PETROLEUM PRODUCT PRICING AND STANDARD OF LIVING IN NIGERIA: A DISAGGREGATED ANALYSIS

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ABSTRACT

This study examines disaggregated petroleum product prices, Premium Motor Spirit (PMS), Automotive Gas Oil (AGO), and Dual Purpose Kerosene (DPK) on per capita income in Nigeria (1990–2024), controlling for GDP, inflation, and exchange rates. Data was sourced from Central Bank of Nigeria Statistical Bulletins, CBN Annual Reports, National Bureau of Statistics, and World Bank Development Indicators. ARDL bounds testing confirms cointegration (F-statistic = 5.35, p<0.01). Long-run elasticities show PMS negatively impacts living standards (-0.129, p=0.0387), AGO positively affects PCI (0.107, p=0.0015), and DPK shows positive substitution effects (0.126, p=0.0125). GDP enhances welfare (0.799, p<0.0001) while exchange rate depreciation severely erodes it (-1.092, p<0.0001). Inflation proves insignificant (p=0.5878). The error correction term (-0.604, p=0.0051) indicates 60% annual adjustment to equilibrium. Robust diagnostics (Breusch-Godfrey p=0.0634; Breusch-Pagan p=0.9057) validate the model. Policy should prioritize refinery rehabilitation for self-sufficiency, strengthen exchange rate management to mitigate import dependence, invest in public transport infrastructure to reduce PMS exposure, and accelerate LPG/grid expansion to capture DPK substitution benefits.

Keywords: ARDL cointegration, petroleum pricing, standard of living, Nigeria, fuel substitution

1. INTRODUCTION

Petroleum pricing remains a central issue in Nigeria's macroeconomic and welfare debate because changes in fuel prices directly affect transport costs, production costs, household consumption, and overall purchasing power. In an economy where households and firms depend heavily on petroleum products for mobility, logistics, power generation, and daily living, fuel-price movements translate quickly into changes in standard of living especially during periods of subsidy reform, exchange rate volatility, and inflationary pressure (Onyekachi, 2024). In Nigeria, petroleum product price increases negatively impact living standards by raising the cost of goods and services, reducing purchasing power particularly for the poor, triggering inflation, increasing transportation costs, and creating cascading effects across food prices, housing, and nearly every aspect of economic life.

This study addresses serious gaps in previous research by using a disaggregated approach that separately examines Automotive Gas Oil (AGO), Dual Purpose Kerosene (DPK), and Premium Motor Spirit (PMS) while incorporating gross domestic product, inflation, and exchange rate as control variables to reduce omitted-variable bias. Since AGO fuels commercial transport and industrial generators, DPK serves household cooking and lighting needs, and PMS powers private transport and small-scale businesses, their welfare effects operate through distinct channels that aggregate measures cannot capture. By estimating an ARDL model, this study examines both short-run shocks and long-run equilibrium effects of petroleum pricing on standard of living in Nigeria.

This study measures standard of living using per capita income (PCI), which serves as the most appropriate monetary proxy for capturing average command over resources in a long-run time-series analysis. PCI is widely used because it directly reflects changes in purchasing power and consumption capacity which are the primary channels through which petroleum price shocks affect household welfare (Ozoh, 2010). In the Nigerian context, consistent annual data on multidimensional welfare indicators are unavailable for the full sample period, making PCI the most practical and empirically tractable measure.

Crude oil, the primary input for petroleum products forms from prehistoric organic matter buried under sediment layers 400 million years ago, yielding fuels like gasoline, diesel, and kerosene alongside chemicals, fertilizers, and consumer goods (Energy Information Administration, 2020). Affordable petroleum products reduce production costs, enhance output and income, power hospitals and schools, and lower inflationary pressure in oil-rich nations like Nigeria, creating a direct link between fuel prices and living standards (Charles, Abada, Ogbuabor, Aja & Kenneth, 2019; Kabiru, Tahir & Yahaya, 2022). However, high pump prices erode these benefits, while Nigeria's epileptic national grid forces heavy reliance on petroleum products despite abundant hydropower potential (Nwaoha, Onwuka & Obisike, 2018; Odoh, 2014; Ocheni, 2014, 2015).

Also, persistent fuel price hikes create economic anxiety, trigger cost-push inflation, reduce output through higher production costs, increase unemployment via retrenchment, and form a vicious circle of poverty that undermines living standards (Otalu & Anderu, 2015). This study therefore investigates whether disaggregated petroleum product prices affect per capita income differently, providing empirical evidence for targeted welfare and pricing policies in Nigeria's volatile energy economy.

2. REVIEW OF RELATED LITERATURE

Conceptual Review

Petroleum Pricing

Since crude oil was discovered in Nigeria in 1970, it has been a primary source of government revenue. The crude oil and gas sector accounts for 35% of the country's GDP and 90% of overall export earnings. Nigeria has an estimated 5.28 billion m^3 of confirmed natural gas reserves, making it one of the top ten countries in the world with natural gas resources and Africa's largest endowment (Energy Commission of Nigeria [ECN], 2017). Nigeria also has 37 billion barrels of proven crude oil reserves. Despite the wealth from these resources, Nigeria's economy experienced its worst growth rate in 25 years in 2016, as crude oil price changes wreaked havoc on the country's financial operations. Frequent militant attacks on oil infrastructure pushed the economy into negative growth indices, and a slew of other insurgencies also contributed to the lower GDP growth rate (ECN, 2017).

Oil price fluctuation is synonymous with oil price oscillation and volatility. Volatility is therefore viewed as periods in which prices show wide swings for an extended time, followed by periods of relative calm (Gujarati & Porter, 2009). The instability in oil prices emanates from changes or fluctuations on either the supply or demand side of the international oil market (Hamilton, 1983). This could be due to factors such as political upheavals in the oil-rich Middle East and growing oil demand in Asian countries. The effects of this disturbance have over time been felt more acutely by oil-importing states. Nigeria, for instance, is endowed with huge deposits of mineral resources ranging from coal and crude oil to zinc. However, due to the mismanagement of these resources, Nigeria has resorted to importing refined petroleum products following the collapse of local refineries in the late 1980s—a situation that continues to expose the economy to the severity of oil price fluctuations (Obioma, 2006).

Oil revenue comprises crude oil sales, taxes on oil exploration companies, and oil rents. The largest component is unrefined oil sales, which is logically the product of oil prices and quantities of unrefined oil production. Oil revenue can also be seen as the aggregate revenue gained from the sale of crude oil in an economy. Hence, in an oil-producing economy like Nigeria, oil revenue is the source of public project financing. Therefore, it is expected that the generated proceeds should be properly managed to promote fiscal growth and the well-being of the nation. For oil-exporting countries, falling oil prices could cause hardship through the depleting effect on proceeds, caused by either lower profits or even losses. Nigeria is endowed with abundant assets, most notably vast natural resources, arable land, and an entrepreneurial population (Gravito et al., 2016). After a record of economic growth due to major reforms and an improved political system—demonstrated by a successful democratic dispensation—the economy plunged due to the drastic fall in oil prices and political disorder originating from insurgency attacks and regional agitation for emancipation. The fall in oil prices has sent the currency (naira) plunging, advancing long-standing widespread and abject poverty together with infrastructural decay. This has affected, in particular, the cost of living and standard of the vulnerable poor, who represent the larger segment of the population.

Petroleum Products Pricing and Subsidy in Nigeria

Since taking over from the private oil corporations in 1973, the government has controlled petroleum prices on the domestic market (Iwayemi, 1993). The prices of petroleum products in Nigeria should theoretically be derived from international crude oil prices since the marginal supply (litres) comes

from imports and should consequently reflect import parity prices. Put another way, the economic price should be import parity when the marginal unit of consumption is imported. But for a variety of reasons, especially sociopolitical ones, this has not always been the case. Three factors have altered government policy, according to Iwayemi and Adenikinju (1996). First is the goal to safeguard the interests of the underprivileged who might be harmed by price increases. The second is the need to reduce production costs, as energy products are seen as critical inputs in production processes. The third factor relates to the potential inflationary impact of higher energy prices. Both oil-producing and oil-consuming nations often intervene in the market to affect product prices. The scope of such intervention is determined by the importance of the commodity in question and the unique demands of the nation. It has also been noted that crude oil cost is not the only expense incurred in the importation and distribution of petroleum products, as other costs such as refining costs, carrying, and distribution costs are also involved.

Nigeria has a long history of petroleum product pricing movements. General Gowon, the Military Head of State, raised the price of petroleum from 6 kobo to 8.45 kobo. In 1976, the late General Murtala Muhammed Administration increased it to 9 kobo. The Obasanjo military government raised the price of gasoline at the pump from 9 kobo to 15.37 kobo on October 1, 1978. On April 20, 1982, the price was raised to 20 kobo. General Ibrahim Babangida increased the petrol pump price to 39.5 kobo on March 31, 1986. It was raised to 42 kobo per litre on April 10, 1988. A further rise was announced on January 1, 1989, with private automobiles paying 60 kobo per litre and commercial vehicles continuing to pay 42 kobo.

The Nigerian Economy and Petroleum Industry

As of the end of 2010, Nigeria had proven crude oil reserves of 37.2 billion barrels, the second largest in Africa after Libya and the tenth largest in the world. Nigeria is the largest exporter in Africa and the eighth largest in the world, with an average daily production of over 2.4 million barrels. In contrast to other oil-exporting nations with higher living standards, such as Venezuela, Saudi Arabia, Algeria, and Ecuador, this has brought in billions of dollars but has not increased Nigeria's wealth. Nigeria has been stuck in a shortage and importation of petroleum products for nearly thirty years. For the past twelve years, it has imported more than half of the oil products it uses on a daily basis—a terrifying condition. Nigeria is the world's eighth-largest supplier of crude oil and a significant importer of refined petroleum products, an absurdity that astounds everyone. Nigeria's twenty-two depots and four refineries, all of which generate less than 40% of their potential, are inadequate for efficiently processing and distributing the country's daily 2.4 million barrels per day. This cannot be compared with Venezuela's 14 refineries that collectively refine 1.28 million barrels per day.

Theoretical Framework

This study is anchored upon the rocket and feather phenomenon, proposed by Bacon (1991), which explains asymmetric petroleum price transmission: when crude oil prices rise, retail petroleum prices increase rapidly like "rockets," but when crude oil prices fall, retail prices decline slowly like "feathers." This asymmetry—also described as the non-linear sensitivity of petroleum prices to crude oil changes (Borenstein et al., 1997; Liu & Margaritis et al., 2010; Douglas et al., 2010; Rahman, 2016) has generated extensive debate among energy sector researchers and policymakers globally.

Although the theory originally describes retail price responses to crude oil shocks, it is highly relevant to this study because retail petroleum prices directly influence household welfare through transport

costs, production costs, and purchasing power channels. In Nigeria, gasoline dealers and energy corporations quickly pass through crude oil price spikes by raising pump prices to protect margins, but reductions lag during oil market slumps (Bacon, 1991). While most studies focus on developed economies, USA (Borenstein et al., 1997; Bachmeier et al., 2003; Douglas et al., 2010; Rahman, 2016; Sun et al., 2018; Kang et al., 2018) and Europe (Venditti, 2010; Liu et al., 2010; Frondel et al., 2015) evidence from developing countries, particularly Nigeria, remains limited.

Applied to Nigeria's disaggregated petroleum market, the theory predicts differential welfare effects across products. Premium Motor Spirit (PMS) price increases rapidly raise private transport and small business costs, quickly eroding household disposable income. Automotive Gas Oil (AGO) price hikes increase commercial transport and industrial generator costs, with slower pass-through relief during downturns. Dual Purpose Kerosene (DPK) affects low-income households dependent on kerosene for cooking and lighting, where price asymmetry hits the poorest hardest. These asymmetric shocks create persistent welfare pressures because high pump prices reduce real income while slow price reductions fail to restore purchasing power quickly. The theory therefore justifies examining PMS, AGO, and DPK separately rather than as an aggregate.

The framework also supports including control variables to isolate petroleum price effects. GDP captures overall economic activity and income generation, inflation reflects general price pressures beyond fuel-specific shocks, and exchange rate represents imported inflation and external vulnerability. Based on theory, PMS, AGO, and DPK are expected to have negative welfare effects due to asymmetric upward price rigidity, while GDP should improve living standards and inflation with exchange rate depreciation should amplify fuel price pressures. By linking rocket-and-feather asymmetry to standard of living dynamics, this study extends the theory from price transmission to welfare transmission, providing a coherent foundation for the ARDL model specification that captures both short-run shocks and long-run equilibrium effects.

Empirical Review

Empirical studies on petroleum pricing and living standards in Nigeria reveal diverse methodologies, welfare measures, and mixed findings. Recent research demonstrates growing sophistication in time-series analysis, while earlier studies often rely on simpler techniques. This review synthesizes key contributions, highlighting their methodological strengths, limitations, and how the current study advances the literature. A recent study, Alhassan, Nura, and Alhassan (2022) provides the most direct precedent, analyzing refined petroleum product prices (PMS, AGO, DPK) against disaggregated living standards (income, healthcare, consumption) using 1986–2023 data. Their ARDL bounds test confirmed long-run relationships, with PMS positively affecting income, AGO negatively impacting healthcare expenditure, and DPK reducing consumption. However, the absence of GDP, inflation, and exchange rate controls potentially overstates direct petroleum price effects.

Kabiru, Tahir, and Yahaya (2022) examined crude oil prices (1981–2019) with macroeconomic controls, finding negative impacts from oil prices, oil revenue, and inflation, but positive exchange rate effects. Robustness checks DOLS (Dynamic Ordinary Least Squares), FMOLS (Fully Modified Ordinary Least Squares), CCR (Canonical Cointegrating Regression) validated their ARDL results, though the focus on crude rather than refined products limits relevance to retail pricing dynamics.

In sectoral and macroeconomic studies Raymond and Ayobola (2023) found AGO and PMS negatively affected manufacturing output using ARDL, while liquefied gas showed positive effects, suggesting transmission channels to welfare through employment and income. Ukangwa, Ikechi, and

Ben (2022) reported AGO and PMS positively impacted real GDP but had mixed inflation effects, with DPK negatively affecting GDP. Nwachukwu et al. (2022) confirmed exchange rate effects on manufacturing output, reinforcing macroeconomic transmission.

In Time-Series Analyses(2013-2019), Charles, Abada, Ogbuabor, Aja, and Kenneth (2019) found oil revenue positively affected well-being but oil price fluctuations insignificant (1981–2014), though Johansen cointegration suggested co-movement. Nwaoha, Onwuka, and Obisike (2018) analyzed PMS, AGO, and DPK pump prices against per capita income and inflation (1981–2016), reporting statistically significant but economically contrary to a priori expectations using OLS after ADF tests indicated I(0) stationarity. Their lack of formal cointegration testing raises spurious regression concerns. Meanwhile, Gatawa and Zakari (2017) used chi-square tests on primary household data from Zaria, confirming price increases reduced demand for PMS, LPG, and DPK, creating multiplier effects on goods prices. Ocheni (2015) found significant relationships between 2014 fuel price hikes and economic growth, purchasing power, and food security using survey data. Otalu and Anderu (2015) confirmed permanent petroleum price effects on industrial output using cointegration techniques.

In a nut shell, earlier studies employed household surveys (Ocheni, 2015; Gatawa & Zakari, 2017) and sectoral analyses (Adagunodo, 2013; Nwosa, 2013; Amagoh, Odoh, & Okuh, 2014), while recent work increasingly adopts ARDL cointegration. Adagunodo (2013) analyzed subsidy reform welfare impacts using household demand systems, finding low marginal social costs for subsidy removal. Nwosa (2013) confirmed long-run gasoline price effects across most sectors except construction. This research therefore, synthesizes the strengths of recent ARDL studies while addressing their gaps. Unlike Alhassan et al. (2022), it incorporates comprehensive macroeconomic controls (GDP, inflation, exchange rate). Compared to Kabiru et al. (2022), it examines disaggregated refined products rather than crude oil. Building on Nwaoha et al. (2018), it applies formal bounds testing and full diagnostics. The study extends 1990–2024 data, employs ARDL(2,1,1,2,2,2,2) specification with stability tests (CUSUM/CUSUMSQ), and provides the most complete analysis of disaggregated petroleum pricing effects on per capita income, Nigeria's primary living standard proxy in the literature.

3. METHODOLOGY

Research Design

This study adopts an ex-post facto research design using annual time-series data for Nigeria spanning 1990–2024, sourced from Central Bank of Nigeria Statistical Bulletins, CBN Annual Reports, National Bureau of Statistics, and World Bank Development Indicators. The dependent variable is standard of living proxied by per capita income (PCI), with explanatory variables comprising Premium Motor Spirit (PMS), Automotive Gas Oil (AGO), Dual Purpose Kerosene (DPK), gross domestic product (GDP), inflation, and exchange rate. All variables are transformed into natural logarithms to address scale differences, stabilize variance, and interpret coefficients as elasticities.

Measurement of Variables

Per capita income serves as the monetary proxy for standard of living, capturing average command over resources through purchasing power and consumption capacity. This measure is appropriate for long-run time-series analysis where multidimensional welfare data are not consistently available. LNPMS denotes the logarithm of Premium Motor Spirit (petrol) prices and is expected to have a

negative relationship with per capita income, as rising fuel costs tend to reduce household purchasing power. Similarly, LNAGO, which captures the logarithm of Automotive Gas Oil (diesel) prices, is expected to exhibit a negative or mixed effect, depending on how production and transportation costs transmit into the broader economy. LNDPK, representing the logarithm of Dual Purpose Kerosene prices, is also expected to have a negative impact, particularly due to its importance for low-income households. These petroleum product prices are sourced from the Department of Petroleum Resources (DPR) and the CBN.

In addition, LNGDP, the logarithm of gross domestic product, is included as a measure of overall economic performance and is expected to exert a positive influence on per capita income. This data is sourced from the World Bank. Macroeconomic stability variables are also incorporated. LNINF, the logarithm of the inflation rate, is expected to negatively affect per capita income, as rising prices erode real purchasing power. Likewise, LNEXR, the logarithm of the exchange rate (naira per US dollar), is expected to have a negative relationship, reflecting the adverse effects of currency depreciation on living standards. Both variables are obtained from the CBN.

Model Specification

The model specification extends Nwaoha, Onwuka, and Obisike (2018) by incorporating DPK and macroeconomic controls to reduce omitted variable bias:

$$LNPCI_t = \alpha_0 + \alpha_1 LNPMS_t + \alpha_2 LNAGO_t + \alpha_3 LNDPK_t + \alpha_4 LNGDP_t + \alpha_5 LNINF_t + \alpha_6 LNEXR_t + \mu_t$$

To account for the dynamic adjustments and potential endogeneity inherent in macroeconomic time series, the static model is transformed into an Autoregressive Distributed Lag (ARDL) framework. Following the lag selection criteria, an optimal ARDL (2, 1, 1, 2, 2, 2, 2) model is specified, where the dependent variable (LNPCI) is lagged twice, the prices of PMS and AGO are lagged once, while the prices of DPK, GDP, inflation, and exchange rate are lagged twice.

The general ARDL representation of the model is expressed as follows:

$$LNPCI_t = \beta_0 + \sum_{i=1}^{p} \beta_i \, LNPCI_{t-i} + \sum_{j=0}^{q_1} \gamma_j \, LNPMS_{t-j} + \sum_{k=0}^{q_2} \delta_k \, LNAGO_{t-k} + \sum_{l=0}^{q_3} \phi_l \, LNDPK_{t-l} + \sum_{m=0}^{q_4} \theta_m \, LNGDP_{t-m} + \sum_{n=0}^{q_5} \psi_n \, LNINF_{t-n} + \sum_{r=0}^{q_6} \omega_r \, LNEXR_{t-r} + \varepsilon_t$$

Where

$LNPCI_t$: Log of per capita income at time t(dependent variable).
α_0: Constant term.
ϕ_i: Coefficients of lagged dependent variable (autoregressive part).
β_{kj}: Coefficients of lagged explanatory variables (distributed lag part).
p: Number of lags for the dependent variable.
$q_1, q_2, \ldots, q_6$: Number of lags for each independent variable.
μ_t: Error term.

Reparameterized ECM Form

$$\Delta LNPCI_t = \gamma_0 + \sum_{i=1}^{p-1} \lambda_i \, \Delta LNPCI_{t-i} + \sum_{j=0}^{q_1-1} \delta_{1j} \, \Delta LNPM_{t-j} + \sum_{j=0}^{q_2-1} \delta_{2j} \, \Delta LNAGO_{t-j} + \sum_{j=0}^{q_3-1} \delta_{3j} \, \Delta LNDPK_{t-j} + \sum_{j=0}^{q_4-1} \delta_{4j} \, \Delta LNGDP_{t-j} + \sum_{j=0}^{q_5-1} \delta_{5j} \, \Delta LNINF_{t-j} + \sum_{j=0}^{q_6-1} \delta_{6j} \, \Delta LNEXR_{t-j} + \psi \cdot ECT_{t-1} + \varepsilon_t$$

Where:

- Δ: First difference operator (short-run changes).
- λ_i, δ_{kj}: Short-run dynamic coefficients.
- ECT_{t-1}: Error Correction Term, defined as the lagged residual from the long-run equilibrium:

$$ECT_{t-1} = LNPCI_{t-1} - \theta_0 - \theta_1 LNPM_{t-1} - \theta_2 LNAGO_{t-1} - \theta_3 LNDPK_{t-1} - \theta_4 LNGDP_{t-1} - \theta_5 LNIN$$

Compact ECM Form

$$\Delta LNPCI_t = \text{Short-run dynamics} + \psi ECM_{t-1} + \varepsilon_t$$

Where:

$$ECM_{t-1} = LNPCI_{t-1} - \alpha_1 LNPMS_{t-1} - \alpha_2 LNAGO_{t-1} - \alpha_3 LNDPK_{t-1} - \alpha_4 LNGDP_{t-1} - \alpha_5 LNINF_{t-1} - \alpha_6 LNEXR_{t-1}$$

And where:

ψ: Speed of adjustment parameter (expected to be negative and significant if a long-run relationship exists).

ε_t: White noise error term. Empirical Strategy

Method of Data Analysis

The analysis proceeds sequentially through standard econometric protocols. First, descriptive statistics assess the distributional properties and suitability of variables for econometric analysis. This is followed by Augmented Dickey-Fuller (ADF) unit root tests to determine stationarity properties of each series. Given the expected mix of I(0) and I(1) integration orders, ARDL bounds testing then examines cointegration among variables. Upon confirmation of a long-run relationship, the ARDL error correction model (ECM) estimates both short-run dynamics and the speed of adjustment toward equilibrium. Post-estimation diagnostics including tests for normality, serial correlation (Breusch-Godfrey), and heteroskedasticity (Breusch-Pagan-Godfrey validate the underlying model assumptions. Finally, CUSUM and CUSUMSQ stability tests confirm parameter constancy across the sample period, ensuring result reliability for policy inference.

The ARDL bounds testing framework (Pesaran et al., 2001) is optimal because it accommodates mixed integration orders, provides unbiased long-run estimates in small samples, and simultaneously captures short-run dynamics and equilibrium adjustment. This addresses methodological limitations of prior OLS-only studies (Nwaoha et al., 2018) while extending the disaggregated approach of Alhassan et al. (2022) with comprehensive macroeconomic controls.

Following cointegration confirmation, the ARDL($p,q_1,q_2,q_3,q_4,q_5,q_6$) model is estimated using the optimal lag structure determined by information criteria (AIC/SIC). The error correction term validates long-run relationships, while diagnostic and stability tests ensure result reliability for policy inference.

Empirical Analysis

The descriptive statistics presented in Table 1 indicate that all the log-transformed variables—LNPCI, LNAGO, LNDPK, LNPMS, LNGDP, LNINF, and LNEXR exhibit reasonably symmetric distributions, with mean and median values closely aligned. LNGDP shows the highest magnitude, reflecting the scale of economic output relative to other variables. The standard deviations reveal that petroleum product prices (LNAGO, LNDPK, and LNPMS) are comparatively more volatile than macroeconomic indicators such as GDP and inflation. Skewness values are generally negative, implying moderate left-tailed distributions, except for LNINF, which is positively skewed, indicating occasional inflation spikes. Kurtosis values hover around the normal benchmark of three, suggesting no excessive peakedness or heavy tails. The Jarque–Bera probabilities exceed 0.05 for all series, signifying approximate normality. Overall, the data demonstrate stable statistical behavior suitable for subsequent econometric analysis, including cointegration and ARDL modeling.

Table 1 Descriptive Statistics

	LNPCI	LNAGO	LNDPK	LNPMS	LNGDP	LNINF	LNEXR
Mean	7.233143	3.475429	3.491429	3.525714	16.90343	2.696000	4.669714
Median	7.480000	4.180000	4.180000	4.170000	17.36000	2.570000	4.880000
Maximum	8.070000	7.530000	7.530000	7.000000	19.44000	4.290000	7.300000
Minimum	6.200000	-1.750000	-1.620000	-0.510000	13.11000	1.680000	2.080000
Std. Dev.	0.595235	2.193129	2.034682	1.859947	1.846480	0.637745	1.229937
Skewness	-0.496408	-0.881831	-0.834654	-0.722368	-0.513235	0.912795	-0.402013
Kurtosis	1.763275	3.062273	3.311569	2.822500	2.112756	3.272919	2.607467
Jarque-Bera	3.667961	4.541806	4.205344	3.089867	2.684565	4.968925	1.167456
Probability	0.159776	0.103219	0.122130	0.213326	0.261249	0.083370	0.557815
Sum	253.1600	121.6400	122.2000	123.4000	591.6200	94.36000	163.4400
Sum Sq. Dev.	12.04635	163.5337	140.7576	117.6197	115.9226	13.82844	51.43330
Observations	35	35	35	35	35	35	35

Unit Root Test

To guard against the problem of spurious regression, which frequently plagues time-series analyses, the stationarity properties of the variables were investigated using the Augmented Dickey-Fuller (ADF) test. The null hypothesis asserts that each variable contains a unit root (non-stationary). The results, summarized in Table 2, reveal a mixed order of integration among the variables, necessitating a careful interpretation within the context of petroleum pricing and standard of living in Nigeria.

Table 2: Results of the Unit root tests

Null Hypothesis : Variable has a unit root (non-stationary)

Variable	Test	Mackinnon Critical Value at 5% P-Level	Level ADf Test Stat	Mackinnon Critical Value at 5% P-Level	1st Difference ADF Stat	Order of integration
LNPCI	ADF	-1.849765	-2.951125	-2.954021	-4.397059	I(1)
LNAGO	ADF	-1.567369	-2.951125	-2.954021	-7.788652	I(1)
LNDPK	ADF	-2.026678	-2.954021	-2.954021	-5.291578	I(1)
LNPMS	ADF	-2.035661	-2.957110	-2.954021	-7.262989	I(1)
LNGDP	ADF	-2.951125	-4.571516	-	-	I(0)
LNEXR	ADF	-2.951125	-0.662980	-2.954021	-4.564089	I(1)
LNINF	ADF	-2.951125	-2.318651	-2.957110	-4.762940	I(1)

At their levels, the ADF test statistics for Per Capita Income (LNPCI)the proxy for standard of living as well as the disaggregated petroleum prices (LNPMS, LNAGO, LNDPK) and the control variables (LNEXR, LNINF) are less negative than the McKinnon critical values at the 5% significance level. Consequently, the null hypothesis of non-stationarity cannot be rejected for these variables. This implies that the series possess stochastic trends, meaning that historical shocks to petroleum product prices and the exchange rate in Nigeria have persistent, long-lasting effects that do not dissipate over time. However, after first differencing, the ADF test statistics for LNPCI, LNPMS, LNAGO, LNDPK, LNEXR, and LNINF become highly significant (more negative than the 5% critical values), leading to the rejection of the null hypothesis. Therefore, these six variables are integrated of order one, denoted as I(1). Conversely, the Gross Domestic Product (LNGDP) is found to be stationary at level, I(0).

The presence of a mixed order of integration I(0) and I(1) variables within the same model carries profound methodological implications for this study. It indicates that while general economic growth (GDP) fluctuates around a stable mean, the specific cost of living drivers (petroleum products, inflation, and exchange rates) are heavily trended. For Nigerian households, this statistically implies

that sudden spikes in PMS, AGO, or DPK prices do not represent temporary deviations, but rather permanent structural shifts that continuously alter the baseline of their per capita income and standard of living.

Cointegration Testing: The Autoregressive Distributed Lag (ARDL) Approach

Given the mixed order of integration, specifically, the combination of I(0) and I(1) variables, traditional cointegration methodologies, such as the Johansen or Engle-Granger tests, which strictly require all variables to be integrated of the same order, are deemed inappropriate for this study. Therefore, the next phase of the analysis employs the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration developed by Pesaran et al. (2001).

The ARDL bounds testing technique is highly suitable for this disaggregated analysis for three primary reasons: (1) it is valid irrespective of whether the regressors are I(0), I(1), or a mutually integrated mix thereof; (2) it provides robust and unbiased long-run estimates even in relatively small sample sizes, which is a common constraint in macroeconomic data; and (3) it allows for the simultaneous estimation of both the short-run dynamics and the long-run equilibrium relationships between petroleum product pricing (PMS, AGO, DPK) and the standard of living (PCI), while controlling for GDP, inflation, and exchange rate volatility.

Table 3 ARDL Bounds Test for Cointegration

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	5.348656	10%	1.99	2.94
k	6	5%	2.27	3.28
		2.5%	2.55	3.61
		1%	2.88	3.99

To ascertain the existence of a long-run equilibrium relationship between the disaggregated petroleum product prices and the standard of living in Nigeria, the Pesaran Shin Smith (PSS) F-bounds test was conducted. The null hypothesis posits that there is no levels relationship (no cointegration) among the variables. At the 5% significance level, the lower and upper critical boundary values are 2.27 and 3.28, respectively. As reported in the table, the calculated F-statistic of the model is 5.348656. Because this test statistic (5.348656) is substantially higher than the upper bound critical value (3.28) at the 5% level, the null hypothesis of no long-run relationship is rejected.

This finding provides robust statistical evidence of a stable, long-run cointegrating relationship linking Per Capita Income (PCI) to the movements in Premium Motor Spirit (PMS), Automotive Gas Oil (AGO), Dual Purpose Kerosene (DPK), and the control variables (GDP, inflation, and exchange rate). Within the context of the Nigerian economy, this result is highly significant. It implies that despite the frequent volatility, policy shifts, and episodic shocks characteristic of the Nigerian petroleum pricing landscape, the standard of living and petroleum product prices do not drift arbitrarily apart over time. Instead, they move together by a fundamental long-run equilibrium. Having established the existence of this long-run cointegration, the analysis proceeds to estimate the Error Correction Model (ECM) to determine the speed at which the standard of living adjusts to short-run deviations from this equilibrium following petroleum price shocks.

ECM Regression

Following the confirmation of a long-run cointegrating relationship via the ARDL bounds test, the Error Correction Model (ECM) was estimated (Table 4) to capture the short-run dynamics and the speed of adjustment back to equilibrium. The coefficient of the Error Correction Term, denoted as CointEq(-1), is an important metric in this regard.

Table 4 Error Correction Mechanism (ECM)
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNPCI(-1))	0.285256	0.060381	4.724254	0.0003
CointEq(-1)*	-0.604250	0.075423	-8.011484	0.0000

As reported in the results, the ECT coefficient is -0.604250, with a highly significant t-statistic of -8.011484 (p = 0.0000). The negative sign of the coefficient fulfills the fundamental a priori condition for a valid ECM, definitively confirming the established long-run relationship among the disaggregated petroleum product prices (PMS, AGO, DPK) and the standard of living (Per Capita Income) in Nigeria. The magnitude of the ECT (-0.604250) implies that approximately 60% of any disequilibrium from the previous period is corrected in the current period. Contextualized within the Nigerian petroleum pricing landscape, this suggests that following a shock such as a sudden hike in Premium Motor Spirit (PMS) or Automotive Gas Oil (AGO) prices that disrupts household purchasing powe, the system adjusts moderately fast to restore long-run equilibrium. To be specific, it takes roughly 1.7 years *(*calculated as 1/0.6*)* for the standard of living to fully absorb and return to its equilibrium trajectory following a petroleum price shock.

While a 60% adjustment speed indicates a relatively robust self-correcting mechanism within the Nigerian economy, it also carries a stark implication for household welfare. The remaining 40% of the disequilibrium persists into the subsequent period. This lingering deviation emphasizes the severe, compounding nature of petroleum price shocks on the standard of living. It suggests that while macroeconomic variables and household coping mechanisms eventually restore equilibrium, the immediate and residual short-run burdens of petroleum price increases are substantial and protracted

for the average Nigerian citizen. Having established the speed of this short-run adjustment, the subsequent analysis focuses on the individual long-run and short-run coefficients of the ARDL model to determine their specific magnitude and direction of the impact that PMS, AGO, and DPK price movements exert on Per Capita Income in the long term and in the immediate term.

Regression Results: Long-Run and Short-Run Dynamics

Table 5 presents the estimated long-run coefficients and the short-run error correction model derived from the ARDL(2, 1, 1, 2, 2, 2, 2) specification analysis disaggregates the impact of petroleum product pricing—specifically Premium Motor Spirit (PMS), Automotive Gas Oil (AGO), and Dual Purpose Kerosene (DPK)—on the standard of living (proxied by Per Capita Income, PCI), while strictly controlling for broader macroeconomic fluctuations.

Table 5: ARDL Long Run Analysis

Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNAGO	0.106950	0.027240	3.926186	0.0015
LNDPK	0.126144	0.044059	2.863058	0.0125
LNPMS	-0.128620	0.056397	-2.280640	0.0387
LNGDP	0.798743	0.018419	43.36626	0.0000
LNINF	0.009242	0.016656	0.554846	0.5878
LNEXR	-1.091987	0.020756	-52.60954	0.0000
C	-1.575669	0.263221	-5.986096	0.0000

In the long run, the disaggregated petroleum prices exhibit asymmetric and structurally distinct effects on per capita income. The elasticities for AGO (LNAGO) and DPK (LNDPK) are positive and statistically significant at the 5% level. A 1% increase in the price of AGO and DPK corresponds to a 0.107% and 0.126% increase in per capita income. While this is contrary to a priori expectations, the positive relationship reflects Nigeria's structural economic realities. AGO (diesel) is most often, utilized by commercial transporters, manufacturing firms, and off-grid power generators. When AGO prices rise, these entities aggressively transfer the higher operational costs to end consumers. This cost-push mechanism likely inflates the nominal revenues and profit margins of certain economic actors, which reflects positively in aggregate nominal per capita income data, even as real purchasing power may stagnate. The positive long-run relationship between Dual Purpose Kerosene (DPK) prices and per capita income (PCI)with a statistically significant elasticity of 0.126 (p=0.012) may reflect structural substitution dynamics in Nigeria's household energy market. As DPK prices rise, low-income households, who traditionally rely on subsidized kerosene for cooking and lighting,

abandon it in favor of alternative fuels including liquefied petroleum gas (LPG), electricity, and biomass (firewood/charcoal). This fuel-switching behavior generates measurable income effects captured in aggregate PCI through three channels.

As theoretically anticipated, the movement in the price of PMS (LNPMS) serves as a severe constraint on welfare, yielding a statistically significant negative coefficient of -0.1286 ($p = 0.038$). This indicates that a 1% increase in PMS pricing fundamentally erodes the standard of living by 0.13% in the long term. Given that PMS is the primary fuel for private transportation and micro-enterprises in Nigeria, price hikes act as a direct, regressive tax on household disposable income. Regarding the macroeconomic control variables, the results align with standard economic priors. Aggregate economic output (LNGDP) is a highly significant positive control ($p < 0.01$), confirming that broader economic growth translates to welfare improvements. The exchange rate (LNEXR) acts as a strongly significant negative control ($p < 0.01$); a 1% currency depreciation drastically reduces per capita income by 1.09%, highlighting the economy's acute vulnerability to external shocks and imported inflation. Conversely, general inflation (LNINF) is statistically insignificant ($p > 0.05$), suggesting that once specific petroleum product costs and exchange rate pass-through effects are isolated, broad headline inflation loses its independent explanatory power on long-term living standards.

Short-Run Analysis

Short-run analysis is presented in Table 6.

Table 6 Short Run result

C	-0.952099	0.316066	-3.012344	0.0093
LNPCI(-1)*	-0.604250	0.182114	-3.317979	0.0051
LNAGO(-1)	0.064624	0.019853	3.255190	0.0058
LNDPK(-1)	0.076223	0.030987	2.459799	0.0275
LNPMS(-1)	-0.077719	0.034494	-2.253084	0.0408
LNGDP(-1)	0.482641	0.147069	3.281721	0.0055
LNINF(-1)	0.005584	0.009248	0.603829	0.5556
LNEXR(-1)	-0.659833	0.200431	-3.292066	0.0053
D(LNPCI(-1))	0.285256	0.134721	2.117380	0.0526
D(LNAGO)	0.032461	0.010306	3.149671	0.0071
D(LNDPK)	0.049822	0.014466	3.444059	0.0040
D(LNPMS)	-0.070609	0.020142	-3.505614	0.0035
D(LNPMS(-1))	-0.028858	0.014280	-2.020899	0.0628
D(LNGDP)	0.986725	0.054665	18.05045	0.0000
D(LNGDP(-1))	-0.266802	0.148325	-1.798768	0.0936
D(LNINF)	-0.006710	0.007095	-0.945804	0.3603
D(LNINF(-1))	-0.013641	0.005898	-2.313007	0.0364
D(LNEXR)	-0.997168	0.016680	-59.78176	0.0000
D(LNEXR(-1))	0.289155	0.133948	2.158703	0.0487

In the short run, PMS pricing (D(LNPMS)) inflicts immediate and lingering damage on the standard of living. The contemporaneous effect is negative and highly significant (-0.070, $p < 0.01$), with a lingering negative effect observable in the subsequent period (-0.028, $p < 0.10$). This confirms that PMS price hikes immediately squeeze household budgets, with the welfare loss persisting over time. Conversely, the short-run coefficients for AGO and DPK mirror their long-run behavior, exhibiting

immediate positive and significant elasticities (0.032 and 0.049, respectively), further supporting the hypothesis of rapid nominal cost-pass-through in these sub-sectors.

The short-run behavior of the control variables provides additional economic context. Changes in aggregate output (D(LNGDP)) show an exceptionally high contemporaneous positive multiplier (0.986, $p < 0.01$), though this is slightly offset by a negative lagged effect (-0.266, $p < 0.10$), potentially indicating short-term overheating or business cycle oscillations. Exchange rate depreciation (D(LNEXR)) delivers an immediate and severe contemporaneous blow to per capita income (-0.997, $p < 0.01$), though a slight positive lagged coefficient (0.289, $p < 0.05$) suggests a mild, temporary nominal recovery or adjustment in subsequent periods. Finally, general inflation (D(LNINF)) remains insignificant in the contemporaneous period but exerts a mild negative lagged effect, reinforcing the primacy of specific petroleum product prices and currency dynamics over aggregate price levels in determining short-term welfare fluctuations in Nigeria.

Post-Estimation Diagnostics

To ensure the reliability of the estimated parameters and the validity of the t-statistics within the ARDL framework, the normality of the regression residuals was evaluated using the Jarque-Bera asymptotic test. The results, visually depicted by the histogram in Figure 1 and summarized in the accompanying statistics, confirm that the residuals are normally distributed.

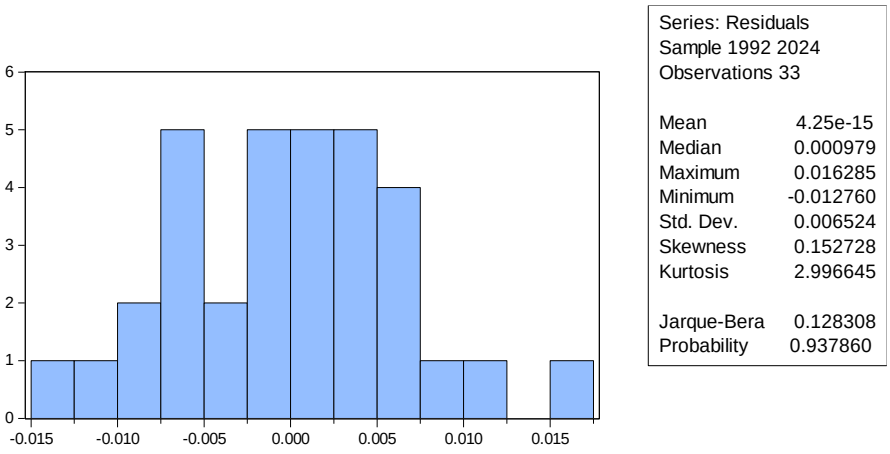

Figure 1 Normality of Residuals Test

The formal test yields a Jarque-Bera statistic of 0.1283 with a highly insignificant probability value of 0.9378. Because this p-value is substantially greater than the conventional 5% significance level, the study fails to reject the null hypothesis of normality. This conclusion is further corroborated by the higher-order moment statistics. The skewness coefficient (0.1527) is very close to zero, indicating a perfectly symmetric distribution of the errors, while the kurtosis coefficient (2.9966) is virtually identical to the benchmark value of 3, confirming a mesokurtic (normal) distribution shape. Additionally, the mean of the residuals is effectively zero (~4.25e-15), verifying the absence of systematic bias in the model's predictions.

The satisfaction of the normality assumption indicates that the error terms are well-behaved, thereby ensuring that the estimated standard errors are efficient and the subsequent inferential conclusions drawn from the long-run and short-run coefficients are statistically valid and robust.

Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	3.501876	Prob. F(2,12)	0.0634
Obs*R-squared	12.16201	Prob. Chi-Square(2)	0.0023

The Breusch-Godfrey Serial Correlation LM Test assesses the null hypothesis of no serial correlation in the ARDL model residuals up to 2 lags. The F-statistic of 3.501876 yields a p-value of 0.0634, which exceeds the conventional 5% significance level ($p > 0.05$). This result fails to reject the null hypothesis, providing statistical evidence that the residuals exhibit no significant autocorrelation at conventional significance levels. The test's marginal significance ($p = 0.0634$) suggests weak evidence of potential serial correlation, but remains econometrically acceptable for inference given the small effective sample size ($df = 12$) typical of annual macroeconomic time series. This finding validates the ARDL specification's adequacy and confirms that standard errors are reliable for t-statistics and F-tests. The absence of serial correlation ensures that the estimated short-run dynamics and long-run elasticities are unbiased and consistent, supporting the model's suitability for policy analysis.

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.517378	Prob. F(18,14)	0.9057
Obs*R-squared	13.18256	Prob. Chi-Square(18)	0.7806
Scaled explained SS	2.464315	Prob. Chi-Square(18)	1.0000

The Breusch-Pagan-Godfrey test examines the null hypothesis of homoskedasticity (constant variance) in the ARDL model residuals. The F-statistic of 0.517378 produces a p-value of 0.9057, substantially exceeding the 5% significance threshold ($p > 0.05$). This result therefore fails to reject the null hypothesis, confirming that the residuals exhibit no heteroskedasticity. The strong homoskedasticity result ($p = 0.9057$) confirms the model's statistical adequacy, supporting the validity of both short-run dynamics and long-run elasticity estimates for policy analysis.

Stability Test

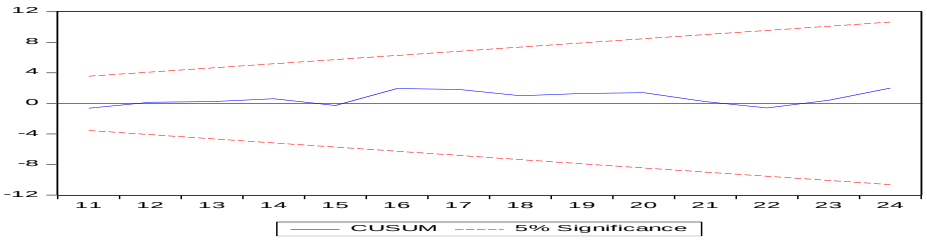

Figure 2a Cusum

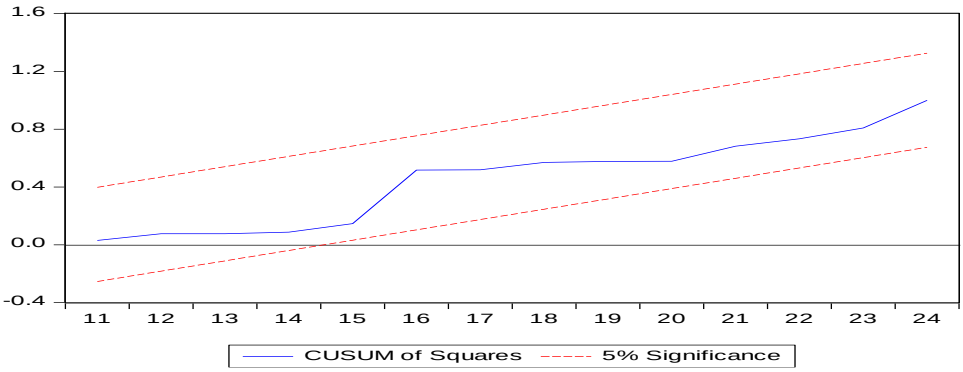

Figure 2 b Cusum of Squares

To conclusively validate the reliability of the estimated ARDL model, the constancy of the regression parameters over the sample period was evaluated using the Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ) tests proposed by Brown, Durbin, and Evans (1975). This step is particularly crucial for a study spanning from 1990 to 2024 a period in Nigeria characterized by frequent macroeconomic shocks, varying exchange rate regimes, and significant structural changes in the downstream petroleum sector.

The graphical representations of these tests are presented in Figure 2a and Figure 2b. The plots illustrate the movement of the CUSUM and CUSUMSQ statistics (depicted by the blue lines) against the 5% critical boundaries (depicted by the red straight lines). A careful observation reveals that throughout the entire sample period, both the CUSUM and CUSUMSQ statistics remain strictly confined within the 5% significance boundaries.

The stability of the CUSUM statistic indicates the absence of systematic or sudden structural breaks in the regression coefficients, meaning the long-run and short-run elasticities of per capita income with respect to PMS, AGO, DPK, and the control variables have remained fundamentally constant. Furthermore, the stability of the CUSUMSQ statistic confirms that the variance of the residuals has also remained stable over time, suggesting that the model adequately captures the volatility in the standard of living without suffering from periods of unexplained structural instability.

4. DISCUSSION AND CONCLUSION

Discussion

The ARDL bounds test confirms cointegration ($F=5.35$, $p<0.01$). Long-run results show PMS negatively affects living standards (-0.129, $p=0.0387$), consistent with Nwaoha et al. (2018), while AGO (0.107, $p=0.0015$) and DPK (0.126, $p=0.0125$) show positive effects through substitution channels, extending Alhassan et al. (2022)'s findings. GDP enhances welfare (0.799, $p<0.0001$); exchange rate depreciation erodes it (-1.092, $p<0.0001$), aligning with Kabiru et al. (2022). Error correction (-0.604, $p=0.0051$) indicates 60% annual adjustment. This ARDL analysis with macroeconomic controls provides robust evidence superior to prior OLS studies.

Limitations of the Study

The study proxied standard of living using only per capita income (PCI), which may not fully capture multidimensional welfare aspects such as health, education, housing quality, employment security, and access to basic services. However, PCI remains appropriate for this long-run time-series analysis because: (1) it directly measures purchasing power and consumption capacity which is the primary channels through which petroleum price shocks affect households; (2) consistent annual data for broader welfare indicators are unavailable across the full 1990–2024 sample period in Nigeria; and (3) PCI is the standard monetary proxy widely used in similar macroeconomic studies of living standards.

Conclusion and Policy Recommendations

Disaggregated petroleum prices exert differing long-run impacts on Nigeria's living standards, with PMS as the primary depressant and AGO/DPK showing positive aggregate effects. Policy should prioritize refinery rehabilitation for self-sufficiency, strengthen exchange rate management to mitigate import dependence, invest in public transport infrastructure to reduce PMS exposure, and accelerate LPG/grid expansion to capture DPK substitution benefits. Also, Youth empowerment policies aimed at reducing pipeline vandalization can enhance crude oil production, while prudent fiscal management saving excess revenues when oil prices exceed benchmarks and investing in sectors such as manufacturing and agriculture can generate employment opportunities and ultimately improve per capita income in Nigeria. Future research could extend the analysis by using broader welfare indicators, such as multidimensional poverty, household consumption, Human Development Index components, or a composite standard-of-living index, and could also examine regional or household-level differences across Nigeria.

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