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Asymmetric impacts of exchange rate and petroleum pump price on economic welfare in Nigeria

Sesan Sunday Abere

Department of Economics, Ajayi Crowther University, Oyo, Oyo State, Nigeria
Corresponding author: ss.abere@acu.edu.ng or sundayoluwasesan1@gmail.com

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Abstract

Purpose — This study examines the asymmetric effects of exchange rate fluctuations and petroleum pump prices on economic welfare in Nigeria. While previous research examined these shocks in isolation, this study jointly evaluates their short-run and long-run effects, thereby addressing a key gap in the literature.

Methods — The study employs the Nonlinear Autoregressive Distributed Lag (NARDL) model to analyse time-series data from 1970 to 2023.

Findings — Exchange rate depreciations and petroleum price increases have larger and lasting welfare losses than the short-run benefits of appreciations and price declines. In the long run, these shocks can be turned into potential welfare benefits through structural changes and redistribution of the budget. Inflation, unemployment, subsidies and international oil prices further mediate outcomes.

Implications — Policymakers should strike a balance between short-term household protection and longer-term structural changes. With the complete removal of petroleum subsidies in Nigeria in May 2023, the focus should shift to special transfers, social security, and compensation to mitigate welfare losses. Exchange rate stability, fiscal discipline and diversification are equally essential for enhancing long-term welfare.

Originality — This study advances understanding of welfare by concurrently examining the asymmetries of exchange rates and petroleum pump prices, thereby moving beyond the single-shock approach.

Keywords — Exchange rate, oil price, economic welfare, subsidies, unemployment

Introduction

There is no gainsaying that the Nigerian economy is heavily influenced by the petroleum sector, which has served as a primary source of government revenue and a critical input to various economic activities since the 1970s. As Africa's largest oil producer and one of the world's top oil producers, Nigeria is profoundly affected by changes in global oil prices (Adams & Olamide Bello, 2022; Ojumu & Osho, 2023). Oil exports account for a significant share of the country's gross domestic product (GDP) and foreign exchange earnings (Okon et al., 2020), making the economy highly susceptible to fluctuations in global oil prices and exchange rates. This dependence has created a situation of which the nation's well-being is closely tied to the health of the petroleum sector, making it a vital area of focus for economic stability and welfare.

In recent years, exchange rate volatility has been a persistent issue in Nigeria, driven by various factors, including global oil market dynamics, domestic economic policies, and fluctuations

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in foreign exchange reserves. Based on data from the Central Bank of Nigeria (CBN), the naira has experienced significant depreciation, with the average exchange rate rising from approximately N197 per USD in 2015 to about N365 per USD in 2019 and N460 per USD in mid-2023, before depreciating drastically to over N1000 per USD after the adoption of floating exchange rate system in the third quarter of 2023. Such depreciation has a direct impact on the cost of imported goods and services, including petroleum products, since Nigeria imports a substantial share of its fuel. Exchange rate movements can cause significant shifts in the price of petroleum, affecting consumers and businesses alike.

Petroleum products play a fundamental role in the Nigerian economy, powering transportation, manufacturing, and various other sectors. The Nigerian National Petroleum Corporation (NNPC) reported that in 2020, Nigeria imported about 20 billion litres of petrol. As a result of this heavy reliance on imported fuel, the cost of petroleum prices is susceptible to exchange rate fluctuations. For instance, when the naira weakens, the cost of importing fuel rises, leading to higher domestic pump prices. A depreciation of 10% in the naira, for example, could lead to a corresponding increase in petrol import costs by roughly the same percentage, or more, ultimately driving up consumer prices. As petroleum products become more expensive, transportation and production costs rise, contributing to overall inflation and eroding the purchasing power of Nigerian consumers.

The impact of fuel price hikes is particularly severe for low-income households, who spend a substantial portion of their income on necessities, including transportation. According to the CBN, annual inflation rates in Nigeria increased from 9% in 2015 to 15.7% in the following year, and to about 22% in 2023, with a notable portion of the rise attributed to higher fuel prices. This inflationary trend erodes real incomes, exacerbates poverty, and widens the gap between wealthy and vulnerable segments of the population. The World Bank, for instance, estimates that as of 2019, 40.1% of Nigerians were living below the poverty line, surviving on less than $1.90 per day. Rising fuel prices further strain these households by limiting their access to essential goods and services and diminishing their overall quality of life.

In addition to its impact on the cost of living, exchange rate, and petroleum price volatility can also destabilise the broader economy. Rising input costs can discourage investment and reduce business profitability, with adverse effects on employment levels. Nigerian unemployment rate, as reported by the NBS, surged to 33.3% in the fourth quarter of 2020 and to 35% in 2023, underscoring the country's broader economic challenges. A high unemployment rate, coupled with increasing inflation and fluctuating fuel prices, poses a substantial risk to economic welfare and social stability.

Meanwhile, the Nigerian government has attempted to mitigate these issues through various policy interventions, including subsidies and price controls. In 2020, for example, Nigeria allocated over N2 trillion to fuel subsidies, which increased to about N3 trillion in 2023, aiming to shield consumers from the full impact of rising petroleum prices. While subsidies may provide temporary relief, they also place a heavy burden on the national budget and may not address the basic factors driving price volatility (Jayne & Rashid, 2013). Furthermore, the Nigerian government's periodic adjustments to fuel prices often lead to public dissatisfaction and uncertainty, eroding consumer confidence and complicating long-term economic planning. Hence, the current administration in Nigeria announced the total removal of petroleum subsidies on May 29, 2023, citing a paucity of funds and the need of diversify the economy as the bases.

Despite these contributions, the literature remains fragmented. Most studies investigate oil prices, exchange rates, or subsidies separately, focusing on outcomes such as trade balance (Areghan et al., 2022), fiscal costs (Aruofor & Ogbeide, 2023; Okwanya et al., 2015; Orlu, 2018), and inflation (Adams et al., 2024; Maku et al., 2018; Sakanko et al., 2021). Some concentrate on fluctuations in exchange rates without explicitly linking them with welfare outcomes (Aimer & Lusta, 2021). However, little empirical attention has been given to the combined and asymmetric effects of exchange rate fluctuations and petroleum pump price changes on economic welfare in an oil-reliant country such as Nigeria. Moreover, the distinction between short-run and long-run effects is commonly neglected. This paper fills existing gaps by applying the NARDL model to analyse the asymmetric effects of exchange rate variation and petroleum pump price on economic

welfare in Nigeria between 1970 and 2023. This method generates new perspectives on the interaction of essential macroeconomic factors that influence welfare outcomes and provides empirical direction for policy reforms.

The Mundell-Fleming model extends the IS-LM framework to open economies, illustrating how exchange rates, interest rates and output interact under different exchange rate regimes (Bofinger et al., 2009). It suggests that under a fixed exchange rate, fiscal policy is more effective while monetary policy is constrained (Serrano & Summa, 2015). Conversely, under a flexible exchange rate, monetary policy dominates, influencing capital flows, interest rates, and trade balances (Darius, 2010). Nigeria's alternating exchange rate regimes affect imports, inflation, and economic growth, predominantly by influencing petroleum prices and overall welfare. Similarly, the purchasing power parity theory posits that exchange rates should adjust to equalise the price levels of goods across countries (Nakorji et al., 2021). However, Nigerian exchange rate misalignments and market imperfections create price disparities in petroleum products, affecting the cost of living and welfare.

Also, the exchange rate pass-through theory investigates the extent to which exchange rate changes influence domestic prices (Aron et al., 2014; Zubair et al., 2013). High pass-through rates indicate that exchange rate fluctuations significantly affect inflation, whereas low pass-through rates suggest a moderate impact. In Nigeria, a high pass-through rate, due to import reliance and petroleum price sensitivity, contributes to economic instability. In addition, welfare economics provides a framework for assessing the impact of monetary policies on individual well-being (Engelbrecht, 2009). Fluctuations in exchange rates and petroleum prices affect real income, consumption patterns, and inequality. Changes in petroleum pump prices alter transportation costs and household expenditures, influencing welfare. Meanwhile, the resource curse theory suggests that countries rich in natural resources, such as oil, may experience slower economic growth due to challenges including rent-seeking behaviour, corruption, and financial volatility (Henri, 2019; Mlambo, 2022). Nigeria exemplifies the resource curse as its dependence on oil has led to economic instability, exchange rate volatility and obstacles to sustainable development.

Areghan et al. (2022) show that exchange rate stability is critical for maximising the contributions of the oil sector to the balance of payments. Also, Abere (2023) reaches the same conclusion that naira undervaluation enhances balance of trade while overvaluation worsens performance, and shows that foreign trade is vulnerable to fluctuations in the exchange rate. Adagunodo (2013) maintains that whereas the removal of PMS subsidies could yield significant fiscal savings, the welfare justification of kerosene subsidies is far-fetched. Using an error-correction model, Okwanya et al. (2015) and Orlu (2018) show that PMS price increases had decreased growth and created short-term inflationary pressures. Aruofor & Ogbeide (2023) cautiously note that the removal of subsidies might reduce production, suppress demand, and worsen the risk of inflation. Similarly, Amaechi (2024) notes that the withdrawal of fuel subsidies has an adverse though insignificant effect on the standard of living in Nigeria. These studies portray trade-offs between fiscal sustainability and welfare protection.

However, Sakanko et al. (2021) demonstrate that a petroleum price shock creates lasting inflationary pressure, while Maku et al. (2018) show that increases in pump prices and inflation have a net detrimental effect on welfare by disrupting the economy. Adams et al. (2024) state that an increase in the price of petrol significantly increases the consumer price index in the short run, but the effect decreases over time. Similarly, Orekoya et al. (2024) expand on this evidence by showing asymmetric impacts of domestic prices of oil price shocks on domestic prices. In the short term, positive shocks have a greater effect than their negative counterparts, but in the long term, adverse shocks have a greater impact. These suggest that a long-term price stabilisation could be achieved by removing subsidies and investing in refining capacity.

Olayungbo (2019) argues that oil revenue has significantly contributed to economic growth, while also creating structural inadequacies, such as poor human capital and restrictive trade policies. Okon et al. (2020) also report a positive effect of oil revenue on GDP, but caution against overdependence on oil and suggest the diversification of the economy with agriculture. Adams & Olamide Bello (2022) emphasise the importance of downstream production and private sector

involvement in sustaining growth. Ojumu & Osho (2023) shift the focus to declining U.S. demand for Nigerian oil and its economic implications, particularly in terms of trade surpluses and the depletion of foreign reserves, thereby exposing Nigeria's vulnerability to global oil market fluctuations. Also, Somoye et al. (2024) indicate that the use of fossil fuels and renewable energy sources helps increase life expectancy in both the short and long term. As Wasurum (2025) shows, oscillations in oil prices and exchange rates support economic growth in Nigeria, but with uneven impacts through the channels of life expectancy and literacy.

Aimer & Lusta (2021) demonstrates that oil price shocks have a more pronounced impact on the exchange rate than U.S. economic policy uncertainties, leading to adverse currency effects. Ojeyinka & Aliemhe (2023) demonstrate that demand-driven oil price shocks positively affect aggregate and sectoral stock returns, whereas supply shocks are significant only for the oil and gas sector. El Yadmani (2025) concludes that fluctuations in oil prices negatively impact Morocco due to its high dependence on imported fossil fuels, therefore, compromising its long-term growth and household welfare.

Methods

Model Specification

To determine the effects of exchange rate fluctuations and petroleum pump price on economic welfare, this study adapts the models by Ighosewe et al. (2021) and Areghan et al. (2022). Thus,

$$ECOW_t = f(EXR_t, PPP_t) \quad (1)$$

where$ECOW_t$, EXR_t and PPP_trepresent the economic welfare index, the exchange rate and the petroleum pump price, respectively, at time t. While EXR and PPP are exogenous variables, the model also includes some control variables.

$$ECOW_t = f(EXR_t, PPP_t, INFR_t, UEMPR_t, SUB_t, COIP_t) \quad (2)$$

where $INFR_t$, $UEMPR_t$, SUB_t and $COILP_t$ represent the inflation rate, unemployment rate, government expenditure on subsidies and crude oil price, respectively, at time t. The model is explicitly expressed as:

$$ECOW_t = \alpha_0 + \alpha_1 EXR_t + \alpha_2 PPP_t + \alpha_3 INFR_t + \alpha_4 UEMPR_t + \alpha_5 SUB_t + \alpha_6 COILP_t + \mu_t \quad (3)$$

where all variables are as earlier stated, μ_t is the stochastic term and $\alpha_i (i = 0,1,2,3,\ldots,6)$ are the estimated parameters. The data measurement and sources are presented in Table 1.

Table 1. Data Measurement and Sources

Variable	Measurement	Source
Economic welfare (ECOW)	Composite index based on poverty headcount, Gini coefficient, and real per capita income (through PCA)	WDI; Naveed & Gordon (2024); Smiech et al. (2025)
Exchange rate (EXR)	Nominal annual average exchange rate of the naira against the US dollar	CBN
Petroleum pump price (PPP)	Annual mean retail pump price of petrol (litre)	NNPC
Inflation rate (INFR)	Annual percentage change in consumer price index	CBN
Unemployment rate (UNEMPR)	Proportion of the labour force without jobs and in pursuit of employment opportunities	CBN
Government expenditure on subsidies (SUB)	Annual government spending on petroleum subsidies	CBN
International oil prices (COILP)	Annual average Brent crude oil price (USD/barrel)	OPEC

PCA: Principal Component Analysis, CBN: National Bureau of Statistics, Nigerian National Petroleum Corporation (NNPC), OPEC: Organisation of Petroleum Exporting Countries, WDI: World Development Indicators

Estimation Technique

To determine the asymmetric effects of exchange rate fluctuations and petroleum pump prices on economic well-being, this study employs the Nonlinear Autoregressive Distributed Lag (NARDL) technique developed by Shin et al. (2014). This paradigm decomposes the explanatory variables into positive and negative changes, thereby quantifying possible asymmetry in both long- and short-term dynamics.

Decomposition of Shocks

Following Shin et al. (2014), the exchange rate (EXR) and petroleum pump price (PPP) are decomposed into cumulative sums of positive and negative changes.

$$EXR_t^+ = \sum_{j=1}^{t} \Delta EXR_j^+ = \sum_{j=1}^{t} max(\Delta EXR_j, 0) \quad (4)$$

$$EXR_t^- = \sum_{j=1}^{t} \Delta EXR_j^- = \sum_{j=1}^{t} min(\Delta EXR_j, 0) \quad (5)$$

$$PPP_t^+ = \sum_{j=1}^{t} \Delta PPP_j^+ = \sum_{j=1}^{t} max(\Delta PPP_j, 0) \quad (6)$$

$$PPP_t^- = \sum_{j=1}^{t} \Delta PPP_j^- = \sum_{j=1}^{t} max(\Delta PPP_j, 0) \quad (7)$$

Here, EXR_t^+ and PPP_t^+ are cumulative increases while EXR_t^- and PPP_t^- are cumulative decreases. The asymmetric effects are tested through these decompositions (Baharumshah et al., 2017; Widarjono et al., 2023).

Pre-estimation Tests

ADF and PP unit root tests are conducted to determine the order of integration of variables. NARDL accommodates $I(0)$ and $I(1)$ variables but excludes $I(2)$ to ensure the validity of its bounds test (Pesaran et al., 2001). The Akaike Information Criterion determines the optimal lag length (AIC) for efficiency (Baharumshah et al., 2017).

Cointegration and Diagnostic Tests

The existence of a long-run relationship is tested using the bounds test developed by Pesaran et al. (2001). The null hypothesis of no cointegration is rejected, implying a long-run relationship. Diagnostic tests – Breusch-Godfrey (serial correlation), Breusch-Pagan-Godfrey (heteroskedasticity), Jarque-Bera (normality) and Ramsey-RESET (functional form) – are conducted to validate model adequacy.

Asymmetry tests

The Wald test is utilised to verify whether positive and negative changes exert symmetric or asymmetric effects. For instance, $\alpha_1 = \alpha_2$ measures whether exchange rate appreciation and depreciation have equal impacts while $\alpha_3 = \alpha_4$ testing the symmetry of petroleum pump price changes.

Error Correction Representation

After establishing cointegration, the NARDL model is expressed in error correction form:

$$\Delta ECOW_t = \phi ECT_{t-1} + \sum_{i=1}^{p} \beta_i \Delta ECOW_{t-1} + \sum_{j=0}^{q_1} \left(\tau_j^+ \Delta EXR_{t-j}^+ + \tau_j^- \Delta EXR_{t-j}^-\right) + \sum_{j=0}^{q_2} \left(\delta_j^+ \Delta PPP_{t-j}^+ + \delta_j^- \Delta PPP_{t-j}^-\right) + \sum_{k=0}^{q_3} \lambda_k \Delta OV_{t-k} + \mu_t \quad (8)$$

where ECT_{t-1} is the error correction term, and its coefficient ϕ must be negative and significant to confirm convergence to the long-run equilibrium. The index k denotes the lag order of the control variables (OV).

Long-run Model

The NARDL long-term asymmetric relationship is derived as:

$$ECOW_t = \theta_0 + \theta_1^+ EXR_t^+ + \theta_1^- EXR_t^- + \theta_2^+ PPP_t^+ + \theta_2^- PPP_t^- + \sum_{s=1}^{S} \lambda_s OV_{s,t} + \quad (9)$$

where θ_1^+ and θ_1^- capture the long-run effects of exchange rate appreciation and depreciation, θ_2^+ and θ_2^- capture the long-run effects of petroleum pump price increases and decreases, $OV_{s,t}$ denotes the control variables at time t, λ_s represents long-run coefficients of control variables, and S is the total number of control variables.

Results and Discussion

Unit Root Tests

Since most time series data are non-stationary at the level, the literature suggests that stationarity tests should be conducted. Hence, the variables in the estimated model are tested for the presence or absence of a unit root. As shown in Table 2, both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests indicate that government expenditure on subsidies (SUB) is stationary at level $I(0)$, while the other variables become stationary after first differencing $I(1)$. Meanwhile, the $NARDL$ technique is suitable for handling a model comprising a mixture of $I(0)I(1)$ variables (Pesaran et al., 2001).

Table 2. Unit Root Test

Variable	ADF Level	ADF First Difference	PP Level	PP First Difference	Remark
ECOW	-1.627	-7.694***	-1.671	-7.694***	I(1)
EXR	0.336	-5.497***	0.935	-5.274***	I(1)
PPP	-2.169	-6.390***	-2.342	-6.384***	I(1)
INF	-3.757**	-	-2.976	-5.694***	I(1)
UNEMPR	-6.290***	-2.076	-2.076	-7.767***	I(1)
SUB	-4.878***	-	-5.208***	—	I(0)
COILP	-2.563	-6.536***	-2.709	-6.593***	I(1)

*** and ** indicate 1% dan 5% levels of significance, respectively

Optimum Lag Selection

The VAR lag-order selection criteria in Table 3 indicate that the Akaike Information Criterion (AIC), Hannan-Quinn Criterion (HQ), Final Prediction Error (FPE), and Sequential Likelihood Ratio (LR)all indicate four delays. At the same time, the Schwarz Criterion (SC) suggests only one lag. This study uses four lags, as indicated by most criteria, especially AIC. Furthermore, the model selection summary $(4,4,4,4,4,3,4,4,4)$ of Figure 1 shows that most variables enter the model with four lags, except subsidy, which has three lags. This structure captures both current and past effects, allowing us $NARDL$to model dynamic and asymmetric responses of economic welfare $(ECOW)$ to changes in the explanatory variables.

Table 3. Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1272.134	NA	3.92e+13	51.165	51.433	51.267
1	-926.827	580.115	2.85e+08	39.313	41.455*	40.129
2	-861.108	92.007	1.64e+08	38.644	42.660	40.173
3	-750.897	123.436	1.94e+07	36.195	42.085	38.438
4	-655.612	80.039*	6.16e+06*	34.344*	42.107	37.301*

* Indicate lag order selected by criterion

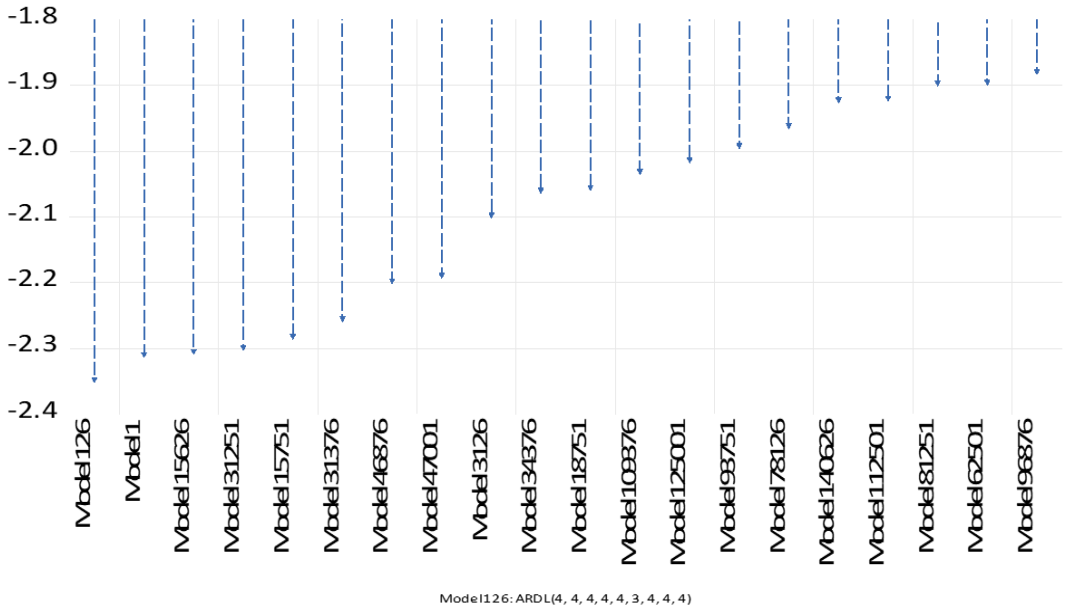


Figure 1. Akaike Information Criterio (top 20 models)

Diagnostic Tests

This study employs several diagnostic tests to guarantee the reliability of its findings (Table 4). The multiple coefficient of determination $(R-squared)$and the adjusted multiple coefficient of determination$(Adjusted\ R-squared)$ help assess the fitness of the estimated $NARDL$model, as $Adjusted\ R-squared$shown by the fact that about 98% of the overall variation in economic welfare is jointly captured by the exogenous variables. The non-significance of $Jarque-Bera$ statistic implies that the variables are normally distributed. Also, the insignificance of $F-statisticSerial\ Correlation$ the test suggests the absence of autocorrelation, indicating that the residuals of the estimated model are uncorrelated. Similarly, the non-significance of $F-statistic$ in the $Heteroskedasticity$ test indicates that the residuals are homoscedastic, implying that they do not differ across all values of the exogenous variables.

Table 4. Diagnostic Test

Test	Statistic	(p-value)
R-squared	0.995	-
Adjusted R-squared	0.984	-
Jarque-Bera	1.051	(0.591)
Breusch-Godfrey Serial Correlation	7.751	(0.065)
Breusch-Pagan-Godfrey Heteroskedasticity	0.604	(0.833)

Cointegration Test

The $F-bounds$statistic $(F=12.277)$ is substantially above the upper threshold $1\%(3.77)$ (Table 5). Since the computed$F-statistic$ exceeds all critical values $I(0)$ and $I(1)$, the null hypothesis of no level relationship is strongly rejected. This confirms the existence of a co-integrating relationship over time.

Table 5. NARDL F-Bounds Test

Test Statistic	Value	Sig.	I(0)	I(1)
F-statistic	12.277	10%	1.85	2.85
k	8	5%	2.11	3.15
		2.5%	2.33	3.42
		1%	2.62	3.77

Asymmetric Tests

This study investigates the asymmetric effects of the exchange rate and the petroleum pump price on economic welfare using the NARDL model. The $Wald\ test$ results in Table 6 provide significant evidence of asymmetry in both the short- and long-run. The null hypotheses of symmetry are consistently rejected, indicating that positive and negative shocks do not exert equal effects on economic welfare. In the short run, the $Wald\ test$ results show the existence of statistically significant asymmetry in the effects of exchange rate shocks $(t = -3.61, \rho < 0.05; F = 13.02, \rho < 0.05; \chi^2 = 13.02, \rho < 0.01)$. The restriction estimate of $-0.378\ (SE = 0.105)$ shows that the cumulative effect of depreciations exceeds that of appreciations in magnitude. In the long run, asymmetry persists, as the $Wald\ test$data consistently reject the null hypothesis of symmetry $(t = -4.22, \rho < 0.01; F = 17.82, \rho < 0.01; \chi^2 = 17.82, \rho < 0.01)$. The restriction estimate of $-0.318\ (SE = 0.075)$ suggests that the negative effects of depreciations on welfare are noticeably higher than the potential benefits of appreciation. This outcome aligns with the findings by Areghan et al. (2022), which emphasises the importance of currency stability for sustaining external balance and welfare.

Table 6. Asymmetric Test (Wald Test)

NARDL Shortrun Asymmetry			
Asymmetric Variable		EXR	PPP
Test Statistic	df	Value (Probability)	Value (Probability)
t-statistic	5	-3.608 (0.015)	-5.350 (0.003)
F-statistic	(1,5)	13.015 (0.015)	28.618 (0.003)
Chi-square	1	13.015 (0.000)	28.618 (0.000)
Normalised Restriction [Std.Error]			
NARDL Longrun Asymmetry			
Asymmetric Variable		EXR	PPP
Test Statistic	df	Value (Probability)	Value (Probability)
t-statistic	5	-4.222 (0.008)	-6.048 (0.002)
F-statistic	(1,5)	17,824 (0.008)	36.576 (0.002)
Chi-square	1	17,824 (0.000)	36.576 (0.000)
Normalised Restriction [Std.Error]		-0.318 (0.075)	-0.585(0.097)

***, **, and * indicate 1%, 5%, and 10% levels of significance respectively

Similarly, the results show considerable evidence of asymmetry in the short-run effects of changes in petroleum pump prices. The $Wald\ test$ data substantially support the rejection of the null hypothesis of symmetry $(t = -5.35, \rho < 0.01; F = 28.62, \rho < 0.01; \chi^2 = 28.62, \rho < 0.01)$. The restriction estimate of $-0.850\ (SE = 0.159)$ indicates that price increases have a more substantial negative influence than the positive effect of price decreases. This is consistent with empirical evidence that pump price increases have immediate inflationary and welfare-reducing effects while price reductions provide only transient relief (Aruofor & Ogbeide, 2023; Orlu, 2018). The null hypothesis of symmetry is unequivocally rejected in the long run $(t = -6.05, \rho < 0.01; F = 36.58, \rho < 0.01; \chi^2 = 36.58, \rho < 0.01)$. The restriction estimate of $-0.585\ (SE = 0.097)$ confirms that pump price increases exhibit greater persistent and detrimental impacts on economic welfare than decreases. These finding complements Sakanko et al. (2021) and Maku et al. (2018), who emphasise that pump price shocks induce lasting inflationary pressures, while subsidy-driven price reductions offer only limited and uneven welfare benefits.

The findings are consistent in suggesting that both exchange rate and petroleum pump price shocks are asymmetric in both the short-run and long-run. The negative restriction estimates across all specifications indicate that the net adverse impacts of negative shocks – exchange rate depreciation and fuel price increases – are much larger and more persistent than the potential benefits of appreciations or price reductions. Thus, exchange rate depreciation worsens welfare more persistently than the modest benefits from appreciation. At the same time, petroleum price

hikes impose immediate welfare losses that outweigh the temporary relief provided by price cuts. These results underscore the need to stabilise the exchange rate in response to ongoing depreciation pressures and to design fuel price reforms alongside compensatory social protection programs. By acknowledging asymmetry, policymakers can better anticipate the disproportionate costs of adverse shocks and avoid the erroneous assumption of symmetric adjustment in macroeconomic management.

Short-run Dynamics

The short-run result in Table 7 shows strong asymmetric effects of exchange rate fluctuations on economic welfare. Positive shocks to the exchange rate (naira depreciation) consistently diminish welfare, while adverse shocks (appreciation) yield mixed results: initially beneficial but, with lags, thereafter detrimental. This result corroborates the findings of studies by Areghan et al. (2022) and Abere (2023), which emphasises the importance of exchange rate stability and undervaluation for trade performance. The results show that prolonged depreciation decreases welfare by increasing import costs and reducing purchasing power, whereas appreciation may only provide temporary relief before adjustment costs materialise.

Table 7. NARDL Error Cointegration Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(ECOW(-1))	0.114*	0.055	2.074	0.093
D(ECOW(-2))	0.193**	0.067	2.903	0.034
D(ECOW(-3))	-0.307***	0.052	-5.873	0.002
D(EXR_POS)	-0.003	0.001	1.942	0.199
D(EXR_POS(-1))	-0.048***	0.003	-14.525	0.000
D(EXR_POS(-2))	-0.067***	0.004	-16.419	0.000
D(EXR_POS(-3))	-0.029***	0.003	-11.019	0.000
D(EXR_NEG)	0.316**	0.031	10.338	0.000
D(EXR_NEG(-1))	-0.008	0.026	-0.314	0.766
D(EXR_NEG(-2))	-0.158***	0.030	-5.272	0.003
D(EXR_NEG(-3))	-0.164**	0.043	-3.772	0.013
D(PPP_POS)	0.0003	0.001	0.303	0.774
D(PPP_POS(-1))	-0.185***	0.008	-22.075	0.000
D(PPP_POS(-2))	-0.130***	0.009	-14.287	0.000
D(PPP_POS(-3))	-0.066***	0.005	-14.519	0.000
D(PPP_NEG)	0.585***	0.026	22.311	0.000
D(PPP_NEG(-1))	-0.313***	0.017	-18.249	0.000
D(PPP_NEG(-2))	-0.598***	0.031	-19.351	0.000
D(PPP_NEG(-3))	-0.566***	0.038	-14.825	0.000
D(INFR)	-0.003*	0.001	-2.482	0.056
D(INFR(-1))	0.013***	0.001	9.030	0.000
D(INFR(-2))	0.013***	0.001	10.999	0.000
D(UNEMPR)	-0.347***	0.015	-22.503	0.000
D(UNEMPR(-1))	0.123***	0.014	9.004	0.000
D(UNEMPR(-2))	0.358***	0.020	17.700	0.000
D(UNEMPR(-3))	0.195***	0.010	18.616	0.000
D(LNSUB)	1.204***	0.098	12.244	0.000
D(LNSUB(-1))	1.255***	0.075	16.780	0.000
D(LNSUB(-2))	1.448***	0.101	14.294	0.000
D(LNSUB(-3))	0.736***	0.099	7.474	0.001
D(COILP)	-0.020***	0.003	-6.773	0.001
D(COILP(-1))	0.003	0.003	0.965	0.379
D(COILP(-2))	-0.020***	0.003	-7.940	0.001
D(COILP(-3))	-0.019***	0.002	-7.858	0.001
CointEq(-1)*	-1.313***	0.071	-18.541	0.000

***, **, and * indicate 1%, 5%, and 10% levels of significance respectively

Similarly, petroleum pump price adjustments exert significant asymmetric short-run effects. Increases in pump prices reduce welfare through adverse, persistent lagged effects, while decreases yield immediate welfare gains that quickly revert. This reinforces findings of Okwanya et al. (2015) who assert that increases in petroleum prices reduce growth and trigger inflationary pressures, alongside Aruofor & Ogbeide (2023) who note that the withdrawal of subsidies may reduce consumption and further worsen welfare outcomes. The mixed results on adverse price shocks resonate with Amaechi (2024), who found that subsidy removal has an insignificant effect on living standards, highlighting the transitory nature of welfare gains from fuel price reductions.

Inflation and unemployment are also projected to have noticeable impacts. Inflation reduces welfare contemporaneously, but its lagged positive effects reflect delayed nominal adjustments, confirming the results of Adams et al. (2024) and Sakanko et al. (2021), which indicates that petroleum-induced price shocks initially worsen consumer welfare before gradually subsiding. Unemployment exerts negative immediate effects but becomes positive with lags, reflecting structural labour-market adjustments in which informal employment offsets shocks. This corresponds with Maku et al. (2018), who found that inflation and employment-related mechanisms interact with petroleum prices to disrupt short-term welfare. Government expenditure on subsidies demonstrates a robust, consistent positive impact, affirming its protective function in sustaining household wellbeing. This concurs with Aruofor & Ogbeide (2023), who draw attention to the issue of welfare trade-offs connected with subsidy reform. Conversely, an increase in crude oil prices diminishes welfare both immediately and over time, aligning with the findings of Ojumu & Osho (2023) and El Yadmani (2025) that global oil dynamics affect family welfare. The error-correction term is substantial, negative, and significant, indicating rapid adjustment towards the long-run equilibrium. This supports Wasurum's (2025) claim that oil price fluctuations and exchange rates affect welfare in Nigeria through long-run channels.

Long-run Result

The long-run results in Table 8 show that both the exchange rate and the petroleum pump price have a significant asymmetric impact on economic welfare. The effect of positive exchange rate shocks (EXR_POS), denoting depreciation, is positive in the long run; however, the impact of adverse shocks (EXR_NEG), signifying appreciation, is even stronger. This finding reinforces trade-oriented literature such as Areghan et al. (2022) and Abere (2023), which emphasises the importance of exchange rate fluctuations in achieving external equilibrium. Although depreciation may increase the competitiveness of the tradeable sector and indirectly boost welfare, the greater welfare gains from appreciation suggest that stability and reduced import costs yield longer-lasting effects, consistent with the sensitivity of welfare to currency valuation.

Table 8. NARDL Long-run Estimate

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXR_POS	0.057**	0.018	3.110	0.026
EXR_NEG	0.345**	0.097	3.538	0.017
PPP_POS	0.097***	0.023	4.216	0.008
PPP_NEG	0.744***	0.182	4.083	0.010
INFR	-0.017***	0.003	5.772	0.002
UNEMPR	-0.409**	0.111	-3.691	0.014
LNSUB	1.020***	0.137	7.434	0.001
COILP	-0.026***	0.008	-3.439	0.019
c	-2.358***	0.192	-12.307	0.000

***, **, and * indicate 1%, 5%, and 10% levels of significance respectively

The effects of petroleum pump prices are asymmetrical. Positive shocks (PPP_POS), corresponding to price increases, contribute significantly to better welfare in the long term, while negative shocks (PPP_NEG), denoting price declines, have a greater beneficial effect. This result aligns with Orlu (2018) and Okwanya et al. (2015), who also found that price increases cause short-

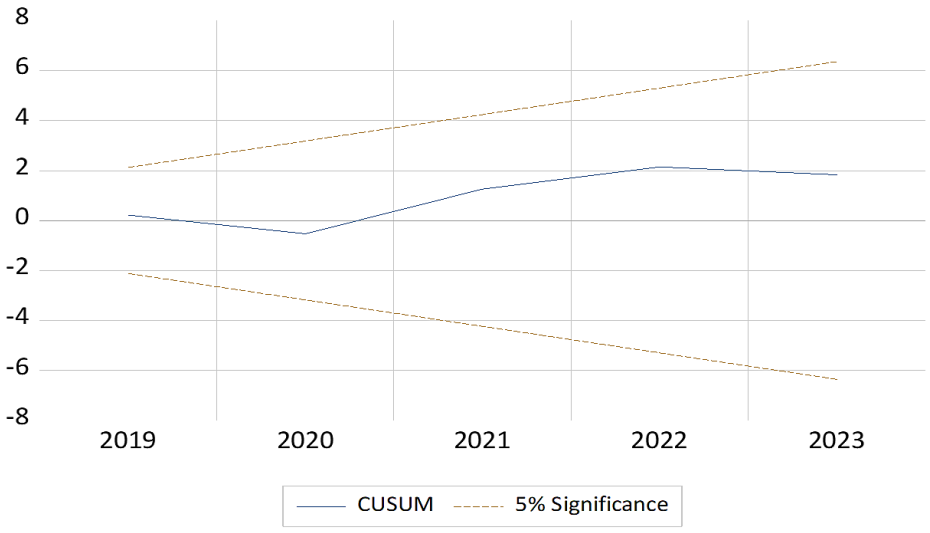
term distortions. However, it differs from the results of Aruofor & Ogbeide (2023) and Amaechi (2024), who emphasise the adverse welfare effects of subsidy removal. The finding implies that, in the long term, higher pump prices may enhance fiscal capacity and reallocate investment, while price reductions may temporarily alleviate household expenditure burdens. These suggest that welfare responses to petroleum prices are complex and context-dependent.

Controlling variables that significantly reduce welfare include inflation and unemployment, consistent with the results of Sakanko et al. (2021), who focuses on the inflationary transmission of petroleum price shocks, and Maku et al. (2018), who shows that both inflation and unemployment adversely affect welfare. Conversely, government subsidies demonstrate significant benefits, emphasising their stabilising role, as noted by Aruofor & Ogbeide (2023). Crude oil prices adversely affect welfare.

Unlike the short-run results, these long-run results show more stable and positive welfare responses to exchange rate and petroleum price changes. Both depreciation and appreciation positively influence welfare in the long run, with the latter being more significant. Similarly, while initial increases in petroleum prices negatively impact welfare, they are associated with improved long-run performance, possibly because increased fiscal capacity enables more public investment. However, price declines always have a larger impact on welfare. The findings show that the sustainability of long-term welfare depends on effective policy management, particularly in subsidy removal and exchange rate adjustment. These policies may impose short-run costs but can be more sustainable in the long run if accompanied by compensatory measures such as targeted transfers or productive investments. The distinction between short-term and long-term outcomes pinpoints the trade-off between immediate welfare protection and long-term economic adjustment.

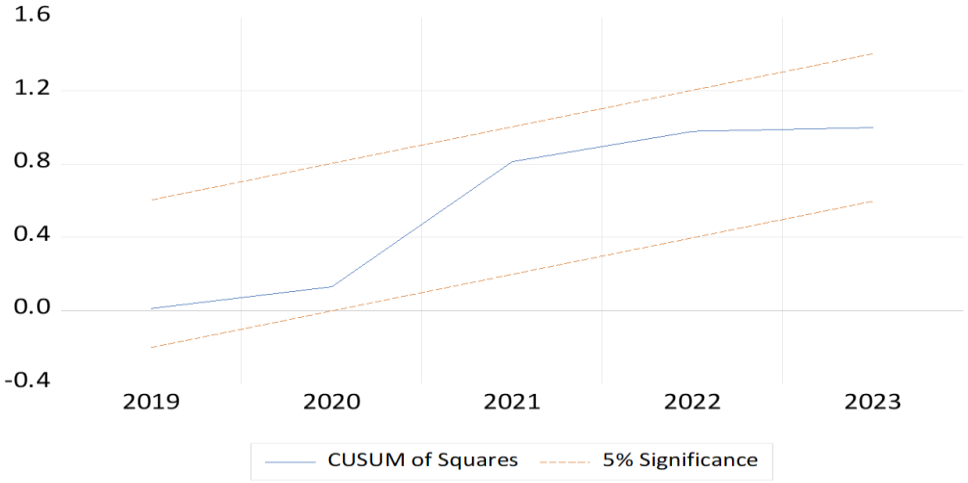
Stability Tests

To ascertain the stability, or otherwise, of the long-run coefficients of the $NARDL$ model, this study performs the cumulative sum $(CUSUM)$ and the cumulative sum of squares $(CUSUMSQ)$ tests. As shown in Figures 2 and 3, the $CUSUM$ and the $CUSUMSQ$ graphs indicate that the long-run coefficients are stable, as their plots remain within the 5% critical bounds. Thus, the graphs buttress the long-run impacts of the exogenous variables on economic welfare in Nigeria. Also, the study utilises the nonlinear dynamic multiplier to verify whether the exchange rate and petroleum pump price have a symmetric (when the broken red line is close to zero) or asymmetric (when the broken red line deviates from or is far from zero) relationship with economic welfare. The dynamic multiplier graphs in Figures 4 and 5 reveal the existence of an asymmetric relationship between the exchange rate and the petroleum pump price with economic welfare in Nigeria.



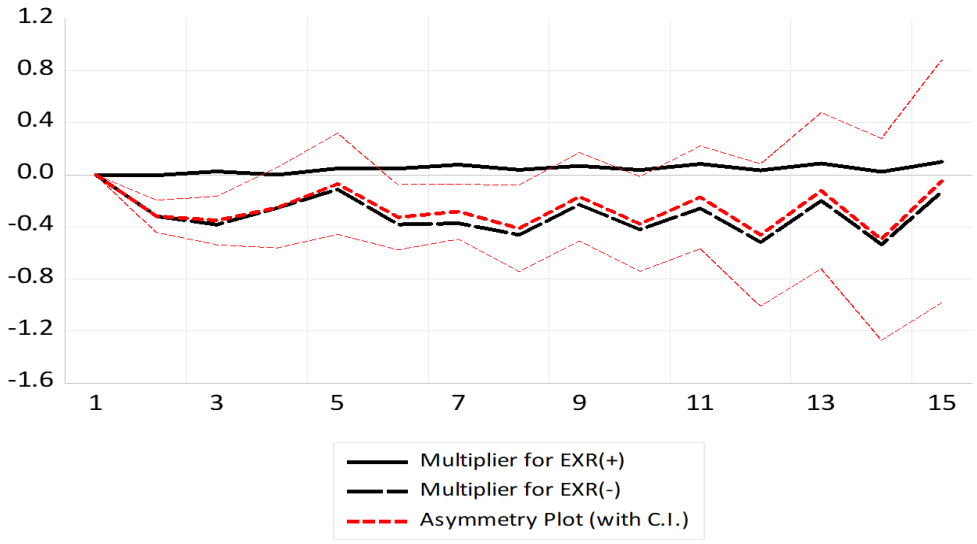
Source: Author's analysis

Figure 2. Cumulative Sum (CUSUM)



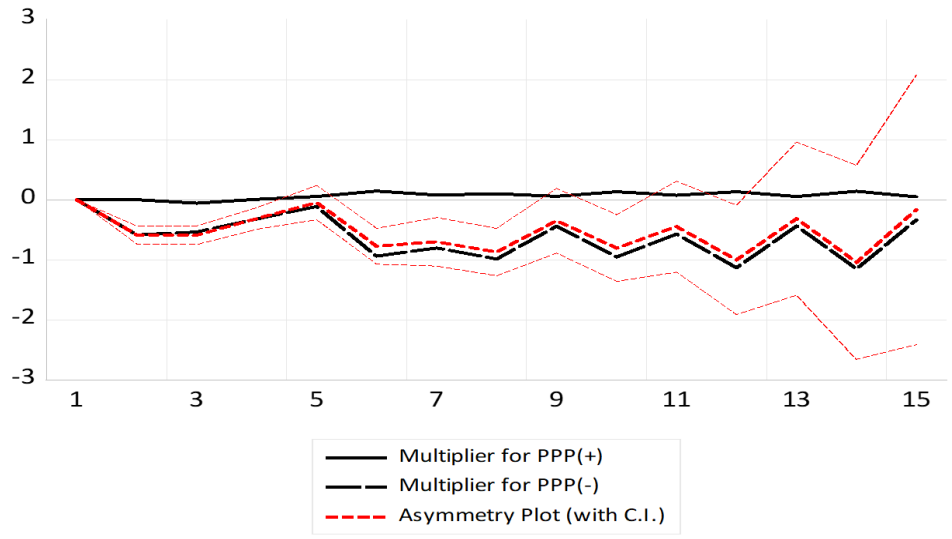
Source: Author's analysis

Figure 3. Cumulative Sum of Square (CUSUMSQ)



Source: Author's analysis

Figure 4. Dynamic Multiplier Graph of Exchange Rate



Source: Author's analysis

Figure 5. Dynamic Multiplier Graph of Petroleum Pump Price

Conclusion

This study examines the asymmetric effects of exchange rate fluctuations and petroleum pump price on economic welfare in Nigeria using the $NARDL$ approach. The results confirm the existence of both short-run and long-run asymmetries: exchange-rate depreciations and increases in the petroleum pump price led to more substantial and more persistent welfare losses than moderate and temporary welfare gains associated with appreciations and price reductions. As implied by the short-run dynamics, there is an immediate loss of welfare due to the impact of inflationary pass-through and the loss of household purchasing power. At the same time, the long-run analysis indicates that structural reforms and fiscal reallocation can offset the shocks to enhance welfare benefits. The findings also demonstrate a critical trade-off: short-term protection requires cushioning households from inflationary and petroleum price pressures. At the same time, long-term welfare depends on sound macroeconomic management, such as fiscal discipline and structural transformation. Sequel to the removal of the petroleum subsidy in Nigeria since May 2023, the findings reinforce the need for targeted social protection and inclusive measures to alleviate the social costs of reforms, while channelling fiscal savings into productive sectors to enhance long-term development.

Based on the findings of this study, the following recommendations are made to improve economic welfare in Nigeria. There is a need to maintain a unified macroeconomic policy to protect welfare in Nigeria. Exchange rate stability should be prioritised as persistent depreciation increases inflation and disproportionately affects consumers. In the aftermath of the removal of the petroleum subsidy in May 2023, compensatory measures such as targeted transfers, subsidised transport, and the availability of alternative energy sources are essential to safeguard vulnerable groups and sustain popular support for reform. Strengthening the social protection system is equally vital, as it will ensure that aid is well-targeted and responsive to exchange rate shocks and fuel price pressures. Similarly, macroeconomic policy should also address inflation and unemployment by investing in infrastructure, agriculture and small-scale enterprises to increase employment opportunities and support the purchasing power. Nigeria needs to reduce its reliance on oil revenues by diversifying the economy and allocating the fiscal savings from subsidy removal towards education, healthcare and infrastructure. Such proactive investments will transform short-term fiscal adjustments into sustainable welfare improvements.

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Use of AI tools declaration

The authors used AI tools (ChatGPT and DeepSeek) for language editing and grammar review of this manuscript. The authors are fully responsible for the content of this publication.

Conflict of interest

The authors declare no conflicts of interest.

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