewable share shows a negative shock-buffering effect, although this is only weakly significant in the main models. By contrast, electricity access exerts a clearer and more consistent protective effect, especially in reducing inflation stress. This implies that expanding electricity access may provide more immediate resilience benefits than focusing on renewable share alone. In practical terms, countries may gain more from ensuring that energy systems are widely accessible than from relying only on generation-mix improvements that may not be fully transmitted through the broader economy.

Third, the results caution against assuming that greater electricity access automatically strengthens the protective role of renewable energy. The positive three-way interaction and the conditional-effect estimates show that the negative resilience effect of renewable share weakens as electricity access rises. This suggests that renewable-energy planning and electricity-access expansion should not be framed as mechanically reinforcing channels. Instead, policymakers should recognize that the relationship between renewable penetration, access, and resilience is more complex and may depend on deeper structural conditions such as how electricity is used across sectors, the extent of fossil-fuel reliance outside the formal electricity system, and the broader organization of domestic energy markets.

Overall, the policy message is not that renewable energy is unimportant, but that renewable energy and electricity access appear to function as complementary yet non-reinforcing resilience channels. A more effective resilience strategy would therefore combine renewable expansion, improved electricity access, and broader efforts to reduce exposure to imported oil across transport, households, and productive sectors.

5.2 Conclusion

This study examined whether electricity access conditions the resilience effect of renewable energy during the Iran war shock in a panel of African countries. The results show, first, that the Iran war shock significantly increased domestic fuel-price stress and inflation stress. Second, both renewable-energy share and electricity access contributed to reducing the domestic transmission of the shock, although the evidence for renewable share is weaker and less robust than that for electricity access. Third, and most importantly, the results do not support the original expectation that electricity access strengthens the resilience effect of renewable share. Instead, the positive three-way interaction indicates that the negative effect of renewable share becomes weaker as electricity access rises.

The study therefore reaches a more nuanced conclusion than initially expected. Renewable energy and electricity access both matter for resilience, but their joint effect is not a simple amplification effect. Electricity access appears to be the stronger and more immediate resilience mechanism, especially in the inflation equation, while the protective effect of renewable share is more limited and fades at higher levels of access. This suggests that the resilience value of renewable energy depends on a broader set of structural conditions than the original hypothesis assumed. This conclusion is further strengthened by the dynamic fixed-effects and system GMM robustness checks, which confirm the persistence of inflation stress and the relatively stronger buffering role of electricity access compared with renewable share alone.

In this sense, the paper contributes by showing that African energy resilience cannot be understood through renewable penetration alone. It requires closer attention to how access, infrastructure, and system structure shape the domestic pass-through of external shocks. Rather than concluding that renewable-energy expansion automatically produces stronger resilience when access expands, the findings point to a more complex policy reality that deserves further investigation.

5.3 Limitations

This study has several limitations. First, the sample covers 20 African countries over a relatively short monthly panel, which may limit the broader generalizability of the results. Second, the analysis focuses on fuel-price stress and inflation stress, which are important but not exhaustive indicators of energy-shock transmission. Third, electricity access is treated as a structural conditioning variable, but the dataset does not directly capture how electricity is consumed across households, firms, transport systems, and productive sectors. Fourth, the study uses a common external shock framework, which is well suited to panel analysis, but some country-specific transmission mechanisms may remain unobserved.

In addition, the inability to estimate some post-estimation margins in the fixed-effects framework reflects the fact that renewable share and electricity access are effectively time-invariant at the country level in this dataset. As a result, the paper relies on interaction-based conditional effects rather than fully flexible marginal prediction plots.

5.4 Future Research

Future research can build on this study in several directions. One avenue is to examine whether the resilience effects identified here differ across subregions or country groups, such as net energy importers versus exporters, or low-access versus high-access economies. A second

direction is to extend the analysis to other outcomes, including fiscal stress, transport costs, exchange-rate pressure, or food-price inflation. A third avenue is to investigate more deeply why the renewable-access interaction does not strengthen resilience as expected. This may require incorporating additional structural variables such as electricity reliability, grid quality, off-grid renewable use, transport fuel dependence, and industrial energy mix.

Future work could also distinguish more clearly between renewable presence and renewable usability, especially by examining whether the economic benefits of renewable electricity depend on sectoral access, productive use, and integration into domestic value chains. Such extensions would help clarify the channels through which renewable energy and electricity access shape resilience under external fossil-fuel shocks.

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