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MONETARY POLICY TRANSMISSION TO THE ENERGY SECTOR IN NIGERIA: A COMPARATIVE ARDL INVESTIGATION OF RENEWABLE AND NON- RENEWABLE SOURCES

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Abstract

Nigeria faces an energy paradox characterised by a heavy reliance on unsustainable traditional biomass and the growing consumption of fossil fuels, despite the global push for a clean energy transition. The role of monetary policy in shaping this trajectory remains inconclusive, as the extant literature lacks a comparative analysis of its effects on both fossil and renewable energy consumption. This study therefore investigates the short- and long-run effects of monetary policy instruments (the monetary policy rate, liquidity ratio, and broad money supply) on renewable and fossil fuel energy consumption in Nigeria from 1990 to 2022. Using the Autoregressive Distributed Lag (ARDL) bounds testing approach, the findings reveal that a contractionary monetary policy stance, characterised by an increase in interest rates, negatively affects renewable energy consumption but increases fossil fuel consumption in the short run. In the long run, the liquidity ratio significantly sustains dependence on fossil fuels without promoting growth in renewable energy. The study concludes that conventional monetary policy is ineffective for promoting sustainable energy in Nigeria and recommends the implementation of targeted green financing instruments, such as differentiated cash reserve requirements for banks' lending to renewable projects and coordinated macroeconomic policies to de-risk investments in the energy sector.

Keywords: Monetary policy rate, liquidity ratio, money supply, renewable energy, fossil fuel energy, energy transition, sustainable energy.

Introduction

The global pursuit of sustainable development has placed energy consumption at the forefront of economic and environmental policy debates. A critical, yet complex, aspect of this dialogue is the role of national financial systems and, specifically, monetary policy in shaping a country's energy trajectory. While monetary policy is traditionally designed to achieve price stability and foster full employment, its transmission mechanisms inevitably ripple through every sector of the economy, including energy. The cost of capital, influenced by central bank's monetary policy rates, affects investment decisions in long-term energy projects. Similarly, liquidity conditions and the money supply influence aggregate demand, which in turn drives energy consumption patterns (Auclert *et al.*, 2023). Consequently, understanding how monetary policy impacted the consumption of both fossil fuels and renewable energy become a prerequisite for designing policies that align economic stability with environmental sustainability.

The existing literature provides valuable but fragmented insights into this relationship. Several studies have established a link between expansionary monetary policy and high carbon emissions, largely driven by stimulated economic activity and higher fossil fuel consumption (Qingquan *et al.*, 2020; Wu, Yang, and Chen, 2024). Conversely, other research highlights the positive impact of lower interest rates on renewable energy development by reducing the cost of financing for capital-intensive green projects (Hashmi *et al.*, 2022). However, a few studies have analysed the effects of monetary policy on both fossil and renewable energy consumption (Bildirici, Çırpıcı, and Ersin, 2023). This omission is critical, as it obscures the potential trade-offs or synergies that monetary policy creates between these two competing energy sources. For instance, an expansionary policy boosts both economic activity (increasing fossil fuel use) and renewable investment, but the net effect on the energy mix remains ambiguous without direct comparison (Jin *et al.*, 2023). This study seeks to fill this gap by focusing on the Nigerian economy.

Nigeria has a paradoxical energy situation, being rich in resources like oil, gas, and solar energy but suffering from widespread energy poverty and access issues for millions of citizens. As a major oil-producing nation, its economy is heavily reliant on fossil fuels, both for export revenue and domestic consumption (Alimi, 2015). Nevertheless, the country faces a severe energy crisis, with inadequate electricity access hindering economic growth (Isola, Mesagan, and Alimi, 2017; Ajide, Dauda, and Alimi, 2023). Paradoxically, despite the high share of renewable energy in its total final energy consumption, primarily from traditional biomass, modern renewable penetration remains low. Renewable energy consumption (dominated by biomass) has consistently been above 80% of total final energy consumption between 1990 and 2022, but this masks energy poverty and the use of inefficient and unsustainable sources. Furthermore, fossil fuel consumption has demonstrated an upward trend, rising from 20.52% in 1990 to 22.62% in 2022 (World Bank, 2024). This indicates a growing dependency on fossil fuels, even as the global community advocates for a transition.

Meanwhile, Nigeria has experienced significant volatility in its monetary policy, as evidenced by the fluctuations in the monetary policy rate, which ranged from a low of 6% in 2009 to a high of 26% in 1993. Liquidity ratios and broad money supply (% of GDP) have also shown considerable variation over the same period (Central Bank of Nigeria, 2024). The co-movement of these monetary policy variables with the trends in energy consumption suggests a potential relationship that warrants empirical investigation. For example, the period following the 2008 financial crisis saw a sharp reduction in the policy rate to 6% alongside an expansion in broad money. This was followed by a notable spike in renewable consumption (88.68% in 2009) and a dip in fossil fuel use (15.85%), but these trends reversed in subsequent years as policy tightened (Central Bank of Nigeria, 2024). This study therefore investigates the effects of key monetary policy variables, the monetary policy rate, liquidity ratio, and broad money supply, on both fossil fuel and renewable energy consumption in Nigeria within the period 1990–2022.

This study employed the Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran *et al.* (2001). The ARDL methodology is particularly suited for this investigation for several reasons. First, it is robust for analysing time-series data with variables integrated of different orders, such as $I(0)$ and $I(1)$, which is a common feature in macroeconomic data. Second, it provides unbiased estimates of both short-run dynamics and long-run relationships, offering a comprehensive view of how monetary policy shocks transmit

energy markets over time.

The remaining part of this study is structured as follows. The second section succinctly summarises existing literature. Section 3 addresses the data and methodology employed in the study. Section 4 presents the analysis and discussion of the estimation results. The study concludes by emphasising the main findings and policy suggestions.

Literature Review

Empirical evidence on the hypothesis remains mixed, as results are highly sensitive to factors such as the countries studied, the time period, the chosen variables, and the econometric methodologies employed. Sohail *et al.* (2021) investigate if there is an uneven effect of US monetary policy uncertainty on energy consumption using both symmetric and asymmetric autoregressive distributed lag (ARDL) estimation methods. It reveals that monetary policy uncertainty negatively affects on renewable energy consumption in both the short and long term within the linear model. Additionally, a reduction in monetary policy uncertainty significantly decreases renewable energy consumption in the USA, as observed in the non-linear model. Nevertheless, the analysis reveals that the level of uncertainty in monetary policy has a negligible influence on non-renewable energy consumption in both the short and long term. However, heightened uncertainty in monetary policy in the United States has adverse consequences, whereas reduced uncertainty has beneficial effects on non-renewable energy consumption in both the short and long term, as indicated by the non-linear model.

Qingquan *et al.* (2020) examined the influence of monetary policies on carbon emissions in certain Asian economies from 1990 to 2014. The findings, derived from the Pedroni and Kao co-integration tests, the fully modified panel, and the panel dynamic least squares approaches, demonstrated a significant and positive relationship between expansionary monetary policy and carbon emissions. The contractionary monetary policy is an effective measure to reduce carbon emissions. Moreover, enhancements in human capital yield a positive effect on mitigating carbon emissions. Remittances and fossil fuels significantly influence carbon emissions. Hashmi, Syed, and Inglesi-Lotz (2022) investigated the relationship between monetary policy and renewable energy in the United States by examining the effects of monetary policy on renewable energy. The findings demonstrate that implementing expansionary monetary policy has a positive impact on the development and adoption of renewable energy sources, both in the long term and short term. Moreover, the influence of monetary policy is considerably significant in the short term.

Auclert *et al.* (2023) analysed the macroeconomic impacts of energy price shocks in energy-importing nations using a heterogeneous-agent model. They found that when the marginal propensity to consume is high and the elasticity of substitution between energy and domestic products is significantly low, an increase in energy costs leads to a decrease in real wages and triggers a recession, regardless of whether the central bank tightens monetary policy or not. Imported energy inflation led to wage inflation through a wage-price spiral, but such an action does not alleviate the decrease in real wages. Sun *et al.* (2022) conducted a study on the relationship between the monetary and fiscal policies of G7 countries and the generation of renewable energy from 2000 to 2018. The researchers use the Stochastic Impact of Regression on Population, Affluence, and Technology (STIRPAT) model and employ cross-sectional augmented econometric methods to provide impartial and efficient findings. The findings indicate that increasing government spending has a significant and positive impact on the production of renewable energy. At the same time, the expansionary monetary policy of the



countries demonstrates an adverse reaction against investment in renewable energy generation. Furthermore, the study observed a similar pattern of reaction across various levels

of energy production. Also, the causality test indicated that there is a one-way causality from renewable energy to the fiscal and monetary policy indicators of G7 economies.

Jothr, Jummaa, and Ambariyani (2023) analysed the impact of monetary policy instruments, namely interest rate, exchange rate, and money supply, on five sustainable development indicators defined by the United Nations in Iraq. The sustainable development indicators comprise the proportion of the population living below the international poverty line (1.1.1), proportion of population using safely managed drinking water (6.1.1.), change in water-use efficiency (6.4.1), renewable energy (7.2.1) share in the total final energy consumption, and annual growth rate of real GDP per capita (8.1.1). Applying the two-stage least squares (2SLS) technique, the findings indicate that the exchange rate has a positive impact on poverty indices, effective water resource management, and per capita economic growth. However, it has an adverse influence on access to safe drinking water. Out of all the tools used in monetary policy, money supply has a positive impact on poverty. Wu, Yang, and Chen (2024) investigated the impact of monetary policy on carbon emissions in specific nations throughout the time frame of 2000-2019, focusing on non-linear effects. The study utilised the Panel Smooth Transition Regression (PSTR) method and discovered a non-linear and positive relationship between the quantity of money supply and carbon emissions. Moreover, the impact of monetary policy on carbon emissions is insignificant in nations that have greater levels of human development or modest proportions of manufacturing in their GDP.

Wang, Wang, and Wang (2022) used the panel system generalized moments approach to examine the influence of monetary policy on the energy security of 16 Asian nations during the period from 2000 to 2019. The study finds that there is a positive link between the real interest rate, total reserve, and exchange rate with energy security. In other words, when these three indicators decrease, the risk of energy security also increases. Jin *et al.* (2023) examined the impact of two types of monetary policies (targeted refinancing, and broad refinancing) on the optimization of the energy supply structure. This is done using a dynamic stochastic general equilibrium model. The findings indicate that targeted refinancing efforts result in a specific rise in bank loans to the green energy industry, accompanied by reduced interest rates. Conversely, when it comes to broad refinancing, there is a substantial increase in loans for fossil energy, resulting in higher production. However, such an increase has a detrimental influence on the output of the green sector.

Razmi, Moghadam, and Behname (2021) examined the influence of monetary policy on the production of renewable energy in Iran. The analysis focuses on three categories of renewable energy production: overall renewable energy production, solid biomass and biogas energy production, and the combined energy production from hydropower, solar, and wind sources. The study used the Kalman filter and vector autoregression (VAR) models to analyse annual data spanning from 1984 to 2016. The Kalman filter model demonstrated that the money supply parameter had a significant impact, except for a sudden disruption during the Iran-Iraq War. The results of the VAR model suggest that only a perturbation in the money supply has the potential to impact all three types of renewable energy output. Pirgaip and Dinçergök (2020) examined the causal link between economic policy uncertainty and energy consumption as well as CO₂ emissions in G7 countries. The analysis utilises a bootstrap panel test for Granger causality test, which was created by Kónya (2006). The test uses a yearly dataset covering the period from 1998 to 2018. The findings show substantial evidence for a one-way relationship

economic policy uncertainty influences energy consumption in Japan, CO₂ emissions in the USA and Germany, and both energy consumption and CO₂ emissions in Canada. In Italy,

there is a causal relationship where CO₂ emissions influence economic policy uncertainty. Additionally, there is a bidirectional causal relationship between economic policy uncertainty and energy use. Additionally, it discovered a one-way relationship in which energy usage influences CO₂ levels in the USA.

While the existing body of research provides insights into the relationship between monetary policy and energy markets, a critical gap remains. Specifically, there is a lack of a comparative analytical framework that directly investigates the mechanisms of monetary policy on both fossil fuel and renewable energy consumption. The reviewed literature is fragmented, with studies typically focusing on one energy type or an aggregate outcome like carbon emissions. For example, Sohail *et al.* (2021) and Hashmi *et al.* (2022) focus on renewable energy, finding conflicting short-term impacts of expansionary policy. Qingquan *et al.* (2020) and Wu *et al.* (2024) link monetary policy to carbon emissions, implicitly tying it to fossil fuel use, but did not disentangle its direct effect on fossil consumption versus its indirect effect through economic activity. Jin *et al.* (2023) highlighted a crucial divergence in how different monetary instruments affect energy supply (green vs. fossil lending), but this supply-side focus does not extend to the final consumption of these energy sources. Thus, existing literature lacks explicit models that compare the responsiveness of fossil fuel and renewable energy consumption to monetary policy variables (such as interest rates, money supply, and liquidity ratio).

Methodology

Analytical framework and model specification

This study hinges on the Heterogeneous Agent New Keynesian (HANK) models to discuss the theoretical link between monetary policy and energy consumption. The hypothesis incorporates the critical channels through which policy shocks transmit to the real economy and energy demand (Auclert *et al.*, 2023). This model improves upon earlier frameworks by accounting for the significant heterogeneity in households' marginal propensity to consume. When central banks adjust policy rates, the impact on aggregate energy consumption is not uniform; households with a high marginal propensity to consume, typically those with lower wealth or liquidity constraints, exhibit a stronger immediate response in their spending (including on energy) to changes in income or borrowing costs (Auclert *et al.*, 2023; Audzei and Sutóris, 2024). Furthermore, the HANK model is particularly effective for analysing energy price shocks, which function as negative income shocks. A calibrated HANK model shows that rising energy prices depress real incomes and triggers a recession, compelling a monetary policy response even though tightening may have a limited direct effect on imported energy inflation (Auclert *et al.*, 2023; Chen and Lin, 2024; Lupu *et al.*, 2024). Following the framework, this study adapted and modified the empirical model of Sohail *et al.* (2021) and Hashmi, Syed, and Inglesi-Lotz (2022) to estimate the effects of monetary policy variables on energy consumption in Nigeria. These studies posit monetary policy variables as key determinants of energy usage, contending that monetary policy instruments govern factors influencing economic activities, thereby fostering enhanced energy consumption. Consequently, the model is formulated functionally as follows:

$$EC_t = f(Y_t, K_t, MPR_t, MS_t, LR_t) \quad (1)$$

Therefore, the model incorporating control variables is specified as follows:

$$\ln EC_t = \phi_0 + \phi_1 \ln Y_t + \phi_2 \ln K_t + \phi_3 MPR_t + \phi_4 \ln MS_t + \phi_5 \ln LR_t + e_t \quad (2)$$

EC denotes energy consumption; Y represents output growth; K is capital investment; MPR is monetary policy rate, MS denotes money supply, and LR represents liquidity ratio.

Also, ϕ_0 is constant, and ϕ_{1-5} are the parameters of energy consumption with respect to output, capital, monetary policy rate, money supply and liquidity ratio respectively; t is time; and e is error term.

***A priori* expectations**

The theoretical expectations for the first model regarding energy consumption, output growth, capital investment, monetary policy rate, money supply, and liquidity ratio are presented as follows. We expected that energy consumption would positively relate with output growth. Higher levels of economic output typically require increased energy usage to fuel production processes and meet rising demand for goods and services. Energy consumption is anticipated to have a positive relationship with capital investment. Thus, greater investment in capital-intensive industries and infrastructure often leads to higher energy usage as machinery, equipment, and facilities require energy inputs to operate efficiently. The impact of the monetary policy rate on energy consumption is less straightforward. A higher policy rate, indicative of tighter monetary policy, may initially suppress economic activity and reduce energy consumption. Conversely, a lower policy rate, indicating accommodative monetary policy, may stimulate economic growth and lead to increased energy usage in the long run. Energy consumption is expected to have a positive association with the money supply. Expansionary monetary policy, characterised by an increase in the money supply, tends to stimulate economic activity and raise energy demand as businesses and consumers have access to more liquidity for spending. The liquidity ratio's effect on energy consumption is likely to be ambiguous. A higher liquidity ratio, indicating a more conservative approach to lending by financial institutions, may constrain economic activity and suppress energy demand. Conversely, a lower liquidity ratio signals a weak credit environment, may stimulate economic growth and boost energy usage.

Estimation methods

This study employs a sequential econometric methodology, beginning with unit root tests, Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS), to ascertain the stationarity properties of the variables and ensure the validity of the subsequent Autoregressive Distributed Lag (ARDL) bounds testing approach, developed by Pesaran, Shin, and Smith (2001). This methodology is particularly well-suited for this study for several compelling reasons. First, it is applicable irrespective of whether the underlying regressors are purely $I(0)$, purely $I(1)$, or mutually cointegrated. This flexibility is a significant advantage over traditional cointegration methods like the Johansen test, which require all variables to be non-stationary at levels (Alimi, Fagbohun, and Abubakar, 2021; Alimi and Oyeku, 2023). Given the mixed nature of economic time series, the ARDL approach provides a more reliable framework. Second, the ARDL model provides unbiased estimates of the long-run coefficients and super-consistent short-run dynamics, even in the presence of endogenous explanatory variables (Mesagan, Alimi, and Adebisi, 2018; Mesagan, Alimi, and Yusuf, 2018; Mesagan *et al.*, 2019; Ogbuji, Mesagan, and Alimi, 2020).

Third, it is statistically more efficient in small sample sizes, such as the 33-year period (1990–2022) used in this study. Following the ARDL estimation, a comprehensive set of diagnostic tests, including checks for serial correlation (Breusch-Godfrey), heteroskedasticity (Breusch-Pagan-Godfrey), normality (Jarque-Bera), and model specification (Ramsey RESET), were conducted to ensure the reliability of the inferences, while the stability of the coefficients was

and using the Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ) of recursive residuals tests.

Results and Discussion of Findings

Summary statistics

The descriptive statistics of the variables presented in Table 1 indicate that the average share of renewable energy consumption in the total final energy mix stands at 85.05% for the period under review. This high mean value suggests a significant reliance on renewable sources within the Nigerian economy, albeit predominantly from traditional biomass. Conversely, the mean value for fossil fuel use is 19.77%, demonstrating a substantial, though secondary, dependence on non-renewable energy sources. Concerning the monetary policy variables, the average monetary policy rate was 13.74%, reflecting a generally high cost of borrowing environment, while the mean liquidity ratio and broad money supply as a percentage of GDP were 49.54% and 18.18%, respectively. For the control variables, the average economic growth rate was 4.29%, and the average growth of gross fixed capital formation was 2.30%, indicating modest levels of investment and economic expansion over the studied period.

Table 1 Descriptive statistics

Signs	Variable Measurements	Mean	Std Dev.	Max.	Min.	Kurtosis	Skewness	Jarque-Bera	Prob.
ren	Renewable energy consumption (% of total final energy consumption)	85.050	2.315	88.68	80.64	-0.991	-0.333	1.995	0.369
nen	Fossil fuel energy consumption (% of total)	19.771	1.762	22.85	15.85	-0.788	-0.037	1.001	0.606
mpr	Monetary Policy Rate	13.742	3.811	26	6	2.683	0.783	9.233	0.010
lr	Liquidity ratio	49.536	15.457	104.2	26.39	4.002	1.516	25.977	0.000
ms	Broad money (% of GDP)	18.181	6.140	27.38	9.063	-1.718	0.030	3.726	0.155
y	GDP growth	4.288	3.958	15.33	-2.035	0.662	0.487	1.398	0.497
k	Gross fixed capital formation (annual % growth)	2.302	12.268	40.39	-23.75	2.424	0.303	5.399	0.067
l	Labor force participation rate, total (% of total population ages 15+)	58.914	6.284	76.34	55.4	3.439	2.151	33.666	0.000

Note: Std Dev. – standard deviation; Max. – maximum; Min. – minimum; Prob. – probability; Observation is 33.

Source: Authors' computation (2025).

Regarding the distributional properties of the series, the skewness statistics show that renewable energy consumption (ren) and fossil fuel consumption are negatively skewed with values of -0.333 and -0.037, respectively, indicating a longer left tail in their distributions. The monetary policy rate and liquidity ratio are positively skewed, with the latter having a pronounced skewness of 1.516. The kurtosis values identify that renewable energy consumption (ren), fossil fuel consumption, and broad money supply are platykurtic (kurtosis < 3), implying a flatter distribution than normal. In contrast, the liquidity ratio is leptokurtic (kurtosis > 3), suggesting a peaked distribution. The Jarque-Bera test probabilities confirm that for variables like monetary policy rate and liquidity ratio, the null hypothesis of normal distribution is rejected at a 5% significance level, whereas for renewable energy, fossil fuel consumption, and money supply, the test fails to reject normality, as their probabilities exceed the conventional significance levels.

Correlation analysis

Table 2 presents the partial correlation matrix for GDP growth, monetary policy variables, energy consumption, and capital formation in Nigeria using an annual dataset from 1990 to 2022. The correlation coefficients indicating the level of association among the variables are generally low to moderate, and none of them is 0.9, suggesting that severe multicollinearity is not a pervasive issue among the regressors for subsequent empirical modelling. Furthermore, the coefficients exhibit a mix of positive and negative signs, reflecting diverse interrelationships within the economy. The result shows that GDP growth has a negative level of association with the monetary policy rate, liquidity ratio, and broad money supply, whereas it correlates positively with capital formation.

Table 2: Correlation matrix

	<i>y</i>	<i>mpr</i>	<i>lr</i>	<i>ms</i>	<i>ren</i>	<i>nen</i>	<i>k</i>
<i>mpr</i>	-0.178	1					
<i>lr</i>	-0.154	0.094	1				
<i>ms</i>	-0.172	-0.359	0.115	1			
<i>ren</i>	0.051	-0.007	-0.365	-0.439	1		
<i>nen</i>	-0.121	0.489	0.307	0.038	-0.388	1	
<i>k</i>	0.206	-0.060	0.244	-0.122	-0.015	0.045	1
<i>l</i>	-0.313	-0.092	0.138	0.587	-0.592	0.141	-0.052

Source: Authors' computation (2025).

Regarding the key variables of interest, the monetary policy rate demonstrates a moderate positive correlation with fossil fuel use at 0.489, suggesting a potential link between tighter monetary policy and increased fossil fuel use. Conversely, the liquidity ratio and broad money supply show negative correlations with renewable energy consumption at -0.365 and -0.439, respectively. A notable inverse relationship is observed between renewable and fossil fuel energy consumption, which is negative at -0.388, hinting at a substitution effect between the two energy sources in the Nigerian context.

Unit root test

This section presents the results of the unit root test as it examines the stationarity level of the variables. It is used to check for the presence of a unit root, i.e., if the variables are not stationary at levels. This test is carried out using the Augmented Dickey-Fuller (ADF), Phillip-Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. The results of ADF, PP, and KPSS tests are presented in Table 3.

Table 3: Unit root test results [trend and intercept]

Variables	Augmented Dickey Fuller (ADF)		Phillip-Perron (PP)		Kwiatkowski–Phillips–Schmidt–Shin (KPSS)		I(d)
	Levels	1st Difference	Levels	1st Difference	Levels	1st Difference	
<i>y</i>	-1.9368	-9.1197***	-3.6049**	—	0.1514	0.0900***	I(1)
<i>mpr</i>	-3.3552*	-7.7846***	-3.3348*	-8.6703***	0.1282	0.0901***	I(1)
<i>lr</i>	-3.3540*	-6.7948***	-3.4026*	-11.041***	0.0040***	—	I(1)
<i>ms</i>	-2.2634	-4.5166***	-1.9491	-6.4175***	0.1054	0.0646***	I(1)
<i>ren</i>	-1.8221	-4.8257***	-1.8221	-4.8229***	0.0589***	—	I(1)
<i>nen</i>	-2.0158	-5.5926***	-1.9502	-6.1300***	0.1221	0.0561***	I(0)

	-10.245***	—	-12.462***	—	0.0229***	—	
1	-4.8408***	—	-2.1829	-4.9726***	0.0868***	—	I(1)

Note: ***, ** and * signify significance level at 1%, 5% and 10% respectively.

Sources: Authors' computation (2025).

Furthermore, the a priori expectation when using the ADF and PP tests is that a variable is stationary when the value of their test statistics is greater than the critical value at a specified significance level, while for the KPSS test, the null hypothesis is that the series is stationary. From the test results reported in Table 4.3, the variable for capital formation was found to reject the null hypothesis of a unit root at the 1% significance level in both the ADF and KPSS tests at level, indicating it is integrated of order zero, I(0). However, the series for GDP growth, monetary policy rate, liquidity ratio, broad money supply, renewable energy consumption, and labour are not stationary at levels. They were found not to reject the null hypothesis of a unit root at level for the ADF/PP tests, but after first differencing, the series became stationary at the 1% significance level. This indicates that the first difference of these series was stationary; thus, they are integrated at order one, i.e., I(1). The fossil fuel consumption series presents a mixed outcome but is concluded to be I(1) based on the ADF and PP test results at first difference.

Cointegration test result

The study tests the long-run relationship between monetary policy, energy consumption, and other controlling variables using the autoregressive distributed lag (ARDL) bounds cointegration test. The ARDL bound test is employed because it is suitable for variables at a different order of integration, as established by the unit root tests. The F-statistic estimates for testing the existence of a long-run relationship are presented in Table 4.

Table 4: ARDL bound test of monetary policy and energy consumption

Test Statistic	Value	K
F-statistics (ren k, l, mpr, ms, lr)	4.2445	5
F-statistics (nen k, l, mpr, ms, lr)	3.5319	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.08	3.00
5%	2.39	3.38
2.5%	2.70	3.73
1%	3.06	4.15

Source: Authors' computation (2025).

In Table 4, the estimated F-statistic for the renewable energy consumption model ($F_{ren} = 4.2445$) is greater than the upper critical bound of 4.15 at the 1% significance level. This implies that the null hypothesis of no long-run relationship is rejected at the 1% significance level. Similarly, for the fossil fuel energy consumption model ($F_{nen} = 3.5319$), the estimated F-statistic exceeds the upper critical bound of 3.38 at the 5% significance level. The implication of these estimations is that monetary policy variables (monetary policy rate, liquidity ratio, and broad money supply), control variables (capital and labour), and their respective energy consumption variable all have an equilibrium condition that keeps them together in the long run. Thus, there exists a long-run relationship between monetary policy and both renewable and fossil fuel energy consumption in Nigeria.

Short-run and long-run estimation results

A) Effect of monetary policy on renewable energy

This section answers the null hypothesis that monetary policy has no significant effect on renewable energy consumption in Nigeria. It examines both the short-run and long-run relationship estimates using the estimated ARDL approach. The selected model, ARDL (3, 2, 1, 1, 1, 1), was chosen based on the Akaike Information Criterion, ensuring sufficient degrees of freedom. The short-run estimation results show the error correction mechanism, which measures the speed of adjustment. The coefficient of the ECT is found to be negative and statistically significant at the 1% level. The ECT value of -0.9807 implies a very high speed of adjustment, indicating that the model corrects its short-run disequilibrium by about 98.07% annually to return to the long-run equilibrium. This suggests that deviations from the long-run equilibrium are corrected very quickly within a year.

Table 5: Results of the estimated ARDL model of renewable energy

Dependent Variable: Renewable energy (ren)				
Selected Model: ARDL (3, 2, 1, 1, 1, 1)				
Sample: 1990 2022			Included observations: 30	
<i>Short-Run Estimates</i>				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Δ(ren(-1))	0.589941	0.185323	3.183306	0.0062
Δ(ren(-2))	0.349120	0.177941	1.961996	0.0686
Δ(k)	-0.080993	0.022855	-3.543696	0.0029
Δ(k(-1))	0.074965	0.019312	3.881785	0.0015
Δ(l)	-0.070980	0.063365	-1.120178	0.2803
Δ(mpr)	-0.112355	0.061333	-1.831878	0.0869
Δ(ms)	0.238084	0.094788	2.511765	0.0239
Δ(lr)	0.018384	0.018229	1.008546	0.3292
ECT(-1)	-0.980661	0.209098	-4.689962	0.0003
<i>Long-run Estimates</i>				
k	-0.207054	0.098186	-2.108792	0.0522
l	-0.237192	0.069550	-3.410396	0.0039
mpr	0.030245	0.113784	0.265807	0.7940
ms	-0.021756	0.073894	-0.294421	0.7725
lr	-0.043406	0.028700	-1.512391	0.1512
c	101.4622	3.363231	30.16807	0.0000
R-squared	0.5852	F-stat	4.7867 (0.0024)	
Adj. R-squared	0.4271	D-Watson	1.7898	

Diagnostic tests of selected ARDL model

Serial Correlation: 0.5461 [0.5919] **Normality Test:** 0.1227 [0.9405]
Functional Form: 0.6952 [0.4983] **Heteroskedasticity Test:** 0.5766 [0.8448]

Source: Authors' computation (2025).

The coefficients of the short-run dynamics reveal the immediate impacts of the variables. The first and second lags of the change in renewable energy consumption have positive and significant effects on its current change, indicating a strong inertial component. The change in capital formation has a negative immediate impact, but its first lag exerts a positive and

significant influence, suggesting complex investment dynamics. Most critically for this study, the change in the monetary policy rate has a negative and statistically significant effect (at the

10% level) on renewable energy consumption in the short run, implying that an increase in interest rates quickly reduces renewable energy use. Conversely, the change in the money supply has a positive and significant impact, highlighting the importance of liquidity.

The long-run estimates indicate that capital formation and the labour force have a negative and statistically significant influence on renewable energy consumption in the long run. A 1% increase in the labour force is associated with a 0.24% decrease in the share of renewable energy. However, the key monetary policy variables, the monetary policy rate, money supply, and liquidity ratio, all show negative but statistically insignificant coefficients in the long run. This implies that while monetary policy shocks have immediate short-run effects, their long-run impact on the equilibrium level of renewable energy consumption in Nigeria is not statistically discernible within this model.

The model's goodness-of-fit is assessed through diagnostic statistics. The explanatory variables account for about 58.52% of the variation in renewable energy consumption, according to the coefficient of determination (R-squared) of 0.5852. The F-statistic of 4.7867, statistically significant with a probability value of 0.0024, confirms the overall significance of the model. Furthermore, the Durbin-Watson statistic of 1.7898 is close to 2, suggesting the absence of first-order serial correlation in the residuals, which supports the reliability of the estimated coefficients. Also, the estimated ARDL model is tested for heteroscedasticity, serial correlation, functional form misspecifications, parameter stability, and normality. The results from these tests are shown in Table 5. The estimated ARDL model revealed that it passed the serial correlation, normality, and heteroskedasticity tests. It means that the error terms are normally distributed with the same variances, and they are not serially correlated. Furthermore, the Ramsey RESET test was satisfactory for the ARDL model indicating that the model is well distributed. Additionally, the ARDL model, passed the Ramsey RESET test, showing that it was evenly specified. Additionally, Figures 1 and 2 show that the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) are steady.

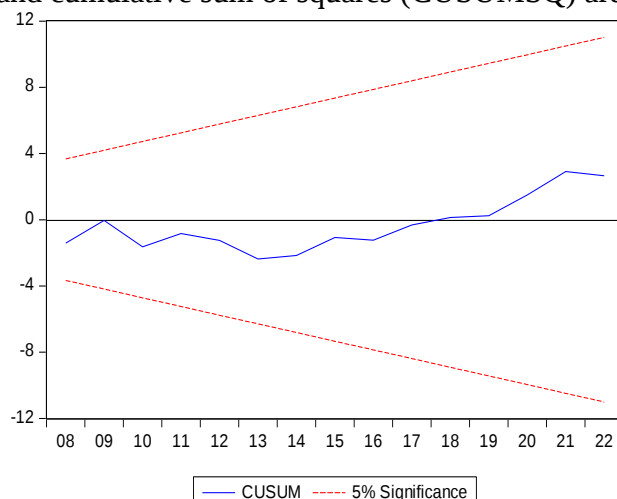


Figure 1: Cumulative sum

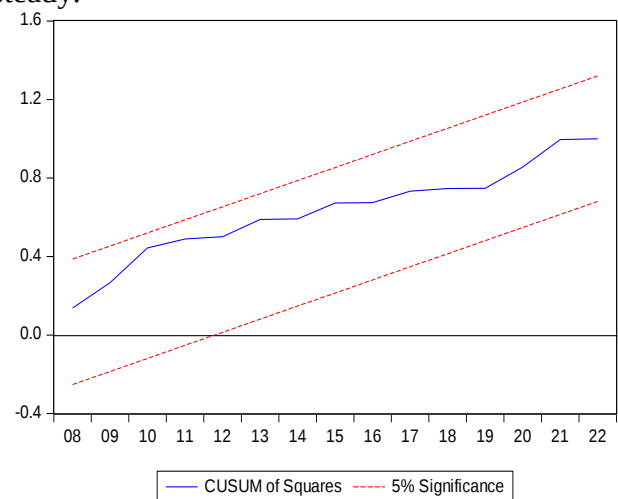


Figure 2: Cumulative sum of squares

B) Effect of monetary policy on non-renewable energy

This section addresses the null hypothesis that monetary policy has no significant effect on fossil fuel energy consumption in Nigeria by examining the short-run and long-run estimates

estimated from the ARDL approach. The selected model for this analysis is ARDL (3, 0, 0, 1, 2). The short-run results include the error correction term (ECT), which is crucial for

understanding the dynamics of adjustment. The coefficient of the ECT is found to be negative and statistically significant at the 1% level. The value of -0.6402 indicates a moderately high speed of adjustment, meaning that approximately 64.02% of any disequilibrium in fossil fuel consumption caused by a shock to the explanatory variables is corrected within one year, leading the system back to its long-run equilibrium path.

Table 6: Results of the estimated ARDL model of non-renewable energy

Dependent Variable: Non-renewable energy (nen)

Selected Model: ARDL (3, 0, 0, 1, 2, 2)

Sample: 1990 2022

Included observations: 30

<i>Short-Run Estimates</i>				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
$\Delta(\text{nen}(-1))$	0.120344	0.117044	1.028198	0.3192
$\Delta(\text{nen}(-2))$	0.226954	0.118250	1.919268	0.0730
$\Delta(\text{mpr})$	0.151583	0.039668	3.821290	0.0015
$\Delta(\text{ms})$	-0.091618	0.063635	-1.439750	0.1692
$\Delta(\text{ms}(-1))$	-0.203791	0.066052	-3.085329	0.0071
$\Delta(\text{lr})$	0.012407	0.010531	1.178168	0.2560
$\Delta(\text{lr}(-1))$	-0.044711	0.011946	-3.742899	0.0018
ECT(-1)	-0.640225	0.109807	-5.830439	0.0000
<i>Long-run Estimates</i>				
k	-0.002465	0.026901	-0.091619	0.9281
l	0.041631	0.058150	0.715924	0.4844
mpr	0.084038	0.109898	0.764695	0.4556
ms	0.043219	0.073650	0.586821	0.5655
lr	0.082205	0.024602	3.341449	0.0041
c	11.29333	3.382300	3.338950	0.0042
R-squared	0.7642	F-stat	6.9534 (0.0002)	
Adj. R-squared	0.6892	D-Watson	2.0495	

Diagnostic tests of selected ARDL model

Serial Correlation: 3.0256 [0.0809] **Normality Test:** 0.1257 [0.9391]
Functional Form: 0.0742 [0.9418] **Heteroskedasticity Test:** 1.0327 [0.4688]

Source: Authors' computation (2025).

The short-run dynamics reveal the immediate impacts of monetary policy variables. The change in the monetary policy rate has a positive and statistically significant effect (at the 1% level) on fossil fuel consumption, suggesting that an increase in interest rates leads to an immediate increase in the use of non-renewable energy. The changes in the money supply and the first lag of the liquidity ratio show negative and significant impacts, indicating that expansions in liquidity conditions can suppress fossil fuel consumption in the short run. The second lag of the dependent variable is also positive and significant, reflecting inertial momentum in fossil fuel use.

The long-run estimates offer details about the sustained equilibrium relationship. Contrary to the short-run findings, the monetary policy rate and money supply show positive but

statistically insignificant coefficients, suggesting their long-run influence on the equilibrium level of fossil fuel consumption is not robust. However, the liquidity ratio exhibits a positive

and highly significant long-run effect. A 1% increase in the liquidity ratio is associated with a 0.082% increase in fossil fuel consumption, significant at the 1% level. This indicates that long-term liquidity conditions in the banking system are a key determinant of sustained fossil fuel use.

The model demonstrates a strong explanatory power. The coefficient of determination (R-squared) is 0.7642, indicating that the independent variables explain about 76.42% of the total variation in fossil fuel use in Nigeria. The adjusted R-squared value of 0.6892 further confirms the model's robustness. The F-statistic of 6.9534, significant at the 1% level, validates the overall significance of the model. Finally, the Durbin-Watson statistic of 2.0495, which is very close to 2, indicates the absence of first-order serial correlation in the residuals, affirming the reliability of the coefficient estimates. The estimated ARDL model is also tested for heteroscedasticity, serial correlation, functional form misspecification, parameter stability and normality. The results from these tests are shown in Table 6. The estimated ARDL model revealed that it passed the serial correlation, normality, and heteroskedasticity tests. It means that the error terms are normally distributed with the same variances, and they are not serially correlated. Furthermore, the Ramsey RESET test was satisfactory for the ARDL model, indicating that the model is well distributed. Additionally, the ARDL model passed the Ramsey RESET test, showing that it was evenly specified. Additionally, Figures 3 and 4 show that the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) are steady.

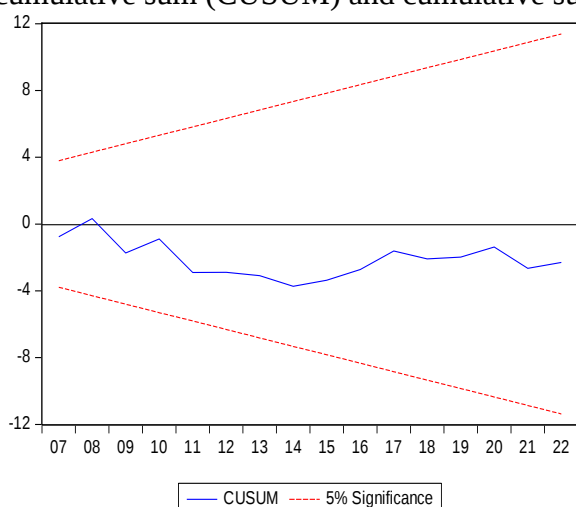


Figure 3: Cumulative sum

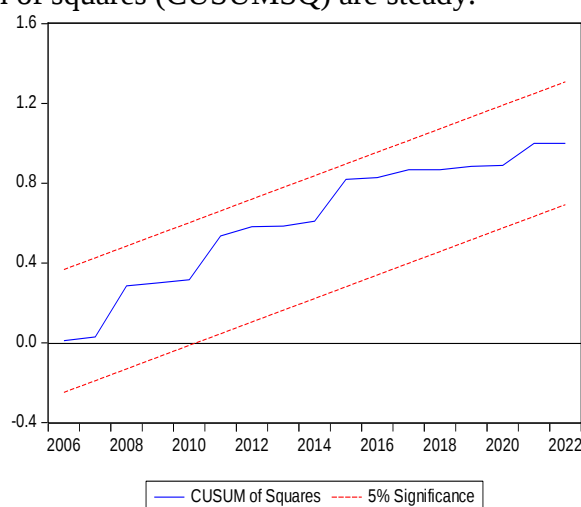


Figure 4: Cumulative sum of squares

Discussion findings

The empirical findings of this study reveal a relationship between monetary policy and energy consumption in Nigeria, offering both points of convergence and divergence with the existing international literature. For renewable energy, the results indicate that the monetary policy rate exerts a significant negative short-run effect. This finding aligns with the work of Sun *et al.* (2022), who found that expansionary monetary policy in G7 countries had an adverse effect on renewable energy generation, suggesting that lower interest rates may not necessarily channel funds towards renewable investments in certain economic contexts. Conversely, it contrasts with Hashmi *et al.* (2022), who documented a positive impact of expansionary policy on renewable energy in the US. This discrepancy points out the importance of financial market depth and policy frameworks; in Nigeria, underdeveloped capital markets and a lack of targeted



financing instruments may mean that lower interest rates primarily stimulate consumption and traditional sectors rather than capital-intensive renewable projects.

Furthermore, the long-run insignificance of the monetary policy rate and money supply on renewable consumption echoes the findings of Sohail *et al.* (2021) regarding the long-term effects of policy uncertainty, suggesting that without structural policies, monetary measures alone are insufficient to sustainably alter the renewable energy trajectory.

Regarding fossil fuel energy consumption, the results demonstrate a significant positive short-run impact of an increase in the monetary policy rate. This counterintuitive finding can be interpreted through the lens of the economic structure of Nigeria, a major oil-producing nation. A contractionary policy (higher monetary policy rate) may slow down general economic activity, but it can also trigger a depreciation of the local currency (if the central bank does not fully defend it), thereby increasing the Naira value of exported crude oil. This result incentivises increased domestic extraction and consumption of fossil fuels in the short term. This aligns with the broader finding of Qingquan *et al.* (2020) that expansionary policy (which is the opposite of a rate hike) can increase carbon emissions but highlights a different transmission channel, through the exchange rate and export sector, in a commodity-dependent economy. Moreover, the significant positive long-run effect of the liquidity ratio on fossil fuel consumption is critical. It suggests that sustained liquidity in the banking system fundamentally supports the fossil fuel sector, a result that finds strong support in the theoretical work of Jin *et al.* (2023), who distinguished between general refinancing (which boosts fossil energy) and targeted refinancing (which supports renewables). In Nigeria, the financial system's historical alignment with the oil and gas sector means that increased liquidity naturally flows towards and sustains fossil fuel-related activities, crowding out green alternatives.

The results show that MPR negatively affects renewables in the short run and positively affects fossils, while the liquidity ratio sustains fossils in the long run, creating a monetary policy framework that is inherently tilted against the energy transition in Nigeria. This supports the caution raised by Wu *et al.* (2024) for countries with a significant reliance on a primary commodity (like oil) and lower levels of human development, where conventional monetary stimulus can have adverse environmental consequences. The findings also relate to the concerns raised by Wang *et al.* (2022) about energy security risks from loose monetary policy, but in the Nigerian context, the risk is not just about import dependency but also about locking in a carbon-intensive domestic energy system. The fact that money supply had a negative short-run impact on fossil fuels (through its lagged values) indicates that the relationship is not monolithic and that the timing and specific instrument matter, echoing the complex dynamics found by Razmi *et al.* (2021) in Iran.

Conclusion

This study investigates the effects of monetary policy on both renewable and fossil fuel energy consumption in Nigeria from 1990 to 2022. The empirical findings, derived from the ARDL bounds testing approach, reveal a distinct and symmetric impact. In the short run, a tightening of monetary policy (an increase in the policy rate) adversely affects renewable energy consumption while paradoxically increasing fossil fuel use. In the long run, the key finding is that the liquidity ratio sustains and reinforces fossil fuel energy consumption, whereas conventional monetary policy instruments exhibit no significant long-run effect on renewable energy. This indicates that the prevailing monetary policy framework in Nigeria inadvertently supports the fossil fuel economy and fails to provide a sustained impetus for the transition to renewables. The energy mix is therefore more responsive to short-term policy shocks than to a



Based on these findings, the study offers the following recommendations. Firstly, the Central Bank of Nigeria should transition from a universal monetary policy to specific green financing instruments. This could include differentiated dynamic cash reserve requirements that incentivise banks to allocate a higher proportion of their credit portfolio to renewable energy projects at concessional interest rates, effectively creating a “targeted refinancing window,” as suggested in the literature. Second, macroprudential policies should be deployed to deliberately de-risk lending to the green sector, potentially through a credit guarantee scheme for renewable energy investments. Finally, there is an urgent need for policy coordination between the monetary authority, the government, and the energy sector to ensure that monetary measures are complemented by fiscal incentives and regulatory reforms that create a conducive ecosystem for renewable energy development. Without such a coordinated and targeted approach, monetary policy will continue to perpetuate an unsustainable energy consumption pattern in Nigeria, undermining both environmental goals and long-term energy security.



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