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The combined effects of retail energy prices, and exchange rates on inflation in Nigeria States

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ABSTRACT

This paper explores the nonlinear dynamics relationship between petroleum product prices and inflation in Nigeria. By focusing on the role of exchange rate fluctuations in amplifying the relationships, the paper employs a multiplicative interaction approach to address the nonlinear effects of petroleum prices on inflation. Utilizing data from 2016: Q1 to 2024: Q2 from the National Bureau of Statistics and the Central Bank of Nigeria, the study introduces interaction terms to capture how petroleum prices and exchange rates interact to influence inflation. The methodology includes static and dynamic panel estimators, with a focus on the within effect model to account for unobserved state-specific factors. Key findings reveal that AGO and PMS prices significantly drive both headline and food inflation, while DPK's impact varies, and GAS shows minimal effect. The study highlights those geographical factors—proximity to seaports and fuel depots—significantly influence inflationary pressures. States closer to these facilities experience lower inflation due to reduced distribution costs. This suggests that policies aimed at partial subsidization for states farther from key infrastructure could mitigate regional inflation disparities. The findings contribute to the understanding of inflation dynamics, emphasizing the need for targeted policy interventions tailored to regional economic conditions in Nigeria.

Introduction

The link between petroleum product prices and inflation is known to be nonlinear, particularly in economies like Nigeria, where external factors such as exchange rate volatility play a significant role in shaping inflationary trends. Previous research, including studies by Olasunkanmi & Oladele (2018), Tuaneh & Wiri (2019), Usman, Iorember & Uzner (2020), and Özmen & Özşahin (2023), has acknowledged this nonlinearity. Economic theory supports this observation, suggesting that shifts in energy prices influence inflation differently depending on external conditions, such as changes in the exchange rate. Seminal studies by Kilian and Park (2009) and Hamilton (1983) emphasized that the inflationary impact of energy prices is amplified when exchange rates fluctuate.

In Nigeria, this relationship is particularly complex due to the country's heavy reliance on imported petroleum products. This dependency has been exacerbated since the full removal of subsidies, which triggered significant increases in inflation and a steep depreciation of the domestic currency. By the end of the second quarter of 2024, headline inflation jumped from 22.41% in May 2023 (the final month of the subsidy regime) to 33.40%, a 49.04% increase. Food inflation rose from 24.82% to 39.53%, a 59.27% increase, while energy inflation surged from 18.72% to 36.91%, an alarming 97.18% rise, according to the National Bureau of Statistics (July 2024). During this period, the Naira devalued by over 217.99% against the US dollar. These statistics illustrate the profound economic and social disruption following subsidy removal, underscoring Nigeria's vulnerability to global oil price changes and exchange rate volatility. As a result, the country's reliance on imported refined petroleum products exposes it to cost-push inflation, where rising fuel prices drive up transportation, production costs, and general consumer prices.

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This study explores the nonlinear impact of petroleum product prices on inflation, diverging from earlier research that predominantly focused on the overall influence of crude oil. Prior studies by Sek et al. (2015), Salisu, Isah, Oyewole, & Akanni (2017), Babuga & Ahmad (2021), and Ikue et al. (2024) centered on crude oil's broader effect on inflation but often overlooked the direct impacts of refined products like AGO and PMS, which are crucial in the Nigerian context. These products have an immediate influence on inflation, as they are essential for transportation and the production of goods.

Sodipo et al. (2024) made progress in identifying the impact of petroleum product prices on inflation but did not consider factors specific to Nigerian states, such as proximity to petroleum depots and seaports, which can cause inflationary pressures to vary significantly by region. For example, transportation costs for energy products differ widely based on geographic location. Additionally, Sodipo's study did not fully account for the role of exchange rates as external shocks, which can heighten inflation when the Naira depreciates. In a country like Nigeria, where exchange rate movements heavily affect import costs, this factor is critical.

This study integrates variables such as proximity to key infrastructure and exchange rate changes to test the hypothesis that inflationary pressures are not uniform across Nigerian states. It is expected that states further from petroleum depots and seaports will experience higher cost-push inflation, while states with better access to energy supplies and infrastructure will face lower inflationary pressures. These regional differences are vital for understanding Nigeria's inflation dynamics, providing a basis for creating more targeted and effective policy interventions to control inflation at the state level. Such insights are essential for developing strategies that mitigate the negative impact of inflation, especially in economically weaker regions, and ensure a fairer distribution of resources and economic stability across the country.

The study also highlights the limitations of using additive models to analyze inflation in Nigeria, where economic shocks—such as fluctuations in global oil prices or domestic energy reforms—create nonlinear effects that simple additive models cannot capture. The study employs a multiplicative interaction approach, which better reflects how one variable, such as exchange rate volatility, can amplify or diminish the effect of petroleum product prices on inflation. This method is particularly relevant in post-subsidy Nigeria, where the removal of fuel subsidies and the unification of the Naira have made the economy more sensitive to both domestic policies and global economic shifts.

The methodological approach focuses on the interaction between petroleum product prices, exchange rates, and inflation, employing literature-supported techniques (Aiken & West, 1991; Kruschke, 2014; Zahonogo, 2017; Ikue et al., 2022; Denwi et al., 2021) that emphasize the importance of interaction terms in capturing non-additive relationships. Interaction terms allow the influence of each petroleum product price on inflation to vary with changes in the exchange rate, focusing on how these variables behave differently across various states. The model also addresses potential multicollinearity issues by centering petroleum product prices and exchange rates around their sample means to reduce the risk of inflated standard errors and unreliable estimates (Allison, 1977; Shieh, 2011; Liu et al., 2017).

The study's focus on the nonlinear relationship between petroleum product prices, exchange rates, and inflation sheds light on the factors driving inflation differently across Nigerian states. The diverse economic landscapes of the states—such as revenue-generating capacities and geographic advantages—affect how petroleum product prices and exchange rate policies impact inflation. Ultimately, the study aims to deepen the understanding of how these variables interact to influence inflation, particularly on the differentiated responses across states based on economic strength and proximity to energy depots. The analysis illuminates the uneven distribution of inflationary pressures and the underlying causes of these disparities, offering valuable guidance for policymakers in crafting interventions that are both effective and equitable, tailored to the specific economic conditions of each region in Nigeria.

Literature Review

Stylize Facts

The Nigerian States can be classify as affected by inflation rates, exchange rates, and retail energy prices, it's crucial to understand the metrics and rationale behind this categorization. The classification into blue, yellow, and red states is based on economic strength, measured by two key indicators: Internally Generated Revenue (IGR) and Federation Accounts Allocation Committee (FAAC) revenue.

The IGR serves as a vital measure of economic strength. It represents the revenue collected by state governments from within their territories through taxes and other levies. The data from 2012 to 2022 reveals that four states—Lagos, Rivers, Ogun, and Delta—accounted for approximately 60.29% of the total IGR for the 36 states exception of the Federal Capital. This high contribution signifies substantial economic activities and higher productivity levels within these states. Thus, the IGR reflects the economic vibrancy and the ability of state governments to generate income internally, making it a robust indicator of economic strength.

Secondly, FAAC revenue represents the federal transfers allocated to states, distributed based on a predetermined formula. This revenue source is a measure of excess liquidity, providing additional income that is not directly linked to the state's productivity. According to Sodipo et al. (2024), this extra income can enhance spending power and potentially trigger demand-pull inflation. The study uses the average monthly FAAC allocations from January 2016 to May 2024.

The classification of states into blue, yellow, and red categories is as follows:

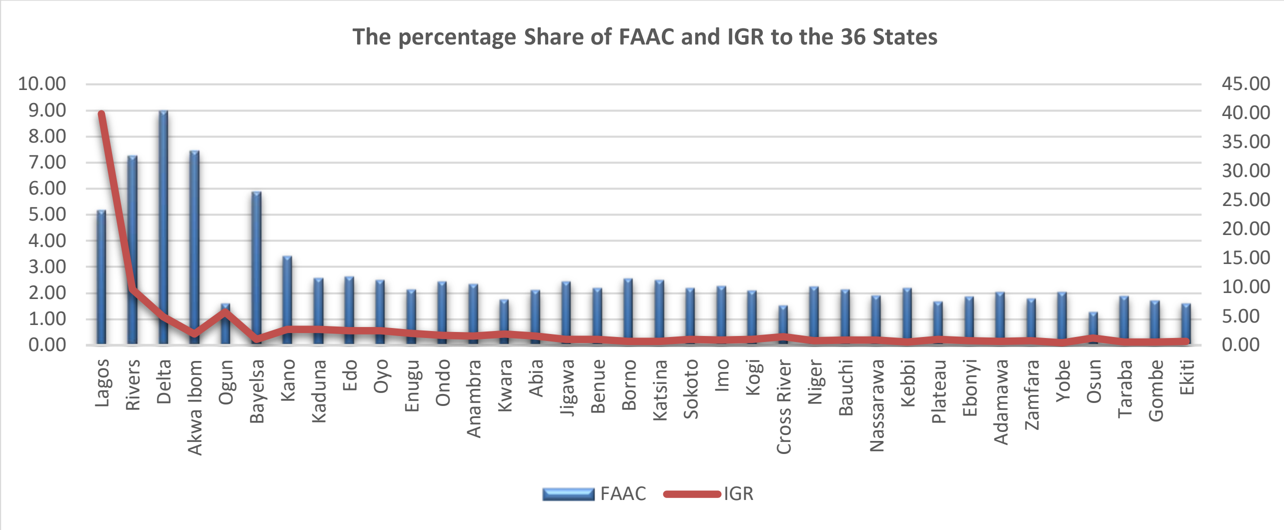

Figure 1: The percentage Share of FAAC and IGR to the 36 States

The blue states, including Lagos, Rivers, Delta, Akwa Ibom, and Ogun stand out due to their significant economic contributions. Lagos dominates with a staggering 39.92% share in IGR, demonstrating its strong economic base and minimal reliance on FAAC, which stands at 5.16%. The combined FAAC and IGR share for Lagos is 45.08%, with an average yield of 22.54, underscoring its financial robustness. Rivers follows with a significant, though much lower, IGR share of 9.65%, but a higher FAAC reliance at 7.26%, resulting in a total of 16.91%. The average yield for Rivers is 8.45, reflecting its balanced contribution from both sources. Delta and Akwa Ibom, both oil-rich states, show high FAAC shares (8.97% and 7.44%, respectively) but considerably lower IGR, indicating a reliance on federal allocations despite their resource wealth. Ogun, although not as prominent in terms of FAAC, maintains a moderate balance with a combined revenue share of 7.34%, supported by a relatively strong IGR. The blue states exhibit similarities as they are closer to seaports and energy depots in Nigeria.

The yellow states, such as Bayelsa, Kano, Kaduna, Edo, etc exhibit a more balanced but moderate economic profile. These states have a more equal distribution between FAAC and IGR shares, with neither source significantly outpacing the other exception of Bayelsa state that has a FAAC share of 5.88% but a low IGR of 0.98%, resulting in a combined total of 6.87% and an average yield of 3.43. Kano and Kaduna both have moderate contributions from FAAC and IGR, resulting in total shares of 6.14% and 5.28%, respectively, with average yield values around 3.07 and 2.64, indicating moderate economic stability.

The red states, including Jigawa, Benue, Borno, Katsina, and others, represent areas with the lowest economic contributions and the highest dependency on FAAC. These states generally have low IGR shares, often below 1%, and rely heavily on FAAC allocations for their financial sustenance. For example, Jigawa has a FAAC share of 2.45% and an IGR share of just 1.00%, resulting in a total of 3.45% and an average yield of 1.72. Similarly, Benue and Borno have nearly identical financial profiles, with FAAC shares of around 2.18% and IGR shares around 1.00%, leading to average yield values close to 1.59. These figures reflect the economic challenges faced by these states, highlighting their heavy reliance on federal support and limited internal revenue generation.

The figure clearly delineates the economic landscape of Nigeria's states, with the blue states exhibiting strong financial independence, the yellow states showing moderate economic stability, and the red states highlighting areas of significant financial vulnerability. The study aims to capture the varied economic environments across Nigerian states and their impact on inflation dynamics. The classification underscores the role of federal transfers and internal revenue in shaping local economies and inflation rates. For instance, states with higher FAAC allocations may experience increased spending power, potentially leading to demand-pull inflation. Conversely, states with higher IGR are likely to exhibit stronger economic activities and productivity, influencing inflation through different mechanisms. This approach of using IGR and FAAC revenues as indicators aligns with the study’s objectives, providing a framework to understanding how inflation rates in varying Nigerian states responded to economic policies of exchange rates and retail energy prices.

Table 1: Analysis of Inflation and Retail Energy Prices Across Income Levels in Nigerian States

	pms_b	ago_b	cpi_b	cpi_f_b	pms_y	ago_y	cpi_y	cpi_f_y	pms_r	ago_r	cpi_r	cpi_f_r
Jun-23	540.09	804.42	24.42	42.93	544.32	795.05	23.34	41.89	548.23	825.48	22.39	39.56
Jul-23	595.14	837.89	27.82	38.60	597.52	837.77	26.80	40.57	602.15	861.36	24.84	40.09
Aug-23	617.54	878.93	29.00	27.82	622.91	893.89	27.54	26.47	631.12	888.35	25.62	24.53
Sep-23	619.16	878.93	29.83	29.88	623.17	893.89	28.15	28.58	629.74	888.35	26.25	25.51
Oct-23	618.48	969.79	30.71	33.06	624.39	1024.97	28.80	31.03	636.19	1005.39	27.21	27.89
Nov-23	652.67	998.77	30.95	34.25	652.89	1041.03	29.69	32.10	646.58	1069.93	28.07	29.09
Dec-23	675.52	1,056.80	32.47	35.89	656.17	1125.33	32.67	32.94	678.86	1143.07	31.08	29.97
Jan-24	666.67	1,121.08	34.11	37.82	666.55	1140.46	34.38	34.18	671.24	1161.48	32.40	31.09
Feb-24	670.01	1,267.10	34.80	38.14	673.81	1250.68	34.58	35.38	685.48	1251.86	33.04	32.39
Mar-24	678.85	1,334.10	34.47	34.81	686.75	1365.90	35.04	34.05	705.90	1325.23	33.58	36.08
Apr-24	665.39	1,391.83	34.46	40.55	687.92	1421.19	35.35	39.16	717.62	1434.88	33.71	36.90
May-24	737.51	1,379.97	32.57	42.82	770.67	1347.72	34.05	41.68	781.85	1441.99	33.88	38.73
Jun-24	740.21	1,448.08	26.21	41.81	749.56	1397.10	24.95	42.43	755.41	1503.78	22.95	39.97
Jul-24	694.87	1,310.62	29.71	41.50	765.46	1320.10	29.39	42.83	795.44	1421.77	29.80	40.25

Author’s Computation,

Table 1 presents a comparative analysis of the indices for PMS, AGO CPI for all items, and Food CPI across the three categories of Nigerian states—higher income or blues states (HY), medium income or yellow states (MY), and low-income or red states (LY)—from June 2023 to July 2024. The data offer insights into how retail energy prices and inflation dynamics differ across these income groups, reflecting the varying economic conditions and purchasing power within these regions.

Retail Energy Prices (PMS and AGO): Higher Income States (HY): PMS prices in higher income states showed a steady increase from ₦540.09 in June 2023 to ₦740.21 in June 2024. AGO prices rose sharply from ₦804.42 in June 2023 to ₦1,448.08 by June 2024. The consistent rise in energy prices in HY states, despite their higher economic strength, underscores the broad impact of market dynamics and potentially stronger demand-side pressures in these regions.

Medium Income States (MY): PMS prices in MY states followed a similar trajectory, increasing from ₦544.32 in June 2023 to ₦749.56 in June 2024. AGO prices also saw significant growth from ₦795.05 to ₦1,397.10 over the same period. MY states experienced slightly lower PMS and AGO prices compared to HY states, likely reflecting slightly reduced purchasing power and lower economic activity relative to HY states.

Low Income States (LY): PMS prices in LY states, while following the general upward trend, were consistently higher than those in MY and HY states, starting at ₦548.23 in June 2023 and reaching ₦755.41 in June 2024. AGO prices also displayed significant increases, peaking at ₦1,503.78 in June 2024. The higher energy prices in LY states may indicate the compounded effects of supply chain challenges, higher transportation costs, and weaker local currency impacts in these regions.

Consumer Price Index (CPI): Higher Income States (HY): CPI in HY states rose from 24.42 in June 2023 to a peak of 34.80 in February 2024 before slightly declining to 29.71 in July 2024. The initial rise in CPI reflects the immediate impact of rising energy prices on general inflation, while the later stabilization might be linked to stronger economic resilience and possible government interventions in these states.

Medium Income States (MY): CPI in MY states followed a similar pattern, increasing from 23.34 in June 2023 to 35.35 in April 2024 before declining to 29.39 in July 2024. The fluctuations in CPI here suggest a lagged response to energy price shocks and a potential re-adjustment period as economic activities stabilize.

Low Income States (LY): CPI in LY states showed a more gradual increase, starting from 22.39 in June 2023 and peaking at 33.88 in May 2024. However, by July 2024, CPI had slightly decreased to 29.80. The lower CPI in LY states compared to HY and MY states might be attributed to reduced consumption capabilities and the higher proportional impact of energy prices on the overall cost of living.

Food Consumer Price Index (CPI_F): Higher Income States (HY): Food CPI (CPI_F) in HY states showed significant fluctuations, with an increase from 42.93 in June 2023 to a peak of 42.82 in May 2024, followed by a slight decline to 41.50 in July 2024. This reflects the direct impact of energy prices on food production and distribution costs in wealthier regions, which, despite better infrastructure, still experience volatility in food prices.

Medium Income States (MY): CPI_F in MY states saw similar fluctuations, with a rise from 41.89 in June 2023 to 42.83 in July 2024, peaking at 42.43 in June 2024. The steady CPI_F increase suggests that food prices in these states are heavily influenced by energy costs, possibly exacerbated by less efficient supply chains compared to HY states.

Low Income States (LY): In LY states, CPI_F decreased initially from 39.56 in June 2023 to 24.53 in August 2023 before rising again to 40.25 in July 2024. This pattern may indicate extreme vulnerability to energy price shocks, with a delayed recovery in food prices, reflecting the severe impact on food affordability and availability in these regions.

Theoretical Review: Cost-Push theory

The theoretical framework for examining the effects of retail energy prices, exchange rates, and inflation in Nigeria is grounded in both Demand-Pull and Cost-Push inflation theories. This dual approach not only illuminates the inflationary dynamics present in Nigeria's economy but also provides insights into how exchange rate fluctuations contribute to these inflationary pressures.

Cost-Push Theory: The Cost-Push theory emphasizes that inflation can arise from rising production costs, particularly when the depreciation of a currency leads to higher prices for imported raw materials and goods (Nugraha et al., 2023). In Nigeria, the reliance on imported petroleum products means that a weaker Naira directly translates to increased costs of energy, which in turn affects the overall cost structure for businesses. Producers, facing escalated costs, are compelled to pass these expenses onto consumers, thus contributing to inflation. For instance, the increasing costs associated with importing energy products can lead to heightened production and transportation expenses, fueling inflationary trends (Akidi et al., 2024; Sodipo et al., 2024; Ikue et al., 2024; Chirat & Clerc, 2024). Whereas the Demand-Pull theory asserts that currency depreciation can enhance the competitiveness of domestically produced goods by making them relatively cheaper than imports. This shift stimulates domestic demand, ultimately leading to price increases (Hassan et al., 2023). In the Nigerian context, where a significant portion of consumer goods is imported, a weaker Naira can lead to a surge in demand for local alternatives, inadvertently pushing prices upward. This dynamic suggests that as the exchange rate deteriorates, the heightened demand for local goods, combined with a potential decline in supply capacity due to other economic challenges, can result in substantial inflationary pressures

Asymmetric Exchange Rate Effects: This framework also encompasses the asymmetric nature of exchange rate pass-through to inflation. During periods of currency depreciation, the inflationary response tends to be more pronounced due to the combined effects of increased import costs and rising domestic demand. Conversely, the inflationary relief experienced during currency appreciation is often muted. This is attributed to price stickiness and structural inefficiencies that hinder the full transmission of cost savings to consumers (Kalu, 2023 and Ikue et al., 2024). Positive asymmetry, therefore, manifests as a sharp rise in inflation during currency depreciation, while negative asymmetry reflects the limited ability of currency appreciation to effectively mitigate inflation.

Furthermore, Nigeria’s economic landscape is characterized by various structural inefficiencies—market rigidities, supply chain constraints, and persistent price stickiness—that complicate the exchange rate-inflation relationship (Akidi et al., 2024). These barriers impede the smooth transmission of exchange rate changes to domestic prices, thus diminishing the effectiveness of exchange rate policies aimed at stabilizing inflation. The inability of monetary policy to adequately address these challenges can lead to more severe inflationary scenarios, such as hyperinflation or galloping inflation (Rawaa, 2023).

The interplay between retail energy prices, exchange rates, and inflation is crucial for formulating effective policy responses in Nigeria. The dual application of Demand-Pull and Cost-Push theories provides a comprehensive framework for analyzing how exchange rate fluctuations influence inflationary dynamics. By acknowledging both the demand-side and supply-side factors at play, policymakers can better navigate the complexities of inflation management in the face of ongoing economic challenges. This nuanced approach is essential for developing targeted interventions aimed at mitigating the inflationary impacts associated with exchange rate volatility and energy price fluctuations.

Theory of Petroleum Product Pricing in oil-producing countries

The Paper of Gupta, Clements, Fletcher, & Inchauste, (2002) on issues in domestic petroleum pricing in oil-producing countries. analyzes the domestic pricing of petroleum in oil-producing nations, offers an insightful lens to examine the recent economic developments in Nigeria, particularly after the removal of fuel subsidies. This study makes a strong argument against the retention of petroleum subsidies, emphasizing the economic inefficiencies and equity concerns tied to such policies. However, Nigeria's experience post-subsidy removal suggests that the practical implications of these theoretical propositions are far from straightforward, leading to significant economic consequences that need critical examination.

The paper's assertion that petroleum subsidies are economically inefficient and inequitable holds some merit. Subsidies can result in substantial opportunity costs, diverting resources from more productive investments in infrastructure, education, and healthcare. In oil-producing countries, like Nigeria, subsidies have historically been a tool for political appeasement, allowing governments to mask underlying structural economic weaknesses. However, the policy recommendations of Gupta et al. must be scrutinized considering Nigeria's experience, where the complete removal of subsidies has led to a sharp increase in inflation. By the end of the second quarter of 2024, headline inflation surged from 22.41% in May 2023, the final month of the subsidy era, to 33.40%, reflecting a 49.04% increase. Food inflation climbed from 24.82% to 39.83%, a rise of 59.27%, while energy inflation spiked from 18.72% to 36.91%, an alarming 97.18% increase. Concurrently, the naira depreciated by over 217.99% against the US dollar. These figures underscore the social and economic disruption that subsidy removal has entailed for Nigeria.

One of the primary critiques of the policy recommendation lies in the assumption of a well-functioning and competitive market, which is not applicable in the Nigerian context. Removing subsidies without addressing the broader market inefficiencies—such as the lack of adequate infrastructure, monopolistic tendencies in the downstream sector, and logistical bottlenecks—can exacerbate inflationary pressures. Nigeria's significant reliance on imported refined petroleum products compounds these challenges, leading to vulnerability to international market volatility, currency depreciation, and domestic supply chain disruptions. Thus, the inflationary outcomes observed post-subsidy removal highlight a failure to account for Nigeria's unique economic and structural realities, which were not fully anticipated in the paper's generalized recommendations.

Furthermore, the 2002 study emphasizes that petroleum subsidies are procyclical, complicating macroeconomic management. While this is theoretically sound, the removal of subsidies in Nigeria has not necessarily stabilized macroeconomic variables. The inflationary surge has put pressure on real wages, household purchasing power, and overall economic stability. The short-term inflationary spike suggests that while subsidies might distort markets, their removal, especially without compensatory measures, can trigger adverse shocks. The country's inflation crisis post-subsidy removal underscores the necessity of a phased approach, which the paper only briefly alludes to. A gradual and carefully managed transition, accompanied by social safety nets and economic diversification efforts, might have mitigated the disruptive consequences observed in Nigeria.

Politically, Gupta et al. acknowledge the difficulty in eliminating subsidies due to public resistance. Nigeria's experience validates this observation, as the social backlash and the economic strain on households have intensified. While the paper recommends countervailing measures and publicity campaigns to engender support, Nigeria's communication strategy during the subsidy removal lacked clarity, transparency, and effective public engagement. The absence of trust between the government and citizens has exacerbated public discontent, complicating the implementation of economic reforms. This failure to secure public buy-in has, to some extent, undermined the economic rationale behind the subsidy removal.

The Nigerian case reflects the importance of considering the broader socioeconomic environment when implementing such macroeconomic policies. Gupta et al. focus on the inefficiencies of petroleum subsidies, yet the paper does not fully grapple with the social implications of such policies, particularly in economies with high levels of poverty, unemployment, unequal economic strength and access to key infrastructures among the 36 states. In Nigeria, the subsidy removal has had a regressive impact, disproportionately affecting low-income households that are heavily reliant on subsidized energy for transportation and basic needs. The resulting food and energy inflation exacerbates inequality and undermines social welfare, highlighting a disconnect between theoretical efficiency gains and real-world social equity outcomes. While this paper acknowledges the theoretical soundness of Gupta et al.'s arguments against petroleum subsidies, Nigeria's post-subsidy inflationary experience demonstrates the limitations of a one-size-fits-all approach. The Nigerian case illustrates that the removal of subsidies, though aimed at reducing inefficiencies, must be context-specific, gradual, and supported by robust safety nets and economic reforms to cushion the adverse impacts. Without these considerations, the removal of subsidies may lead to unintended and severe economic consequences, as evidenced by Nigeria's recent inflationary surge across multiple categories.

Empirical Review

Several studies have empirically examined the relationship between inflation and energy prices across various countries, employing diverse methodologies and approaches. For instance, Güdükçam (2023) offers a critical perspective on the long-run relationships between fuel prices and food inflation, demonstrating that rising fuel prices drive food inflation in Türkiye. This finding is particularly relevant to Nigeria, where the agricultural sector relies heavily on energy inputs. The similarities between Türkiye and Nigeria underscore the potential impact of energy prices on food inflation dynamics, especially in states where agriculture is a key economic sector.

Sodipo et al. (2024) provide key insights into the relationship between retail energy prices and inflation across Nigerian states, which is highly relevant to the current study on the combined effects of retail energy prices, exchange rates, and inflation in Nigeria. Their focus on the distinct impacts of PMS, AGO, HHK, and Gas prices on inflation helps establish a foundation for understanding how changes in energy prices drive inflationary pressures. This directly informs the current study's emphasis on the inflationary consequences of energy price fluctuations, particularly PMS and AGO, which Sodipo et al. found to have the largest effect on the Consumer Price Index (CPI). However, the current study advances this analysis by introducing exchange rates as an additional factor. While Sodipo et al. primarily focus on the demand-pull and cost-push effects of energy prices, the current study adds exchange rate fluctuations, particularly depreciation, as a driver that exacerbates the pass-through of higher energy prices to inflation. This expands the scope of the inquiry by considering how currency depreciation amplifies the cost-push inflationary impact of rising energy prices, making the inflationary dynamics more complex.

Unlike Sodipo et al, (2024), The study by Akidi, Ikue, and Ewubare (2024) focuses on the impact of retail energy prices and exchange rates on food inflation in Nigeria, employing a Structural Vector Autoregressive (SVAR) model based on aggregated national data. This approach allows for the analysis of dynamic interactions and the pass-through effects of these variables over time. The study highlights the lagged impacts of energy price increases and currency depreciation on food inflation, emphasizing the role of broader macroeconomic factors. In contrast, we adopted a multiplicative approach within a panel framework that incorporates individual state effects. This method allows us to account for variations across states, integrating factors such as proximity to seaports and oil depots. By examining state-level data, this study captures more localized dynamics, including how regional differences in energy accessibility and infrastructure influence inflation. While both studies address the relationship between energy prices, exchange rates, and inflation, they differ fundamentally in their methodological approaches and data scopes. Akidi et al. focus on national-level aggregates, providing a broader perspective on macroeconomic trends, while the panel study emphasizes the heterogeneity among states, highlighting the importance of local factors like geographic proximity to critical infrastructure. This divergence allows for complementary insights: the former offers a macroeconomic view, while the latter provides a granular understanding of regional variations in inflation dynamics.

Abdallah & Kpodar (2023) explore how inflation responds to changes in retail energy prices across different countries, noting that increases in fuel prices generally have a more pronounced effect on inflation than decreases. This insight is crucial for our analysis, suggesting that the inflationary response to rising energy prices may vary across Nigerian states, potentially influenced by their income levels and economic structures. Korgbeelo (2022) directly investigates the relationship between petroleum product prices and inflation in Nigeria, finding significant impacts from kerosene and petrol prices. This aligns with our focus on the role of specific energy products in influencing inflation in Nigeria.

Uchechi, Iheukwumere, & Ogbonna (2022) assess the impact of petroleum product pricing on Nigeria's economy, revealing a significant relationship between oil prices and GDP but a weaker link with inflation. This finding suggests that while oil prices are a major economic driver, their direct influence on inflation may vary across different states, which is a key consideration in our comparative analysis.

Bassey & Ekong (2019) offer insights into the influence of energy consumption on inflation, suggesting that some energy sources can exert non-inflationary effects. This complexity implies that the relationship between energy prices and inflation is not uniform and can vary depending on the specific energy source or the state's economic condition. Nwaoha et al. (2018) examine the effects of petroleum product prices on macroeconomic indicators, noting significant impacts on GDP and inflation. Their findings are particularly useful for understanding how shifts in petroleum prices might differentially affect higher, medium, and low-income states in Nigeria.

Kpagih, Amini, and Odungweru (2022) analyze the short-run impacts of energy prices on inflation, revealing that these effects can vary over time. This temporal dimension is crucial, suggesting that the impacts of energy prices on inflation are not static and can change depending on broader economic conditions. In the Nigerian context,

Agboje (2018) provides a critical foundation by analyzing the implications of fuel subsidy reforms on household welfare using a static computable general equilibrium model. His findings emphasize that the removal of petrol subsidies—whether partial or total—leads to reduced household consumption and increased overall expenditure, highlighting the economic repercussions of fuel price adjustments and their pass-through effects on inflation. Nwaoha et al. (2018) further explore the macroeconomic implications of petroleum product prices, revealing that prices for premium motor spirit and dual-purpose kerosene negatively affect GDP. This underscores the interconnectedness of fuel prices, economic output, and inflation.

Finally, Bobai (2015) and Eregha et al. (2015) reinforce the notion that rising petroleum product prices directly correlate with inflation levels in Nigeria, aligning with the cost-push inflation theory. Their work highlights the pressing need for monitoring and controlling energy prices to stabilize inflation, a perspective that complements the broader findings of this study.

The examination of the combined effects of retail energy prices, exchange rates, and inflation in Nigeria has been the subject of considerable research. Previous studies have contributed valuable insights into how these factors interact, but our study introduces several distinct elements that refine and expand upon existing knowledge.

Our study distinguishes itself from the existing literature in several keyways. First, we employ an interactive multiplicative model to analyze the combined effects of retail energy prices and exchange rates on inflation. This approach allows us to explore how these factors interact and influence inflation in a more integrated manner, offering a refined perspective compared to the often-separate analyses provided by previous studies. Additionally, our focus on state-specific variations within Nigeria addresses a critical gap in the literature. While past research has offered broad insights, our study examines how different income levels and economic structures across Nigerian states affect the pass-through effects of energy prices and exchange rates on inflation. This state-level analysis provides a more detailed understanding of regional dynamics, which is essential for formulating targeted policy interventions.

Furthermore, our analysis incorporates recent data and considers the effects of policy changes, such as the removal of petroleum subsidies and currency unification policies. This temporal dimension ensures that our findings are relevant to the current economic environment and can capture the evolving nature of inflationary pressures. By including a comprehensive set of variables—such as the Consumer Price Index (CPI), various types of petroleum products (AGO, DPK, PMS, GAS), and exchange rates (EXR)—our study offers a clearer examination of how each component contributes to inflation. This level of detail allows us to provide insights that are more specific than those found in broader studies, enhancing our understanding of the intricate relationships between energy prices, exchange rates, and inflation. in all, while existing literature has laid a solid foundation for understanding the impacts of energy prices and exchange rates on inflation, our study advances this knowledge by employing a sophisticated methodological approach, focusing on state-specific variations, and incorporating recent economic developments. These distinctions contribute to a more comprehensive and actionable understanding of inflation dynamics in Nigeria.

Methodology

Data

The data for the study range from 2016: Q1 to 2024: Q2 and sourced from the e-Library of the NBS and the Central Bank of Nigeria (CBN) website. The variables in the models are Petroleum Products prices, such as AGO, PMS, DPK, and GAS, they are key drivers of inflation due to their broad use in transportation, manufacturing, and household consumption. An increase in the price of these energy products directly raises production and transportation costs, leading to cost-push inflationary theory.

AGO (diesel) and PMS (petrol): a more pronounce inputs of industries and transportation. Changes in AGO prices leads to changes in production costs, thus CPI.

DPK (kerosene): major households' input, changes in the price of DPK directly impacts household expenditures, contributing to inflationary pressure.

GAS: Domestic gas prices affect both households and industrial production, influencing inflation through energy costs for heating and cooking.

The exchange rate (EXR) use in the study is the real effect exchange rates of the numbers of United State Dollars required to purchase a naira, it influences inflation by affecting the cost of imported goods, including petroleum products. A depreciation of the Naira against the US Dollar increases the domestic price of imported energy products, translating into higher inflation. reflecting a direct pass-through of exchange rate changes to domestic prices.

PY (State Revenue per capita income) represents the output gap or demand-pull factor. PY is calculated by dividing each state's monthly Federation Accounts Allocation Committee (FAAC) revenue by its population size. It serves as a measure of excess liquidity, as it represents additional income provided to states that is not directly linked to productivity. According to Sodipo et al. (2024), this extra income can enhance spending power and potentially trigger demand-pull inflation.

In this study, we introduce two dummy variables, Sp (nearness to seaports) and Dp (nearness to fuel depots), to capture the geographic advantages of Nigerian states in relation to inflation dynamics. These dummies account for the role of proximity to key infrastructure in driving inflation, especially for energy products.

$S_P = 0 \; or \; 1 \; and \; D_P = 0 \; or \; 1$ where 0 is nearness to seaport or depot, and 1 is distance away from seaports or depots. Inclusion of Sp and Dp strengthens the model's ability to explain regional variations in inflation by addressing cost-push factors specific to logistics and infrastructure. This approach aligns with the asymmetric impact framework, acknowledging that inflationary pressures are not uniform across states but are influenced by geographic and infrastructural disparities. By capturing these differences, the study enhances the understanding of state-level inflation, providing more accurate insights for targeted policy interventions.

Theoretical Framework

The study adopted the cost-push inflation theory, it offers a foundational framework to explain how increases in production costs, particularly driven by fluctuations in petroleum products prices and exchange rate fluctuation, contribute to inflationary pressures.

The base line model for this study is estimated as:

$$cpi = f(pep \; exr, py, sp, dp) \quad (1)$$

$$lncpi_{i,t} = \pi_0 + \pi_1 lnpep_{i,t} + \pi_2 lnexr_{i,t} + \pi_3 lnpy_{i,t} + \pi_4 sp_{i,t} + \pi_5 dp + \omega_{i,t} \quad (2)$$

where pep $= \; ago, dpk, pms \; and \; gas$, $lnpep_{i,t}$ is the natural logarithm of the petroleum products prices, whereas $lnexr \; and \; lnpy$ is the natural logarithm of the exchange rate of 1 USD to the Naira and demand pull factor.

The theoretical expectations for the coefficients are linear thus, π_1 >0, indicating that increases in these petroleum products prices are expected to raise inflation. This implies that higher petroleum products prices lead to increased costs of production, which, in turn, drives up the overall price level, contributing to inflation. This relationship has been supported by studies such as Nusair (2019). Babuga &Ahmad, (2021), Sodipo et al. (2024) and Akidi, Ikue and Ewubare, (2024). Regarding the exchange rate, $\pi_2 <0$, as an appreciation in the real effective exchange rate typically reduces inflation in the long run. When the domestic currency appreciates, domestic goods become more expensive in the international market, leading to a decrease in demand and production, which ultimately lowers the price level. Sek et al. (2015) and Babuga &Ahmad, (2021) have noted that exchange rate appreciation negatively affects inflation in oil-exporting countries. π_3>0 indicating the inflationary potential of untethered revenue sources. Finally, if $\pi_4 \; and \; \pi_5 >0$ implies distance away from seaports and deport. That is, states closer to seaports and depots experience lesser impact of petroleum products price on inflation.

Model with Interaction Terms

Economic theory posits that the relationship between energy prices and inflation exhibits nonlinear dynamics, contingent on various exogenous factors, (Kilian and Park, 2009 and Hamilton 1983). In the case of Nigeria, where petroleum products prices significantly impacted by exchange rate volatility, the interaction between petroleum products and the exchange rate is crucial for understanding their pass-through to inflation, (Tuaneh & Wiri, 2019). The inclusion of the interaction terms allows for nonlinear and conditional responses, where exchange rate depreciation exacerbates the inflationary impact of rising petroleum products prices. This study draws inspiration from previous studies, (Sek et al., 2015; Babuga &Ahmad, 2021, and Sodipo et al., 2024). However, it departs significantly from these studies by concentrating on the effects of petroleum products prices, rather than oil prices on Inflation in Nigeria. This choice is driven by the belief that these specific energy products have a more pronounced impact on inflation in Nigeria, particularly considering the country's recent policy shift to fully remove petroleum product subsidies.

To account for nonlinearity in our model, we assume a situation where the impact of petroleum products prices on inflation depends on the fluctuation of the exchange rate, since significant quantities of the petroleum products in Nigeria within the periods of this study are imported. Thus, the inflationary impact of petroleum products could change under different exchange rate regimes. The interaction terms would allow the model to capture these conditional relationships.

Accordingly, equation 3 is as follows:

$$lncpi_{i,t} = \pi_0 + \pi_1 lnpep_{i,t} + \pi_2 lnexr_{i,t} + \pi_3 lnpy_{i,t} + \pi_4 sp_{i,t} + \pi_5 dp + \pi_i Z_{i,t} + \omega_{i,t} \quad (3)$$

To assess the significance of the interaction term πi and mitigate the challenges posed by multicollinearity, we employed the subtractive significance approach. This method involves transforming the variables pep and exr linearly such that their values are centered around the moderator Z. Specifically, pep and exr are centered at their respective sample means. This approach helps ensure that the transformed values are zero when the moderator Z is at its specific raw value, (Allison, 1977; Van-Eeuwijk, 1995; Shieh 2011 and Liu, et al., 2017).

Where $Z_{i,t}$= $(lnago * lnexr) = (lndpk * lnexr) = (lnpms * lnexr) = (\text{lngas} * lnexr)$ and π_i represent the interaction effects between each petroleum products price and the exchange rate. These terms allow the effect of each petroleum product's price on CPI to vary depending on the value of the exchange rate. The use of multiplicative interaction term is justifiable in empirical literature, (Aiken & West 1991; Van-Eeuwijk, 1995; Kruschke, 2014; Zahonogo, 2017; and Ikue, et al., 2021).

Econometric Techniques

The static and dynamic panel estimators is considered for the analytical approach. The within effect model is used because it focuses on controlling for unobserved, time-invariant state-specific factors that may affect the relationship between the variables of interest. The technique isolates the changes within each state over time, removing the effect of any state-specific characteristics that are constant across time.

The within effect model is casted as follows

$$lncpi_{i,t} = \delta_i + \beta_1 lnpep_{i,t} + \beta_2 lnexr_{i,t} + \beta_3 lnpy_{i,t} + \beta_4 sp_{i,t} + \beta_5 dp + \beta_i Z_{i,t} + \epsilon_{i,t} \quad (4)$$

Where;

δ_i represents the **state-specific fixed effects**, capturing all time-invariant characteristics of each state iii that affect inflation.

$\epsilon_{i,t}$ is the error term for state i at time t, capturing all unobserved factors that vary over time within the state and affect inflation.

The within effect model subtracts the state-level mean for each variable from the variable itself, which effectively eliminates the state-specific fixed effects:

First, calculate the mean of each variable for each state as follows:

$$\overrightarrow{CPI_{\iota,t}} = \frac{1}{T}\sum_{t=1}^{T} CPI_{i,t}, \quad \overrightarrow{pep_{\iota,t}} = \frac{1}{T}\sum_{t=1}^{T} pep_{i,t}, \ \overrightarrow{exr_{\iota,t}} = \frac{1}{T}\sum_{t=1}^{T} exr_{i,t}, \ \overrightarrow{PY_{\iota,t}} = \frac{1}{T}\sum_{t=1}^{T} PY_{i,t}, \ \overrightarrow{Sp_{\iota,t}} = \frac{1}{T}\sum_{t=1}^{T} Sp_{i,t},$$

$$\overrightarrow{Dp_{\iota,t}} = \frac{1}{T}\sum_{t=1}^{T} Dp_{i,t}, \ and \ \overrightarrow{Z\iota_{\iota,t}} = \frac{1}{T}\sum_{t=1}^{T} Zi_{i,t}, \quad (5)$$

Secondly subtract these means from the original values to eliminate the state-specific fixed effects δ_i:

$$(CPI_{i,t} - \overrightarrow{CPI_{\iota,t}}) = (pep_{i,t} - \overrightarrow{pep_{\iota,t}}) + \ldots + (Zi_{i,t} - \overrightarrow{Z\iota_{\iota,t}}) \quad (6)$$

The process of equation (5) and (6) demeans the data, leaving only the within-state variations over time, thereby allowing us to isolate how changes in petroleum product prices, exchange rates, and other variables affect inflation within each state.

Difference GMM

The dynamic panel model is estimated with the System GMM, this method was introduced by Blundell & Bond (1998). The techniques transform the model by taking first differences to eliminate individual-specific effects and uses lagged levels of the dependent and independent variables as instruments.

$$\Delta cpi_{i,t} = \Delta cpi_{i,t-1} + \alpha_1 \Delta pep_{i,t} + \alpha_2 \Delta exr_{i,t} + \alpha_3 \Delta py_{i,t} + \alpha_4 \Delta sp_{i,t} + \alpha_5 sp_{i,t} + \alpha_6 \Delta Z_{i,t} + \Delta \varphi_{i,t} \ (7)$$

We use the lagged levels of the variables as instruments for the differenced equations

$$E[\![Z_{i,t-k} \Delta \varphi_{i,t}]\!] = 0 \ (8)$$

Where $Z_{i,t-k}$ are the instruments, which are the lagged levels of the independent variables and $k\ is\ the\ maxium\ lag\ length$..

Instrumented Selected is the lagged differences of the variables for the level equation and lagged levels of the variables for the differenced equation:

$$E[\![Z_{i,t-k} \Delta \varphi_{i,t} \big(cpi_{i,t} - \alpha - \alpha_1 pep_{i,t} - \alpha_2 exr_{i,t} - \alpha_3 py_{i,t} - \alpha_4 \Delta sp_{i,t} - \alpha_5 sp_{i,t} - \alpha_6 Z_{i,t} - \varphi_{i,t}\big)]\!] = 0 \ \ (9)$$

Results and Discussions

In both the headline and food inflation models, the coefficients for the price of automotive gas oil are consistently positive and highly significant at the 1% level. This implies that an increase in AGO prices leads to an upward pressure on both headline and food inflation. The strength of this relationship is slightly more pronounced in the food inflation models, with the coefficients rising from 0.365 in the headline inflation model without interaction to 0.448 in the food inflation model with interaction. The consistently high t-values (ranging from 12.39 to 13.12) further validate the robustness of the results. This suggests that AGO price movements have a significant impact on inflation, especially food prices, likely due to the importance of fuel in transportation and logistics costs in the Nigerian economy. The coefficients for Premium Motor Spirit (PMS) prices are also positive and significant across all models. With coefficients ranging between 0.149 and 0.179, PMS prices have a notable influence on inflation, although their impact is not as strong as that of AGO. The t-values range between 5.16 and 6.81, indicating that the relationship is statistically significant. PMS price increases contribution to both headline and food inflation reflects the extensive use of petrol in daily activities and production processes. This finding is in line with literature as various studies had observed a positive impact of increase retail energy prices on inflationary dynamics, (Sodipo et al, 2024; Akidi et al, 2024; Ikue et al, 2024; Güdükçam, 2023 and Abdallah & Kpodar, 2023)

The price of Dual-Purpose Kerosene has a similar positive impact on inflation, with the coefficient increasing from 0.106 in the headline inflation model without interaction to 0.177 in the headline inflation model with interaction. In food inflation models, the impact is smaller but still significant, with coefficients around 0.104 to 0.133. This reflects the role of kerosene in cooking and other household activities, particularly in rural areas where it is widely used, contributing to inflation pressures. This finding is in line with Akidi et al, 2024; Ikue et al, (2024) and Korgbeelo (2022) that observed positive and direct impacts of kerosene prices on inflation dynamics.

Interestingly, the impact of gas prices on inflation is negative in all models, but not statistically significant. The coefficients range from -0.043 to -0.1065, with t-values below the threshold for significance. This could be due to the relatively lower reliance on gas for daily consumption compared to other energy sources like firewood's and DPK. The negative sign could be reflective of a demand-side substitution effect, where increases in gas prices lead to lower consumption, thus mitigating inflationary pressures. This finding is in line with the observations of Sodipo et al, 2024 and Akidi et al, (2024). These studies notice a negative and delay impact of gas prices on inflation in Nigeria.

The exchange rate has a strong negative relationship with inflation across all models, with coefficients ranging from -0.193 to -0.327, significant at the 1% level. The negative sign indicates that exchange rate depreciation leads to inflationary pressures, particularly on food prices, as Nigeria relies heavily on imports. The stronger impact in models with interaction terms suggests that exchange rate effects become more pronounced when accounting for other variables, likely due to the interaction between energy prices and exchange rate dynamics. Ikue et al, (2024) and Sa'ad et al. (2023) echo the same sentiment as they delve into the asymmetric effects of oil prices and exchange rates on inflation. They reveal that devaluation significantly impacts inflation rates in Nigeria,

Income per capita consistently shows a positive and significant impact on inflation, with the strongest effect seen in the food inflation model without interaction (0.331). The significance of income per capita reflects the demand-pull aspect of inflation, where higher incomes lead to increased consumption, thereby driving up prices. This finding is supported by sodipo, et al., (2024)

Table 2: Static Models

	Headline Inflation Models				Food Inflations Models			
Models	$without\ Interation$		$with\ Interation$		$without\ Interation$		$with\ Interation$	
	$coef$	t_{Value}	$coef$	t_{value}	$coef$	t_{value}	$coef$	t_{value}
$lnago_{it}$	0.365^{***}	12.61	0.382^{***}	12.70	0.427^{***}	12.39	0.448^{***}	13.12
$lnpms_{it}$	0.149^{***}	5.21	0.156^{***}	6.81	0.179^{***}	6.68	0.165^{***}	5.16
$lndpk_{it}$	0.106^{***}	3.04	0.177^{***}	4.38	0.104^{***}	2.55	0.133^{***}	3.03
$lngas_{it}$	-0.043	-1.28	-0.1065	-2.93	-0.035	-0.90	-0.066	-1.61
$lnexr_{it}$	-0.193^{***}	-9.00	-0.262^{***}	-9.68	-0.234^{***}	-9.30	-0.327^{***}	-10.78
$lnpy_{it}$	0.268^{***}	16.33	0.145^{***}	11.34	0.331^{***}	17.20	0.309^{***}	16.20
Sp_{it}	0.110^{***}	3.01	0.132^{***}	3.04	0.140^{***}	4.00	0.148^{***}	3.99
Dp_{it}	0.208^{***}	12.11	0.231^{***}	13.01	0.171^{***}	8.90	0.226^{***}	8.11
$lnZa_{it}$	-	-	0.466^{***}	4.22	-	-	0.479^{***}	5.17
$lnZp_{it}$	-	-	0.168^{***}	3.09	-	-	0.198^{**}	2.29
$lnZd_{it}$	-	-	-0.213^{***}	-4.93	-	-	-0.207^{**}	-2.07
$lnZg_{it}$	-	-	0.237^{***}	2.61	-	-	0.103^{*}	1.79
c	1.617	11.14	2.712	16.22	0.959	5.63	1.546	7.63
R^2	0.8794		0.8916		0.8757		0.9212	
$Sigma_u$	0.142		0.048		0.151		0.141	
$Sigma_e$	0.132		0.129		0.155		0.151	
rho	0.536		0.125		0.487		0.465	
F_{Stat}	1436.14^{***}		8231.38^{***}		1387.88^{***}		8871.67^{***}	
H_test	118.63^{***}		98.64^{***}		138.33^{***}		25.26^{***}	
$obs.$	1224		1224		1224		1224	

Note: ***. **, * implies significance of 1%, 5%, 10% respectively. H_test represent Hausman test statistics

The introduction of interaction terms in the models adds complexity to the analysis:

Za is positive and significant in the headline and food inflation models, with coefficients of 0.466 and 0.479, respectively. This suggests that the combined effects of AGO and exchange rate amplify inflationary pressures. This Zp also shows positive coefficients, albeit smaller, implying that the interaction between PMS and the exchange rate contributes to inflation, but to a lesser extent than AGO. Z_d has a negative coefficient, indicating that the combined effects of DPK and exchange rate could reduce inflationary pressures. This may reflect substitution effects or policy measures. lnZg_it has a positive coefficient, though smaller in magnitude, suggesting that gas price interactions may also influence inflation, particularly in the headline inflation model.

The coefficient for the lagged consumer price index (CPI) is highly significant across all models, indicating strong persistence in both headline and food inflation. In models without interaction, the coefficient is approximately 0.735–0.740, while in models with interaction, it rises slightly to around 0.800 and 0.782 for headline and food inflation, respectively. This suggests that previous periods' inflation exerts a dominant effect on current inflation, reinforcing inflationary persistence—a common finding in inflation dynamics literature.

The coefficient for AGO is positive and significant across both headline and food inflation models, reflecting the strong impact of diesel prices on inflation. In models without interaction, the coefficient for headline inflation is 0.159 and for food inflation is 0.121, indicating that increases in AGO prices contribute significantly to inflation. When interaction terms are included, the effect becomes much larger, with coefficients rising to 0.685 and 0.513 for headline and food inflation, respectively. This suggests that the inclusion of interaction terms amplifies the role of diesel prices, due to their interaction with exchange rates.

PMS, or petrol prices, also positively and significantly affect inflation across models. In the headline inflation model without interaction, the coefficient is 0.112, while it increases to 0.231 with interaction. Similarly, for food inflation, the coefficient rises from 0.107 to 0.201 when interaction terms are considered. The significant positive coefficients suggest that fuel price fluctuations have a notable cost-push effect on inflation, particularly in the presence of interactions with exchange rates.

Interestingly, the effect of DPK is negative and significant in both headline and food inflation models, particularly in models without interaction. The coefficient for headline inflation without interaction is -0.107 and for food inflation is -0.107, suggesting that changes in kerosene prices have a deflationary impact. However, this effect may reflect lower consumption of kerosene or substitution effects with other fuels. In the models with interaction, the negative impact is intensified, with coefficients dropping further to -0.293 for food inflation. This intensified effect could result from the interaction of kerosene prices with exchange rates that further exacerbate their negative impact.

The impact of gas prices is generally insignificant or weakly significant in most models. For headline inflation without interaction, the coefficient is -0.020, while it becomes more pronounced at -0.312 in the interactive model, indicating a significant negative effect.

In food inflation models, gas prices appear to have minimal effect, with coefficients ranging from 0.033 to -0.071. This lack of significance may suggest that gas prices do not have the same direct influence on inflation as other energy products like diesel or petrol.

Exchange rate depreciation, as expected, has a strong negative impact on inflation. In the headline inflation model without interaction, the coefficient is -0.190, while in the interactive model, it becomes much larger at -0.697. For food inflation, the effect is also strong, with coefficients of -0.207 and -0.811 without and with interaction, respectively. This large negative effect underscores the significant cost-push inflationary pressure resulting from currency depreciation, as Nigeria's heavy reliance on imports makes inflation highly sensitive to exchange rate movements.

Zone-Specific Variables

The inclusion of the variables Sp and Dp in both static and dynamic models offers crucial insights into Nigeria's inflation dynamics. These variables account for geographic and logistical factors influencing inflationary pressures, especially for energy-related goods.

Static Models: In the static models for both headline and food inflation, Sp and Dp exhibit positive and highly significant coefficients, underscoring the importance of proximity to seaports and fuel depots in moderating inflation. States closer to these facilities tend to experience lower transportation and distribution costs for goods, particularly energy products, leading to a relatively lower inflationary burden. For example, the coefficient of Sp for food inflation is higher (0.140–0.148), indicating that proximity to seaports significantly affects food prices, given Nigeria's reliance on imported food items. The consistently significant coefficients of Dp across headline and food inflation models (0.171–0.231) highlight the critical role of proximity to fuel depots in stabilizing energy prices. This reflects how states closer to fuel depots benefit from lower distribution costs, which in turn reduces inflationary pressures from energy products like PMS, AGO, and DPK.

Dynamic Models: In the dynamic models, Sp and Dp maintain positive and significant coefficients, reinforcing their role in moderating inflation in both headline and food price models. The lower values in the dynamic models suggest a more gradual, yet persistent, impact over time. For instance, the Sp coefficients range between 0.08 and 0.103, indicating that states near seaports experience a slower but steady moderation in inflation due to more efficient access to imports. Dp continues to have a strong influence in the dynamic context, with coefficients up to 0.230 in food inflation models, pointing to the significant role fuel depot proximity plays in energy price stability. This dynamic interaction highlights how geographic factors create regional disparities in inflation across Nigerian states, with proximity to infrastructure directly influencing inflationary pressures.

The significance of Sp and Dp in these models suggests that geographic and infrastructural disparities are critical determinants of inflationary pressures in Nigeria. States near seaports and fuel depots face lower inflationary impacts due to reduced logistical costs, especially in the transport and energy sectors. This underscores the need for partial subsidization of petroleum products to state relative faraway from fuel depots states, that could face higher inflation due to logistical challenges.

Table 3: Dynamic Models

Models	***Headline Inflation Models***				***Food Inflations Models***			
	without Interation		*with Interation*		*without Interation*		*with Interation*	
	$coef$	t_{Value}	$coef$	t_{value}	$coef$	t_{value}	$coef$	t_{value}
$\Delta lncpi_{it\_1}$	0.735^{***}	34.96	0.800^{***}	8.03	0.740^{***}	31.67	0.782^{***}	7.19
$\Delta lnago_{it}$	0.159^{***}	2.79	0.685^{***}	4.63	0.121^{***}	2.69	0.513^{***}	4.17
$\Delta lnpms_{it}$	0.112^{***}	4.70	0.231^{***}	2.81	0.107^{***}	4.17	0.201^{**}	2.46
$\Delta lndpk_{it}$	-0.107^{***}	-3.40	-0.097^{***}	-4.49	-0.107^{***}	-2.81	-0.293^{***}	-4.09
$\Delta lngas_{it}$	-0.020	-0.44	-0.312	-4.23	0.033	0.58	-0.071	-3.81
$\Delta lnexr_{it}$	-0.190^{***}	-5.25	-0.697^{***}	-3.03	-0.207^{***}	-4.73	-0.811^{***}	-2.89
$\Delta lnpy_{it}$	0.105^{***}	3.81	0.127^{***}	3.72	0.135^{***}	3.63	0.158^{***}	3.15
ΔSp_{it}	0.090^{***}	5.80	0.103^{***}	5.85	0.10^{***}	4.91	0.08^{**}	2.11
ΔDp_{it}	0.191^{***}	3.44	0.203^{***}	3.09	0.171^{***}	4.00	0.230^{***}	4.08
$\Delta lnZa_{it}$	-	-	0.814^{***}	4.38	-	-	0.923^{***}	3.90
$\Delta lnZp_{it}$	-	-	0.589^{***}	2.89	-	-	0.799^{**}	2.72
$\Delta lnZd_{it}$	-	-	-0.538^{***}	-4.47	-	-	-0.591^{*}	-1.72
$\Delta lnZg_{it}$	-	-	-0.555^{***}	-3.86	-	--	-0.048^{*}	-3.55
c	0.069^{***}	0.33	3.579^{***}	3.50	-0.251	-0.95	4.297	3.38
In^{no}	11		15		15		15	
AR_1	−2.04 [0.041]		−2.63 [0.009]		−1.94 [0.049]		−2.51 [0.012]	
AR_2	1.29 [0.197]		-1.96 [0.082]		1.46 [0.145]		-1.92 [0.055]	
S_test	0.35 [0.321]		0.34 [0.951]		34.83 [0.069]		0.35 [0.809]	
Ha_test	7.30 [0.063]		1.30 [0.613]		14.74 [0.101]		8.10 [0.144]	
$obs.$	1224		1224		1188		1188	

Note: ***. **, * implies significance of 1%, 5%, 10% respectively. Probability values are in square bracket, $Ha_{test} and\ S\_test$ *represent* Hansen and Sargan test statistics

The R-squared values for both headline and food inflation models are relatively high (ranging from 0.8757 to 0.9212), indicating that the models explain a large portion of the variation in inflation. The inclusion of interaction terms improves the explanatory power of the models, as evidenced by the increase in R-squared values.

i. The Hausman test statistics are significant, indicating that the fixed effects specification is appropriate for these models. This reinforces the idea that state-specific factors and other unobserved characteristics are important in explaining inflation dynamics across Nigeria's states.

ii. The F-statistics are highly significant in all models, confirming that the explanatory variables collectively have a significant impact on inflation. The rho values, which measure the proportion of variance due to the individual effects, are lower in the models with interaction terms, suggesting that the introduction of interactions helps to account for more variation in the data.

iii. AR Tests: The AR(1) test shows negative and significant values, indicating some degree of autocorrelation in the models. However, the AR(2) test results are mostly insignificant, implying no serious issues with second-order autocorrelation.

iv. Sargan and Hansen Tests: The Sargan test results are generally insignificant, suggesting that the instruments used in the models are valid. The Hansen test is also mostly insignificant, further supporting the validity of the instruments.

Conclusion

The study confirms that the relationship between petroleum product prices and inflation in Nigeria is significantly nonlinear, aligning with earlier findings. The hypothesis positing that retail energy prices and exchange rates play an asymmetric role in influencing inflationary pressures across different states has been validated. This research adds to the academic literature by highlighting the distinctive dynamics in Nigeria's context—particularly post-subsidy removal, where the economic landscape has shifted due to the elimination of fuel subsidies and the depreciation of the Naira. By integrating geographic and infrastructural factors, such as proximity to petroleum depots and seaports, the study provides a more comprehensive understanding of inflationary pressures, underscoring the heterogeneity of inflation impacts across Nigerian states.

The study's results are valuable in delineating the specific role of refined petroleum products—AGO, PMS, and DPK—in driving both headline and food inflation. The findings underscore the limitations of previous research that focused predominantly on aggregate crude oil prices, failing to capture the immediate and regionally diverse impacts of refined product prices on inflation. This research advances the methodology by employing interaction terms, which reveal how exchange rate fluctuations exacerbate or moderate the inflationary effects of petroleum products. Such an approach addresses the shortcomings of additive models that cannot capture the complex interplay between multiple economic shocks, such as international oil price volatility and domestic pricing reforms.

However, the study acknowledges several constraints. The reliance on available data, which may not fully capture informal market dynamics, introduces a constraint. The complexity of Nigeria's retail energy market, influenced by factors like smuggling and unofficial transactions, may lead to underestimations or overestimations of certain price impacts. Additionally, the study's focus on state-level geographic differences, while informative, does not account for intrastate disparities, particularly in larger states with diverse economic activities. These limitations suggest that future research should explore sub-state level data to refine the understanding of regional inflation dynamics further.

Considering these findings, several areas warrant future exploration. Further research could integrate more granular variables, such as household energy consumption patterns, local production structures, and state-level economic resilience indicators. Examining the long-term effects of exchange rate stabilization policies, as well as the implementation of alternative energy sources, could provide valuable insights into mitigating inflationary risks associated with retail energy price fluctuations. Additionally, the role of market competition within the downstream petroleum sector merits deeper investigation, particularly in the context of Nigeria's evolving subsidy and exchange rate policy landscape.

The study's results carry critical implications for economic policy in Nigeria. The evidence points to the necessity of region-specific strategies for managing inflation, given the varying impacts of petroleum product prices across states. Policymakers should prioritize enhancing infrastructure in regions far from petroleum depots and seaports to reduce transportation costs, thereby mitigating inflationary pressures. The study also highlights the importance of maintaining a stable exchange rate to curb the pass-through effects of imported energy price shocks. In the post-subsidy era, fostering competitive market conditions within the downstream petroleum sector can help buffer the economy from global oil price volatility, stabilizing inflation rates. Moreover, the research suggests the need for phased and well-communicated policy changes, including targeted social safety nets, to cushion the adverse effects on vulnerable households, particularly those heavily reliant on subsidized energy.

In conclusion, this study not only enhances the understanding of Nigeria's inflation dynamics but also contributes to the broader literature on the interaction between retail energy prices and macroeconomic stability in developing economies. It emphasizes that policy interventions must be carefully designed to account for Nigeria's unique economic structure, which is heavily influenced by external shocks, domestic vulnerabilities, and geographic disparities. Without a context-specific approach, attempts to manage inflation through conventional macroeconomic measures may fall short, as Nigeria's recent experience with subsidy removal and exchange rate unification vividly demonstrates. Thus, the research underscores the necessity for adaptive, evidence-based economic policies to ensure equitable economic development and stability across the country.

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