Oil Price Fluctuations and Food Inflation in the Comoros: A Nonlinear ARDL Approach

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Abstract— The asymmetric transmission of oil price fluctuations into food inflation in Small Island Developing States (SIDS) remains insufficiently explored, despite its importance for price stability and economic resilience. This study addresses this gap by focusing on the Comoros, an import-dependent island economy where exposure to external shocks is structurally amplified. Using a Nonlinear Autoregressive Distributed Lag (NARDL) framework complemented by Quantile Regression from 2000 to 2024, we uncover the complex dynamics linking oil prices, exchange rate movements, GDP per capita growth, and food inflation. The results show clear short-run asymmetries: positive oil price shocks significantly raise food inflation ($\beta = 12.74$, $p < 0.01$), while negative shocks produce an even stronger deflationary effect ($\beta = –22.10$, $p < 0.01$), confirming a pronounced "rocket and feather" pattern. Exchange rate depreciation emerges as the dominant driver of short-run inflation ($\beta = 56.98$, $p < 0.001$), while improved economic conditions exert a mild stabilizing effect ($\beta = –1.23$, $p < 0.05$). The error correction term (–0.91) indicates rapid adjustment toward long-run equilibrium. Quantile estimates reveal that oil price shocks intensify during high-inflation regimes (90^{th}), whereas exchange rate shocks are most destabilizing during low-inflation(50^{th}) periods, highlighting substantial distributional heterogeneity. These findings offer critical insights for policymakers in SIDS seeking to design targeted, shock-responsive inflation management strategies.

Keywords: Food Inflation, NARDL, Oil Price Chocks, Quantile Regression, Small Island Developing State

I. INTRODUCTION

Managing food inflation is a paramount challenge for the Comoros, a Small Island Developing State (SIDS) whose economic stability and household food security are perpetually threatened by global market volatility. The nation's profound vulnerability stems from its near-total dependence on imported food and fuel. This dual dependency creates a direct and potent transmission channel, meaning international price shocks for these essential commodities can rapidly destabilize domestic price levels (Kamara et al., 2025; Mezouri,Benharrat, 2022) . The recent Ukraine-Russia conflict has starkly illustrated how geopolitical events can trigger global energy and food price surges, with severe repercussions for import-dependent nations, particularly in regions like the Middle East and North Africa (MENA) which share similar vulnerabilities with the Comoros (Mezouri,Benharrat, 2022). In such contexts, understanding the

precise mechanics of how international oil prices translate into domestic food inflation is not merely an academic exercise but a necessity for effective policy formulation.

A central issue complicating inflation management in import-dependent economies is the potential presence of asymmetric price transmission, often described as the "rocket and feather" effect. This phenomenon occurs when global oil price increases are passed through to consumers quickly (like a rocket), but price decreases are absorbed slowly by intermediaries (like a feather) (Lawali et al., 2025; Yu et al., 2023a) . Such asymmetry can severely erode the purchasing power of households and create persistent inflationary pressures that are unresponsive to temporary dips in global commodity prices. This complicates the central bank's monetary policy, which may be ill-equipped to handle cost-push inflation driven by such market imperfections (Lawali et al., 2025). Furthermore, the relationship may not be uniform across all levels of inflation, behaving differently during periods of price stability versus high inflation crises.

While the oil-food price nexus is a well-researched area globally, existing literature, including studies on Nigeria (Lawali et al., 2025), China (Yu et al., 2023a), and MENA countries (Mezouri,Benharrat, 2022), has made significant strides, yet critical gaps remain concerning the Comoros. Firstly, most studies predominantly assume a symmetric relationship between oil and food prices, an assumption that is increasingly being challenged (Yu et al., 2023; Kamara et al., 2025). Secondly, many analyses fail to account for how this relationship might evolve across different inflationary conditions (quantiles). As demonstrated by (Yu et al., 2023a), the oil-food price connection can be weak at moderate inflation levels but intensify dramatically during high-inflation periods. Finally, the unique economic context of the Comoros characterized by its status as a SIDS, extreme import dependency, and small market size remains critically underexplored through a nonlinear and conditional lens.

The Comoros's economic structure amplifies its susceptibility to these asymmetric and state-dependent shocks. Unlike larger, more diversified economies, it lacks the fiscal buffers and domestic production capacity to insulate itself effectively. Therefore, to address the gap in context-specific and methodologically appropriate research, this study moves beyond conventional linear frameworks. The primary objective is to rigorously investigate the presence and nature of asymmetric effects of international oil price fluctuations on domestic food inflation in the Comoros, and to determine how these effects vary across different states of the food inflation distribution.

To achieve this, the paper applies an integrated methodological framework combining the Nonlinear Autoregressive Distributed Lag (NARDL) model with Quantile Regression analysis. The NARDL model, successfully employed in recent asymmetric analyses (Kamara et al., 2025; Mezouri,Benharrat, 2022) allows for the explicit testing of the "rocket and feather" hypothesis by decomposing oil price movements into positive and negative partial sums. Complementing this, the Quantile Regression approach (Yu et al., 2023) is employed to uncover the potentially heterogeneous effects of oil prices at different points of the food inflation distribution from low to high inflation regimes. This integrated approach offers a more holistic and nuanced understanding, aiming to generate robust policy insights tailored to the specific economic realities of the Comoros, thereby contributing to more effective and resilient inflation management strategies for one of the world's most vulnerable economies.

II. LITERATURE REVIEW

The relationship between oil price fluctuations and food inflation is a critical area of macroeconomic research, with a vast body of evidence highlighting its complexity and context-dependence. Early literature often relied on linear, symmetric models, but a dominant theme in recent studies is the exploration of nonlinearities, asymmetries, and conditional dynamics that govern this nexus. This review synthesizes global evidence around three key

advancements: the prevalence of asymmetric "rocket and feather" effects, the conditional nature of the relationship across market regimes, and the significant variation in transmission channels across different economic contexts.

A robust finding across diverse economies is the asymmetric transmission of oil price shocks to food prices, often termed the "rocket and feather" effect, where food prices rise more quickly and strongly with oil price increases than they fall with oil price decreases. Studies employing the Nonlinear Autoregressive Distributed Lag (NARDL) model have consistently confirmed this asymmetry in contexts such as the Euro Area (Borrallo et al., 2024), Nigeria (Adeosun et al., 2023; Yusuf et al., 2024) ,and Malaysia (Ibrahim & Mansor, 2015), with positive oil price shocks exerting a significant and persistent impact while negative shocks are often statistically weak or insignificant. This pervasive pattern challenges linear modeling and strongly justifies the use of an asymmetric NARDL framework for an import-dependent and vulnerable economy like the Comoros.

Beyond simple asymmetry, advanced quantile-based methodologies reveal that the oil-food price linkage is not uniform; its strength and even direction vary significantly with the state of the market. The pioneering work of (Yu et al., 2023b) in China, using a Quantile-on-Quantile (QQ) approach, demonstrated that the effect is weakest (or even negative) at lower and medium quantiles of food inflation but intensifies into a strong positive correlation at higher quantiles a pattern also observed in other studies (Chang et al., 2024; Derindag et al., 2023). This indicates that oil price shocks have a disproportionately larger effect during crises of high food inflation. Furthermore, research decomposing oil shocks into supply, demand, and risk components shows heterogeneous impacts across inflation environments (Ge & Sun, 2024; Mishra et al., 2024), while other work finds that connectedness and spillover effects between oil and agricultural commodities are markedly stronger during extreme market conditions than in normal periods(Dejan et al., 2019; Olayinka et al., 2025). This body of evidence underscores the necessity of complementing asymmetric cointegration analysis with Quantile Regression to understand the full spectrum of dynamics in the Comoros, from stable periods to episodes of severe price surges.

The strength and nature of the oil-food price link also demonstrate significant regional and contextual variations, influenced by economic structure, policy, and external shocks. A broad consensus from studies in Latin America (Köse & Ünal, 2022) , the European Union (Balogh & Sárvári, 2025), and South Asia (Mishra et al., 2024; Nayak & Jena, 2025) affirms that oil prices are a significant driver of food inflation. Transmission channels, however, are multifaceted and can include bidirectional influences through biofuel demand (Adeosun et al., 2023; Salles, 2024) or be amplified by factors such as monetary policy, exchange rate crises, and economic sanctions (Mahmoudinia, 2021). Conversely, some research presents a more nuanced or muted role for oil prices, suggesting that in certain contexts such as MENA countries domestic food prices can be a more dominant driver of consumer prices than external oil shocks (Belke & Dreger, 2015). The relationship can also vary across specific food commodities, with stronger long-term linkages observed for staples like meat and cereals and weaker ones for others (Ebadi et al., 2024; Roman et al., 2020).

Synthesizing this global evidence reveals a clear and critical research gap. While the methodological superiority of NARDL and Quantile Regression for capturing asymmetric and conditional dynamics is well-established, and the vulnerability of import-dependent economies is documented, there is a conspicuous absence of focused research on Small Island Developing States (SIDS) like the Comoros. The unique economic structure of the Comoros marked by extreme import dependency, a narrow production base, limited financial depth, and high exposure to external shocks creates a transmission mechanism fundamentally different from the larger, more diversified economies typically studied. The existing literature provides the analytical toolkit but not the specific application. Therefore, this study aims to fill this critical void by applying an integrated NARDL and Quantile Regression framework to the Comorian case. This approach will rigorously test for asymmetric "rocket and feather" effects while simultaneously uncovering

how these impacts vary across different food inflation regimes, from low-stability to high-crisis quantiles. In doing so, it will generate policy insights specifically tailored to the precarious economic reality of a SIDS, offering a more nuanced and actionable understanding than what can be extrapolated from studies on larger or structurally different economies.

III. DATA AND MATERIALS

III.I. DATA SOURCES AND DESCRIPTIONS

The variable selection for this analysis is grounded in the established theoretical channels of international price transmission and tailored to the specific economic context of the Comoros. The core relationship under investigation is between domestic food inflation (f_inflation), the dependent variable, and the global crude oil price (crude_oil_price), proxied by the Europe Brent spot price. This primary independent variable is justified by the multiple pathways through which oil prices affect food costs, including agricultural production inputs (fertilizers, machinery), transportation, and processing.

Critically, for a small, import-dependent nation like the Comoros, the exchange rate channel is paramount. Fluctuations in the international price of oil, which is denominated in US Dollars, are filtered through the domestic exchange rate (exchange_rate), defined as Comorian Francs (KMF) per US Dollar (USD). An appreciation of the USD can significantly increase the domestic cost of imported oil and food, even if international prices remain stable. Therefore, omitting this variable would risk model misspecification and an inaccurate estimation of the true pass-through effect.

The study utilizes annual data from 2000 to 2024, sourced from authoritative databases like FAOSTAT and Our World in Data. This timeframe captures multiple global oil price cycles and food crises, providing a robust period for analysis. A detailed summary of the data is presented in **Table 1**.

***Table 1**:Description of variables and sources*

Code	Variable	Proxy	Source
FoodPrice	Food Inflation	Inflation, food consumer prices (annual %)	FAOSTATS
OilPrice	Crude Oil Price	Global price Brent Crude (US$/barrel)	FRED
ExchangeRate	Exchange Rate	KMF per USD (periode average)	Our World in Data
GdpPCGrowth	Gdp per capita growth	Gdp Growth Rate (%)	World bank open data

Figure 1 shows that between 2000 and 2024, oil prices fluctuated sharply while food inflation remained relatively moderate. From 2000 to 2007, oil prices rose steadily, but food inflation stayed low, suggesting limited immediate transmission of energy costs to food prices. During 2008-2013, oil prices reached their highest levels, and food inflation increased slightly, reflecting some delayed impact of global oil and commodity shocks.

Between 2014 and 2019, oil prices dropped and then partially recovered, but food inflation showed little change, indicating a weak link between the two variables during this stable period. From 2020 to 2024, both oil prices and food inflation rose sharply, especially around 2021-2022 mainly due to the combined effects of the COVID-19 pandemic, supply disruptions, and global inflation pressures.

Overall, the relationship between oil prices and food inflation appears partial and asymmetric. Food inflation reacts to major oil price surges, especially during crises, but with smaller magnitude and some delay, showing that other structural and policy factors play a key role in moderating this link.

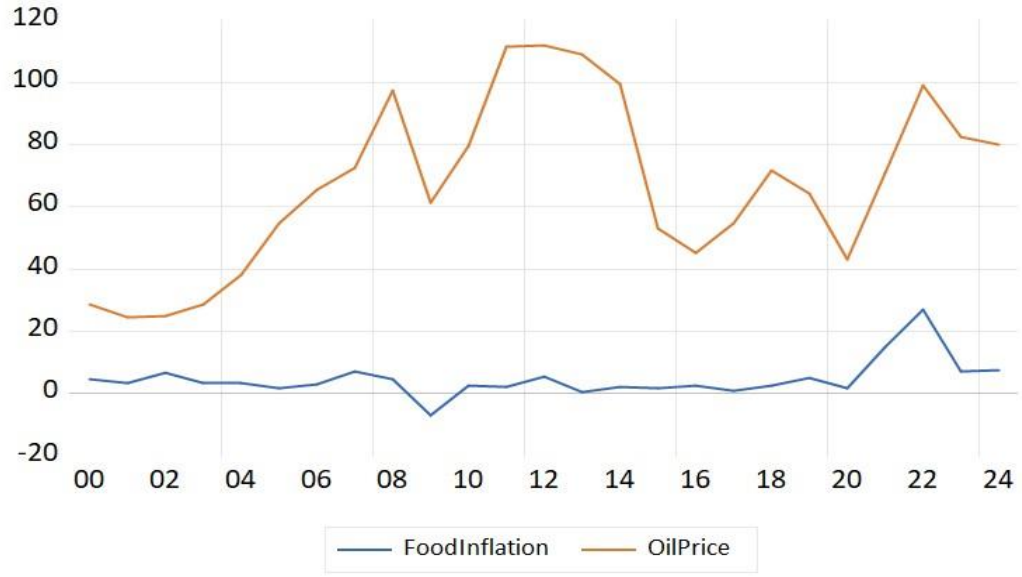

Figure 1: *Evolution of food inflation and oil fluctuation price*

III.II. DESCRIPTIVE STATISTICS

The characteristics of the series are presented in **Table 2** . Food inflation shows considerable volatility, with a standard deviation of 2.87 around a mean of 2.67, and a significant negative skewness due to the sharp deflation in 2009. The oil price also exhibits high volatility. The correlation matrix indicates a moderate negative correlation between the exchange rate and oil price, which is intuitive (a stronger KMF, i.e., a lower exchange rate number, is often associated with periods of higher global commodity prices). More importantly, the correlations between the independent variables are not excessively high, suggesting that multicollinearity is not a severe concern for the model estimation.

Table 2*:Descriptive Statistics and Correlation Matrix*

Variables	FoodPrice	lnOilPrice	lnExchangeRate	GdpPCGrowth
Mean	4.581466	4.10805	6.034579	1.948439
Median	3.292057	4.183648	6.03209	1.451231
Maximum	27	4.718603	6.309517	8.740015
Minimum	-6.946012	3.20736	5.816677	-1.189074
Std.Dev.	5.979451	0.469068	0.131039	2.250807
Skewness	2.121417	-0.560421	0.404689	1.417109
Kurtosis	9.610565	2.274187	2.523332	4.845501
Jarque-Bera	64.27209	1.857385	0.919067	11.91527
Probability	0.0000	0.39507	0.631578	0.002586

FoodPrice	1	0.1772	0.3042	-0.2780
lnOilPrice	0.1772	1	-0.6896	0.1747
lnExchangeRate	0.3042	-0.6896	1	-0.0640
GdpPCGrowth	-0.2780	0.1747	-0.0640	1
Observations	25	25	25	25

Source: Author's calculation.

IV. ECONOMETRICS METHODOLOGY

IV.I. NARDL APPROACH

Conventional linear econometric methodologies, such as the standard Autoregressive Distributed Lag (ARDL), Johansen cointegration, and Vector Error Correction Models (VECM), are fundamentally limited by their implicit assumption of symmetric adjustments. This foundational premise renders them insufficient for comprehensively examining the dynamic relationship between oil prices and food inflation, as they cannot capture nuanced phenomena like the "rocket and feather" effect, where positive and negative oil price shocks transmit asymmetrically. In recognition of this methodological gap, a growing body of recent research has successfully turned to nonlinear frameworks to model the food inflation-oil price nexus, demonstrating their pronounced superiority in contexts characterized by market imperfections and external shocks, as evidenced by studies from (Alauddin et al., 2024), (Bawa et al., 2021),(Ettayib Mezouri et al., 2024) , and (Kamara et al., 2025), among others.

It is within this advanced nonlinear paradigm that the present study is situated. To rigorously test for these hidden asymmetric effects in the specific context of the Comoros, this research employs the Nonlinear Autoregressive Distributed Lag (NARDL) model advanced by (Shin et al., 2011) . The core analytical strength of the NARDL approach lies in its decomposition of a key explanatory variable in this case, oil prices into distinct partial sum processes for positive and negative shocks. This critical decomposition allows for the separate estimation of both the short-run and long-run impacts of oil price increases and decreases on food inflation, thereby providing a direct and powerful test for the presence of asymmetry.

The selection of the NARDL framework is further justified by its suite of compelling econometric advantages. First, unlike threshold cointegration methods that primarily assess long-run asymmetries, the NARDL model seamlessly integrates and tests for asymmetries in both the short and long run within a single, unified specification. Second, it offers considerable flexibility regarding the order of integration of variables, remaining applicable whether the regressors are integrated of order zero I(0), order one I(1), or a mutually cointegrated combination; this effectively avoids the pre-testing constraints inherent in traditional cointegration methods. Finally, the NARDL approach is notably parsimonious, sidestepping the convergence issues often associated with more parameter-intensive nonlinear models like smooth transition or threshold VECMs. Ultimately, by quantifying the distinct effects of positive and negative shocks, the NARDL model yields the nuanced and actionable insights necessary for formulating effective, targeted policy responses to manage food inflation in the Comoros. The empirical model utilized in this study, building upon this robust framework, can be expressed as follows:

$$FoodPrice_t = \beta_0 + \beta_1^+ lnOilPrice_t + \beta_2^- lnOilPrice_t + \beta_3 lnExchangeRate_t + \beta_4 GdpPCGrowth_t + \varepsilon_t \quad (1)$$

Where, $\beta_=$ (β_1^+, β_2^-, β_3) shows the long run coefficient. As $lnENERG\_PRICE_t^+$ shows the positive partial sum decomposition and $lnENERG\_PRICE_t^-$ shows the negative partial sum decomposition in LnENERG_PRICE:

$$lnOilPrice_t^+ = \sum_{j=1}^{t} \Delta lnOilPrice_j^+ = \sum_{j=1}^{t} \max(\Delta lnOilPrice_j, 0) \quad (2)$$

$$lnOilPrice_t^- = \sum_{j=1}^{t} \Delta lnOilPrice_j^- = \sum_{j=1}^{t} min(\Delta lnOilPrice_j, 0)$$

From equation (1), Non-linear ARDL model of Shin et al. (2014) is expressed using the following cointegration equation:

$$\Delta FoodPrice_t = \delta_0 + \sum_{i=1}^{p} \delta_1 \Delta FoodPrice_{t-1} + \sum_{i=1}^{q} (\delta_2^+ \Delta lnOilPrice_{t-1}^+ + \delta_3^- \Delta lnOilPrice_{t-1}^-) + \sum_{i=1}^{m} \delta_4 \Delta lnExchangeRate_{t-1} + \sum_{i=1}^{n} \Delta GdpPCGrowth_{t-1} + \lambda_1 FoodPrice_{t-1} + \lambda_2^+ lnOilPrice_{t-1}^+ + \lambda_3^- lnOilPrice_{t-1}^- + \lambda_4 lnExchangeRate_{t-1} + \lambda_5 GdpPCGrowth_{t-1} \quad (3)$$

Where p, q, m, and n present the orders of lags. To estimate equation (1) without the problem of hidden cointegration, the following restrictions on the coefficient of equation (3) are required as:

$\beta_1^+ = \lambda_2^+ / \lambda_1$ and $\beta_2^- = \lambda_3^- / \lambda_1$

And $\sum_{i=1}^{q} \delta_2^+$ calculate the positive effect and $\sum_{i=1}^{q} \delta_3^-$ calculate the negative effect in the short run of lnENERG_PRICE on Food_price, respectively. From equation (3), the error correction model is expressed by following equation:

$$\Delta FoodPrice_t = \gamma_0 + \sum_{i=1}^{p} \gamma_1 \Delta FoodPrice_{t-i} + \sum_{i=1}^{q} (\gamma_2^+ \Delta lnOilPrice_{t-i}^+ + \gamma_3^- \Delta lnOilPrice_{t-i}^-) + \sum_{i=1}^{m} \gamma_4 \Delta lnExchangeRate_{t-i} + \sum_{i=1}^{n} \gamma_5 \Delta GdpPCGrowth_{t-i} + \omega_i ECT_{t-i} \quad (4)$$

Here, γ_1, γ_4 and γ_5 show the coefficients in short run, while γ_2^+ and γ_3^- show the adjustment of symmetry in the short run and ω_i is the ECM.

Wald introduced a hypothesis test to examine the presence of either symmetric or asymmetric effects, which is outlined as follows:

- For the long run:

$H_0: \frac{\lambda_2^+}{\lambda_1} = \frac{\lambda_3^-}{\lambda_1}$ ⇒ Symmetric effect of lnOilPrice in the long run

$H_1: \frac{\lambda_2^+}{\lambda_1} \neq \frac{\lambda_3^-}{\lambda_1}$ ⇒ Asymmetric effect of lnOilPrice in the long run

- For the short run :

$H_0: \frac{\delta_2^+}{\delta_1} = \frac{\delta_3^-}{\delta_1}$ ⇒ Symmetric effect of lnOilPrice in the short run

$H_1: \frac{\delta_2^+}{\delta_1} \neq \frac{\delta_3^-}{\delta_1}$ ⇒ Asymmetric effect of lnOilPrice in the short run

IV.II. QUANTILE REGRESSION

This approach allows us to rigorously investigate whether the pass-through of international oil prices to Comorian food inflation is uniform or if it intensifies, weakens, or changes direction across different market conditions. This

methodology is vital for moving beyond average effects, which can mask critical dynamics during both periods of price stability and inflationary crises. The necessity of such granular analysis is strongly supported by a growing body of global evidence employing quantile-based techniques. Studies by (Yu et al., 2023a),(Roman et al., 2020), and (Chang et al., 2024), among others, have consistently demonstrated that the oil price-food inflation nexus is highly regime-dependent, with transmission elasticities varying significantly and often non-monotonically between low, moderate, and high inflation quantiles. For instance, research in various contexts has found that pass-through can be muted during periods of price stability but becomes significantly amplified during high-inflation episodes, a finding echoed in the work of (Mahmoudinia, 2021) ,(Derindag et al., 2023) , and (Yodah et al., 2024) . By applying this advanced framework to the Comoros, our study aims to uncover these hidden, context-specific dynamics, thereby providing a much more complete and policy-relevant picture than conventional methods permit.

The quantile regression can be expressed as follows:

$$\min_{\xi \in \Re} \sum \rho_\tau (y_i - \xi), \qquad (5)$$

Where the function $\rho_\tau(.)$ is titled absolute value function appearing in **Figure 2**, gives the τth sample quantile function as its solution.

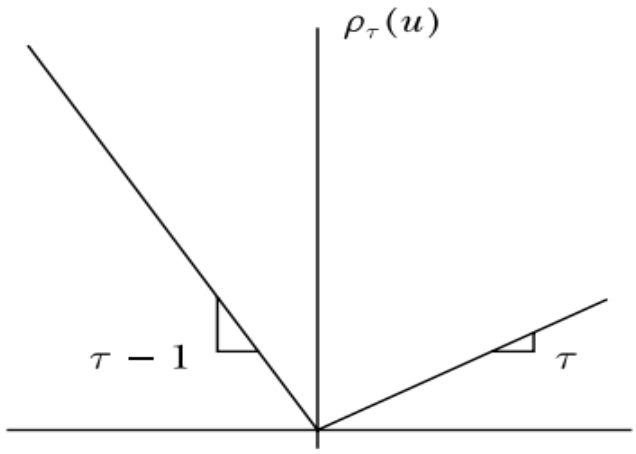

***Figure 2**:Quantile regression ρ function*

An estimate of the conditional median function can be obtained by replacing the scalar ξ in equation (5) by the parametric function $\xi(x_i, \beta)$, and setting τ to $1/2$. Estimates of the other conditional quantile functions can be obtained by replacing the absolute values by $\rho_\tau(.)$, and solving expression (6) by linear programming:

$$\min_{\beta \in \mathbb{R}_p} \sum \rho_\tau \big(y_i - \xi(x_i, \beta)\big) \qquad (6)$$

We apply quantile regression to investigate the relationship between the logarithmic oil fluctuations, exchange rate and GDP per capita growth.

V. EMPIRICAL RESULTS AND DISCUSSIONS

V.I. UNIT ROOT TEST RESULTS

Time series data often contains a trend that violates the stationarity assumption. Therefore, to avoid this error, a unit root test is conducted using the Augmented-Dickey Fuller (ADF) and Phillips-Perron (PP) tests to verify that none of the variables are stationary at second order I(2). The results of the unit root tests, as illustrated in **Table 3 Error! Reference source not found.**, indicate that the variables presented a mixed order of integration between I(0) and I(1) and the dependent variable FoodPrice is integrated after the first difference I (1). Therefore, the condition for conducting asymmetric ARDL bound testing has been confirmed.

***Table 3**:Unit Root Test Results*

	ADF		**PP**	
Variables	Intercept	Intercept & Trend	Intercept	Intercept & Trend
Level I (0)				
FoodPrice	-0.14 (0.04) **	-3.45* (0.07)	-3.16 **(0.04)	-2.68 (0.25)
lnOilPrice	-1.91 (0.32)	-1.82 (0.66)	-1.83 (0.36)	-1.76 (0.24)
lnExchangeRate	-2.05(0.26)	-1.97(0.59)	-2.06 (0.26)	-2.71(0.24)
GdpPCGrowth	-4.88*** (0.00)	-4.81*** (0.00)	-4.75*** (0.00)	-4.69** (0.01)
First diff I (1)				
ΔFoodPrice	-5.39*** (0.00)	-5.66*** (0.00)	-13.25***(0.00)	-13.60*** (0.00)
ΔlnOilPrice	-4.27*** (0.00)	-4.31*** (0.01)	-4.25*** (0.00)	-4.57*** (0.01)
ΔlnExchangeRate	-4.17*** (0.00)	-4.85***(0.00)	-4.16***(0.00)	-4.87***(0.00)
ΔGdPCGrowth	…	…	…	…

N.B: The equations for the ADF and PP tests include both constant terms and trend terms. The *, **, *** represents the significance level for rejecting the hypotheses of unit root test respectively at 10%; 5% and 1% significance level.

IV.II. NARDL RESULTS

The short-run dynamics in **Table 4**, reveal a highly responsive and asymmetric transmission of external shocks to food inflation in the Comoros. A critical finding is the confirmed presence of short-run asymmetry in oil price pass-through. While a 1% increase in oil prices raises food inflation by approximately 12.74 percentage points, a 1% decrease leads to a much larger decline of about 22.10 percentage points. This validates a "rocket and feather" effect where the disinflationary benefit of falling oil prices is more immediate and potent than the inflationary pressure from rising prices, suggesting competitive forces may prompt a swift pass-through of cost savings. Furthermore, the exchange rate emerges as the most powerful short-run driver, where a 1% depreciation of the domestic currency causes a sharp 56.98 percentage point increase in food inflation, highlighting the profound vulnerability of an import-dependent economy. Concurrently, economic growth exerts a mild stabilizing effect, with a 1% increase in GDP per capita reducing food inflation by about 1.23 percent points.

The model's robustness is underscored by a highly significant and negative Error Correction Term (ECT) of -0.907, which indicates a remarkably rapid adjustment process. Approximately 90.7% of any deviation from the long-run equilibrium is corrected within a single period, demonstrating that the Comorian food market, while volatile, is quick to self-correct after a shock. The model's excellent fit, with an R-squared of 0.904 and a statistically significant F-statistic, confirms that these asymmetric and linear factors collectively explain over 90% of the short-run fluctuations in food inflation, providing a reliable foundation for policy analysis.

***Table 4**:Short run NARDL outputs*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ΔlnOilPrice$^+$	12.73526***	4.144677	3.072678	0.0097
Δ lnOilPrice$^-$	22.09809***	4.668387	4.733561	0.0005
ΔlnExchangeRate	56.98182***	9.451344	6.028964	0.0001
ΔGdpPCGrowth	-1.231953**	0.497369	-2.476939	0.0291
ECT (-1)	-0.907542***	0.153408	-5.915875	0.0001
R^2	0.903921	**Mean dependent var**		-0.133316
Adjusted R^2	0.873897	**S.D. dependent var**		11.29789
S.E. of regression	4.011994	**Akaike info criterion**		5.843455
Sum squared residuals	257.5376	**Schwarz criterion**		6.141012
Log likelihood	-58.278	**Hannan-Quinn criterion**		5.91355
D-W	1.873597			
F-statistic	30.10605			
Prob(F-statistic)	0.0000			

N.B: The *, **, *** represents the significance level respectively at 10%; 5% and 1% significance level The lag order utilized in this analysis is 1,1, determined based on Akaike's information criterion (AIC) for selecting the appropriate lag length.

The long-run estimates in **Table 5**, present a contrasting picture to the short-run dynamics, revealing an equilibrium relationship where the direct statistical significance of individual variables diminishes. In the long run, neither positive nor negative oil price shocks exhibit a statistically significant impact on food inflation, as indicated by their high p-values (0.577 and 0.5733, respectively). Similarly, the coefficients for the exchange rate and economic growth, while bearing the expected positive and negative signs, are not statistically significant. This suggests that while these factors are potent drivers of short-term volatility, their isolated, direct influence is absorbed, neutralized, or superseded by other broader economic adjustments over the long term. The convergence of the positive and negative oil price coefficients to nearly identical values (4.32 and 4.43) points to a long-run symmetry, where the cumulative effects of oil price increases and decrease eventually balance out. This finding implies that the structural forces governing the long-run equilibrium of the Comorian economy such as technological adaptation, fiscal policy, or long-

term trade patterns effectively dampen the persistent asymmetric pressures observed in the short run, leading to a state where these specific variables lose their individual statistical prominence.

***Table 5**:Long run NARDL results*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LnOilPrice^{+}(-1)	4.31743	7.530223	0.573347	0.577
lnOilPrice^{-}(-1)	4.431204	7.652626	0.579044	0.5733
lnExchangeRate(-1)	36.87153	27.62038	1.334939	0.2067
GdpPCGrowth(-1)	-0.153236	0.697638	-0.21965	0.8298
C	1.21848	3.339779	0.364838	0.7216

N.B: The *, **, *** represents the significance level respectively at 10%; 5% and 1% significance level The lag order utilized in this analysis is 1,1, determined based on Akaike's information criterion (AIC) for selecting the appropriate lag length.

The F-bound test in **Table 6** was conducted to determine whether a stable, long-run equilibrium relationship exists between the variables in the model. The null hypothesis (H0) of no levels relationship is tested against the alternative that a long-run relationship exists. The computed F-statistic for the model is 5.25. To establish cointegration, this value must be compared against the critical value bounds: the lower bound I (0) represents the critical value if all variables are stationary, and the upper bound I (1) if they are integrated of order one. The results show that the F-statistic of 5.25 exceeds the upper critical value of 5.06 at the 1% significance level. Since the test statistics are greater than the I (1) bound, we can decisively reject the null hypothesis at the 1% significance level. This provides strong evidence for the presence of a long-term cointegrating relationship among food inflation, oil prices, the exchange rate, and economic growth, confirming that the variables move together in a stable equilibrium over time, despite their short-run fluctuations.

***Table 6**:Cointegration Bounds test*

F-Bounds Test			**H0: No levels relationship**	
	Value	**Signif.**	**I(0)**	**I(1)**
		Asymptotic: n=1000		
F-statistic	5.249637	10%	2.45	3.52
K	4	5%	2.86	4.01
		2.50%	3.25	4.49
		1%	3.74	5.06

IV.II.I. DIAGNOSTIC TEST RESULTS

The diagnostic checks conducted on the NARDL model in **Table 7**, confirm its statistical reliability and robustness. The Breusch-Godfrey serial correlation LM test (X^2SC) yields a p-value of 0.29, which is well above the conventional 5% significance level, indicating that we cannot reject the null hypothesis of no serial correlation in the residuals. This suggests the model's error terms are independent. Similarly, the Heteroskedasticity Test (X^2HET) with a p-value of 0.45 fails to reject the null hypothesis of constant variance, confirming that the model does not suffer from heteroskedasticity. The Normality test, with a p-value of 0.46, indicates that the residuals are normally distributed, validating the reliability of the t-statistics and F-statistics used for inference. Finally, the Ramsey RESET test for functional form misspecification, with a p-value of 0.46, suggests that the model is correctly specified and that no important variables or nonlinear forms have been omitted. Collectively, these diagnostic results affirm that the estimated NARDL model is well-specified, efficient, and its statistical inferences are valid.

***Table 7**:Diagnostic tests results*

Tests	F-Statistic (P-value)
X^2_{SC}	1.409727(0.29)
X^2_{HET}	1.064515(0.45)
Normality test	1.540033(0.46)
Ramsey Test	0.590525(0. 46)

Note: X^2_{SC} et X^2_{HET} represent serial correlation and heteroscedasticity, respectively. The parentheses indicate the p-values.

The Wald test results in **Table 8** provide formal statistical evidence for the nature of asymmetry in the oil price pass-through to food inflation. For the long-run asymmetry, the test yields an F-statistic with a p-value of 0.064. This value is marginally above the conventional 5% significance level but falls within the 10% significance threshold. This suggests that while there is some evidence of a differential long-run impact, the distinction between the cumulative effects of oil price increases and decreases is not strongly definitive. In contrast, the test for short-run asymmetry is unequivocal, with a highly significant Chi-square p-value of 0.0034. This result allows us to firmly reject the null hypothesis of short-run symmetry, confirming that the immediate impacts of oil price increases and decreases on food inflation are statistically different in both magnitude and speed. This finding robustly validates the presence of the "rocket and feather" effect in the short-run dynamics of the Comorian economy.

***Table 8**:Wald Test*

	Long-run Asymmetry	Short-run Asymmetry

	F-statistic	P-value	Chi-square	P-value
lnOilPrice	4.157347	0.064	8.570913	0.0034

IV.II.II. STRUCTURAL STABILITY TEST

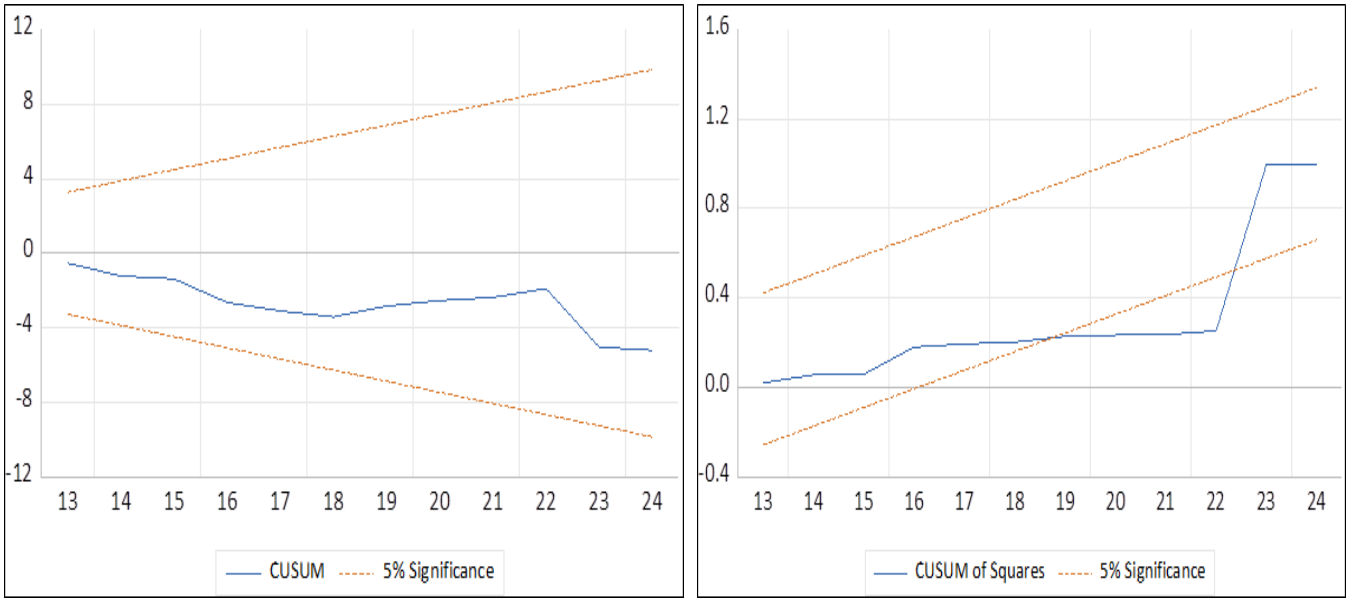

***Figure 3**:CUSUM and CUSUMSQ Plots*

To evaluate the structural integrity of the models, this research incorporated stability analysis methods. **Figure 3** presents the outcomes of two key stability tests: the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ). The statistical results derived from these tests reveal significance at different levels 10% for CUSUM and 5% for CUSUMSQ. These findings point to a notable degree of structural stability in the model coefficients, reinforcing the robustness of the analytical framework employed in this study.

IV.II.III. DYNAMIC MULTIPLIER

The study employs a dynamic multiplier graph to assess the asymmetric effects resulting from decomposing energy consumption per capita into positive and negative shocks. **Figure 4** illustrates these findings, revealing that Comoros' economic growth responds favorably to increases in energy consumption per capita, while decreases lead to negative economic impacts. The analysis indicates that these effects are more pronounced over extended periods compared to short-term horizons. Notably, the long-term economic boost from positive energy consumption shocks outweighs the decline caused by negative shocks, suggesting an asymmetric relationship between energy use and economic performance in Comoros.

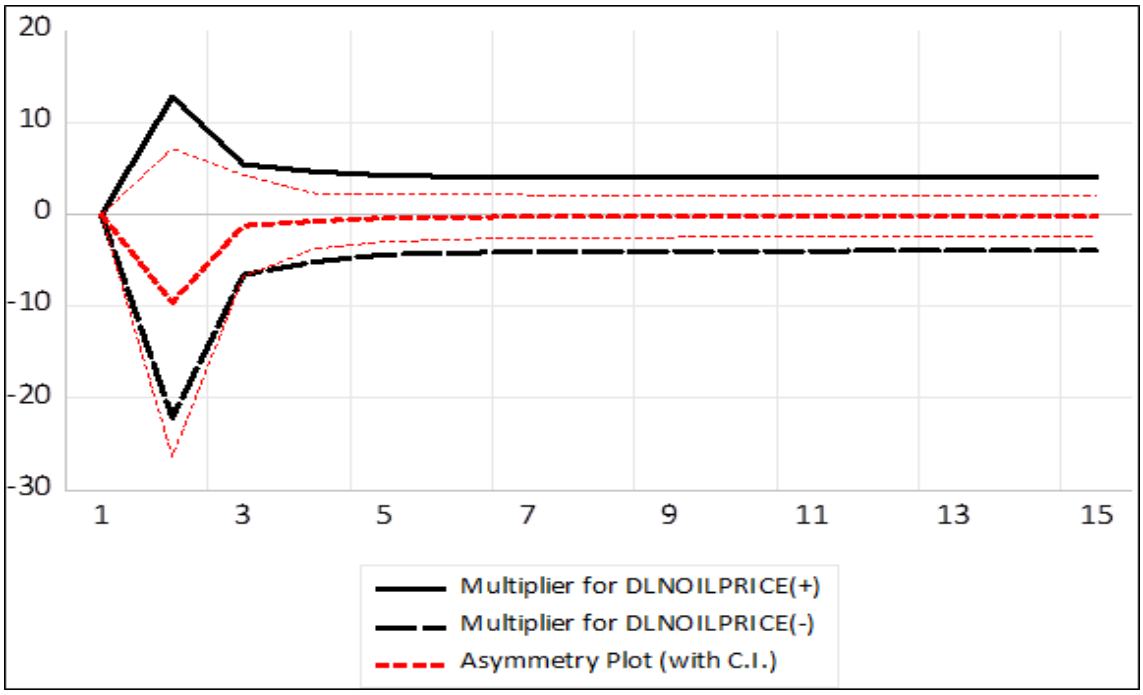

***Figure 4**:Asymmetric dynamic multipliers effects of Energy consumption per capita on GDP*

IV.III. QUANTILE REGRESSION RESULTS

The Quantile Regression analysis reveals significant distributional heterogeneity in the drivers of food inflation across different market conditions. The impact of oil prices is consistently significant and positive at most quantiles, but its influence is most volatile at the lowest inflation regime (10th quantile), where a 1% increase in oil prices leads to a substantial 26.98 percentage point surge in food inflation. As we move to higher inflation quantiles, the oil price effect stabilizes around 15-18 percentage points, becoming most precisely estimated at the 90th quantile. Similarly, the exchange rate exhibits its strongest and most significant impact during low-inflation periods, with a 1% depreciation causing a dramatic 94.90 percentage point increase in food prices at the 10th quantile. This effect diminishes considerably but remains significant at higher quantiles, suggesting that currency shocks are particularly destabilizing during normally stable periods. Economic growth shows no statistically significant effect across the distribution, though the consistently negative coefficients at middle and upper quantiles hint at a potential mild stabilizing role. The escalating Pseudo R^2 values from 0.298 at the 10th quantile to 0.588 at the 90th quantile demonstrate that the model explains nearly 60% of food inflation variation during high-inflation episodes, substantially outperforming its explanatory power during normal periods.

***Table 9**:Quantile Regression results*

Variables	0.10th Coeff.	0.25th Coeff.	0.50th Coeff.	0.75th Coeff.	0.90th Coeff.
DLNOILPRICE	26.982** (12.135)	13.712 (9.725)	16.536** (5.999)	15.178** (5.474)	17.530*** (3.908)
DLNEXCHANGERATE	94.900* (51.499)	44.691 (31.906)	43.250** (17.619)	27.496* (14.273)	28.497* (15.252)
GDPGROWTH	1.020 (1.304)	-1.024 (0.856)	-0.792 (0.615)	-0.472 (0.567)	-0.618 (0.499)

Constant	-8.917 (5.407)	0.046 (3.223)	2.109 (1.442)	4.124*** (1.233)	5.401*** (1.076)
Pseudo R^2	0.2980	0.2141	0.2384	0.4021	0.5875
Observations	*24*	24	24	24	24

Notes: Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

The coefficient estimates for DLNOILPRICE are positive and statistically significant across almost all quantiles, ranging from 13.71 to 26.98. This implies that increases in global oil prices consistently raise food inflation in Comoros, with the effect being slightly stronger at the lower quantiles. The significance of this variable in **Table 9** confirms that energy-related costs play a key role in shaping domestic food prices, which is typical for small island economies heavily dependent on imported energy. **Figure 5** further illustrates this pattern: the green line representing DLNOILPRICE remains relatively stable across quantiles, indicating that oil price shocks exert a persistent inflationary effect regardless of the level of food inflation.

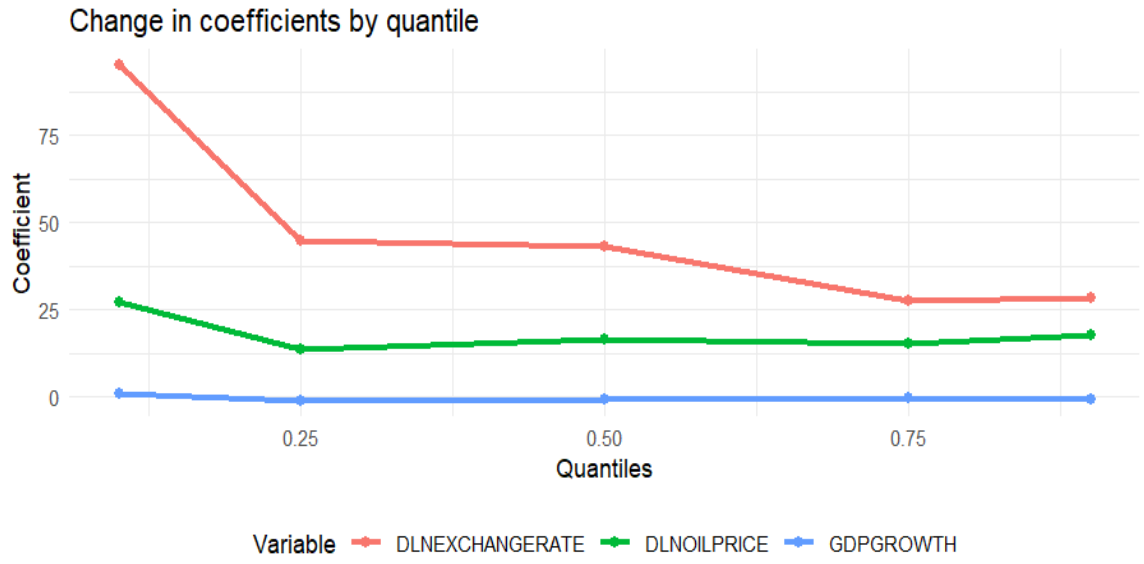

***Figure 5**:Change in coefficients by quantile*

The exchange rate variable (DLNEXCHANGERATE) also shows a positive and significant relationship with food inflation, especially in the lower quantiles, with coefficients declining from 94.9 at 0.10^{th} to 28.49 at 0.90^{th} . This pattern suggests that exchange rate fluctuations have a stronger effect on food inflation when inflation is low. In other words, during stable inflation periods, any depreciation of the local currency can rapidly translate into higher import prices, which in turn drive up food costs. This trend is clearly observed in **Figure 5** , where the red line sharply decreases across quantiles, confirming that exchange rate shocks are more pronounced at the lower tail of the inflation distribution.

By contrast, GDP growth (GDPGROWTH) exhibits small and statistically insignificant coefficients across all quantiles, oscillating around zero. This finding indicates that short-term economic growth does not significantly influence food inflation dynamics in Comoros. It may also reflect structural rigidities in the domestic food market

and a weak transmission channel between economic activity and consumer prices. The constant term becomes significant from the 0.75th quantile onward, implying that unobserved structural factors may drive food inflation at higher levels.

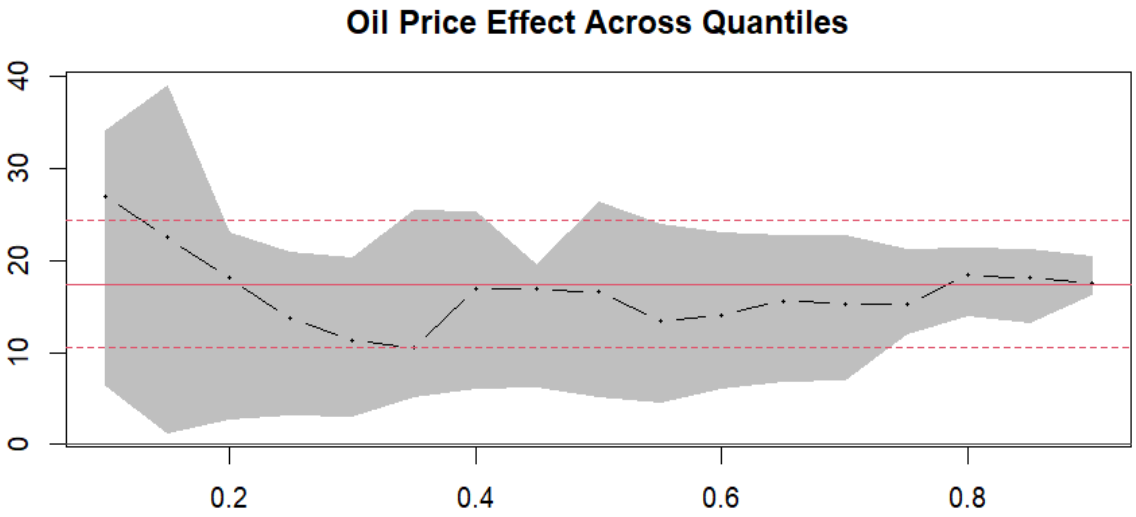

***Figure 6**:Oil Price Effects Across Quantiles*

Finally, **Figure 6** illustrates the effect of oil prices across quantiles, showing that the positive influence of oil price shocks on food inflation remains robust throughout the distribution. The shaded area represents the confidence interval, which is wider at lower quantiles, indicating greater uncertainty when food inflation is low. Overall, the results in Table 2, Figure 2, and Figure 3 highlight the dominant role of external factors especially oil price and exchange rate shocks in shaping food inflation dynamics in Comoros. These findings emphasize the country's vulnerability to global price fluctuations and underscore the importance of policies aimed at enhancing energy efficiency and exchange rate stability.

V. DISCUSSION

The empirical findings of this study, drawn from an integrated NARDL and Quantile Regression framework, reveal a complex and nuanced transmission mechanism of oil price shocks to food inflation in the Comoros, operating through dual asymmetric channels: temporal and distributional. This multifaceted perspective moves beyond conventional linear analyses to provide a granular understanding that aligns with and extends the global evidence on inflation dynamics in vulnerable economies.

First, the analysis of temporal dynamics through the NARDL model reveals a critical short-run asymmetry. The highly significant Wald test for short-run asymmetry (p-value = 0.0034) confirms that the impact of oil price decreases on food inflation is statistically larger than that of increases. This validates a pronounced "rocket and feather" effect in the Comorian context, a pattern documented in regions like the Euro Area (Borrallo et al., 2024). The estimated coefficients show that a 1% fall in oil prices induces a sharp 22.1 percentage point decrease in food inflation, compared to a 12.7 point increase from a price hike. This suggests that competitive pressures and consumer sensitivity force a quicker pass-through of cost savings. Furthermore, the exchange rate is identified as the dominant short-run driver, with a 1% depreciation causing a dramatic 57.0 percentage point surge in food inflation, underscoring the acute vulnerability of this import-dependent economy. The highly significant and negative Error

Correction Term (ECT) of -0.91 indicates that this volatile system is also self-correcting, with over 90% of any disequilibrium being corrected within a single period. Crucially, the F-bounds test (F-stat. = 5.25) confirms a stable long-run relationship exists between these variables, providing a solid foundation for the error-correction mechanism. In contrast to the short run, the Wald test for long-run asymmetry (p-value = 0.064) suggests that the cumulative effects of oil price increases and decreases eventually converge, pointing to a symmetrical equilibrium over time, a finding that resonates with studies from other developing nations (Alauddin et al., 2024) .

Complementing these temporal dynamics, the Quantile Regression analysis uncovers significant distributional heterogeneity, a critical insight echoing the work of (Yu et al., 2023) . The impact of external shocks is not uniform but is critically dependent on the prevailing state of food inflation. The effect of oil prices intensifies and becomes more precisely estimated at higher quantiles, with a 1% increase leading to a 17.5 percentage point rise in food inflation during high-inflation crises (90^{th} quantile). Similarly, the exchange rate, while a powerful driver across all regimes, exhibits its most devastating impact during periods of low inflation (10^{th} quantile), where a 1% depreciation triggers a 94.9 percentage point surge. This indicates that the initial spark of an inflationary crisis may often be lit by currency shocks. The escalating Pseudo R^2 values from 0.30 at the 10th quantile to 0.59 at the 90^{th} demonstrate that the model explains nearly 60% of food inflation variation during high-inflation episodes, substantially outperforming its explanatory power during normal periods. This confirms that the economy becomes significantly more sensitive to external shocks when already in a state of distress, potentially creating a vicious cycle.

In synthesis, the integrated findings demonstrate that oil price transmission in the Comoros is a two-fold process: it is temporally asymmetric in the short run and distributionally heterogeneous across different inflation environments. This multifaceted nature, which aligns with asymmetric findings in the GCC (Ebadi et al., 2024) and Nigeria (Adeosun et al., 2023), explains why conventional linear models fail to capture the full complexity of the inflation process in a vulnerable SIDS. The robustness of these insights is further supported by a full battery of diagnostic tests, which confirm the model is free from serial correlation, heteroskedasticity, and misspecification. Our study thus consolidates separate strands of evidence into a unified framework tailored to the unique economic context of the Comoros, providing a solid empirical basis for targeted policy intervention.

VI. CONCLUSION AND POLICY RECOMMENDATION

This study has rigorously investigated the asymmetric effects of oil price shocks on food inflation in the Comoros through an integrated NARDL and Quantile Regression framework. The empirical findings unequivocally demonstrate that the relationship is fundamentally nonlinear and context-dependent, revealing two distinct dimensions of asymmetry. First, the NARDL results confirm a pronounced short-run "rocket and feather" effect, where a 1% decrease in oil prices leads to a sharp 22.1 percentage point reduction in food inflation, which is significantly larger than the 12.7-point increase caused by a price hike. Second, the Quantile Regression uncovers critical distributional heterogeneity: while oil price impacts are moderate during normal periods, they intensify dramatically during high-inflation crises (90th quantile), with a 1% oil price increase raising food inflation by 17.5 percentage points. Furthermore, the exchange rate emerges as the dominant driver, with a 1% depreciation causing inflationary surges ranging from 28.5 to 94.9 percentage points across different quantiles, highlighting the extreme vulnerability of this import-dependent economy.

These integrated insights yield several critical policy implications. First, policymakers should strategically leverage the short-run asymmetry by implementing proactive stabilization measures during periods of falling global oil prices. The rapid 90.7% monthly adjustment speed suggests a narrow window for intervention, making timely actions like

building strategic food reserves crucial for extending consumer price relief. Second, the regime-dependent nature of oil price transmission demands flexible policy responses: authorities should implement aggressive stabilization measures during high-inflation episodes while maintaining accommodative stances during stable periods. Third, the overwhelming influence of exchange rate fluctuations underscores the vital importance of maintaining currency stability through prudent foreign reserve management and coordinated monetary-fiscal policies.

The demonstrated superiority of nonlinear models necessitates an enhancement of the official inflation forecasting toolkit. Statistical authorities should incorporate NARDL and Quantile Regression frameworks to better anticipate inflation paths under different scenarios, particularly given the model's exceptional explanatory power during high-inflation episodes (Pseudo $R^2 = 0.59$ at 90th quantile). Looking forward, this study opens promising avenues for future research, including incorporating remittances and global food prices, applying Multiple Threshold NARDL to identify critical oil price thresholds, and conducting comparative SIDS panel studies to distinguish Comoros-specific challenges from common vulnerabilities.

In short, effective inflation management in the Comoros requires moving beyond conventional one-size-fits-all approaches. By strategically responding to the dual asymmetric nature of oil price transmission temporal in the short run and distributional across inflation regimes policymakers can design sophisticated, context-specific stabilization policies that effectively safeguard household welfare and promote sustainable economic development in this vulnerable island's economy.

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All authors played a part in shaping the study from the ground up. Mr. Yssoufa Thabiti handled the bulk of the hands-on work preparing materials, collecting data, and running the analysis. Dr. Fatimazahara Moussaid and Dr. Ahmed Irchad were actively involved in writing and helping make sense of the findings.

Since this study didn't involve any experiments or procedures with human subjects, formal ethics approval wasn't required. No personal or identifying information is included, so individual consent for publication wasn't applicable. That said, everyone who took part did so voluntarily, with a clear understanding of what the study was about and what participation involved.

The authors have no competing interests financial or otherwise to declare. All data and materials referenced in this study are available through the sources cited, and anyone with questions is welcome to reach out to the authors for more information.

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