Do institutions mitigate the interactive effects of fuel prices and exchange rates on income inequality in Nigeria?

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Abstract. ***Objective****: This study investigates whether fuel price worsens income inequality in Nigeria and also ascertains whether the interactive effects of fuel price on institutions and exchange rates worsen income inequality.* ***Method****: Employing the UNU-WIDER World Income Inequality Database, Central Bank of Nigeria Statistical Bulletin, World Development Indicators, and Worldwide Governance Indicators, the ARDL framework was employed, while the FMOLS was later employed to check the robustness of the model.* ***Results:*** *The study found that weak institutions and macroeconomic instability increase income inequality in Nigeria, while fuel prices and exchange rates considerably worsen it. The interactions of institutions with exchange rates and fuel prices mitigate income inequality. The long-run cointegration model and the inverted U-shaped Kuznets hypothesis are both supported by the results.* ***Originality****: To explain issues of income inequality in Nigeria, this study combines the effects of fuel prices, institutions, and exchange rates in a novel way by expanding on the fuel-inequality nexus and providing a fresh empirical understanding of the interactive effects of institutions and exchange rate dynamics.*

Keywords*: Fuel price, income inequality, macroeconomic stability, institutions.*
JEL classification*: Q43, D31, E63, O43.*

1. Introduction

Most developing countries are faced with the consequences of the persistent increase in global fuel prices and their distributive effects on income, where the cost of energy determines the dynamics of consumption and production patterns. As one of Africa's largest crude oil producers, Nigeria faces the paradox of resource abundance, frequent fuel shortages, and import dependence (Abenabe & Ekpotuatin, 2024; Okorie et al., 2023). This paradox has significant distributional effects on household vulnerability, widening the income gap (Okereke et al., 2024). The distributional effects not only worsen the socioeconomic vulnerability of households; rather, they are aggravated by weak institutions, which undermine the consistency of equitable allocation of resources. Therefore, considering how the fluctuations in fuel prices, sharpened by institutions, have worsened income inequality remains a central macroeconomic focus in the Nigerian context.

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In a theoretical approach, the Kuznets hypothesis suggests that economic growth and income inequality are U-shaped, with inequality rising and falling as economies develop. In Nigeria, inequality has not declined despite decades of growth, suggesting structural or institutional bottlenecks. Institutional economics suggests that the strength and inclusiveness of institutions determine how economic rents are distributed, with weak institutions facilitating elite capture and policy inconsistency, intensifying inequality (Acemoglu & Robinson, 2012; Rabhi & Parsons, 2024). These establish the role of institutions in moderating the worsening effect of fuel prices on income inequality. Studies show that high fuel prices and exchange rate depreciation can disproportionately burden low-income households, while strong institutional frameworks can implement targeted subsidies and stabilize markets (Yunusa et al., 2023; Oladele, 2024; Demir, 2025; Okoroafor et al., 2025). Therefore, understanding these interactions is crucial for designing inclusive policies that mitigate inequality.

Fuel prices remain a major influence on institutions and macroeconomic stability (Olujobi et al., 2022; Daka, 2023). These influences are a major force behind inflation, exchange rate dynamism, production efficiency, and drifting governance decisions while triggering periodic adjustments to the Consumer Price Index (CBN, 2022). Similarly, businesses and people who depend on credit for growth and survival are adversely affected by the borrowing patterns. Moreover, these longitudinal effects of fuel prices have a significant impact on economic stability, poverty reduction, and income distribution since the effects directly have an impact on living expenses and manufacturing costs (Yunusa et al., 2023; Oladele, 2024). These effects can also transmit through financial markets, influencing interest rates and government bond yields and, consequently, broader macroeconomic conditions. For developing economies like Nigeria, these macroeconomic shifts hit hardest, widening income inequality, making essential goods less affordable, and pushing small businesses closer to collapse (Oxfam America, 2020). Despite these worsened effects on income inequality, the interaction effect of institutions on either fuel prices or exchange rates remains delusional.

Nigeria is not an exception to the urgent concern over wealth disparity on a global scale. The country's Human Poverty Index (HPI) was 38.8%, and 75th out of 103 developing nations in terms of income inequality (Olarinde et al., 2020). In Nigeria, income inequality takes diverse forms, which are not limited to differences in wealth disparity and income distribution. Nigeria's economic expansion has led to income inequality, with the wealthiest Nigerians earning $29.6 billion, despite the country's poverty rate of two million people a year. Oxfam America (2020) estimates it will cost $24 billion to lift all Nigerians out of extreme poverty. This has made income inequality in Nigeria a social and economic issue requiring immediate attention due to rising youth unemployment and dependence on imported fuel due to inefficient refineries. Thus, the vulnerability to global fuel price fluctuations and a national power grid has made fuel price a significant concern for the reduction of income inequality.

Income inequality and economic growth depend on each other, which can also be explained by the Kuznets curve (1955), which states that as an economy develops and grows, income inequality first increases and later decreases, showing an inverted U-shaped curve. Rapid growth produces income inequality, which can also be used as an independent variable to drive additional growth (Shen, Zhao & Song, 2022). Fuel price impacts income inequality by affecting production, transportation, and living costs, with increases significantly affecting income distribution within an economy.

A high misery index, which combines the rates of unemployment and inflation, is associated with greater income inequality because high unemployment causes more financial hardship for those without jobs, which in turn widens the wealth gap, and high inflation lowers purchasing power, particularly for these groups (Osuma & Nzimande, 2025). It is also well recognized that in every economy, institutions have a significant impact on how income is distributed. Institutions and income inequality are correlated in both directions, meaning that one influences the other (Fodo, 2021). Exchange rates, especially depreciation, exacerbate income inequality by elevating import costs and essential goods' prices, disproportionately affecting the poor while benefiting the wealthy. In contrast, policies that promote financial development, trade openness, and inclusive economic growth can help mitigate inequality, though the effects differ across countries and their development stages (Rabhi & Parsons, 2024).

A limited number of studies in Nigeria have examined the growing impact of fuel prices on macroeconomic variables, such as Oladele (2024) and Oyelade, Maku and Adelowokan (2024), who have investigated the regional impact, while Akinlo (2024) examined the non-linear impact of fuel prices

on income inequality in Nigeria. While these studies investigated the impact of several determinants such as corruption, misery index, exchange rates, inflation rates, and unemployment rates, they have not addressed the distorting effects of institutions on the problem. Nonetheless, these studies, however, mostly ignore the interactive effects of institutions, which is the way that institutions regulate the relationship between income inequality and fuel price shocks in Nigeria. Thus, whether and how institutions interact with fuel prices and exchange rates in Nigeria remains unclear in the literature.

Despite the growing investigation in Nigeria on fuel price shocks and income inequality, existing studies have not been able to fill these three gaps. First, as proposed in the World Governance Indicators framework, this study computes the institutions series using Principal Component Analysis. Second, it looks at how institutions and fuel prices interact to affect income inequality, emphasising how poor institutions can worsen the negative distributional effects of fuel price shocks. Third, it explores the interplay between fuel costs and exchange rates, providing fresh perspectives on how fluctuations in both fuel prices and exchange rates worsen inequality in Nigeria. Thus, these gaps are addressed by exploring the impact of institutions, fuel prices, and exchange rates on income inequality in Nigeria. It introduces institutions as a moderating variable in the fuel price-inequality relationship. The study also evaluates how simultaneous changes in fuel prices and exchange rates affect income inequality under varying institutional conditions, providing new evidence on how governance reforms can buffer inequality effects in oil-dependent economies.

Therefore, this study builds on the existing literature by examining whether fuel prices worsen income inequality in Nigeria and ascertaining whether the interactive effect of fuel prices on institutions and exchange rates worsens income inequality. In achieving these goals, this study asks these questions: to what extent do fuel prices worsen income inequality? Second is that, does the interactive effect of fuel price on institutions and exchange rates worsen income inequality? By tackling these issues, the study adds fresh empirical data to the relationship between fuel prices, income inequality, and institutions in developing economies like Nigeria that rely heavily on oil and the informal sector.

2. Literature review

2.1. Empirical review

Numerous studies have explored the relationship between economic growth and income disparity, with inconclusive results on whether economic growth decreases or worsens income inequalities. Mdingi and Ho (2021) examined the nexus between income inequality and economic growth. The study findings show that the relationship is highly positive in some countries, while negative in others. Shen et al. (2022) found no significant relationship across nations at different stages of development. In both developed and developing economies, Saipudin (2024) found that moderate inequality promotes economic growth, but excessive inequality discourages growth by reducing human capital and access to opportunities, especially in developing countries. Using cross-country data, Aiyar and Ebeke (2020) established that less equal societies exhibit less growth.

Numerous studies have shown the relationship between fuel prices and income inequality. In Asian nations, Tan and Uprasen (2023) investigated oil price shocks and income inequality, indicating that rising oil prices increase inequality in oil-importing countries but decrease it in oil exporters, while volatility worsens disparity in both. For instance, in developing countries, Couharde and Mouhoud (2020) recommend that subsidy reforms, although potentially beneficial in terms of economic efficiency, have both positive and negative impacts on income inequality and poverty. In Africa, Oladele (2024) investigates how income inequality and high fuel prices affect low-income households, concluding that rising fuel prices unfairly impact poorer households, worsening income inequality and access to basic goods, and suggesting fair pricing rules to support income equality. Emughedi (2025) revealed that rising fuel prices significantly diminish household purchasing power, resulting in changes in consumption patterns, lower discretionary income, and increased financial strain in the South-Western region.

Different studies have been conducted to check the relationship between the misery index and income inequality. Particularly in SSA, higher misery index values are positively correlated with social

discontent and economic inequality, which provides important information about the state of the economy as a whole and its effects on social welfare (Lelkes, 2013; Tule et al., 2017). The misery index makes socioeconomic inequality worse while unemployment further restricts economic options, inflation erodes households' purchasing power, and renders necessities costly (Kaplan & Schulhofer-Wohl, 2017). Furthermore, Osuji and Nwani (2020) argued that the misery index exacerbates poverty by increasing economic misery, particularly among people who lack access to appropriate sanitation, clean water, and other vital services. Osuma and Nzimande (2025) found that corruption increases income inequality and dilutes the impact of economic growth and foreign direct investments (FDI) on welfare. Institutions are significant in determining income inequality; it is thought to result from democratic systems, laws, taxes, and institutions (Sarkhosh-Sara et al., 2020). This can also be affected by a deficient institutional framework (Albertus & Menaldo, 2014). Barra and Papaccio (2025) found that stronger institutions significantly reduce income inequality, especially in regions with high inequality levels. Blancheton and Chhorn (2021) found that institutions and government action have an inverse effect on income disparity.

Ferrara and Nisticò (2019) claim that inequalities between and within macro regions are influenced by the caliber of the local institutional framework. Using data on developing and developed economies, Asamoah (2021) revealed that institutions decrease income inequality in developing and developed economies. Despite the variance in exchange rates across nations, Parsons and Rabhi (2025) found that exchange rate volatility increases income inequality by raising Gini coefficients, exchange rate depreciation worsens inequality, while appreciation shows uncertain effects. Suratman, Mayudi, and Hayet (2022) evaluated the income disparity at the ASEAN level and concluded that income inequality is still high but decreasing over time and that inflation and exchange rates are both important factors contributing to inequality within the region. In Nigeria, Ogege (2022) found that naira depreciation worsens income inequality, while higher per capita income, investment, education, and trade openness reduce inequality in the long run.

2.2. Theoretical framework

The Kuznets hypothesis explains income inequality dynamics, while the Structural and Institutional Model provides a deeper understanding of economic structures and institutions (North, 1990; Acemoglu et al., 2001). It emphasises the impact of regulatory frameworks, financial market efficiency, governance, and institutions on economic performance. Institutional factors like market distortions, regulatory effectiveness, and subsidy programs also influence income distribution. The model emphasises the importance of good governance and high-quality institutions for long-term economic growth and equitable outcomes. Pinto et al. (2025) argue that economic transformation is not a linear process, influenced by structural changes, institutional frameworks, and policy dynamics. They propose two theories: the inverted U-shaped Kuznets model and the structural and institutional model, emphasising the importance of institutions in economic development.

The Kuznets hypothesis is one of the most hotly contested theoretical frameworks for examining inequality in income. Kuznets initially released the findings of his study on the connection between economic growth and income inequality (Kuznets, 1955). The Kuznets curve suggests that income inequality increases during early development due to lower productivity in the agriculture sector compared to the emerging industrial sector. This inequality decreases during later stages of economic growth due to labour shifts from agriculture to industry and advancements in agricultural productivity and modernisation. Early empirical research in the 1970s corroborated this concept, and the relationship between economic growth and income inequality is commonly represented mathematically as an inverted U-shaped function in the Kuznets model.

$$INEQ_t = f\left(PCY_t, {PCY_t}^2\right) \quad (1)$$

As specified in (1), $INEQ_t$ is income inequality at time t, PCY_t and ${PCY_t}^2$ are the first path of the growth rate of GDP per capita and the squared phase of the growth rate of GDP per capita at time t.

3. Methodology and data

3.1. Data, scope, and description

The study tracked its data between the period of 1991 and 2022. Therefore, to ensure proper accuracy in the dataset, both the dependent and independent variables were sourced from globally reliable secondary sources of data. Fuel price was sourced from the Central Bank of Nigeria (CBN) Statistical Bulletin, as employed in the study of Gold and Yusuf (2025). Fuel price remains a significant macroeconomic impact on distributional equity, production costs, and household welfare, especially in developing oil-producing economies. The fuel price data were transformed into their natural logarithm in order to unify the unit of measurement with other series. The misery index is computed as the sum of the unemployment and inflation rates as a macroeconomic instability measure, causing economic distress.

The selection is justified by studies of Akinbobola and Saibu (2004), Sotoudeh Nia Korrani and Ziya (2023), and Gakuru and Yang (2025). The misery index series is sourced from the 2024 World Bank World Development Indicators. The study includes the foreign exchange rate (US$/₦). To better explain the effects of the macroeconomic instability-income inequality nexus, Nigeria, as an oil-exporting country, has a gap of inequality through trade structures widened through exchange rates (Ogege, 2022). Exchange rates were obtained from the 2024 World Bank World Development Indicators. In this study, fuel costs and exchange rates were transformed into log values to reduce skewness and ensure the variables were measured in the same units.

Institutions in this study are captured by the principal component index of the six estimates of the World Governance Indicators from the 2024 World Bank World Development Indicators. The estimates include the control of corruption, rule of law, voice and accountability, government effectiveness, regulatory control, and political stability. The index of these estimates was used since there is no collective institutional proxy, as any of them often has a higher degree of relationship. As shown in Table 1 makes it difficult to employ just one estimate among these estimates as a proxy for institutions other than computing the Principal Component Index (PCI). In Table 1, it is revealed that there is a positive, strong, and significant relationship between the six governance estimates and the computed component index.

Table 1. Correlation of the six world governance indicators and the index of the principal component

Series	IQ_t	CoC_t	RoL_t	VA_t	GE_t	RQ_t	PS_t
IQ_t	1.0000						
	(----)						
CoC_t	0.9797	1.0000					
	(0.0000)	(----)					
RoL_t	0.9633	0.9646	1.0000				
	(0.0000)	(0.0000)	(----)				
VA_t	0.7576	0.6948	0.7777	1.0000			
	(0.0000)	(0.0000)	(0.0000)	(----)			
GE_t	0.9565	0.9192	0.8664	0.6620	1.0000		
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(----)		
RQ_t	0.9449	0.9426	0.9021	0.6521	0.8781	1.0000	
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(----)	
PS_t	0.8303	0.7873	0.7210	0.3853	0.8681	0.7409	1.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0294)	(0.0000)	(0.0000)	(----)

IQ_t= component index of institutions, CoC_t= estimates of control of corruption, RoL_t= estimates of the rule of law, VA_t= estimates of voice and accountability, GE_t= estimates of government effectiveness, RQ_t= estimates of regulatory quality, PS_t= estimates of political stability.
Source: Authors' compilations.

The appropriate selection of the institution's component index is justified by Adeleye et al. (2017), Arogundade et al. (2022), Adeleye et al. (2023), and Adeleye (2024). The growth rate of GDP per capita was sourced from the 2024 World Bank World Development Indicators. The Gini coefficient

was used as a proxy for income inequality and is supported by Adeleye (2024) and Akinlo (2024). The Gini coefficient was sourced from the UNU-WIDER World Income Inequality Database (WIID).

3.2. Model specification

Following the expression of the Kuznets theoretical framework, the model is investigated through the *ex-post* factor research design by modifying and extending the empirical model of Akinlo (2024) in (1); this study then augmented the model by integrating the principal component of institutions.

$$INEQ_t = \theta_0 + \theta_1 PCY_t + \theta_2 PCY_t^{\,2} + \theta_3 LFP_t + \theta_4 MI_t + \theta_5 IQ_t + \theta_6 LEXR_t + \Phi_7 K_t + \delta_t \quad (2)$$

Where LFP_t represents the log of fuel price, MI_t symbolises the misery index, IQ_t stands for the index of institutions, $LEXR_t$ signifies the log of exchange rates, δ_t denotes the error term, while K_t represents the control variables of the interactive effects. All the variables are respectively expressed at time t. Based on these, the study clinically expresses its baseline econometric model in (3) as,

$$INEQ_t = \theta_0 + \theta_1 PCY_t + \theta_2 PCY_t^{\,2} + \theta_3 LFP_t + \theta_4 MI_t + \theta_5 IQ_t + \theta_6 LEXR_t + \theta_7 (LFP * IQ)_t + \theta_8 (LFP * LEXR)_t + \delta_t \quad (3)$$

From (3), θ's represents the coefficients of estimated independent parameters, $(LFP * IQ)_t$ signifies the interactive effect of fuel price and institutions, while $(LFP * LEXR)_t$ measures the interaction of fuel price and exchange rates at the respective annual period t. As such, it is expected to note that, as estimated in (3), the growth rate of GDP per capita at its initial stage is expected to increase income inequality, while its square at the second phase negatively affects income inequality as theoretically assumed by the U-shaped Kuznets curve. Also, an increase in fuel price, misery index, institutions, and exchange rates; the interactive effect of fuel price and institutions; and the interactive effect of fuel price and exchange rates are expected to stiffen Nigeria's income inequality. This means that the expectations of the coefficients are expected to be positive both in the long- and short-run scenarios. The 12th version of the Econometric Views (EViews) was used to analyse the results.

4. Research results and comments

4.1. Summary statistics and pairwise correlation of the series

Evidence from the raw values exposed the behaviour of the series in Panel A of Table 2. The panel revealed the summary of the descriptive series, which indicates that income inequality is relatively high at 42.54%. The initial stage of per capita growth averages at 1.38%, followed by a non-linear inverted U-shaped square of the per capita growth inequality-growth nexus. Fuel price over the sampled period is averaged at ₦73.28k per litre, followed by a significant economic instability at 22.515%. The exchange rate reflects the persistent depreciation of currency as a result of high volatility, with an average rate of ₦150.88 per US dollar. A weaker institutions index is observed at 0.007. On average, the interactive effects of institutions moderate fuel price by -0.82, which indicates a weaker influence on fuel price. Likewise, exchange rates lessen the effect of fuel price on income inequality by 3.49 US$ per litre. This indicator tells how deep institutions are in Nigeria, following a stiff and low-income inequality index, which also tells that if corruption persists in its present manner, the gap in income inequality will remain wide.

This finding supports the findings of the work of Adeleye et al. (2023), which assert that income inequality in Nigeria is low and that it harms the quality of institutions in Nigeria, which in turn causes a lack of control over corruption. In the same vein, the high variability in fuel price, misery index, and exchange rates specifies the periodic political influence of subsidy removal and currency depreciation, which later causes the eroding negative effect of macroeconomic instability on income inequality and unemployment-inflation dynamics across the sampled period. Likewise, the variability of the combined interactive effects of fuel price on institutions and exchange rates signifies unsteady economic growth and varied exchange rates over time. Over time, all other series except the interactive effect of fuel price and exchange rates are positively skewed in nature. Also, income inequality, fuel price, exchange rates, and the interactive effect of fuel price and exchange rates are platykurtic, while other variables are leptokurtic in nature.

Panel B shows the correlation matrix of the fuel price-income inequality nexus. The results show that income inequality has a negative association with per capita growth rate, the square of per capita growth, fuel price, exchange rates, and the interactive effect of fuel price on exchange rate. This negative association implies that an increase in per capita growth rate, the square of per capita growth, fuel price, exchange rates, and the interactive effect of fuel price on exchange rate yields a corresponding decrease in income inequality, perhaps as a result of the structural economic and subsidy effects. Despite the negative association, fuel price, exchange rates, and the interactive effect of fuel price on exchange rates have a significant link with income inequality in Nigeria. On the other hand, the misery index, institutions, and the interactive effect of fuel price on institutions have a significant, positive, and moderate association with income inequality. This implies that the higher the weaker institutions and misery index, the worse the income inequality. Above all, the negative and significant link between the per capita growth rate, the square of per capita growth, and income inequality reflects that there is a direct nonlinear association with income inequality over the sampled period.

Table 2. Summary of descriptive statistics and correlation matrix

Panel A: Summary of descriptive statistics									
Series	$INEQ_t$	PCY_t	${PCY_t}^2$	FP_t	MI_t	IQ_t	EXR_t	$(LFP * IQ)_t$	$(LFP * LEXR)_t$
Unit	**%**	**%**	**% sq.**	**₦ per litre**	**%**	**Index**	**US $/₦**	**Index/₦ per litre**	**US $/₦ per litre**
Mean	42.5404	1.3800	14.3415	73.2772	22.5136	0.0075	150.8797	-0.8199	3.4920
Std. Dev.	7.7404	3.5831	26.3167	60.6415	16.2848	2.2954	115.7801	2.2463	1.6753
Skewness	0.7139	0.4887	4.38157	0.5506	2.1499	1.7855	0.8310	2.0876	-0.3869
Kurtosis	1.9102	3.9601	22.9446	2.0240	6.6198	4.3914	2.9238	6.1854	2.1741
Jarque-Bera	4.3020	2.5026	632.7705	2.8869	42.1213	19.5847	3.6907	36.7720	1.7076
Prob.	0.1164	0.2861	0.0000	0.2361	0.0000	0.0000	0.1580	0.0000	0.4258
Obs.	32 years	32 years	32 years	32 years	32 years	32 years	32 years	32 years	32 years
Panel B: Correlation matrix									
Series	$INEQ_t$	PCY_t	${PCY_t}^2$	LFP_t	MI_t	IQ_t	$LEXR_t$	$(LFP * IQ)_t$	$(LFP * LEXR)_t$
$INEQ_t$	1.0000 (----)								
PCY_t	-0.2951 (0.1010)	1.0000 (----)							
${PCY_t}^2$	-0.0015 (0.9932)	0.6104 (0.0002)	1.0000 (----)						
LFP_t	-0.9320 (0.0000)	0.1708 (0.3498)	-0.0205 (0.9110)	1.0000 (----)					
MI_t	0.6085 (0.0002)	-0.4350 (0.0128)	-0.0259 (0.8877)	-0.4159 (0.0179)	1.0000 (----)				
IQ_t	0.6871 (0.0000)	-0.5448 (0.0013)	-0.1399 (0.4450)	-0.6518 (0.0001)	0.7965 (0.0000)	1.0000 (----)			
$LEXR_t$	-0.9388 (0.0000)	0.2342 (0.1968)	0.0446 (0.8084)	0.9415 (0.0000)	-0.5219 (0.0022)	0.6646 (0.0000)	1.0000 (----)		
$(LFP * IQ)_t$	0.6547 (0.0000)	-0.5843 (0.0004)	-0.1439 (0.4319)	-0.4772 (0.0057)	0.9039 (0.0000)	0.8853 (0.0000)	-0.5884 (0.0004)	1.0000 (----)	
$(LFP * LEXR)_t$	-0.9497 (0.0000)	0.1289 (0.4819)	-0.0411 (0.8231)	0.9708 (0.0000)	-0.4584 (0.0083)	-0.6052 (0.0002)	0.9758 (0.0000)	-0.5221 (0.0022)	1.0000 (----)

Std. Dev. = Standard Deviation, Prob. Jarque-Bera Probability, Obs. = Observation, % = Percentage, % Sq. = Percentage squared, ₦ per litre = Naira per litre, US $/₦ = United States Dollar per Naira, Parenthesis = Probability of correlation.

Source: Authors' compilation.

4.2. Stationary test

To determine the actual order of the series in the model, the study employed the Phillips-Perron (PP) unit root test at the trend and intercept test equation. To do this, it is necessary to test and determine the status of stationarity of the variables because when conducting regression analysis without knowing the stationary form of the series, it may lead to a spurious result (Anagun *et al.,* 2024). The specified PP unit root test was employed due to two distinct advantages. First is due to the peculiarity of the same critical asymptotic values, which also give a robust check for serial autocorrelation and heteroskedasticity. Second is that the PP unit root tests do not give room for the selection of lag length criteria, and lastly, it helps to avoid errors of heteroscedasticity and dependency error (Phillips & Perron, 1988). As such, this requirement defines the selection of the unit root test for the study. Table 3 presents the summary of the PP unit root test at the trend and intercept test equation, revealing that the per capita gross domestic product and the log of fuel price are stationary at the level, while other series are stationary at the first difference. Summarily, it means that through the trend and intercept test equation, the variables used in this study are of mixed stationary.

Table 3. Summary of the standard Phillip-Perron unit root tests

Variables	Level				First difference		
	PP test Statistic	5% test critical values	Prob.		PP test Statistic	5% test critical values	Prob.
$INEQ_t$	0.1232	-3.5628	0.9961		-7.0139	-3.5683	0.0000
PCY_t	-2.9176	-3.5628	0.1710		-15.9923	-3.5683	0.0000
${PCY_t}^2$	-5.0037	-3.5628	0.0017		-	-	-
LFP_t	-6.2792	-3.5628	0.0001		-	-	-
MI_t	-2.8515	-3.5628	0.1910		-8.7760	-3.5683	0.0000
IQ_t	-1.9252	-3.5628	0.6175		-7.0811	-3.5683	0.0000
$LEXR_t$	-2.5065	-3.5628	0.3230		-5.4809	-3.5683	0.0006
$(LFP * IQ)_t$	-2.5409	-3.5628	0.3078		-11.1251	-3.5683	0.0000
$(LFP * LEXR)_t$	-3.5342	-3.5628	0.0531		-7.4994	-3.5683	0.0000

Source: Authors' compilation.

4.3. Bound test

As a sequel to the PP unit root test, it means that from the test equation of the intercept and trend unit root, the series appears not to employ the Classical Least Squares (CLS), but the appropriate estimation is the Autoregressive Distributed Lag (ARDL), as supported by Pesaran and Shin (1995), Shrestha and Bhatta (2018), and Ogundipe and Anagun (2024). Specifically, the unit root test results also identify that mixed order stationarities adopt the need for an ARDL bound test due to the number of observed years, which is less than 40 (see Clark, 2011). Also, the ARDL technique is essential for determining whether or not the series in the model move or cointegrate in the same direction. The ARDL bound test has a distinct advantage over existing symmetric co-integration tests (Pesaran, Shin, & Smith, 2001). Literally, the ARDL bound test was established by Pesaran et al. (2001) for testing the presence of a cointegrating relationship, having a peculiar advantage over other symmetric tests. To conduct this technique, the decision rule is based on the rejection of the null hypothesis as specified against the F-test, indicating a long-run cointegration among the series in the model. As such, since the study specified its econometric model in (3), a rejection of the null hypothesis for the bounds test is specified in (4), exhibiting that the variables have a long-run cointegrating relationship,

$$H_0: \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq \theta_6 \neq \theta_7 \neq \theta_8 \quad (4)$$

Based on the alternative hypothesis bound test equation, the ARDL short-run and long-run estimates for the model are specified in (5), where $\Omega_1 - \Omega_9$ are the vector parameters of the short-run estimates, μ_0 is the constant parameter, Δ is the operator of the first difference, $\theta_1 - \theta_9$ are the vector

parameters of the long-run estimates, z is the dependent variable maximum lag, $r_1 - r_8$ are the maximum regressor lag, δ_t is the stochastic white noise

$$\Delta INEQ_t = \mu_0 + \theta_1 INEQ_{t-1} + \theta_2 PCY_t + \theta_3 {PCY_t}^2 + \theta_4 LFP_t + \theta_5 MI_t + \theta_6 IQ_t + \theta_7 LEXR_t + \theta_8 (LFP * IQ)_t + \theta_9 (LFP * LEXR)_t + \sum_{i=1}^{z} \Omega_1 \Delta INEQ_{t-i} + \sum_{j=1}^{r_1} \Omega_2 \Delta PCY_{t-j} + \sum_{j=1}^{r_2} \Omega_3 \Delta {PCY^2}_{t-j} + \sum_{j=1}^{r_3} \Omega_4 \Delta LFP_{t-j} + \sum_{j=1}^{r_4} \Omega_5 \Delta MI_{t-j} + \sum_{j=1}^{r_5} \Omega_6 \Delta IQ_{t-j} + \sum_{j=1}^{r_6} \Omega_7 \Delta LEXR_{t-j} + \sum_{j=1}^{r_7} \Omega_8 \Delta (LFP * IQ)_{t-j} + \sum_{j=1}^{r_8} \Omega_9 \Delta (LFP * LEXR)_{t-j} + \vartheta ECT_{t-1} + \rho_t \quad (5)$$

Table 4. ARDL bound test results

Significance Level	I(1)	I(0)	F-Statistic	K	Selected Model
10%	2.85	1.85	218.9077	8	ARDL
5%	3.15	2.11			(1, 0, 2, 2, 2, 2,
1%	3.77	2.62			2, 2, 2)

Source: Authors' computation.

Following the ARDL bound test results in Table 4, the ARDL bound test rule states that if the F-statistic value is greater than the upper bound value of the I(1), it means that the series in the model cointegrates or moves in the same direction, which needs to be corrected. Thus, as shown in Table 4, it is revealed that there exists a disequilibrium in the model, and to correct this economic disequilibrium, the appropriate econometric technique for the model is the Error Correction Model (ECM), and it is specified in (6) as,

$$\Delta INEQ_t = \mu_0 + \sum_{i=1}^{z} \Omega_1 \Delta INEQ_{t-i} + \sum_{j=1}^{r_1} \Omega_2 \Delta PCY_{t-j} + \sum_{j=1}^{r_2} \Omega_3 \Delta {PCY^2}_{t-j} + \sum_{j=1}^{r_3} \Omega_4 \Delta LFP_{t-j} + \sum_{j=1}^{r_4} \Omega_5 \Delta MI_{t-j} + \sum_{j=1}^{r_5} \Omega_6 \Delta IQ_{t-j} + \sum_{j=1}^{r_6} \Omega_7 \Delta LEXR_{t-j} + \sum_{j=1}^{r_7} \Omega_8 \Delta (LFP * IQ)_{t-j} + \sum_{j=1}^{r_8} \Omega_9 \Delta (LFP * LEXR)_{t-j} + \vartheta ECT_{t-1} + \rho_t \quad (6)$$

4.4. Short-run test

Table 5 presents the results of the short-run estimates. In the short run, evidence of the Kuznets curve is one-sided due to the results of the growth rate of GDP per capita without its initial stage. In the initial period of the squared growth rate of GDP per capita, there is a negative impact on income inequality, but when lagged by one period, it reveals a positive impact on income inequality. These results revealed that the assumptions of the Kuznets curve have gone beyond the initial per capita growth rate, indicating an inverted U-shaped income inequality effect in the short run. Therefore, with all things being equal in the short run, at the current period of the squared per capita growth rate, income inequality is significantly mitigated, but when lagged by one period, income inequality is positively worsened by a significant impact. Fuel price significantly mitigates income inequality in its initial period and, when lagged by one period, in the short run. With a one-unit increase in fuel price, income inequality is positively lessened by 2.04 units in its current period, and in its one lagged period, income inequality is positively mitigated by 1.01 units.

Also, in the short run, the misery index at its current period significantly worsens income inequality, while when lagged by one period, the misery index mitigates income inequality significantly,

ceteris paribus. This shows that, in the short run, the misery index in its current period has a positive effect on income inequality by 0.01 unit, but when lagged by one period, it hurts income inequality by 0.01 unit. Contrarily, in the short run, institutions have a significantly negative impact on income inequality by 0.18 and 0.06 units, respectively, in the current period and when lagged by one period. This indicates that institutions significantly worsen income inequality in both periods. Unlike the misery index, exchange rates positively impact income inequality in the current period and when lagged by one period. However, in the current period, exchange rates insignificantly impact income inequality, but when lagged by one period, exchange rates significantly impact income inequality. In the short run, a one-unit increase in exchange rates worsens income inequality by 0.24 units at its current level, while when lagged by one period, income inequality is impacted by 1.12 units, when all things are equal.

Based on the results of the interactive effects, it was revealed that in the short run, the fuel price and institutions' interactive effects worsen income inequality in both periods. In the current period, the interactive effect of institutions on fuel price significantly worsens income inequality by 0.12 units, while when lagged by one period, income inequality is also worsened by 0.08 units, *ceteris paribus*. Contrarily, the interactive effects of exchange rates on fuel prices mitigate income inequality in both periods. In the current period, the exchange rate's interactive effect on fuel prices insignificantly mitigates income inequality by 0.30 units, while when lagged by one period, income inequality is also mitigated by 0.58 units. This shows that in the short run, exchange rates have an interactive effect on fuel prices, causing more harm to income inequality.

The coefficient value of the error correction term (ECT), as revealed in Table 4, explains how the ARDL long-run disequilibrium model is corrected back to equilibrium following a temporary shock. The extent to which the expected negative and significant ECT reflects an adjustment in the short-run equilibrium tells how the long-run equilibrium is rectified using short-run partial dynamics. Thus, the value of the adjustment in the short run indicates an offset by an equilibrium of 0.058 per cent. This shows that it takes strong institutions to restore the long-run equilibrium. The short-run model then stands to be fit for economic policy making as its adjusted R-squared value revealed an independence in the dependent variable by 99.6% in the short run, meaning that the remaining percentage is explained by other unspecified variables in the economy, which could affect income inequality.

Table 5. Estimates of the error correction model

Variable	Coefficient	Std. Error	t-Stat.	Prob.
$\Delta PCY^2{}_t$	-0.0018	0.0003	-6.9311	0.0004
$\Delta PCY^2{}_{t-1}$	0.0058	0.0003	21.212	0.0000
$\Delta(LFP_t)$	2.0459	0.3330	6.1445	0.0009
$\Delta(LFP_{t-1})$	1.0064	0.3316	3.0345	0.0230
$\Delta(MI_t)$	0.0157	0.0015	10.3378	0.0000
$\Delta(MI_{t-1})$	-0.0153	0.0016	-9.4451	0.0001
$\Delta(IQ_t)$	-0.1873	0.0299	-6.2438	0.0008
$\Delta(IQ_{t-1})$	-0.0630	0.0289	-2.1776	0.0723
$\Delta(LEXR_t)$	0.2404	0.1879	1.2796	0.2479
$\Delta(LEXR_{t-1})$	1.1220	0.1839	6.1004	0.0009
$\Delta(LFP * IQ)_t$	0.1290	0.0245	5.2597	0.0019
$\Delta(LFP * IQ)_{t-1}$	0.0884	0.0251	3.5253	0.0124
$\Delta(LFP * LEXR)_t$	-0.3026	0.1554	-1.9470	0.0995
$\Delta(LFP * LEXR)_{t-1}$	-0.5807	0.1530	-3.7944	0.0090
ECT_{t-1}	-0.0583	0.0008	-73.9777	0.0000
Adj. R-Sq.	0.9961	D-W stat.		2.7424

Source: Authors' compilation.

4.5. Long-run test

Table 6 revealed the estimated results of the long-run model. As such, in the ARDL long-run results, the current stage of the per capita gross domestic product insignificantly but positively impacts income inequality. This indicates that, in the long run, a one-unit increase in the growth rate of GDP per

capita positively improves income inequality by 0.003 units. To ascertain the evidence of the inverted U-shaped Kuznets curve in Nigeria, the square of the growth rate of GDP per capita exhibits a negative impact on income inequality in the current, one-lagged, and two-lagged periods, respectively. This shows that a 1% increase in squared of the squared growth rate of GDP per capita brings about a 0.001 unit increase in income inequality in the current period, 0.004 units at its one lagged period, and 0.005 unit when lagged by two periods in the long run. This result is supported by Adeleye et al. (2021) and Osinubi and Olomola (2021).

Fuel price has a positive long-run but insignificant impact on income inequality across its current period, and when lagged one period, but when lagged by two periods, fuel price hurts income inequality. At the current period, a 1% increase in fuel price has a 2.04-unit increase in income inequality, and when lagged by one period, it brings a 1.58-unit increase in income inequality. However, at the second lagged period, an increase in fuel price connotes a long-run 1.01 unit decrease in income inequality. This is also evident from the studies of Akinyemi (2023), Okereke et al. (2024), and Akinlo (2024). The misery index has a positive but insignificant effect on income inequality in the current year and when lagged by one and two years. In the current year, the result revealed that a unit increase in the misery index positively impacts income inequality by 0.02 units, followed by a 0.01-unit increase in the next year, and another 0.02 unit when lagged by two periods. This means that across all periods, the misery index immediately impacts income inequality, worsening income inequality in the long run. This result is supported by the findings of Akinlo (2024).

In the long run, institutions have a negative impact on income inequality in the current period, but in the lag one and lag two periods, institutions have a positive impact on income inequality in Nigeria. Initially, institutions have a negative effect of 0.18 units, but when lagged by one and two years, income inequality is impacted by 0.01 units and 0.06 units, respectively. This is supported by the findings of Osinubi and Olomola (2020). In the same vein, exchange rates at their current level and when lagged by one period have a positive impact on income inequality, but when lag by two periods, income inequality is negatively impacted. The implication is that, in the long run, at both current and lag one period, a one unit increase in exchange rates results in 0.24 units and 0.33 units in income inequality, but when lagged by two periods, income inequality is decreased by 1.12 units. This exhibits that, in the long run, exchange rates in the current period and lag one period impact income inequality, except when lagged by two periods. These results show consistency with the findings of Ali (2018) and Ogege (2022).

In the long run, the interactive effect of institutions on fuel price worsens income inequality, but when lagged by one or two periods, income inequality is mitigated. These results imply that in the current period, a unit increase in the interaction of institutions on fuel price, income inequality by 0.12 units. Although in the long run, when lagged by one and two periods, a unit increase in the interactions of institutions on fuel price brings about a 0.07 unit and 0.08 unit decrease in income inequality. Interestingly, this implies the interactions of institutions on fuel price begin to mitigate income inequality when lagged by one and two periods. Solarin (2022) supports the results that the interactive effect of institutions on fuel price worsens income inequality.

The interactive effect of exchange rates on fuel price mitigates income inequality at the current and lag one period, but when lagged by two periods, income inequality is worsened in the long run. One unit increase in the interactive effect of exchange rates on fuel prices mitigates income inequality by 0.30 units and 0.65 units, *ceteris paribus*. However, after the lag one period of the exchange rates' interactive effect on fuel price, income inequality is worsened by 0.58 units in the long run.

Table 6. Estimates of the long-run model

Variable	Coefficient	Std. Error	t-Stat.	Prob.
Constant	-1.1358	1.4949	-0.7598	0.4761
$INEQ_{t-1}$	0.9417	0.0192	48.982	0.0000
PCY_t	0.0037	0.0113	0.3258	0.7556
${PCY^2}_t$	-0.0018	0.0009	-2.0124	0.0909
${PCY^2}_{t-1}$	-0.0047	0.0007	-7.0399	0.0004

Variable	Coefficient	Std. Error	t-Stat.	Prob.
$PCY^2{}_{t-2}$	-0.0058	0.0007	-8.4293	0.0002
LFP_t	2.0459	1.1542	1.7726	0.1267
LFP_{t-1}	1.5862	1.1442	1.3863	0.2150
LFP_{t-2}	-1.0064	1.0993	-0.9155	0.3952
MI_t	0.0157	0.0086	1.8217	0.1183
MI_{t-1}	0.0116	0.0065	1.8050	0.1211
MI_{t-2}	0.0153	0.0077	1.9857	0.0943
IQ_t	-0.1873	0.1893	-0.9894	0.3607
IQ_{t-1}	0.0099	0.1216	0.0816	0.9376
IQ_{t-2}	0.0630	0.0655	0.9620	0.3732
$LEXR_t$	0.2404	0.6510	0.3694	0.7245
$LEXR_{t-1}$	0.3378	0.5200	0.6497	0.5400
$LEXR_{t-2}$	-1.1220	0.7008	-1.6011	0.1605
$(LFP * IQ)_t$	0.1291	0.1359	0.9497	0.3790
$(LFP * IQ)_{t-1}$	-0.0750	0.0819	-0.9162	0.3949
$(LFP * IQ)_{t-2}$	-0.0884	0.0532	-1.6612	0.1477
$(LFP * LEXR)_t$	-0.3026	0.4776	-0.6336	0.5497
$(LFP * LEXR)_{t-1}$	-0.6545	0.5137	-1.2739	0.2498
$(LFP * LEXR)_{t-2}$	0.5807	0.5144	1.1289	0.3020
Adj. R-Sq.	0.9999	F-statistic		16386.34
D-W stat.	2.7424	Prob. (F-statistic)		0.0000

Source: Authors' compilation.

4.6. Fully modified ordinary least squares (FMOLS) robustness check

To persistently support the ARDL long-run estimates and model, the study employed the Fully Modified Ordinary Least Squares (FMOLS). Adopting the long-run ARDL results, it was revealed that the growth rate of GDP per capita, misery index, institutions, interactive effect of exchange rates on fuel price has a positive impact on income inequality, while squared of the squared growth rate of GDP per capita, fuel price, exchange rates, interactive effect of institutions on fuel price hurts income inequality in Nigeria.

Thus, the robustness check depicts that Table 7 exposes the results that most of the major variables in the model, such as fuel price, misery index, exchange rates, and the interactive effect of exchange rates on fuel price, are consistent with the long-run ARDL results.

Table 7. Fully modified ordinary least squares

Variable	Coefficient	Std. Error	t-Stat.	Prob.
Constant	72.2669	6.7574	10.6945	0.0000
PCY_t	-0.1618	0.1665	-0.9718	0.3417
$PCY^2{}_t$	0.0114	0.0142	0.8033	0.4304
LFP_t	-22.7835	4.9578	-4.5955	0.0001
MI_t	0.0979	0.0417	2.3486	0.0282
IQ_t	-2.8021	0.7569	-3.7021	0.0012
$LEXR_t$	-3.2121	3.7895	-0.8476	0.4058
$(LFP * IQ)_t$	2.3701	0.8338	2.8424	0.0095
$(LFP * LEXR)_t$	3.8463	2.2445	1.7137	0.1006
R-squared	0.9733	Adj. R-squared		0.9635

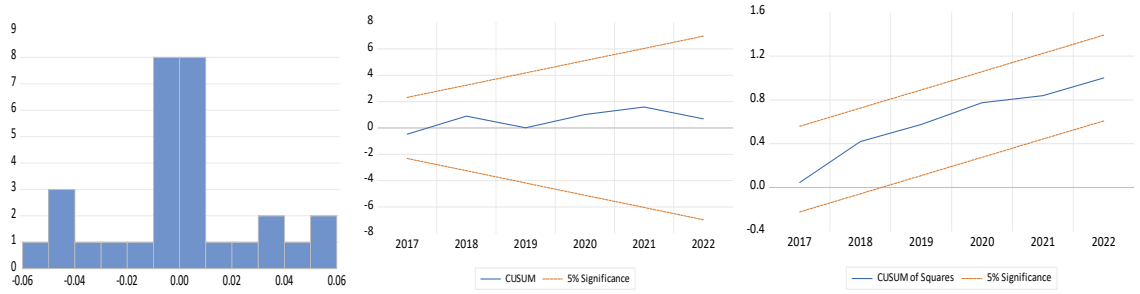
Source: Authors' compilation.

These results support the underpinning of theoretical frameworks that a percentage increase in fuel price and exchange rates reduces income inequality by 22.78% and 3.21%, respectively, while an increase in the misery index connotes a corresponding increase in the disparity of income in Nigeria. Interestingly to note, an increase in the interactive effects of exchange rates on fuel price worsens income inequality by 3.84% in Nigeria. Whereas, results of the robustness check exposed that the current period of the growth rate of per capita gross domestic products and institutions reduces income inequality, while the latter (squared) period of the growth rate of GDP per capita, and the interactive effects of institutions on fuel price improve income inequality. These results indicate that the growth rate of GDP per capita, institutions, and the interactive effects of institutions on fuel price remain sensitive to the dynamics of the time series model due to structural changes of institutions in Nigeria.

4.7. Model diagnostic

To ensure model stability, the study used the cumulative sum of recursive residues (CUSUM) and cumulative sum of recursive residue squares (CUSUM Sq.), as seen in Figure 1. The graph indicates that the model is stable across the estimation period, with residues falling within the 95% confidence range and 5% critical bounds. In summary, the results show that the model has no econometric issues.

Figure 1. Histogram-Normality, and model structural stability tests of the model.



Source: Authors' compilation.

The results of the post (residual) diagnostic tests were also presented in Table 8, indicating that all the post-diagnostic tests had a probability value greater than 5%, indicating that the null hypothesis of no serial correlation, the model is homoscedastic and is statistically normally distributed, and that the model is functionally dependent, implying that the model was correctly specified.

Table 8. Results of the diagnostic test

Test	F- statistics	Prob
Normality test	JB = 0.0924	0.9548
Breusch-Godfrey serial correlation LM test	3.8716	0.1160
Breusch-Pagan-Godfrey heteroscedasticity test	0.7374	0.7263
Ramsey RESET test	0.3887	0.5603
Cumulative sum of recursive residuals		Stable
Cumulative sum of squares of recursive residuals		Stable

Source: Authors' computation.

4.8. Granger causality

To ascertain the direction of the Granger causality between each of the variables, it is revealed in Table 9 that there exists no causal link between the interactive effect of fuel price and exchange rates, the squared growth rate of GDP per capita, exchange rates, and income inequality in both directions. Contrarily, the misery index and institutions Granger-cause income inequality in Nigeria, indicating a unidirectional impact on income inequality. However, income inequality, growth rate of GDP per capita, fuel price, and the interactive effect of fuel price and institutions Granger-cause each other. This further

shows that the series exhibit a bidirectional impact on each other in Nigeria. Summarily, it is concealed that the growth rate of GDP per capita, fuel price, misery index, institutions, and the interactive effect of fuel price and institutions Granger-cause income inequality in Nigeria.

Table 8. Results of the Granger causality test

Null hypothesis	F-statistic	Prob.	Decision
$PCY_t \neq INEQ_t$	4.9122	0.0159	Bidirectional
$INEQ_t \neq PCY_t$	4.1033	0.0288	
$PCY_t^2 \neq INEQ_t$	1.4446	0.2549	No causal link
$INEQ_t \neq PCY_t^2$	0.7656	0.4756	
$LFP_t \neq INEQ_t$	6.7537	0.0045	Bidirectional
$INEQ_t \neq LFP_t$	10.5255	0.0005	
$MI_t \neq INEQ_t$	16.3242	0.0000	Unidirectional
$INEQ_t \neq MI_t$	1.9134	0.1686	
$IQ_t \neq INEQ_t$	12.6059	0.0002	Unidirectional
$INEQ_t \neq IQ_t$	1.7183	0.1999	
$LEXR_t \neq INEQ_t$	0.7522	0.4817	No causal link
$INEQ_t \neq LEXR_t$	0.9903	0.3856	
$(LFP * IQ)_t \neq INEQ_t$	14.3934	0.0000	Bidirectional
$INEQ_t \neq (LFP * IQ)_t$	5.6427	0.0095	
$(LFP * LEXR)_t \neq INEQ_t$	1.9779	0.1594	No causal link
$INEQ_t \neq (LFP * LEXR)_t$	0.8838	0.4257	

≠ exhibit that variable A does not Granger-cause variable B.
Source: Authors' computation.

5. Conclusion

Investigating the interactive effects of institutions and macroeconomic dynamics, this study examines the impact of fuel prices, misery index, institutions, and exchange rates on income inequality in Nigeria between 1991 and 2022, thereby validating the Kuznets hypothesis. The results showed that variation in fuel prices and exchange rates, and poor institutions, greatly weaken income inequality in Nigeria. Nonetheless, strong institutions mitigate the effects of exchange rates by fostering fair income inequality. Results from the long-run ARDL and short-run ECM estimates are backed by the FMOLS robustness checks, confirming that weak institutions increase the impact of fuel price shocks on income inequality.

The study recommends stronger institutions to mitigate the distributional impacts of fuel price shocks and exchange rate fluctuations through regulatory reforms, transparent governance, and the adoption of anti-corruption measures. With this, the distributional dynamics of macroeconomic impacts on income inequality would be lessened. To support this, welfare fairness will also be improved by enacting inclusive energy and fiscal policies that protect low-income groups from changes in fuel prices. This could potentially help reduce inequality and promote inclusive growth in Nigeria by encouraging economic diversification, local refined energy investment in productive areas, and effective subsidy administration. Further studies are also encouraged to investigate the non-linear institutional effect on income inequality.

Authors' contribution*: Introduction: Agiri Ibrahim; Literature review: Agiri Ibrahim & Adefeso Pelumi; Methodology and data: Anagun Adeyemi; Research results and comments: Anagun Adeyemi; Conclusion: Anagun Adeyemi & Agiri Ibrahim.*

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