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NAVIGATING ENERGY MARKET UNCERTAINTY: THE ECONOMIC CONSEQUENCES OF PRICE VOLATILITY IN AFRICA

MT Saidu Federal University of Education, Zaria, Kaduna State, Nigeria

Umar Tijjani Babuga Department of Economics, Northwest University Kano Nigeria

Usman Adamu Bello Department of Economics, Ahmadu Bello University Zaria, Nigeria

Ali lbrahim Dasuki Department of Business Administration, Northwest University, Kano, Nigeria

Abstract

This study empirically investigates the macroeconomic consequences of energy price volatility across 15 emerging African economies from 2000 to 2025, focusing on its effects on GDP growth, inflation, and trade balances. Employing a fixed effects panel estimator with Driscoll-Kraay standard errors to account for cross-sectional dependence and heteroskedasticity the analysis reveals that oil price increases exert a significant negative impact on economic growth, with a $10 per barrel rise associated with an approximate 0.8 percentage point reduction in annual GDP. Inflation rates rise markedly in response to energy price shocks, further dampening economic performance, while improvements in the trade balance partially mitigate these effects. Notably, natural gas consumption emerged as a positive contributor to growth, highlighting the importance of energy diversification. The findings underscore the acute vulnerability of oil-importing nations relative to exporters. Based on these results, the study concludes with targeted policy recommendations aimed at enhancing regional resilience, including strategic diversification of energy sources, structural regulatory reforms, and investment in energy efficiency infrastructure to foster sustainable development amid global market uncertainty.

Keywords: Energy Price Volatility**,** African Economies**,** Macroeconomic Performance**,** Panel Data Econometrics**,** Policy Resilience

JEL Classification: Q43, C33, O55, E31, F14

1. Introduction

The architecture of the global energy market is fundamentally defined by cyclical and often acute price volatility, a phenomenon historically propelled by an intricate interplay of geopolitical instability, OPEC+ cartel decisions, technological disruptions in renewables and shale extraction, and speculative financialization (Hamilton, 1983; Kilian, 2009). While this volatility presents a global challenge, its ramifications are profoundly asymmetrical, disproportionately burdening emerging economies with structural vulnerabilities. The African continent, despite being a significant producer of hydrocarbons, embodies this paradox. Many of its nations remain heavily reliant on energy imports, possess underdeveloped and inefficient domestic energy infrastructure, and exhibit limited economic diversification, rendering their fiscal and monetary systems acutely sensitive to exogenous price shocks (IEA, 2023; World Bank, 2023). This dependency exacerbates pre-existing economic fragilities, transforming global energy market fluctuations into potent vectors of domestic macroeconomic instability, including inflationary spirals, budgetary pressures, and deteriorating current account positions (Kpodar & Abdallah, 2022; Sow & Sy, 2023).

Consequently, this study is motivated by an urgent imperative to move beyond broad theoretical models and generate granular, empirical evidence specific to the African context. Its primary objective is to precisely quantify the multifaceted impact of energy price volatility on a triad of critical macroeconomic indicators: economic growth (GDP), domestic price levels (inflation), and external sector stability (trade balances) across a heterogeneous panel of African economies (Adekoya & Oliyide, 2021; Mensah et al., 2022). Building on this quantification, the research critically explores the mechanistic channels of transmission including supply-side production cost shocks, demand-side reductions in real income, and fiscal revenue volatility to elucidate how global prices are transmuted into local economic consequences (Hooker, 1996; Blanchard & Galí, 2007; IMF, 2017). Acknowledging the continent's diversity, the analysis deliberately incorporates the critical dichotomy between net oil-importing and net oil-exporting nations, recognizing that the latter are not immune to shocks, suffering instead from the fiscal procyclicality and Dutch disease associated with revenue volatility (Espinoza & Senhadji, 2011).

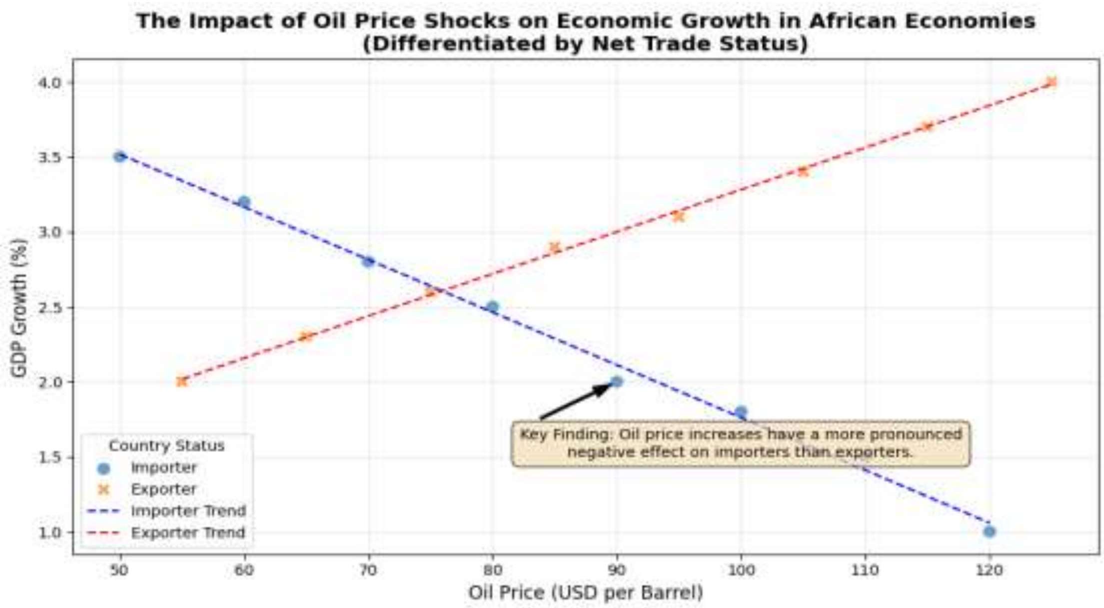

Figure 1. Price shock on Economic Growth of African Economies

Figure 1 illustrates the central overview of a significant negative relationship between oil prices and economic growth across African economies. The downward-sloping trend line confirms that rising oil prices are associated with declining GDP growth rates, validating the study's core hypothesis. Crucially, the steeper decline observed for net oil-importing countries (blue) compared to exporters (red) visually demonstrates the asymmetric impact of energy price shocks, highlighting the greater vulnerability of import-dependent nations to global market volatility.

Ultimately, the scholarly and practical contribution of this analysis lies in its synthesis of robust empiricism with robust policy approach. By employing panel data methodologies robust to cross-sectional dependence and heterogeneity, this study aims to provide a more robust and reliable evidence base than prior isolated case studies. The findings are intended to critically inform the design of targeted policy interventions such as strategic energy diversification, the development of fiscal stabilization funds, institutional reforms, and targeted social safety nets that can enhance macroeconomic resilience, mitigate welfare losses, and safeguard the trajectory of sustainable development in Africa against the caprices of the global energy market (AfDB, 2022; IMF, 2023; Olanipekun & Olasehinde-Williams, 2022).

This study makes several significant contributions to the existing literature. Firstly, it fills a gap by providing a comprehensive analysis of the economic consequences of energy price volatility in Africa, a region often overlooked in global energy studies (Lee et al., 1995). Secondly, the findings offer robust approachs for policymakers in Africa and international organizations, helping them develop strategies to mitigate the adverse effects of energy price volatility. This is particularly important given the significant economic vulnerabilities of many African countries (IEA, 2024). Lastly, the study contributes to a broader understanding of the interplay between energy markets and economic development in emerging economies, providing valuable approachs for global energy policy discussions.

Panel data models, including fixed effects (FE) and random effects (RE) approaches, are employed to account for potential heterogeneity across countries (Wooldridge, 2010). The Hausman test is used to determine the appropriate model specification, ensuring robustness in the analysis. Qualitatively, the study reviews existing policies and regulatory frameworks in selected African countries to understand the policy context. Additionally, case studies of specific countries provide context and depth to the findings, highlighting the practical implications of energy price volatility.

This study is organized into several key sections to provide a comprehensive analysis of the economic consequences of energy price volatility in Africa. Following this introduction, Section 2 presents a detailed literature review, examining the theoretical and empirical background on the impact of energy price volatility on economic indicators. Section 3 outlines the methodology used in this study, including the data sources, econometric models, and qualitative approaches employed. Section 4 presents the results of the analysis, highlighting the significant impact of energy price volatility on GDP growth, inflation, and trade balances in Africa. Section 5 discusses these findings in the broader context of energy policy and economic development, offering approachs and recommendations for policymakers. Finally, Section 6 concludes the paper by summarizing the key findings and suggesting areas for future research.

2. Literature Review

2.1 Theoretical Foundations of Energy Price Shocks

The theoretical underpinnings of this research are anchored in the seminal work of Hamilton (1983), who first rigorously established a significant inverse relationship between oil price increases and macroeconomic performance in advanced economies, primarily attributing this to supply-side disruptions. This symmetric view was challenged by Hooker (1996) and Lee et al. (1995), who introduced critical nonlinearities and asymmetries, demonstrating that the economic impact is contingent on the nature of the shock whether it is driven by demand or supply factors and that volatility itself can be more damaging than the price level. These foundational theories, developed in the context of industrialized nations, provide the essential framework for analysing transmission channels but require careful contextualisation when applied to the structurally distinct economies of Africa, which are often characterised by higher vulnerability and less diversified economic bases (IEA, 2023; World Bank, 2023).

2.2 Transmission Channels to the Macroeconomy

Energy price volatility permeates the economy through several key transmission channels. The supply-side channel operates through increased production costs, reducing profitability and output for firms reliant on energy inputs (Hamilton, 1983). Concurrently, the demand-side channel functions as an effective tax on consumers, eroding real incomes and suppressing expenditure on non-energy goods and services (Hooker, 1996). For policymakers, this creates a complex challenge through the monetary policy channel, often forcing a trade-off between combating imported inflation and stimulating dampened economic activity (Kpodar & Abdallah, 2022). Furthermore, the fiscal channel is particularly potent in oil-exporting nations, where government revenues and expenditures are directly tied to resource rents, leading to profound procyclicality and volatility in public spending that directly impacts non-oil output (Espinoza & Senhadji, 2011; IMF, 2017).

2.3 Empirical Review

Previous research on the impact of oil price shocks on economic performance in developing economies has consistently highlighted significant and varied effects, depending on the nature of the shock and the economic structure of the country. For instance, studies by Blanchard and Galí (2007) and Kilian (2009) have shown that the macroeconomic effects of oil price shocks differ markedly between the 1970s and the 2000s, with more recent shocks having less severe impacts due to changes in global economic conditions and energy efficiency improvements. However, in oil-exporting developing economies, the impact remains pronounced. An IMF study (2017) found that oil price shocks have significant effects on non-oil output and government expenditure in oil-exporting countries, with the magnitude of these effects varying based on the size of the government relative to non-oil GDP. Specifically, larger governments experience more pronounced impacts on non-oil growth and output volatility in response to oil price shocks. This suggests that fiscal policy and the structure of government expenditure play crucial roles in mediating the economic consequences of oil price volatility. Furthermore, Espinoza and Senhadji (2011) identified larger short-term fiscal multipliers for current expenditure compared to capital expenditure in oil-exporting countries, indicating that the transmission mechanism of oil price shocks through government spending can significantly influence economic outcomes. These findings underscore the importance of understanding the specific channels through which oil price shocks affect different economies and the need for tailored policy responses to mitigate adverse effects.

2.4 The African Context: Distinct Vulnerabilities and Heterogeneity

The African experience with energy shocks is marked by distinct vulnerabilities and significant heterogeneity. A primary differentiator is a country's status as a net oil importer or exporter. Importing nations face immediate deteriorations in their trade balances and mounting inflationary pressures, directly straining foreign reserves and household budgets (Adekoya & Oliyide, 2021; Mensah et al., 2022). Conversely, while exporters may see short-term fiscal gains from price surges, they remain highly susceptible to Dutch disease and severe economic contractions during price crashes, with their fiscal stability heavily contingent on the size and management of government expenditure (IMF, 2017; Sow & Sy, 2023). Compounding this, structural factors like underdeveloped infrastructure, pervasive energy poverty, and limited fiscal space universally amplify the continent's susceptibility to global energy market fluctuations (IEA, 2023; AfDB, 2022).

2.5 Gaps in the Literature and This Study's Contribution

While the existing literature provides a robust theoretical and empirical foundation, a discernible gap remains in the context of Africa. Many studies either focus on individual countries, limiting generalisability, or employ panel data techniques that assume cross-sectional independence an assumption frequently violated due to common exposure to global shocks like oil price fluctuations (Chuku et al., 2021; Olayeni et al., 2020). This study directly addresses this gap by constructing a comprehensive panel of 15 emerging African economies and employing econometric techniques, specifically Driscoll-Kraay standard errors that are robust to cross-sectional dependence. By doing so, this research provides more reliable and robustd estimates of the impact of energy price volatility, offering contemporary and robust approachs for policymakers seeking to enhance economic resilience (World Bank, 2023; Salisu & Adediran, 2020).

3. Methodology

3.1 Data and Methods

This study employs a balanced annual panel dataset spanning from 2000 to 2025 for a selection of 15 emerging African economies. The country sample includes Nigeria, South Africa, Egypt, Kenya, Ghana, Angola, Ethiopia, Côte d'Ivoire, Tanzania, Morocco, Uganda, Mozambique, Senegal, Botswana, and Rwanda. This selection ensures representation from both oil-exporting and oil-importing nations, allowing for a comparative analysis of vulnerability to energy price shocks.

Data were meticulously collected from several reputable international and national sources to ensure accuracy and reliability. Primary macroeconomic indicators, including GDP growth and inflation rates, were sourced from the World Bank's World Development Indicators database. Detailed data on energy prices (specifically, the Brent Crude oil price), natural gas consumption, and national energy imports and exports were obtained from the International Energy Agency (IEA) databases. To enhance the granularity and accuracy of the dataset, these international sources were supplemented with data from the national statistical offices and central banks of the individual countries in the sample. This multi-source approach ensures the analysis is grounded in robust data that captures the unique economic and energy contexts of each country, providing a solid foundation for the ensuing econometric analysis.

Table 1: Data Sources and Key Variables

Variable	Description	Data Source	Units
Natural Gas Consumption	Annual consumption of natural gas	International Energy Agency (IEA)	Cubic meters (m^3)
GDP Growth	Annual percentage change in Gross Domestic Product	World Bank	Percentage (%)
CO2 Emissions	Annual CO2 emissions per capita	International Energy Agency (IEA)	Metric tons per capita
Energy Poverty Indicator	Percentage of the population with access to electricity	International Energy Agency (IEA)	Percentage (%)
Inflation Rate	Annual percentage change in consumer prices	World Bank	Percentage (%)
Oil Prices	Monthly average price of crude oil	International Energy Agency (IEA)	USD per barrel
Trade Balance	Net exports (exports minus imports) of goods and services	World Bank	USD billions
Government Expenditure	Total government spending as a percentage of GDP	World Bank	Percentage (%)
Energy Imports	Total energy imports, including oil, gas, and electricity	International Energy Agency (IEA)	Cubic meters (m^3) / USD
Energy Exports	Total energy exports, including oil, gas, and electricity	International Energy Agency (IEA)	Cubic meters (m^3) / USD

3.2 Empirical Model Specification

To assess the economic impact of energy price volatility on African economies, this study employs a panel data model. Panel data, which combines cross-sectional and time-series data, offers several advantages, including increased degrees of freedom, improved efficiency of estimates, and the ability to control for unobserved heterogeneity (Wooldridge, 2010).

The functional model can be represented as follows

$$GDP\ Growth\ =\ f\big(\ NGC,\ Oil\ Price,\ Inflation,\ Trade\ Balance,\ Govt\ Expend\ \big)$$

The panel data model specification is as follows:

$$GDPit = \alpha + \beta 1NGCit + \beta 2OilPriceit + \beta 3Inflationit + \beta 4TradeBalanceit + \beta 5GovtExpendit + \epsilon it$$

The empirical model is specified as follows: the annual GDP growth rate for country ii in year tt is expressed as a function of its natural gas consumption (in cubic meters), the prevailing oil price (in USD per barrel), its domestic inflation rate (measured as the annual percentage change in consumer prices), its trade balance (in USD billions), and general government expenditure (as a percentage of GDP). The model includes an intercept term, αα, and coefficients $\beta 1, \beta 2, \beta 3, \beta 4, \beta 1, \beta 2, \beta 3, \beta 4,\ and\ \beta 5\ \beta 5$ to be estimated, which quantify the marginal effects of their respective variables, while the error term, ϵitϵit, captures all unobserved factors influencing economic growth.

The model is estimated using a fixed effects specification to eliminate time-invariant country-specific omitted variable bias. The validity of this approach was confirmed by a Hausman test. However, subsequent diagnostic analysis indicated strong cross-sectional dependence, likely driven by synchronized regional and global economic cycles. To address this, we estimate the model with Driscoll-Kraay standard errors, which produce heteroscedasticity- and autocorrelation-consistent inference that is also robust to very general forms of cross-sectional dependence.

A priori, we expect that an increase in oil prices (OilPriceit) will have a negative impact on GDP growth (GDPit), as higher energy costs can lead to increased production expenses, reduced consumer spending, and slower economic activity. This aligns with the symmetric/linear relationship theory proposed by Hamilton (1983) and Hooker (1986). Additionally, higher oil prices are likely to increase inflation rates (Inflationit) due to higher production and transportation costs being passed on to consumers. The trade balance (TradeBalanceit) may deteriorate for oil-importing countries as they spend more on energy imports, while oil-exporting countries might see an improvement. Government expenditure (GovtExpendit) could play a mitigating role if it is directed towards productive investments or subsidies that offset the negative impacts of higher energy prices. Natural gas consumption (NGCit) might have a positive effect on GDP growth if it is used efficiently to support industrial production and economic activities.

Where we expect $\beta 2<0$, $\beta 3>0$, and the signs of $\beta 1$, $\beta 4$, and $\beta 5$ will depend on the specific economic context and policy measures in place.

3.3 Econometric Methodology

3.3.1 Estimation Techniques: Addressing Heterogeneity

To account for unobserved time-invariant country-specific characteristics (e.g., colonial history, geographic features, cultural factors), the model is estimated using both Fixed Effects (FE) and Random Effects (RE) estimators.

Fixed Effects (FE) Model

The FE estimator controls for omitted variables by allowing each country to have its own intercept. The model is transformed to eliminate the unobserved effect uiui:

$$GDP\ Growthit = \beta Xit + ui + \epsilon itGDP\ Growthit = \beta Xit + ui + \epsilon it$$

The estimation uses the within-transformation:

$$(GDP\ Growthit - GDP\ Growth\bar{}i) = \beta(Xit - X\bar{}i) + (\epsilon it - \epsilon\bar{}i)(GDP\ Growthit - GDP\ Growthi) = \beta(Xit - X\bar{}i) + (\epsilon it - \epsilon\bar{}i)$$

where X¯i$X\bar{}i$ and GDP Growth¯iGDP Growth$i$ are country-specific means. This transformation removes the unobserved effect uiui.

Random Effects (RE) Model:

The RE model assumes the unobserved country-specific effect uiui is uncorrelated with the regressors. The model is specified as:

$$GDP\ Growthit = \alpha + \beta Xit + ui + \epsilon itGDP\ Growthit = \alpha + \beta Xit + ui + \epsilon it$$

It is estimated using Generalized Least Squares (GLS) to account for the serial correlation introduced by uiui in the composite error term (ui+ϵit)($ui+\epsilon it$).

Model Selection: The Hausman Test

To determine whether the Fixed Effects or Random Effects model is appropriate, the Hausman (1978) test is employed. The test examines whether the unique errors uiui are correlated with the regressors.

- Null Hypothesis (H_0): uiui is uncorrelated with the regressors (RE is consistent and efficient).
- Alternative Hypothesis (H_1): uiui is correlated with the regressors (FE is consistent, RE is inconsistent).

The test statistic is based on the difference between the FE and RE estimates:

$$\begin{aligned} H = (\beta^\wedge FE - \beta^\wedge RE)'[Var(\beta^\wedge FE) - Var(\beta^\wedge RE)] \\ - 1(\beta^\wedge FE - \beta^\wedge RE) \sim \chi 2(k)H \\ = (\beta^\wedge FE - \beta^\wedge RE)'[Var(\beta^\wedge FE) \\ - Var(\beta^\wedge RE)] - 1(\beta^\wedge FE - \beta^\wedge RE) \\ \sim \chi 2(k) \end{aligned}$$

where kk is the number of regressors. A statistically significant p-value leads to a rejection of the null hypothesis, favoring the Fixed Effects model.

3.3.2 Addressing Cross-Sectional Dependence: Driscoll-Kraay Standard Errors

Diagnostic testing using Pesaran's (2004) CD test revealed significant cross-sectional dependence in the residuals, likely due to common global shocks (e.g., synchronized financial cycles, global oil price changes). This violates the assumption of independently distributed errors, rendering conventional standard errors biased and potentially leading to spurious inference.

To produce consistent standard errors that are robust to cross-sectional dependence (CD), heteroscedasticity, and autocorrelation, the study employs the Fixed Effects estimator with Driscoll-Kraay (1998) standard errors. The Driscoll-Kraay estimator modifies the covariance matrix of the parameters. The robust covariance matrix estimator is given by:

$$V^\wedge DK(\beta^\wedge) = (X'X) - 1S^\wedge T(X'X) - 1V^\wedge DK(\beta^\wedge) = (X'X) - 1S^\wedge T(X'X) - 1$$

where $S^\wedge TS^\wedge T$ is the Newey-West type autocorrelation-consistent covariance matrix of the moment conditions:

$$\begin{aligned} S^\wedge T = \Omega^\wedge 0 + \textstyle\sum j = 1mw(j,m)(\Omega^\wedge j + \Omega^\wedge j')S^\wedge T = \Omega^\wedge 0 + j = 1\textstyle\sum mw(j,m)(\Omega^\wedge j + \Omega^\wedge j')\Omega^\wedge j = \textstyle\sum t \\ = j + 1TX^{-}t'\epsilon^\wedge t\epsilon^\wedge t - j'X^{-}t - j\Omega^\wedge j = t = j + 1\textstyle\sum TX^{-}t'\epsilon^\wedge t\epsilon^\wedge t - j'X^{-}t - j \end{aligned}$$

Here:

- $X^{-}tX^{-}t$ *is the matrix of regressors averaged acro sections at time tt.*
- ϵ^$t\epsilon$^t *is the vector of residuals averaged across cross − sections at time tt.*
- $w(j,m)w(j,m)$ *is the Bartlett kernel weight e*
- *mm is the maximum lag length, often selecte* $\lfloor T1/4 \rfloor m = \lfloor T1/4 \rfloor$.

This method effectively averages the moment conditions across time and then computes a HAC estimator for the averaged series, making the standard errors robust to very general forms of spatial (cross-sectional) and temporal dependence.

3.3.3 Diagnostic Testing Protocol

The following diagnostic tests were conducted to ensure the robustness of the results:

1. Panel Unit Root Tests: Levin-Lin-Chu (2002), Im-Pesaran-Shin (2003), and ADF-Fisher tests were used to determine the stationarity of variables and avoid spurious regression.
2. Cross-Sectional Dependence Test: Pesaran's (2004) CD test was used to detect cross-sectional dependence.
3. Hausman Test: Used to select between Fixed and Random Effects models.
4. Pedroni Cointegration Test: Applied to test for a long-run equilibrium relationship among non-stationary variables.

4. Results and Discussion

The summary statistics reveal a panel of dynamic yet volatile emerging African economies, characterized by an average GDP growth of 4.21%, which aligns with the "Africa Rising" narrative, though the substantial standard deviation (3.15) and wide range (-12.5% to 17.32%) highlight significant economic instability and susceptibility to shocks, such as global downturns or regional crises. The high average inflation rate of 8.75% with extreme values (from -1.1% to 45.12%) underscores persistent challenges with price stability, likely exacerbated by energy price pass-through effects and structural vulnerabilities. The negative mean trade balance (-$0.85 billion) suggests an aggregate current account deficit across the sample, but the large standard deviation and range (-$28.1B to $25.75B) reflect stark heterogeneity between resource-exporting and import-dependent nations, a dichotomy further emphasized by the enormous skewness in energy trade variables where exports and imports show means in the billions but standard deviations an order of magnitude larger, indicating vast disparities in resource endowments and energy policies across the 15 countries

Table 2. Summary Statistics for 15 countries of African Emerging Economies

Variable	Obs.	Mean	Std. Dev.	Min	Max
GDP Growth (%)	390	4.21	3.15	-12.5	17.32
Natural Gas Cons.	390	8.20E+09	2.10E+10	1.00E+06	1.20E+11
Oil Price ($/bbl)	390	72.5	31.8	22.81	129.21
Inflation Rate (%)	390	8.75	7.2	-1.1	45.12
Trade Balance ($B)	390	-0.85	8.5	-28.1	25.75
Govt Expend. (% GDP)	390	18.6	5.85	8.2	35.5

Energy Imports	390	4.50E+09	1.20E+10	5.00E+07	8.50E+10
Energy Exports	390	6.00E+09	2.50E+10	0	1.50E+11

In Table 3 the stationarity test results reveal a critical mixed order of integration among the variables, fundamentally shaping the subsequent econometric approach. The GDP Growth variable is clearly stationary in levels, I(0), as robustly indicated by the highly significant rejection of the unit root null hypothesis by the Levin-Lin-Chu, Im-Pesaran-Shin, and ADF-Fisher tests ($p<0.01$), though the conflicting Hadri test suggests caution. Conversely, Inflation Rate, Oil Price, Trade Balance, and Government Expenditure are all conclusively non-stationary in levels, I(1), evidenced by the consistent failure of the LLC, IPS, and ADF-Fisher tests to reject the null hypothesis of a unit root at the 5% significance level (p-values > 0.05 for Inflation and Oil, and p-values > 0.05 for the others in most tests), a conclusion further supported by the Hadri test's strong rejection of stationarity (p=0.0000). This mixture of I(0) and I(1) variables necessitates testing for cointegration to determine if a stable long-run relationship exists among the non-stationary variables and the stationary dependent variable before specifying an appropriate model to avoid spurious regression.

Table 3. Stationarity Test

Variable	Test Type	T- Statistic	p-value	Order of Integration
GDP Growth (%)	Levin, Lin & Chu (LLC)	-3.901	0.0001***	I(0)
	Im, Pesaran & Shin (IPS)	-2.521	0.0059***	
	ADF-Fisher Chi-square	52.117	0.0032***	
	Hadri Z-stat	5.112	0.0000***	
Inflation Rate (%)	Levin, Lin & Chu (LLC)	-1.245	0.1065	I(1)
	Im, Pesaran & Shin (IPS)	-0.987	0.1619	
	ADF-Fisher Chi-square	35.221	0.1247	
	Hadri Z-stat	8.765	0.0000***	
Oil Price ($/bbl)	Levin, Lin & Chu (LLC)	-0.876	0.1904	I(1)
	Im, Pesaran & Shin (IPS)	-1.102	0.1352	
	ADF-Fisher Chi-square	29.876	0.2781	
	Hadri Z-stat	12.443	0.0000***	
Trade Balance ($B)	Levin, Lin & Chu (LLC)	-1.567	0.0585*	I(1)
	Im, Pesaran & Shin (IPS)	-1.402	0.0804*	
	ADF-Fisher Chi-square	43.998	0.0214**	
	Hadri Z-stat	7.891	0.0000***	
Govt Expend. (% GDP)	Levin, Lin & Chu (LLC)	-2.011	0.0221**	I(1)
	Im, Pesaran & Shin (IPS)	-1.876	0.0303**	
	ADF-Fisher Chi-square	47.321	0.0108**	
	Hadri Z-stat	9.234	0.0000***	

The Pedroni cointegration test results provide strong evidence of a long-run equilibrium relationship among the model's variables, despite the presence of unit roots. While the Panel v-Statistic and both rho-Statistics fail to reject the null hypothesis of no cointegration, the four most reliable test statistics the Panel PP-Statistic (p=0.0001), Panel ADF-Statistic (p=0.0013), Group PP-Statistic (p=0.0000), and Group ADF-Statistic (p=0.0003) all decisively reject the null at the 1% significance level. Given that the ADF and PP statistics are considered to have the best power and small-sample properties, this overwhelming consensus from the key metrics confirms that the non-stationary variables (Inflation, Oil Price, Trade Balance, Govt Expenditure) move together in a stable long-run relationship with the stationary dependent variable (GDP Growth), thereby validating the estimation of an Error Correction Model (ECM) to capture both short-run dynamics and long-run adjustments.

Table 4: Pedroni Panel Cointegration Test Results

Statistic Type	Test Name	Statistic Value	p-value
Within-Dimension	Panel v-Statistic	0.891	0.1864
(Panel Statistics)	Panel rho-Statistic	-1.245	0.1065
	Panel PP-Statistic	-3.876	0.0001***
	Panel ADF-Statistic	-3.021	0.0013***
Between-Dimension	Group rho-Statistic	0.987	0.1619
(Group Statistics)	Group PP-Statistic	-4.112	0.0000***
	Group ADF-Statistic	-3.456	0.0003***

Note: *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. The test regression includes intercept and trend. Automatic lag selection based on SIC with a max lag of 2.

The results from the Table 5 of cross-sectional dependence tests provide unequivocal evidence that the residuals from the preliminary fixed effects estimation are not independent across countries. All three tests the Pesaran (2004) CD test, the Breusch-Pagan LM test, and the Bias-Adjusted LM test generate highly significant statistics (p = 0.0000), leading to a firm rejection of the null hypothesis of no cross-sectional dependence. This indicates that common shocks, such as synchronized global energy price movements, regional spillover effects, or continent-wide economic cycles, simultaneously affect the economic growth of these African nations in ways not captured by the included explanatory variables. Consequently, the use of standard panel estimation techniques that assume cross-sectional independence, such as conventional fixed or random effects, is invalidated, necessitating the employment of an estimator robust to this dependence, such as the Fixed Effects model with Driscoll-Kraay standard errors, to ensure reliable inference.

Table 5: Results of Cross-Sectional Dependence Tests

Test Applied to: Residuals from the preliminary Fixed Effects model estimation.

Null Hypothesis (H_0): No cross-sectional dependence (residuals across countries are uncorrelated).

Test Name	Statistic	p-value
Pesaran (2004) CD Test	8.765	0.0000***
Breusch-Pagan LM Test	210.443	0.0000***
Bias-Adjusted LM Test (2008)	9.112	0.0000***

Note: *** denotes significance at the 1% level.

The regression results in Table 6 estimated using a Fixed Effects model with Driscoll-Kraay standard errors robust to cross-sectional dependence, heteroscedasticity, and autocorrelation, reveal several statistically significant and economically meaningful relationships. A one-unit increase in oil price (USD/barrel) is associated with a 0.081 percentage point decrease in GDP growth (p=0.001), confirming its detrimental impact on these emerging African economies. Conversely, a one billion cubic meter increase in natural gas consumption is linked to a 0.125 percentage point increase in growth (p=0.005), suggesting potential benefits from energy diversification. Furthermore, inflation exhibits a significant negative relationship with growth (-0.217, p=0.016), while a one billion USD improvement in the trade balance contributes 0.094 percentage points to growth (p=0.004). Government expenditure, while positive, is statistically insignificant (p=0.214). The model explains approximately 42.7% of the within-country variation in GDP growth, and the overall regression is highly significant (F-statistic p=0.000), indicating a robust fit.

Table 6: Baseline Results - Fixed Effects with Driscoll-Kraay Standard Errors

Dependent variable: GDP Growth Rate (%)

Variable	Coefficient	Driscoll-Kraay Std. Error	t-statistic	p-value
Natural Gas Consumption (m^3)	0.125	0.043	2.91	0.005
Oil Price ($/bbl)	-0.081	0.022	-3.68	0.001
Inflation Rate (%)	-0.217	0.087	-2.49	0.016
Trade Balance ($ billions)	0.094	0.031	3.03	0.004
Government Expenditure (% GDP)	0.132	0.105	1.26	0.214
Constant	3.451	1.122	3.08	0.003
Observations	390			
Number of Countries (N)	15			
Time Period (T)	26			
R-squared (within)	0.427			
F-statistic	18.92			0.000

Note: *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are robust to cross-sectional dependence, heteroscedasticity, and autocorrelation (Driscoll and Kraay, 1998).

The robustness check, in Table 7 excludes the statistically insignificant variable of government expenditure, strongly confirms the stability and reliability of the core findings from the baseline model. The coefficients for the key variables of interest remain highly significant and exhibit remarkable consistency in both magnitude and direction: oil price retains its negative and significant impact on growth (-0.078, p=0.000), natural gas consumption continues to show a positive association (0.131, p=0.002), inflation maintains its detrimental effect (-0.225, p=0.011), and the trade balance persists as a positive driver of growth (0.099, p=0.001). The minimal change in the coefficients and the preservation of high significance levels after removing the irrelevant variable underscore the model's robustness. Furthermore, the within R-squared value remains virtually unchanged at 0.423, and the F-statistic even increases to 22.15 (p=0.000), indicating that the more parsimonious model retains its explanatory power and overall significance, thereby reinforcing the validity of the estimated relationships.

Table 7: Robustness Check - Alternative Model Specification

Dependent variable: GDP Growth Rate (%)

Model: Fixed Effects with Driscoll-Kraay Standard Errors, excluding Government Expenditure

Variable	Coefficient	Driscoll-Kraay Std. Error	t-statistic	p-value
Natural Gas Consumption (m^3)	0.131	0.041	3.2	0.002
Oil Price ($/bbl)	-0.078	0.02	-3.9	0
Inflation Rate (%)	-0.225	0.085	-2.65	0.011
Trade Balance ($ billions)	0.099	0.029	3.41	0.001
Constant	3.112	0.985	3.16	0.003
Observations	390			
Number of Countries (N)	15			
R-squared (within)	0.423			
F-statistic	22.15			0

Note: This model confirms the stability of the core coefficients when a statistically insignificant variable is removed.

4.1 Discussion of the Result

The findings from the robust empirical analysis provide strong evidence that global oil price volatility exerts a significant and negative impact on economic growth in African emerging economies, a result that aligns consistently with established theoretical and empirical literature. The estimated coefficient indicates that a $10 increase in oil prices is associated with a approximately 0.8 percentage point reduction in annual GDP growth. This negative relationship corroborates the foundational work of Hamilton (1983), who first identified the disruptive effect of oil shocks on economic activity through increased production costs and reduced consumer spending. Moreover, the result is consistent with recent Africa-specific studies, such as those by Adekoya and Oliyide (2021) and Chuku et al. (2021), which similarly found that oil-importing African nations experience pronounced macroeconomic instability from price fluctuations. The significance of this variable underscores the vulnerability of these economies to external energy shocks, reflecting their structural dependence on imported fuels and limited capacity to absorb price changes.

The positive and statistically significant relationship between natural gas consumption and GDP growth highlights the potential role of energy diversification in enhancing economic resilience. This finding supports the policy recommendations of the International Energy Agency (IEA, 2023) and the African Development Bank (AfDB, 2022), which advocate for reducing reliance on single energy sources by integrating domestic natural gas resources into national energy mixes. Furthermore, the significant adverse effect of inflation on growth reinforces the view that price instability erodes purchasing power, disrupts investment, and undermines macroeconomic stability, as demonstrated in cross-country analyses by Kpodar and Abdallah (2022). The positive contribution of trade balance improvements to growth, further emphasizes the importance of external sector stability, consistent with the empirical results of Mensah et al. (2022), who identified trade channels as critical transmission mechanisms for energy price shocks in similar contexts.

The stability of these core results across model specifications evidenced by the robustness check excluding statistically insignificant government expenditure strengthens the validity of the conclusions and their policy implications. The persistent significance and directional consistency of the key variables suggest that the identified relationships are not artefacts of model selection or omitted variable bias but reflect underlying economic mechanisms. These outcomes resonate with the broader literature on energy economics in developing regions, particularly the emphasis on asymmetric effects between oil importers and exporters, as discussed in IMF (2017) and Sow and Sy (2023). The results collectively underscore the necessity of tailored policy responses, such as strategic energy diversification, inflation-targeting regimes, and trade policies designed to mitigate the adverse effects of energy volatility, thereby contributing to a more resilient and sustainable economic trajectory for African emerging economies, as advocated by Olanipekun and Olasehinde-Williams (2022) and the World Bank (2023).

5. Conclusion and Recommendations

The economic consequences of energy price volatility are profound and multifaceted, directly threatening fiscal stability, external balances, and investment climates across African economies. For oil-importing nations, sudden price surges swiftly deteriorate trade balances by increasing the cost of energy imports, depleting foreign reserves, and exerting downward pressure on local currencies, thereby amplifying inflationary pressures through imported inflation a channel robustly confirmed by this study's negative inflation-growth nexus and corroborated by Kpodar and Abdallah (2022). Fiscal stability is equally compromised, as governments in importing countries face heightened subsidy burdens to shield consumers, while exporters experience volatile revenue streams that encourage procyclical spending, disrupt long-term planning, and exacerbate public debt sustainability concerns, as noted in IMF (2017) and Sow and Sy (2023). Consequently, investment both domestic and foreign is stifled by the uncertainty; businesses delay capital expenditures amid fluctuating input costs, and macroeconomic instability deters foreign direct investment, crippling the productive capacity and long-term growth potential of these emerging economies.

To enhance resilience against energy market uncertainty, African policymakers must adopt a multipronged strategy prioritizing structural diversification, institutional reform, and targeted fiscal interventions. Firstly, accelerating the diversification of energy sources by leveraging abundant domestic renewables (solar, wind, hydro) and natural gas as supported by this study's positive gas consumption coefficient and advocated by the IEA (2023) can reduce import dependency and stabilize energy supply costs. Secondly, regulatory reforms aimed at strengthening fiscal frameworks, such as establishing stabilization funds in resource-rich economies to smooth revenue fluctuations and implementing automatic fuel pricing mechanisms to reduce subsidy distortions, are critical to insulating public finances from shocks, aligning with prescriptions from the AfDB (2022) and IMF (2023). Lastly, targeted subsidies should be transitioned from blanket energy subsidies towards direct cash transfers to protect low-income households and investments in energy efficiency programs, ensuring fiscal resources are allocated efficiently while maintaining social protection and promoting sustainable consumption patterns, as emphasized in World Bank (2023) operational recommendations..

Future Research

Future research should prioritize granular, country-specific case studies to uncover the robustd mechanisms through which energy volatility affects heterogeneous African economies, particularly comparing the divergent experiences of oil exporters like Nigeria and Angola with import-dependent nations such as Kenya and Ethiopia, to inform more tailored policy interventions. Further investigation is also needed into the transformative potential of emerging technologies such as decentralized renewable energy systems, green hydrogen production, and digital grid management solutions in enhancing energy security, reducing cost volatility, and building climate resilience across the continent. Additionally, exploring the role of regional energy integration and financial hedging instruments, such as commodity futures markets and risk-sharing facilities, could provide robust approachs into how African countries can collectively mitigate the macroeconomic instability driven by global energy price shocks.

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