Research Article ISSN 3143-5807

Journal of Business and Economic Insights

Macroeconomic Drivers of Price Rigidity in Sub-Saharan Africa. What do we know?

Dr Chigozie Chukwu[1*], Dr Ayuba Timothy[2] and Alimi Ahmed Shina[3]

[1]*University of Wolverhampton Business School, University of Wolverhampton, United Kingdom. https://orcid.org/0000-0003-0692-096X.*

[2]*Faculty of Management and Social Sciences, Philomath University, Abuja, Nigeria. https://orcid.org/0000-0002-8490-081X.*

[3]*Federal Ministry of Women Affairs, Abuja, Nigeria.*

***Corresponding Author**

Dr Chigozie Chukwu
University of Wolverhampton Business School, University of Wolverhampton, United Kingdom.
ORCID : https://orcid.org/0000-0003-0692-096X

Submitted: 7 Jul 2026; **Accepted:** 13 Jul 2026; **Published:** 31 Jul 2026

Citation: Chukwu, C. et al., (2026). Macroeconomic Drivers of Price Rigidity in Sub-Saharan Africa. What do we know? . *J Business & Eco Insights.,2*(3):1-18. DOI : https://doi.org/10.47485/3143-5807.1025

Abstract

Keeping prices stable is still a major issue in Sub-Saharan Africa (SSA). Many economies in the region struggle with rising prices, unpredictable exchange rates, and weak connections between monetary policy and the real economy. Most studies so far have focused on how inflation behaves, but there has not been much attention paid to how stubborn prices are, what causes this, and asymmetries of price rigidity across SSA countries. This study aims to fill that gap by examining price rigidity in Nigeria, South Africa, Ghana, and Namibia using monthly data from 2007 to 2024. Our employs an AR (1) model to measure inflation persistence, while Autoregressive Distributed Lag (ARDL) and Nonlinear ARDL (NARDL) models are used to investigate the linear and asymmetric effects of exchange rate volatility, interest rates, and oil prices on inflation dynamics. The findings reveal that inflation tends to stick around for a long time in all the countries examined, with Nigeria exhibiting the highest degree of rigidity. The study further shows that changes in exchange rates, interest rates, and oil prices play a major role in shaping inflation, but these effects vary across countries. The results further show asymmetric price adjustment, whereby inflation responds more strongly to adverse shocks such as currency depreciation and oil price increases than to favorable shocks. The study identifies several reasons for this stubborn inflation, including rigidities in the economic structure, institutional weaknesses, and vulnerability to outside shocks. To help address these issues, the study recommends making monetary policy more credible, managing exchange rates more effectively, developing stronger financial markets, and implementing structural reforms that enhance price flexibility and macroeconomic resilience.

JEL: C22, E31, E52, F31, O55

Keywords: Price Rigidity, Sub-Saharan Africa, Inflation Persistence, Oil Price Shocks, Monetary Policy Transmission, Asymmetric Adjustment.

Introduction

Macroeconomic stability is widely recognized in the economic literature as a fundamental prerequisite for sustainable economic growth, investment, and welfare improvement (Barro, 1995; Bates et al., 2008). It is observed that stable prices enhance economic efficiency by reducing uncertainty, improving resource allocation, and fostering long-term planning by households and firms (Blanchard & Galí, 2007; Mishkin, 2007). However, despite decades of macroeconomic reforms, many Sub-Saharan African (SSA) economies continue to experience persistent inflation volatility, weak monetary transmission mechanisms, and limited responsiveness of prices to policy interventions (Kasekende et al., 2010; Montiel, 2011). This paradox has renewed scholarly interest on the meanings, understanding and significance of price rigidity and its interaction with key macroeconomic indicators across the African continent (Bleaney & Fielding, 2002).

Price rigidity refers to the tendency of prices to adjust slowly or incompletely in response to changes in economic conditions such as demand, costs, exchange rates, or monetary policy shocks (Calvo, 1983; Nakamura & Steinsson, 2013). While classical economic theory assumes flexible prices that adjust instantaneously to equilibrate markets, empirical evidence from developing economies suggests that prices are often sticky due to structural, institutional, and behavioural constraints (Benjamin & Mbaye, 2020; Galí, 2015). In Africa, these rigidities are further amplified by market imperfections, weak competition, infrastructure deficits, informality, and policy uncertainty (Aryeetey & Kanbur, 2017; Rodrik, 2016).

The relevance of price rigidity in SSA is heightened by the continent's macroeconomic environment (Frankel et al., 2013). Many African countries are characterized by recurrent fiscal imbalances, exchange rate volatility, shallow financial markets, and heavy dependence on imported goods (Easterly & Levine, 1997; Yameogo et al., 2014). These conditions influence how prices respond to changes in macroeconomic indicators such as inflation, interest rates, money supply, exchange rates, output growth, and government spending (Akinboade et al., 2004;

Clarida, et al., 1999). For instance, exchange rate depreciation in import-dependent economies often leads to rapid increases in consumer prices, while price reductions during appreciation phases are slow or incomplete, suggesting asymmetric price adjustment behaviour (Goldfajn & Werlang, 2000; Sanusi, 2013).

Graphical Evidence of Inflation and Exchange Rate Trends

The empirical patterns described above are visually evident in the macroeconomic trajectories of the selected countries. Figures 1–4 illustrate the trends of inflation and exchange rates in Nigeria, South Africa, Ghana, and Namibia from 2007 to 2024. These graphs reveal several critical features relevant to price rigidity analysis. First, Nigeria exhibits the most pronounced volatility, with exchange rates showing persistent depreciation punctuated by sharp adjustments, most notably the steep decline in 2016 following the oil price collapse and the 2023–2024 currency reform period. Inflation in Nigeria demonstrates strong persistence, with spikes lagging behind exchange rate movements by several months, consistent with the 84% inflation persistence coefficient documented in the empirical results and confirming gradual price adjustment mechanisms.

Second, South Africa displays relatively stable inflation within its 3–6% target band, with exchange rate fluctuations showing less immediate pass-through to consumer prices compared to Nigeria. This pattern reflects the credibility of South Africa's inflation-targeting regime and more anchored inflation expectations, though the microdata still reveals significant price stickiness at the firm level. Third, Ghana shows cyclical patterns of inflation acceleration coinciding with currency depreciation episodes, particularly during 2014 and 2022, with incomplete pass-through evident in the gradual rather than instantaneous price adjustments. Finally, Namibia demonstrates the strongest deflationary risk in the sample, with inflation occasionally falling below zero despite exchange rate stability, highlighting the asymmetry in price adjustment where downward rigidity prevents rapid price declines even during currency appreciation phases. Collectively, these graphical patterns support the empirical findings of heterogeneous price rigidity across the four economies and justify the comparative analytical framework adopted in this study.

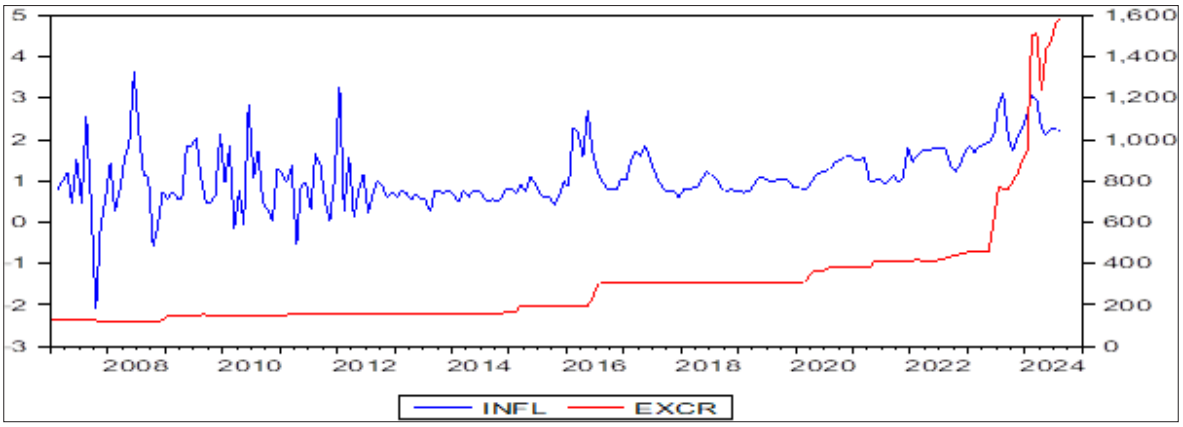

Figure 1: Trend of Inflation and exchange rate in South Africa

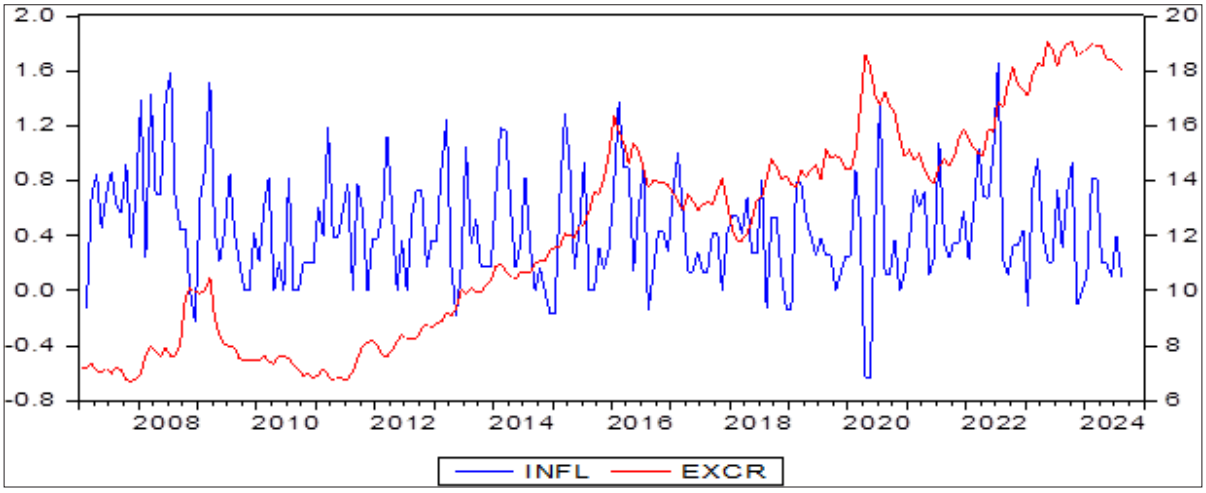

Figure 2: Trend of Inflation and exchange rate in South Africa

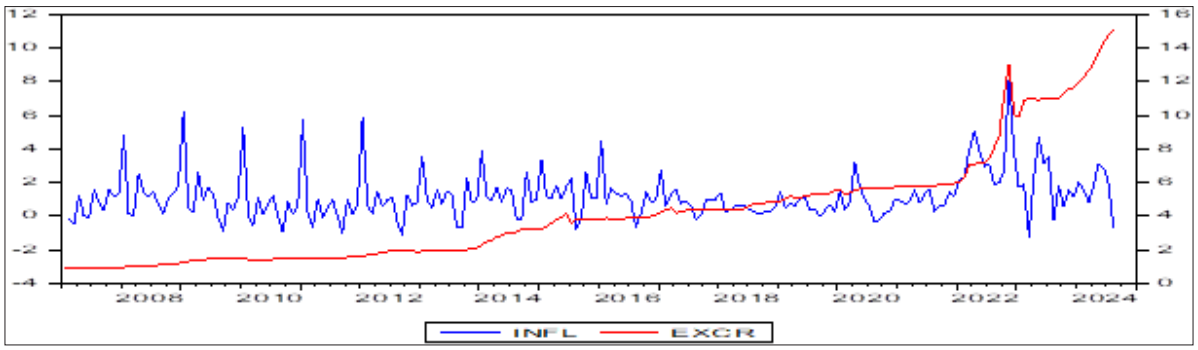

Figure 3: Trend of Inflation and exchange rate in Ghana

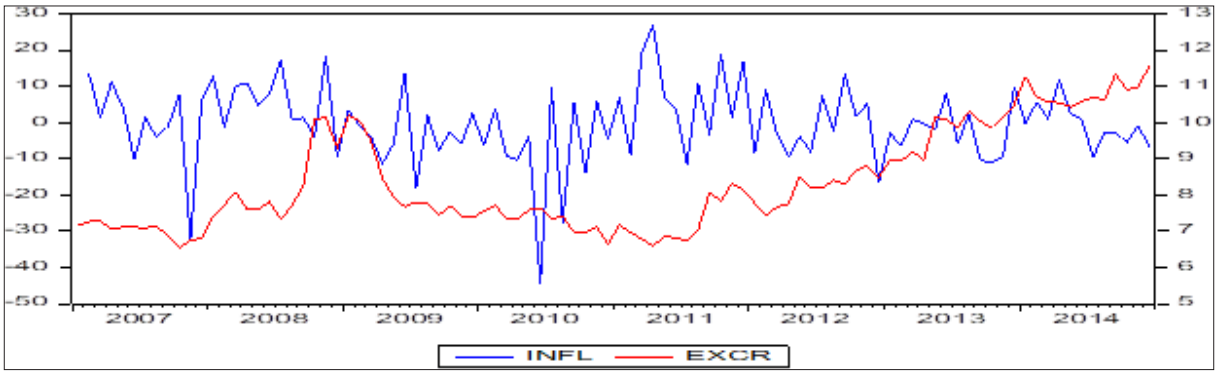

Figure 4: Trend of Inflation and exchange rate in Namibia

In economies with high price rigidity, monetary policy shocks may have prolonged real effects, exacerbate output volatility and weaken inflation control (Balogun, 2007; Bernanke et al., 1999). This challenge is particularly pronounced in African countries where central banks often operate under fiscal dominance, limited credibility, and political constraints, thereby complicating efforts to anchor inflation expectations (Alesina et al., 2008; Sargent & Wallace, 1984). Consequently, even well-designed macroeconomic policies may fail to produce the intended outcomes if price rigidities remain unaddressed (Agénor & Montiel, 2015).

Institutional factors also play a crucial role in shaping price-setting behaviour in Africa (Fosu, 2019; North, 1990). Weak regulatory frameworks, limited contract enforcement, high transaction costs, and the prevalence of informal markets contribute to sluggish price adjustment (Benjamin & Mbaye, 2020; Porta et al., 1998). In addition, structural bottlenecks such as poor transportation networks, energy shortages, and market segmentation increase menu costs and reduce the frequency of price changes (Collier & Gunning, 1999; Vivien & Briceño-Garmendia, 2010). These factors suggest that price rigidity in Africa may differ significantly in magnitude and transmission channels from those observed in advanced and emerging market economies (Hall & Soskice, 2001; Mbaye & Benjamin, 2020).

Despite the growing body of literature on inflation dynamics and monetary policy in SSA, empirical studies that explicitly examine price rigidity and its relationship with macroeconomic indicators remain limited and fragmented (Bleaney & Greenaway, 2001). Existing studies often focus on single-country analyses or short time horizons, leaving significant gaps in understanding cross-country heterogeneity and long-run dynamics (Aron & Muellbauer, 2007; Olayungbo, 2019). Furthermore, many macroeconomic models applied to African economies implicitly assume price flexibility, potentially leading to biased policy conclusions (Gali & Monacelli, 2005).

Against this backdrop, this study seeks to examine the nature and extent of price rigidity in SSA and its relationship with key macroeconomic indicators. By providing empirical evidence on how prices respond to macroeconomic shocks across SSA economies, the study aims to contribute to a deeper understanding of inflation dynamics and policy effectiveness in the region (Khan & Ssnhadji, 2001). Such insights are essential for designing context-appropriate monetary and fiscal policies capable of promoting price stability, enhancing investment, and supporting inclusive economic growth in SSA (Stiglitz, 2010).

The remainder of the paper is organised as follows: Theoretical and empirical literature is explored in section 2 to identify striking notions and glaring gaps to be filled. Section 3 covers the date, sources, and empirical model specification. The data analysis and discussion of the key findings are presented in section 4. Lastly, section 5 presents the study's conclusion and policy implications.

Theoretical Literature: Price Rigidities and Macroeconomic Performance

The relationship between price rigidities and macroeconomic performance is most coherently and rigorously explained by the New Keynesian Price Rigidity Theory. This framework extends traditional Keynesian analysis by embedding nominal rigidities, menu costs, staggered price setting (Calvo pricing),

and imperfect competition into modern dynamic stochastic general equilibrium (DSGE) models (Albanesi, 2004; Calvo, 1983; Clarida et al., 1999). Unlike classical models that assume instantaneous price adjustment, the New Keynesian approach make claim that firms adjust prices infrequently, causing real economic variables such as output and employment to respond significantly to nominal shocks in the short run. Recent extensions of the NK model emphasize heterogeneity across firms and sectors, which is particularly relevant for African economies are characterized by informality, weak competition, and segmented markets (Galí, 2015; Nakamura & Steinsson, 2013).

At the core of the theory is the assumption that firms face menu costs (administrative, informational, and reputational costs associated with changing prices discourage continuous price adjustments even when economic conditions change (Nakamura & Steinsson, 2008). Complementing this is the (Calvo, 1983) in his staggered pricing mechanism, found that only a random fraction of firms can reset prices in any given period. This staggered price-setting behaviour generates aggregate price stickiness, even when individual firms behave optimally. As a result, inflation responds slowly to shocks, giving rise to inflation inertia and short-run deviations of output from its potential level (Galí, 2015).

These nominal rigidities are formalised through the New Keynesian Phillips Curve (NKPC), which links current inflation to expected future inflation and real marginal costs. The NKPC predicts that inflation is forward-looking but also persistent due to staggered price adjustments and strategic complementarities among firms (Albanesi, 2004; Clarida et al., 1999). Recent extensions further show that state-dependent pricing, firm heterogeneity, and sectoral differences in price flexibility amplify macroeconomic volatility and prolong the real effects of shocks (Miyazaki, 2026).

A key implication of the New Keynesian framework is that price rigidities magnify macroeconomic fluctuations. Following contractionary monetary policy or negative aggregate demand shocks, prices adjust sluggishly, leading to declines in output and employment rather than immediate price reductions (Eyster et al., 2021; Galí, 2015). Conversely, expansionary shocks can generate inflationary pressures that persist even after the original shock has dissipated. These mechanisms explain why monetary policy is non-neutral in the short run and why inflation often exhibits persistence across business cycles.

Monetary Transmission Mechanism Theory

The monetary transmission mechanism theory explains how monetary policy affects inflation and real economic activity through interest rates, credit channels, exchange rates, and expectations. in this scenario. Price rigidity plays a central role in this process: when prices are sticky, changes in nominal variables translate into real economic effects.

In African economies, studies show the transmission mechanism is often weakened by shallow financial markets, excess liquidity, fiscal dominance, and limited central bank credibility, resulting in delayed or asymmetric price responses to policy shocks (Mishra et al., 2012). This theoretical perspective supports the inclusion of macroeconomic indicators such as interest rates, money supply, and exchange rates as key determinants of price dynamics. Recent studies show that the effectiveness of monetary transmission in Sub-Saharan Africa depends critically on the degree of price rigidity and exchange rate pass-through (Olayungbo, 2019).

Exchange Rate Pass-Through Theory

The exchange rate pass-through (ERPT) theory provides another important pillar for this study. ERPT explains how changes in exchange rates affect domestic prices, particularly in import-dependent economies. In the presence of price rigidity, exchange rate depreciation tends to be passed through to domestic prices more quickly than appreciation, resulting in asymmetric price adjustment. Sub-Saharan African economies exhibit high ERPT due to import dependence, weak competition, and limited hedging mechanisms, but price rigidities often prevent downward price adjustments during currency appreciation (Gali & Monacelli, 2005). This theory directly supports the study's focus on exchange rates as a key macroeconomic indicator influencing price rigidity. For Sub-Saharan Africa, empirical studies show that limited price flexibility weakens the inflation-output trade-off and complicates inflation targeting, making the NK framework highly applicable (Mishra et al., 2012).

Institutional and Structuralist Theory

Institutional economics provides a complementary framework by emphasizing the role of institutions, market structure, and transaction costs in shaping price-setting behaviour. Weak regulatory frameworks, limited contract enforcement, informality, and infrastructure deficits raise adjustment costs and reinforce price rigidity in developing economies (Fosu, 2019; North, 1990). Recent African-focused studies highlight that structural bottleneck, such as poor transport networks, energy shortages, and market segmentation significantly increase menu costs and reduce the frequency of price changes (Mbaye & Benjamin, 2020). This framework justifies incorporating institutional quality and structural constraints into the analysis of price rigidity in Africa.

Empirical Evidence from Selected SSA Countries

Kemoe et al. (2024) examine the effect of exchange rate movements on inflation in Sub-Saharan Africa with the objective of understanding the extent and asymmetry of exchange rate pass-through to domestic prices. Using monthly panel data for a broad sample of SSA countries covering the period 2000–2023, the authors employ dynamic panel regressions that distinguish between currency depreciation and appreciation episodes. The study finds that exchange rate depreciations are passed through to domestic prices rapidly and persistently, whereas appreciations lead to weak or insignificant price reductions. This asymmetric adjustment implies the presence of downward price rigidity in SSA economies. Compared with earlier country-specific studies, the regional scope of (Kemoe et al., 2024) strengthens the argument that price stickiness

is systemic rather than idiosyncratic, reinforcing findings of (Adekunle & Filson, 2024).

Adekunle and Filson (2024) focus specifically on Nigeria by investigating asymmetric exchange rate pass-through to consumer prices. The study covers the period 1986–2018, coinciding with Nigeria's post-Structural Adjustment era. Using a nonlinear autoregressive distributed lag (NARDL) framework, the authors capture both short-run and long-run asymmetries in price responses to exchange rate changes. Their findings show that exchange rate depreciation significantly increases consumer prices, while appreciation does not generate a proportionate decline. This confirms the presence of price rigidity and adjustment costs at the country level. When compared to (Kemoe et al., 2024), Adekunle and Filson's results suggest that Nigeria's experience reflects a broader SSA pattern of asymmetric price behaviour.

In a related study, Olaoye et al. (2023) shift attention from exchange rates to fiscal conditions as drivers of inflation and implicit price rigidity in Sub-Saharan Africa. Their study, published in 2024, analyses a panel of 44 SSA countries over the period 2003–2020. Employing system Generalized Method of Moments (GMM) and dynamic panel threshold regression techniques, the authors find that public debt significantly increases inflation once a critical threshold of approximately 60 percent of GDP is exceeded. Money supply alone is found to be insignificant unless interacted with fiscal variables, suggesting that fiscal dominance weakens monetary policy effectiveness. In relation to price rigidity, the study implies that persistent fiscal pressures contribute to sustained inflation and slow price adjustment, complementing the exchange-rate-based rigidity documented by (Kemoe et al., 2024).

Meanwhile, Babangida et al. (2024) examine the output–inflation relationship in selected African countries with a focus on inflation volatility and persistence. The study covers 17 African economies between 1995 and 2021 and employs a mixed-frequency GARCH-MIDAS methodology, allowing the authors to capture both short-term and long-term dynamics. Their findings reveal that inflation volatility is highly persistent and that output growth moderates inflation only gradually. This persistence is interpreted as evidence of slow price adjustment following macroeconomic shocks. While the study does not directly estimate price stickiness parameters, its findings align with (Kemoe et al., 2024; Olaoye et al., 2024) in suggesting that prices in SSA respond sluggishly to economic conditions.

More so, Magubane and Nzimande (2024) investigate monetary and macroprudential policy interactions in South Africa, with implications for price dynamics and rigidity. Using quarterly data covering 1980–2023, the authors estimate a Structural Vector Autoregression (SVAR) model to analyse how interest rate and macroprudential shocks affect output and prices. The study uncovers a price puzzle; whereby contractionary monetary policy initially raises the price level before reducing it over time. This delayed response is consistent with sticky prices and expectation-driven inertia. Compared to regional studies such as Kemoe et al. (2024), Magubane and Nzimande (2024) provide deeper country-specific evidence that policy transmission lags can exacerbate price rigidity even in relatively sophisticated African economies.

Conversely, Kayal and Maheswaran (2018) provide a theoretical and empirical analysis of price adjustment in emerging markets, offering insights relevant to SSA. Although not exclusively African, their study draws on emerging-market data covering the period 1990–2016 and develops a framework that links market power, financial frictions, and contract rigidities to sluggish price adjustment. Their findings show that prices in emerging economies adjust slowly to shocks due to institutional and financial constraints. This theoretical perspective supports the empirical findings of Kemoe et al. (2024) and Olaoye et al. (2024) by providing microeconomic foundations for observed price rigidity in SSA.

Hence, the World Bank (2022) report on inflation dynamics and monetary policy transmission in Sub-Saharan Africa provides a complementary institutional perspective. Using cross-country data covering 2000–2021, the report applies panel regressions and structural VAR techniques to assess inflation persistence and policy effectiveness. The findings highlight weak monetary transmission, shallow financial markets, and persistent inflation across SSA. In relation to price rigidity, the report emphasizes that institutional weaknesses and structural bottlenecks delay price adjustment, reinforcing conclusions from both academic and IMF-based studies.

Similarly, the African Development Bank (2023) analyses macroeconomic stability and inflation persistence in Africa using regional panel data spanning 2000–2022. The report finds that inflation in African economies is highly persistent and responds slowly to policy interventions, consistent with the presence of price rigidity. These findings converge with those of Babangida et al. (2024) and Magubane and Nzimande (2024), although the AfDB places greater emphasis on structural transformation and supply-side constraints.

Empirical evidence from the four selected countries reveals varying degrees of price rigidity and inflation persistence. In Nigeria, Rasaki (2017) estimates a New Keynesian Phillips Curve and finds that both forward-looking expectations and backward-looking inflation significantly influence inflation dynamics, implying gradual price adjustment consistent with nominal rigidity.

Recent evidence by Bulus and Umeokwobi (2025) shows that lagged inflation expectations dominate Nigeria's inflation process, indicating strong inflation inertia and limited instantaneous price adjustment. Disaggregated analyses further reveal that price stickiness varies across sectors, with food, housing, and transport prices exhibiting particularly slow adjustment speeds (Adam et al., 2025).

In South Africa, Creamer et al. (2012); Creamer and Rankin, (2008) provide comprehensive micro-evidence on price-setting behavior using CPI and PPI microdata from 2001–2007. Their findings indicate that prices change with a frequency of 17.1%,

with an average price duration of 5.0 months—substantially stickier than assumed in DSGE models. Price increases occurred more frequently than decreases (10.50% versus 5.47% monthly), and the average weighted magnitude of price change was 2.91%. These results confirm state-dependent pricing behavior, where the frequency of price changes is affected by inflation, repo rate increases, and nominal effective exchange rate movements. South Africa's inflation-targeting framework has contributed to lower inflation persistence compared to other SSA economies, though price rigidities remain significant (Aron & Muellbauer, 2007).

For Ghana, empirical studies show incomplete but significant exchange rate pass-through to inflation. Adam and Frimpong (2010) find that a 1% depreciation is associated with a 0.025% increase in inflation after one quarter, rising to 0.09% after eight quarters, indicating persistent but low pass-through effects. Loloh (2014) confirms that exchange rate pass-through is incomplete and modest, decaying within 18–24 months, with stronger effects on non-food inflation than overall CPI. These findings reflect Ghana's increased trade openness and tighter monetary policy under its inflation-targeting regime. More recent evidence indicates threshold effects, where exchange rate depreciation beyond 0.70% monthly generates significant pass-through to inflation.

In Sheefeni and Ocran (2014) examine exchange rate pass-through using SVAR models and find low and incomplete pass-through elasticities—estimated at 0.01 for consumer inflation and 0.04 for imported inflation in the first quarter, increasing to 0.02 after eight quarters. This low pass-through is attributed to pricing-to-market strategies by importers. However, oil price pass-through is substantially higher (0.18 for consumer inflation in the second quarter), and South African food price pass-through is particularly pronounced (0.96 on consumer inflation in the first quarter), reflecting Namibia's strong trade linkages with South Africa. Mushendami and Namakalu (2016) confirm that external shocks play significant roles in Namibian price dynamics, with monetary policy operating through domestic absorption and imported inflation channels.

Disaggregated analyses further reveal that price stickiness varies across sectors, with food, housing, and transport prices exhibiting particularly slow adjustment speeds (Adam et al., 2025).

This sectoral heterogeneity aligns with New Keynesian predictions that differences in price flexibility across industries contribute to persistent aggregate inflation. Additionally, studies on monetary policy effectiveness in Nigeria demonstrate that inflation and output respond to policy and exchange-rate shocks with significant lags, reflecting rigid price structures and weak immediate pass-through mechanisms (Otolorin et al., 2024).

Taken together, these findings suggest that nominal price rigidities are central to understanding Nigeria's macroeconomic performance, particularly persistent inflation, output volatility, and delayed monetary transmission. The Nigerian evidence mirrors broader international findings from Europe, the United Kingdom, Japan, and other advanced economies, where micro-price data confirm infrequent price adjustments and strong inflation persistence (Fabiani et al., 2006).

Methodology

In order to assay the extent of price rigidity in four Sub-Saharan African economies (Nigeria, South Africa, Ghana and Namibia), this study utilized monthly data on consumer price index due to unavailability of disaggregated micro-price data on goods and services in developing countries, exchange rate, interest rate and oil price. The choice of these countries for this study is as a result of diversity in monetary policy frameworks, inflation histories, and exposure to exchange rate fluctuations which are critical to price adjustment as well as institutional development in the countries. In addition, the dataset for this study spans the period of 2007 to 2024 yielding 212 observations for each country. Monthly data on CPI, exchange rate and interest rate are gleaned from International Monetary Fund International Financial Statistics while oil price is sourced from International Energy Agency.

$$\pi_t = 100 * (In(CPI_t) - In(CPI_{t-1}) \quad (1)$$

From Eq. (1) π denote monthly inflation rate a proxy for price adjustment for each country at time *t*.

To determine the degree of price rigidity in each country, we opted for the First-Order Autoregressive model, AR (1) using Ordinary Least Squares with heteroscedasticity and autocorrelation-consistent (Newey-West) standard errors. The AR (1) model offers parsimonious and transparent measures of inflation persistence without imposing restrictive homogeneity assumptions and ensure valid statistical inference in the presence of heteroscedasticity and serial correlation (Elem-Uche et al., 2024; Yule, 1927). The AR (1) model for price rigidity is specified as:

$$\pi_t = \alpha_i + \rho_i \pi_{t-1} + \varepsilon_t \quad (2)$$

From Eq. (2), π_t is the inflation rate, α_i represent country-specific intercept and while ε_t is the error term assumes to be white noise. In addition, p_1 denote inflation persistent coefficient which captures the extent to which current inflation depends on its past value. A higher value of p_1 indicates that inflation shocks dissipate slowly, hence, stronger price rigidity and vice versa.

Furthermore, to analyze how factors like exchange rate volatility, interest rates, and oil price affect how prices adjust in the selected SSA countries, we opted for country-specific Autoregressive Distributed Lag (ARDL) model of (Pesaran et al., 2001). This study adopted for the ARDL estimation technique due to the fact that it captures dynamic adjustment and separate short-run response from long run relationship (Nguyen et al., 2025). In addition, the model accommodates data series with different order of integration and performs well in country-specific time-series setting (Xuan et al., 2025). More so, the technique addresses potential endogeneity issues within its framework to overcome the problem of multicollinearity

or interrelationships between variables (Amin et al., 2025; Nguyen et al., 2025; Xuan, 2025).

The Baseline linear ARDL model for each country is specified as:

$$\Delta\pi_t = \sigma + \sum_{j=1}^{p}\phi_j\Delta\pi_{t-j} + \sum_{k=0}^{q}\psi_{1k}\Delta EXRV_{t-k} + \sum_{k=0}^{q}\psi_{2k}\Delta INT_{t-k} + \sum_{k=0}^{q}\psi_{3k}\Delta OILP_{t-k} + \lambda(\pi_{t-1} - \vartheta_1 EXRV_{t-1} - \vartheta_2 INT_{t-1} - \vartheta_3 OILP_{t-1}) + \varepsilon_t \quad (3)$$

From Eq. [3], π, *EXRV*, *INT* and *OILP* denote inflation rate, exchange rate volatility, interest rate and oil price respectively in year *t*. In addition, Δ and σ are the first difference operator and the intercept, the speed of price adjustment is represented by λ, ψ_j are the short run coefficient while ϑ_j are the long run coefficient, the error term which is assumed to be white noise is denoted by ε_t.

Given that price responds asymmetrically to macroeconomics shocks in SSA region because the economies are characterized by structural rigidities, institutional frictions, and macroeconomic volatility (Kassi et al., 2023; Olaoye et al., 2020; Udeagha & Breitenbach, 2023). The positive or negative shock may yield distinct effects (Trejo-García et al., 2024). In an attempt to circumvent the drawbacks of traditional linear models and to better capture the complex, asymmetric, and dynamic nature of the relations in question, we employ Nonlinear Autoregressive Distributed Lag model (NARDL) credited to (Shin et al., 2014) which allows for differential effects of positive and negative change in the explanatory variables.

The NARDL technique accommodates asymmetric responses by decomposing the macroeconomic factors such as exchange rate volatility, interest rate and oil price into positive and negative partial sums (Shin et al., 2014). Also, Unlike VECM or VAR models that require all variables to be integrated at the same order, NARDL accommodates a mix of I(0) and I(1) series (Pesaran et al., 2001), making it ideal for macroeconomic datasets from developing countries (Arebo, 2025; Sadraoui et al., 2026). Additionally, linear ARDL assumes symmetric adjustment in response to shocks, ignoring how structural bottlenecks and institutional frictions shape policy effectiveness may lead to misspecification (Olaoye et al., 2023).

Following Shin et al. (2014), the explanatory variables (industrial production index, exchange rate, interest rate and oil price) are decomposed into positive and negative partial sum as:

$$X_t = f(EXCR_t, INT_t, OILP_t) \quad (4)$$

$$X_t^+ = \sum_{s=1}^{t}\max(\Delta X_s, 0); \text{ and } X_t^- = \sum_{s=1}^{t}\max(\Delta X_s, 0); \quad (5)$$

The positive and negative decomposition in Eq. [5] allows price to react differently to upward and downward movements. Incorporating these components, the asymmetric NARDL model is expressed as:

$$\Delta\pi_t = \sigma + \sum_{j=1}^{p}\phi_j\Delta\pi_{t-j} + \sum_{k=0}^{q}(\beta^+_{1k}\Delta EXRV^+_{t-k} + \beta^-_{1k}\Delta EXRV^-_{t-k}) + \sum_{k=0}^{q}(\beta^+_{2k}\Delta INT^+_{t-k} + \beta^-_{2k}\Delta INT^-_{t-k}) + \sum_{k=0}^{q}(\beta^+_{3k}\Delta OILP^+_{t-k} + \beta^-_{3k}\Delta INT^-_{t-k}) + \lambda(\pi_{t-1} - \vartheta^+_1 EXRV^+_{t-1} - \vartheta^-_1 EXRV^-_{t-1} - \vartheta^+_2 INT^+_{t-1} - \vartheta^-_2 INT^-_{t-1} - \vartheta^+_3 OILP^+_{t-1} - \vartheta^-_3 OILP^-_{t-1}) + \varepsilon_t \quad (6)$$

From Eq. [6], the first difference operator is signifying Δ while the short run and the long run dynamics of exchange rate volatility, interest rate and oil price are captured by β_j and ϑ_j respectively. In addition, $EXRV^+$, $EXRV^-$, INT^+, INT^-, $OILP^+$ and $OILP^-$ are the asymmetric of exchange rate volatility, interest rate and oil price.

Empirical Results and Discussions

Table 1 presents the descriptive statistics for inflation (INFL), the exchange rate (EXCR), the interest rate (INTR), and oil prices (OILP) across the selected SSA economies: Nigeria, South Africa, Ghana, and Namibia. The results reveal substantial cross-country heterogeneity in macroeconomic volatility. Nigeria's exchange rate exhibits significant volatility, as indicated by a standard deviation of 264.93. The distribution is strongly right skewed (3.1662), suggesting that large currency fluctuations occur frequently and are highest compared to other SSA countries. Additionally, a high kurtosis value (14.11) indicates greater extremes than a normal distribution. These statistical measures reflect persistent depreciation and instability. Comparable patterns are observed in other oil-dependent countries. Adeniyi and Olasunkanmi (2019) finds that exchange rate changes significantly affect inflation in Nigeria. Consistently, inflation data also display moderate positive skewness and high kurtosis (5.31), indicating that inflation spikes occur more often than in a normal distribution.

Ghana exhibits substantial inflation variability, as evidenced by a standard deviation of 1.3784 and a kurtosis of 7.56. These metrics suggest pronounced macroeconomic instability and frequent inflation spikes, aligning with the findings of (Frimpong & Oteng-Abayie, 2010).

In comparison, South Africa displays lower inflation volatility and more symmetric distributions, which reflect the presence of robust institutions and effective inflation targeting. Aron and Muellbauer (2007) provide evidence that credible monetary policy contributes to reduced inflation variability. Namibia has a very low minimum inflation value of -44.47, which shows it is vulnerable to deflationary shocks. This risk seems linked to Namibia's close economic ties with South Africa and related external factors. Summarily, table 1 also shows that macroeconomic instability is greater in Nigeria and Ghana than in South Africa and Namibia.

Table 1: Descriptive Statistics

		INFL	EXCR	INTR	OILP
Nigeria	Mean	1.1264	301.1145	12.2997	78.1065
	Max	3.6229	1587.394	26.7500	132.7200
	Min	-2.1039	117.7200	6.0000	18.3800
	Std. Dev.	0.7235	264.9261	3.8278	24.8468
	Skewness	0.3286	3.1662	1.1622	0.1037
	Kurtosis	5.3155	14.1107	6.1946	2.1086
South Africa	Mean	0.4506	12.1358	6.5947	78.1065
	Max	1.6602	19.0527	12.0000	132.7200
	Min	-0.6309	6.6947	3.5000	18.3800
	Std. Dev.	0.3977	3.8386	2.0053	24.8468
	Skewness	0.4989	0.1296	0.8758	0.1037
	Kurtosis	3.3564	1.7510	3.7152	2.1086
Ghana	Mean	1.1770	4.2328	18.4668	78.1065
	Max	8.2383	15.1037	30.0000	132.7200
	Min	-1.2526	0.9223	12.5000	18.3800
	Std. Dev.	1.3784	3.2656	5.1852	24.8468
	Skewness	1.7153	1.3845	0.9001	0.1037
	Kurtosis	7.5643	4.4544	2.5981	2.1086
Namibia	Mean	-0.2065	8.3806	7.1947	93.0211
	Max	26.8978	11.5809	10.5000	132.7200
	Min	-44.4704	6.5400	5.5000	39.9500
	Std. Dev.	10.8070	1.3944	1.8433	22.2482
	Skewness	-0.7856	0.6877	0.8505	-0.5140
	Kurtosis	5.6535	2.1464	2.1236	2.3150

Note: *Infl, excr, intr and oilp denote inflation rate, exchange rate, interest rate and oil price respectively*

Table 2 shows the Augmented Dickey-Fuller (ADF) test results both with and without structural breaks. Most variables are integrated of order one, I (1). In several countries, inflation is mostly stationary, I (0), at level. Structural breaks have a strong effect on the stationarity results. However, break dates, that is, periods when the statistical properties of a time series change tend to occur during major global shocks such as 2008–2009 (the global financial crisis), 2014 (the oil price collapse), and 2020 (the COVID-19 pandemic). This supports Perron (1989) argument that ignoring breaks sudden changes in trends or averages can bias unit root inference, which is the process of determining whether a time series is stationary or contains a persistent pattern. The breaks in oil prices observed in 2014 and 2020 are consistent with global market disruptions analysed by (Hamilton, 2009). In contrast, the currency exchange rate break in Nigeria (2024M03) aligns with episodes of currency reform and subsequent policy adjustments. Given the mixture of I (0) and I (1) variables, the use of the ARDL bounds testing framework, as developed by Pesaran et al. (2001), is justified.

Table 2: Unit Root Test Results

ADF without Structural Break						ADF with Structural Break			
					Level		First Diff		
Country	**Variables**	**Level**	**First Difference**	**I(d)**	**T-Stat**	**T-Break**	**T-stat**	**T-Break**	**I(d)**
Nigeria	INFL	-9.0673		I(0)	-98550	2012M03			I(0)
	EXV	-1.8127	-14.7652	I(1)	-5.8831	2024M03			I(0)
	LINTR	-1.8682	-14.1708	I(1)	-2.6717	2024M02	-15.3421	2011M10	I(1)
	LOILP	-2.8702	-9.8294	I(1)	-5.1585	2014M09	-11.2913	2020M04	I(1)
South Africa	INFL	-10.8596		I(0)	-11.5691	2008M07			I(0)
	EXV	-4.8799		I(0)	-6.916	2009M05			I(0)
	LINTR	-1.4566	-13.304	I(1)	-3.0302	2022M04	-7.3135	2022M04	I(1)
	LOILP	-2.8702	-9.8294	I(1)	-11.2913	2020M04			I(0)
Ghana	INFL	-11.395		I(0)	-4.2841	2021M12	-9.0054	2022M11	I(1)
	EXV	-11.5108		I(0)	-19.9558	2023M01			I(0)
	LINTR	-1.6763	-15.383	I(1)	-3.0091	2022M02	-7.9549	2021M10	I(1)
	LOILP	-2.8702	-9.8294	I(1)	-5.1585	2014M09	-11.2913	2020M04	I(1)
Namibia	INFL	-10.7674		I(0)	-5.9086	2010M06			I(0)
	EXV	-2.9736	-10.6217	I(1)	-3.9074	2008M11	-16.9675	2008M11	I(1)
	LINTR	-1.4255	-8.7174	I(1)	-5	2009M01			I(0)
	LOILP	-2.2319	-5.1334	I(1)	-3.783	2010M09	-6.1582	2008M12	I(1)

Note: *Infl, excr, intr and oilp denote inflation rate, exchange rate, interest rate and oil price respectively. Note 2: ***, ** and * denote significance at 1%, 5% and 10% respectively.*

Subsequently, table 3 below reports inflation persistence using a lagged inflation model, as lagged inflation captures the inertia[1] and rigidity in price changes. The coefficient of lagged inflation is positive and highly significant across all countries, confirming inflation persistence and price rigidity. Nigeria exhibits the highest level of inflation persistence, with 84% of prior inflation being transmitted to current inflation. This indicates that economic agents anticipate continued price increases and that price adjustments occur gradually. The Calvo (1983) staggered price-setting model provides a theoretical framework for understanding price rigidity in markets characterized by imperfect competition. Similarly, Fuhrer (2000) finds that inflation persistence often reflects adaptive expectations and structural rigidities. The relatively lower persistence in South Africa may indicate that inflation-targeting credibility and anchored expectations weaken the inertia captured by ARDL models. Moreover, high persistence in Ghana and Namibia further suggests structural rigidities, weak expectation anchoring, and supply-side vulnerabilities.

Table 3: Inflation Persistence and Price Rigidity Result

Variable/Test	Nigeria	South Africa	Ghana	Namibia
C	0.1676***	0.3152***	0.8403***	-0.3434
INFL(-1)	0.8479***	0.2871***	0.2268***	0.3591***
Adjusted R	0.1588	0.07888	0.0507	0.1236
D.W.	2.1083	1.8918	1.9513	2.001

*Note 2: ***, ** and * denote significance at 1%, 5% and 10% respectively.*

Table 4 below reveals that the F-statistics exceed the 5% upper critical value, suggesting long-run cointegration[2] among the macro-variables: inflation, the exchange rate, the interest rate, and oil prices. Thus, this supports the existence of long-run equilibrium relationships. The bounds-testing approach is particularly suitable for small samples with mixed integration orders. The strong F-statistics, such as 25.75 for South Africa, suggest robust long-run linkages between monetary variables and inflation.

[1]Because past price increases influence current pricing decisions, inflation tends to persist in the same direction, making it slow to adjust or reverse.

[2]Cointegration implies that deviations from equilibrium are temporary and corrected over time.

Table 4: ARDL Bounds Test for Cointegration

Country	F-Statistics	I(0) 5%	I(1) 5%	Cointegration Decision
Nigeria	9.9707	3.23	4.35	Cointegration exists
South Africa	25.7459	3.23	4.35	Cointegration exists
Ghana	17.3480	3.23	4.35	Cointegration exists
Namibia	7.5372	3.23	4.35	Cointegration exists

Note 1: *Critical values based on Pesaran et al (2001). Note 2: Decision Rule*

Furthermore, table 5 reveal that exchange rates have a strong effect on inflation in Nigeria and Namibia. This supports the idea of exchange rate pass-through (ERPT), in which changes in exchange rates lead to changes in domestic prices. This result is consistent with Taylor (2000), who says ERPT is stronger in economies with high inflation. Interest rates significantly affect inflation in Ghana and Namibia, suggesting that changes in interest rates are effectively passed on to influence prices (known as monetary transmission). Ghana's significant coefficient (a statistical measure of impact, valued at 1.033) indicates that monetary tightening—raising interest rates—has a strong influence on price dynamics. Oil prices have a notable effect on inflation in Namibia. In Nigeria, the lack of significant impact may relate to fuel subsidy regimes and price controls that limit pass-through.

The short-run results are similar to the long-run patterns. The error correction term (ECT) shows how fast the system returns to balance after a change. It is negative and highly significant across all countries, indicating that the model is stable and typically returns to equilibrium. Namibia's adjustment speed (-0.9158) indicates a faster return to equilibrium compared to Nigeria (-0.5799). Diagnostic tests confirm that the residuals exhibit neither serial correlation nor heteroskedasticity, thereby supporting the model's reliability. Summarily, the results are consistent with New Keynesian sticky-price models, exchange rate pass-through research, and structural break analyses. In sub-Saharan African countries, differences in inflation persistence reflect varying monetary policy credibility, exchange rate stability, and the degree of structural reforms.

Table 5: ARDL Estimation Results for Inflation Dynamics in Selected SSA Countries

Variables	Nigeria	South Africa	Ghana	Namibia
Long run Estimate				
EXV	26.2055	0.5672	11.7445	16.0123
	[0.0336]**	[0.9899]	[0.1274]	[0.0383]**
LINTR	0.4615	0.2168	1.033	10.9566
	[0.0953]*	[0.0668]*	[0.0241]**	[0.0444]**
LOILP	-0.0606	0.1464	0.3536	18.0224
	[0.7730]	[0.1829]	[0.2866]	[0.0013]***
C	0.1793	-0.577	-3.3507	-113.6864
	[0.8783]	[0.2669]	[0.1281]	[0.0011]***
Short run Estimate				
ΔEXV	15.1979	0.4274	9.7283	44.2805
	[0.0415]**	[0.9899]	[0.1320]	[0.0421]**
ΔLINTR	0.2676	1.5194	0.8556	10.0337
	[0.0997]*	[0.0304]**	[0.0028]***	[0.0551]*
ΔLOILP	-0.0351	0.7897	0.2929	16.5053
	[0.7725]	[0.0011]	[0.2901]	[0.0029]***
ECT (-1)	-0.5799	-0.7534	-0.8283	-0.9158
	[0.0000]***	[0.0000]***	[0.0000]***	[0.0000]***
R	0.3236	0.3199	0.3093	
F-Stat (Prob)	0.0000***	0.0000***	0.0000***	0.0000***
Diagnostic Test				
Serial Correlation LM (prob)	0.4688	0.3019	0.6587	0.6008
Heteroskedasticity (Prob)	0.2058	0.1531	0.5857	0.7942

*Note: Probability values in parentheses. ***, **, * denote significance at 1%, 5%, and 10%.*

Table 6: NARDL Estimation Results for Inflation Dynamics in Selected SSA Countries

Variables	Nigeria	South Africa	Ghana	Namibia
Long run Estimate				
EXV+	15.7154	-6.3080	-65.1079	17.4055
	[0.2287]	[0.9437]	[0.0952]*	[0.0753]*
EXV-	30.1363	41.5096	-62.7899	7.8178
	[0.3164]	[0.6364]	[0.1058]	[0.1187]
LINTR+	-0.4049	-0.1794	0.0348	-40.0342
	[0.2302]	[0.4413]	[0.9688]	[0.3429]
LINTR-	0.5637	0.1125	4.0690	7.6104
	[0.3129]	[0.7329]	[0.0026]***	[0.7162]
LOILP+	0.2126	0.2145	1.3034	15.9006
	[0.3116]	[0.1470]	[0.0036]***	[0.1057]
LOILP-	-0.1029	0.0640	0.4665	22.5129
	[0.6400]	[0.5882]	[0.2187]	[0.0193]**
C	0.8673	0.7784	-0.1622	-9.1846
	[0.0037]***	[0.0000]***	[0.6958]	[0.1310]
Short run Estimate				
ΔEXV+	30.1087	-58.8562	20.4612	61.0958
	[0.0649]*	[0.3555]	[0.0249]**	[0.0809]*
ΔEXV-	-36.9000	61.7109	-7.0177	75.1503
	[0.6107]	[0.8358]	[0.0733]*	[0.1241]
ΔLINTR+	-0.4869	2.4788	1.3508	-9.1162
	[0.7076]	[0.0349]**	[0.7132]	[0.3524]
ΔLINTR-	-1.4406	-0.1958	6.2463	7.4359
	[0.2981]	[0.8454]	[0.1889]	[0.7182]
ΔLOILP+	-0.0974	-0.1535	3.2513	15.5361
	[0.9128]	[0.7945]	[0.1061]	[0.1171]
ΔLOILP-	0.6314	1.3155	-2.6812	21.9967
	[0.2842]	[0.0009]***	[0.0353]**	[0.0236]**
ECT (-1)	-0.6816	-0.8058	-0.8884	-0.9770
	[0.0000]***	[0.0000]***	[0.0000]***	[0.0000]***
R	0.7236	0.7199	0.7127	0.7513
F-Stat (Prob)	0.0000***	0.0000***	0.0000***	0.0000***
Diagnostic Test				
Serial Correlation LM (prob)	2.8513	0.1670	0.6526	0.1475
Heteroskedasticity (Prob)	0.2.3895	2.1404	0.2423	0.3310

*Note: Probability values in parentheses. ***, **, * denote significance at 1%, 5%, and 10%.*

Table 6 below reports estimate from the Nonlinear ARDL (NARDL) model, which examines how the selected macroeconomic variables - exchange rate volatility, the interest rate, and oil prices affect inflation in selected SSA countries, both in the long and short run. Thus, this nonlinear approach distinguishes between the impacts of positive and negative shocks, which aligns with the work of Shin et al. (2014), who show that macroeconomic relationships may display asymmetry. Most of the long-run coefficients are significant at the 10% level. Ghana and Namibia are exceptions to positive exchange rate shocks. In Ghana, the significant negative coefficient shows that exchange rate appreciation shocks reduce inflation over time. This result supports the exchange rate pass-through theory (Choudhri & Hakura, 2006; Taylor, 2000). Whereas, in Nigeria and South Africa, positive exchange rate shocks have no significant effect, suggesting incomplete pass-through. This supports Coulibaly and Kempf (2010) finding that inflation-targeting regimes reduce pass-through in emerging economies.

Ghana exhibits a strong long run asymmetry for negative interest rate shocks ($p < 0.01$), which means that easing

monetary policy leads to a significant rise in inflation. This finding supports Mishkin (2016) view that expansionary policy increases price pressures when inflation expectations are less stable. However, the weaker results in other countries suggest that monetary credibility differs across SSA. Oil price asymmetry is significant in Ghana (positive shocks) and Namibia (negative shocks). This finding reveals that oil prices pass through to domestic inflation in commodity-dependent economies (Hamilton, 2009; Kilian, 2008). Additionally, the observed asymmetry supports the "rockets and feathers" hypothesis Bacon (1991), which holds that prices respond differently to increases and decreases in oil prices.

Short-run effects are more visible in Ghana and Namibia; however, South Africa exhibits a different pattern. Ghana displays significant short-run exchange rate and oil price asymmetry, suggesting immediate pass-through effects, consistent with (Balke et al., 2002). South Africa, in contrast, shows short-run interest rate significance, consistent with inflation-targeting responsiveness (Aron & Muellbauer, 2007). The Error Correction Terms (ECT) are negative and highly significant across all countries examined, confirming the presence of long-run equilibrium relationships. Adjustment speeds range from 68% in Nigeria to 98% in Namibia, indicating that disequilibrium is rapidly corrected. These rapid adjustment rates provide empirical support for the cointegration theory advanced by (Pesaran et al., 2001).

Table 7: Result of Wald test for Asymmetric Effects

Country	Variable	Long run Asymmetric	Short run Asymmetric
Nigeria	EXV	0.0903[0.7640]	0.0380[0.8455]
	INTR	2.7455[0.0666]*	0.0114[0.9149]
	OILP	5.4459[0.0206]**	0.0002[0.9988]
South Africa	EXV	3.6408[0.0578]*	0.1994[0.6556]
	INTR	2.6479[0.0733]*	0.5497[0.4593]
	OILP	9.3270[0.0001]***	0.0787[0.7792]
Ghana	EXV	5.7904[0.1223]	0.0001[0.9991]
	INTR	6.3279[0.0127]**	4.7269[0.0309]**
	OILP	6.1001[0.0027]***	0.1785[0.6731]
Namibia	EXV	0.2121[0.6463]	0.0254[0.8737]
	INTR	0.7294[0.3955]	0.6588[0.4192]
	OILP	0.1692[0.6818]]	0.0384[0.8451]

*Note: Values in parentheses are the Probability values while ***, **, and * measure significance at 1%, 5% and 10% respectively.*

Table 7 shows the Wald test results for long-run and short-run asymmetry using the NARDL framework. These results formally test whether positive and negative shocks have different effects on inflation. The findings indicate that oil price shocks have statistically significant long-run asymmetry in Nigeria (5%), South Africa (1%), and Ghana (1%). The findings indicate that rising oil prices create stronger inflationary pressures than falling prices can counteract through disinflation. This asymmetry supports the hypothesis documented by Hamilton (2009), who shows that increases in energy prices have larger macroeconomic effects than declines.

Furthermore, in the long run, interest rate asymmetry is statistically significant in Ghana at the 5% level and somewhat significant in South Africa at the 10% level. This implies that expansionary monetary shocks increase inflation more than contractionary shocks decrease it. These findings align with the theory of Clarida et al. (1999), which asserts the roles of expectations and credibility in shaping inflation. Exchange rate volatility does not show strong long-run asymmetry, indicating symmetric pass-through effects. This aligns with Choudhri and Hakura (2006), who argue that credible monetary regimes can moderate pass-through. In Ghana, short-term asymmetry is visible because inflation reacts quickly to changes in oil prices and interest rates. This finding matches the nonlinear framework from Shin et al. (2014), which suggests that macroeconomic relationships are often state-dependent instead of symmetric.

Conclusions and Policy Implications

Conclusion

Overall, the New Keynesian price rigidity theory provides the most comprehensive and policy-relevant framework for analysing the interaction between price rigidities and macroeconomic performance. By explicitly linking micro-level price-setting behaviour to aggregate inflation, output, and employment dynamics, the theory successfully explains inflation inertia, short-run monetary non-neutrality, and persistent output gaps. Empirical evidence from Nigeria strongly supports these predictions, confirming that price rigidities play a decisive role in shaping macroeconomic outcomes in developing economies as well as advanced ones.

This study looks at price rigidity in Nigeria, South Africa, Ghana, and Namibia between 2007 and 2024. The results show that inflation remains persistent, and price adjustments often occur unevenly. These rigidities strongly affect how macroeconomic policies work. Thus, by applying New Keynesian theory and using AR (1), ARDL, and NARDL models, the study provides evidence to improve policy design in Sub-Saharan Africa. Price rigidity is prevalent and persistent in Sub-Saharan African economies. AR (1) estimates show sustained inflation

in all four countries. Nigeria has the highest persistence. In the selected SSA countries, current inflation depends on previous inflation. This causes slow price adjustments aftershocks. This inertia, consistent with New Keynesian price rigidity theory, highlights that inflation in SSA reflects not only short-term monetary factors but also deeply entrenched structural issues.

Inflation persistence has important macroeconomic consequences. Specifically, when it is present, shocks, whether from exchange rate fluctuations, oil price changes, or policy decisions, have prolonged effects on the price level. As a result, monetary policy becomes less effective because interventions take longer to be reflected in the economy. By generating uncertainty, this persistence discourages investment and weakens long-term economic planning. Within this context, the study confirms that price rigidity is a crucial channel for sustaining macroeconomic instability in SSA.

Another key finding is strong but varied ERPT effects among the selected countries. ARDL results indicate that exchange rate movements significantly influence inflation in Nigeria and Namibia. The effects are weaker or insignificant in South Africa and Ghana. These differences stem from changes in the economic structure, the degree of trust in monetary policy, and the extent to which a country relies on imports. In countries that depend heavily on imports, like Nigeria, a weaker currency quickly raises domestic prices and leads to inflation. On the other hand, when the currency gets stronger, prices rarely fall right away or by much. This shows that prices tend to be slow to go down.

The NARDL results show that price changes in Sub-Saharan Africa (SSA) are uneven. When there are positive shocks, such as a weaker exchange rate or higher oil prices, inflation rises faster and more sharply than it falls after negative shocks. This supports the "rockets and feathers" hypothesis, which says prices rise quickly but fall slowly. This behaviour suggests that there are built-in obstacles in the economy, such as inflexible systems, flaws in market functioning, and a lack of strong competition. Together, these factors make it hard for prices to fall when they should. The results from the Wald test show that changes in oil prices affect some countries more than others, highlighting the importance of exogenous shocks in influencing domestic inflation dynamics.

How much interest rates affect inflation isn't the same everywhere—it depends on how well each country's financial system passes on policy changes. In Ghana and Namibia, raising or lowering interest rates clearly affects inflation, indicating that their financial systems are better at transmitting these changes. But in Nigeria and South Africa, interest rates have a weaker or inconsistent effect on inflation. This constraint could result from a high level of informality and limited access to credit. The results show that simply changing interest rates may not be enough to keep inflation under control in Sub-Saharan Africa. For monetary policy to work well, it needs to be backed up by improvements in the wider financial system and stronger institutions.

The study also shows that, over the long term, there's a steady relationship between inflation and major economic factors such as exchange rates, interest rates, and oil prices, as evidenced by the ARDL bounds test. It implies that even though inflation fluctuates in the short run, its overall pattern is anchored in fundamental macroeconomic factors such as exchange rates, interest rates, and oil prices. Consequently, the presence of structural breaks associated with global events such as the 2008 financial crisis, the 2014 oil price drop, and the COVID-19 pandemic has had a significant impact on economies in Sub-Saharan Africa. These shocks make it harder for prices to settle and can exacerbate a country's economic stability.

A valuable contribution of our paper lies in its cross-country comparative approach, showing the multiplicity of inflation dynamics across Sub-Saharan Africa economies. All four countries in the study exhibit price rigidity, however, the magnitude of this vary significantly. South Africa stands out for having less stubborn inflation and more predictable price changes, reflecting credibility of its inflation management system and robust institutions. On the other hand, Nigeria struggle with more unpredictable and persistent inflation, largely because of exchange rate instability, fiscal pressure, and weak economic policies. Namibia presents a unique case, with lower pass-through but significant exposure to external shocks due to its economic linkages with South Africa.

These differences highlight why each country must develop its own approach to managing inflation dynamics. As challenges and economic conditions vary across Sub-Saharan Africa, a universal solution likely won't work. Policymakers should design strategies tailored to the specific issues driving price rigidity in the respective countries. The study shows that inflation in SSA is intricate, it's influenced by many factors driven by the combination of demand-side, supply-side, and the way institutions work. When prices are slow to adjust, it makes economic shocks hit harder and last longer, and it also makes it tougher for government policies to work as intended. To tackle inflation, countries need to look at the bigger picture and use a mix of strategies, not just the conventional tools like adjusting interest rates.

Conclusively, the study reveals that prices in Sub-Saharan Africa tend to be slow to change, which has a big impact on economic stability and how well policies work. By providing robust empirical evidence on inflation persistence, how exchange rates affect prices, and asymmetric price adjustment, the study contributes to a deeper understanding of the structural challenges facing SSA economies. The findings make it clear that economies in Sub-Saharan Africa need stronger institutions, reliable and credible monetary frameworks, and reforms that make markets work better and lower the costs of adjusting prices. In the end, keeping prices stable in the SSA region is not just about good economic policy, it also requires ongoing efforts to fix the root causes that make prices slow to move in the first place.

Policy Implications

The empirical findings reveal several critical characteristics of inflation dynamics in the selected SSA economies - Nigeria, South Africa, Ghana, and Namibia. The findings include

1. structural breaks associated with global shocks,
2. heterogeneous effects of monetary transmission,
3. strong exchange rate pass-through in certain economies,
4. significant inflation persistence, and
5. stable long-term relationships among macro-variables. The findings show that inflation in Sub-Saharan African (SSA) economies is deeply rooted, influenced by exogenous factors, and affected by weak institutions. As a result, policy responses should follow a broader and strategic approach.

1. Anchoring Inflation Expectations and Reducing Persistence

The data reveals that inflation has proven persistence across all the Sub-Saharan African (SSA) countries examined, especially in Nigeria, Ghana, and Namibia. This ongoing trend means that people tend to rely on past prices when they think about the future, and prices don't adjust quickly, an idea that matches the staggered price-setting model from (Calvo, 1983). What does this mean for policy? First, central banks need to build trust in their inflation-targeting strategies. Second, they should communicate more clearly with the public. Third, it's important to make forward guidance a regular part of the policy toolkit. Lastly, central banks should be open and transparent about their decisions. When institutions are credible, they help keep inflation in check by shaping expectations, as Mishkin (2007) points out. South Africa's experience, with lower inflation persistence, shows how credibility can help steady expectations. Other SSA countries should focus on making their central banks independent and avoiding too much government influence over monetary policy.

2. Enhancing Monetary Transmission Effectiveness

In some countries, changes in interest rates have a strong impact on the economy, showing that monetary policy can be effective. However, this isn't true everywhere in Sub-Saharan Africa as some economies experience weaker effects. Often, this is because their financial markets are underdeveloped, banks face little competition, and many transactions happen outside the formal system (Chukwu, 2025). To address these challenges, countries should focus on deepening financial markets, encouraging more competition among banks, improving systems that track credit information, and strengthening rules to manage risks in the financial sector. Each of these policies support the next, creating a well-rounded strategy. When monetary policy is transmitted effectively, central banks are better able to keep inflation under control. As Woodford and Walsh (2005) point out, managing expectations and strengthening financial channels are key elements in today's monetary policy frameworks.

3. Managing Exchanging Rate Pass-Through

The ARDL results reveal that exchange rates have a big impact on inflation in many countries, confirming the existence of exchange rate pass-through, especially where trust in monetary policy is low and inflation is already high. In Nigeria, where exchange rates often swing wildly, keeping them stable is crucial to fighting inflation. Policymakers can help by increasing foreign reserves, making currency markets clearer, simplifying exchange rate systems, and supporting a wider range of exports. Oil-dependent countries are hit hardest by exchange rate changes, so it is especially important for them to diversify their economies, as studies on the resource curse suggests.

4. Addressing Oil Price Vulnerability

Sudden changes in oil prices can quickly drive-up inflation, especially in countries that use a lot of energy or import most of it. The sharp falls in oil prices in 2014 and during the COVID-19 pandemic exposed just how fragile the global economy is. This supports Hamilton (2009) views that oil price shocks often trigger wider economic problems. To insulate against these challenges, countries should build up oil reserves, switch to renewable energy, cut reliance on imports, and use stronger fiscal policies. Diversifying energy sources can help lower inflation from abroad, thereby mitigating external pass-through effects.

5. Institutional and Structural Reforms

Cointegration reveals long-run equilibrium between inflation and macroeconomic indicators. When inflation doesn't go away, it often points to deeper problems that need fixing. To tackle this, countries should upgrade infrastructure, boost agricultural productivity to stabilize food prices, promote new industries, and make sure markets stay competitive. These reforms help lower costs and keep prices stable. Such reforms address the root causes of inflation, matching what prior studies on developing economies recommends. By focusing on these areas, countries can achieve more stable growth and better control over inflation in the long run.

In these SSA economies, inflation is shaped by ongoing trends, unstable exchange rates, oil prices, and institutional factors. To keep prices in check, it is vital to have strong, independent central banks and stable exchange rates. Policies should reach all parts of the economy, while government spending stays disciplined. Fixing supply-side issues and having clear plans for energy and commodity shocks are also key. Acting quickly on these measures helps keep inflation under control and make economies more resilient. Conclusively, inflation control in SSA cannot rely solely on interest rate adjustments. Achieving this objective requires coordinated macroeconomic governance, institutional strengthening, and structural transformation. These findings reinforce the broader consensus in the macroeconomic literature that sustainable price stability results from credible institutions, diversified economic structures, and coherent fiscal-monetary coordination.

Declaration of Conflicting Interests

The authors declare that they have no conflicts of interest related to the authorship or publication of this article. There were no financial, professional, or personal relationships that swayed the research, analysis, or findings shared in this study. They have followed all ethical guidelines and academic integrity standards closely, which helps maintain the objectivity and credibility of their work.

Funding Declaration

The authors declare that no specific grant, funding, or financial support was received from any organization – whether public, private, non-profit, or government for any part of this research. Every stage of the study, from the initial idea to collecting and analysing data, as well as writing the paper, was done independently. All expenses related to the research and the preparation of the manuscript were covered by the authors themselves.

References

1. Barro, R. J. (1995). Inflation and economic growth. National bureau of economic research. https://www.nber.org/system/files/working_papers/w5326/w5326.pdf
2. Bates, R. H., Collier, P., Ndulu, B. J., O'Connell, S. A., & Soludo, C. C. (2008). The political economy of economic growth in Africa, 1960–2000. Cambridge University Press.
3. Blanchard, O., & Galí, J. (2007). Real wage rigidities and the New Keynesian model. *Journal of money, credit and banking*, 39, 35-65. DOI: https://doi.org/10.1111/j.1538-4616.2007.00015.x
4. Mishkin, F. S. (2007). The economics of money, banking, and financial markets. Pearson education. https://unitimesofficial.wordpress.com/wp-content/uploads/2020/10/the-economics-of-money-banking-and-financial-markets-mishkin-f.-s.-2011.pdf
5. Kasekende, L. Brixova, Z., & Ndikumana, L. (2010). Africa: Africa's counter-cyclical policy responses to the crisis. *Journal of Globalization and Development, 1*(1). https://www.afdb.org/fileadmin/uploads/afdb/Documents/Financial-Information/Africa%27s%20counter-cyclical%20policies%20-%20JGD%20vol%201%281%29%2016%20Dec%202009.pdf
6. Montiel, P. J. (2011). Macroeconomics in emerging markets. Cambridge University Press. https://assets.cambridge.org/97805217/80605/sample/9780521780605ws.pdf
7. Bleaney, M., & Fielding, D. (2002). Exchange rate regimes, inflation and output volatility in developing countries. *Journal of Development Economics, 68*(1), 233-245.
8. Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of monetary economics, 12*(3), 383-398. DOI: https://doi.org/10.1016/0304-3932(83)90060-0
9. Nakamura, E., & Steinsson, J. (2013). Price rigidity: Microeconomic evidence and macroeconomic implications. *Annual Review of Economics, 5*(1), 133-163.DOI: https://doi.org/10.1146/annurev-economics-061109-080430
10. Benjamin, N. C., & Mbaye, A. A. (2020). The failure of structural transformation in Francophone Africa and the rise of the informal sector. In Formal and informal enterprises in Francophone Africa: Moving toward a vibrant private sector (pp. 137–156). World Bank.
11. Galí, J. (2015). Monetary policy, inflation, and the business cycle: an introduction to the new Keynesian framework and its applications (2nd ed.). Princeton University Press. https://press.princeton.edu/books/hardcover/9780691164786/monetary-policy-inflation-and-the-business-cycle?srsltid=AfmBOop5QvBrpwzgPA69PxTZcU9HS4xZ8xsMHKUh6xPKRptt6-x-07zC
12. Aryeetey, E., & Kanbur, S. R. (2017). The economy of Ghana sixty years after independence. Oxford University Press. https://api.pageplace.de/preview/DT0400.9780191067778_A30389922/preview-9780191067778_A30389922.pdf
13. Rodrik, D. (2016). Premature deindustrialization. *Journal of Economic Growth, 21*(1), 1-33. DOI: https://doi.org/10.1007/s10887-015-9122-3
14. Frankel, J. A., Vegh, C. A., & Vuletin, G. (2013). On graduation from fiscal procyclicality. *Journal of Development Economics, 100*(1), 32-47. DOI: https://doi.org/10.1016/j.jdeveco.2012.07.001
15. Easterly, W., & Levine, R. (1997). Africa's growth tragedy: policies and ethnic divisions. *The Quarterly Journal of economics, 112*(4), 1203-1250. DOI: https://doi.org/10.1162/003355300555466
16. Yameogo, N. D., Nabassaga, T., Shimeles, A., & Ncube, M. (2014). Diversification and sophistication as drivers of structural transformation for Africa: The economic complexity index of African countries. *Journal of African Development, 16*(2), 1-39. https://ideas.repec.org/a/afe/journl/v16y2014i2p1-31.html
17. Akinboade, O. A., Siebrits, F. K., & Niedermeier, E. W. (2004). The determinants of inflation in South Africa: An econometric analysis.
18. Clarida, R., Gali, J., & Gertler, M. (1999). The science of monetary policy: a new Keynesian perspective. *Journal of economic literature, 37*(4), 1661-1707. DOI:10.1257/jel.37.4.1661
19. Goldfajn, I., & Werlang, S. R. C. (2000). The pass-through from depreciation to inflation: a panel study. SSRN Electronic Journal. https://www.researchgate.net/publication/24124178_The_Pass-through_from_Depreciation_to_Inflation_A_Panel_Study
20. Sanusi, S. L. (2013). Banks in Nigeria and national economic development: A critical review.
21. Balogun, E. D. (2007). Monetary policy and economic performance of West African Monetary Zone countries. RePEc. https://www.researchgate.net/publication/24113917_Monetary_policy_and_economic_performance_of_West_African_Monetary_Zone_Countries

22. Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. Handbook of macroeconomics, 1, 1341-1393. DOI: https://doi.org/10.1016/S1574-0048(99)10034-X
23. Alesina, A., Campante, F. R., & Tabellini, G. (2008). Why is fiscal policy often procyclical? *Journal of the European Economic Association, 6*(5), 1006-1036. DOI: https://doi.org/10.1162/JEEA.2008.6.5.1006
24. Sargent, T. J., & Wallace, N. (1984). Some unpleasant monetarist arithmetic. In B. Griffiths & G. E. Wood, (eds.), Monetarism in the United Kingdom (pp. 15-41). Springer. DOI: https://doi.org/10.1007/978-1-349-06284-3_2
25. Agénor, P.-R., & Montiel, P. J. (2015). Development macroeconomics (4th ed.). Economics Books.
26. Fosu, A. K. (2019). Institutions and African economic development. https://drupalwebprodfiles.up.ac.za/Public/media/83/documents/inline/39875/wp_2022_02.zp214289.pdf?VersionId=L_aBQb3EIkr1I8wnu4om7o27wXqdieXX
27. North, D. C. (1990). Institutions, institutional change and economic performance. Cambridge University Press.
28. Mbaye, A. A., & Benjamin, N. (2020). The Informal Sector in Francophone Africa: The Other side of Weak structural transformation. https://www.brookings.edu/wp-content/uploads/2020/07/20.07.06-Failure-of-ST_Mbaye_Benjamin_FINAL.pdf
29. Porta, R. L., Lopez-de-Silanes, F., Shleifer, A., & Vishny, R. W. (1998). Law and finance. *Journal of political Economy, 106*(6), 1113-1155. DOI: https://doi.org/10.1086/250042
30. Collier, P., & Gunning, J. W. (1999). Explaining African economic performance. *Journal of economic literature, 37*(1), 64-111. DOI: https://doi.org/10.1257/jel.37.1.64
31. Vivien, F., & Briceño-Garmendia, C. (Eds.). (2010). Africa's infrastructure: A time for transformation. World Bank.
32. Hall, P. A., & Soskice, D. (2001). An introduction to varieties of capitalism. Debating varieties of capitalism. A reader, 21-74. https://www.researchgate.net/publication/313549561_An_Introduction_to_Varieties_of_Capitalism
33. Bleaney, M., & Greenaway, D. (2001). The impact of terms of trade and real exchange rate volatility on investment and growth in sub-Saharan Africa. *Journal of Development Economics, 65*(2), 491-500. DOI: https://doi.org/10.1016/S0304-3878(01)00147-X
34. Aron, J., & Muellbauer, J. (2007). Inflation dynamics and trade openness: with an application to South Africa. RePEc.https://ideas.repec.org/p/csa/wpaper/2007-11.html
35. Olayungbo, D. O. (2019). Effects of global oil price on exchange rate, trade balance, and reserves in Nigeria: A frequency domain causality approach. *Journal of Risk and Financial Management, 12*(1), 43. DOI: https://doi.org/10.3390/jrfm12010043
36. Gali, J., & Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. The review of economic studies, 72(3), 707-734. https://crei.cat/wp-content/uploads/users/pages/roes8739.pdf
37. Khan, M. S., & Ssnhadji, A. S. (2001). Threshold effects in the relationship between inflation and growth. *IMF Staff papers, 48*(1), 1-21. https://econpapers.repec.org/article/palimfstp/v_3a48_3ay_3a2001_3ai_3a1_3ap_3a1.htm
38. Stiglitz, J. E. (2010). Freefall: America free markets and the sinking of the world economy. WW Norton & Company.
39. Albanesi, S. (2004). Interest and prices: Foundations of a theory of monetary policy, by Michael Woodford. NBER Macroeconomics Annual, 19, 333–345.
40. Nakamura, E., & Steinsson, J. (2008). Five facts about prices: A reevaluation of menu cost models. *Quarterly Journal of economics, 123*(4), 1415-1464. DOI: https://doi.org/10.1162/qjec.2008.123.4.1415
41. Miyazaki, K. (2026). Closed-Form of Two-Agent New Keynesian Model with Price and Wage Rigidities. arXiv preprint. DOI: https://doi.org/10.48550/arXiv.2508.12073
42. Eyster, E., Madarász, K., & Michaillat, P. (2021). Pricing under fairness concerns. *Journal of the European Economic Association, 19*(3), 1853-1898. DOI: https://doi.org/10.1093/jeea/jvaa041
43. Mishra, P., Montiel, P. J., & Spilimbergo, A. (2012). Monetary transmission in low-income countries: effectiveness and policy implications. I*MF Economic Review, 60*(2), 270-302. https://ideas.repec.org/a/pal/imfecr/v60y2012i2p270-302.html
44. Kemoe, L., Mbohou, M., Mighri, H., Quayyum, M. S. N., & Quayyum, S. (2024). Effect of exchange rate movements on inflation in sub-Saharan Africa. International Monetary Fund. https://www.imf.org/en/publications/wp/issues/2024/03/15/effect-of-exchange-rate-movements-on-inflation-in-sub-saharan-africa-545750
45. Adekunle, B., & Filson, G. (2024). In Sub-Saharan Africa. Africa's Trade, 257.
46. Olaoye, O. O., Omokanmi, O. J., Tabash, M. I., Olofinlade, S. O., & Ojelade, M. O. (2023). Soaring inflation in sub-Saharan Africa: A fiscal root? Quality & Quantity, 1-23. DOI: https://doi.org/10.1007/s11135-023-01682-z
47. Babangida, H. C., Belonwu, M., Sani. A., Pennap, N., Wilfred, M., Okafor, S. Eyinla, T., & Onuogu, I. (2024). Output–Inflation nexus in selected African countries: A GARCH-MIDAS approach. Scientific African, 23, e02075. DOI: https://doi.org/10.1016/j.sciaf.2024.e02075
48. Magubane, K., & Nzimande, N. P. (2024). A structural vector autoregression exploration of South Africa's monetary and macroprudential policy interactions. *Economies, 12*(10), 278. DOI: https://doi.org/10.3390/economies12100278
49. Kayal, P., & Maheswaran, S. (2018). Speed of price adjustment towards market efficiency: evidence from emerging countries. *Journal of Emerging Market Finance, 17*(1_suppl), S112-S135. DOI: https://doi.org/10.1177/0972652717751542
50. Rasaki, M. G. (2017). An estimated new keynesian phillips curve for nigeria. *Acta Oeconomica, 13*(2), 203-211. https://www.researchgate.net/publication/342500959_An_Estimated_New_Keynesian_Phillips_Curve_for_Nigeria

51. Bulus, Y. D., & Umeokwobi, R. (2025). Does Inflation Expectation Matter for Inflation in Nigeria? *Applied Journal of Economics, Management and Social Sciences, 6*(2), 8-21. DOI: https://doi.org/10.53790/ajmss.v6i2.106\
52. Adam, S. U., Jimoh, S. O., Adamu, M. S., Yusuf, Y. T., Adam, L. S., & Shitu, A. M. (2025). Inflation Dynamics in Nigeria: A Disaggregated Approach. *Lafia Journal of Economics and Management Sciences, 10*(1), 184-207. DOI: https://doi.org/10.70118/lajems-10-1-2025-010
53. Creamer, K., Farrell, G., & Rankin, N. (2012). What price-level data can tell us about pricing conduct in South Africa. *South African Reserve Bank, 80*(4), 490-509. https://www.resbank.co.za/content/dam/sarb/publications/working-papers/2012/5117/WP1204.pdf
54. Creamer, K., & Rankin, N. (2008). Price setting in South Africa 2001 to 2007 stylised facts using consumer price micro data. *Journal of Development Perspectives, 4*(1), 93-118. https://ideas.repec.org/p/pra/mprapa/16905.html
55. Adam, A. M., & Frimpong, S. (2010). Can Stocks Hedge Against Inflation in the Long Run: Evidence from Ghana Stock Market. SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1585577
56. Loloh, F. W. (2014). Exchange rate pass through in Ghana. SSRN. DOI: https://dx.doi.org/10.2139/ssrn.2412128
57. Sheefeni, J. P. S., & Ocran, M. (2014). Exchange rate pass-through to domestic prices in Namibia: SVAR evidence. *Journal of Economic and Financial Sciences, 7*(1), 89-102. DOI: https://doi.org/10.4102/jef.v7i1.132
58. Mushendami, P., & Namakalu, H. (2016). Exchange Rate Pass Through to Inflation in Namibia. Journal of Emerging Issues in Economics, *Finance & Banking, 5*(2). https://www.bon.com.na/CMSTemplates/Bon/Files/bon.com.na/aa/aadc8975-a961-4662-979f-ad6936685083.pdf
59. Otolorin, G. E., Orebiyi, P. A., & Akpan, G. (2024). Exchange rate dynamics and regimes in Nigeria: New evidence from a modified sticky price model. *West African Monetary Agency (WAMA) Review, 8*(1). https://amao-wama.org/wp-content/uploads/2025/11/EXCHANGE-RATE-DYNAMICS-AND-REGIMES-IN-NIGERIA-%E2%80%93-NEW-EVIDENCE-FROM-A-MODIFIED-STICKY-PRICE-MODEL-Vol.-8-%E2%80%93No.1-Dec.2024.pdf
60. Fabiani, S., Druant, M., Hernando, I., Kwapil, C., Landau, B., Loupias, C., Martins, F., Matha, T., Sabbatini, R., Stahl, H. & Stokman, Ad. (2006). What firms' surveys tell us about price-setting behavior in the Euro area. *International Journal of Central Banking, 2*(3). https://www.ijcb.org/sites/default/files/journal/v2n3/ijcb-v2n3-what-firms-surveys-tell-us-about-price-setting-behavior-euro-area.pdf
61. Elem-Uche, O., Okereke, E. W., & Omekara, C. O. (2024). Garima First-Order Autoregressive Process: Properties, Estimation Methods and Application. *Journal of the Royal Statistical Society Nigeria Group, 1*(2), 279-294. https://publications.funaab.edu.ng/index.php/JRSS-NIG/article/view/1874
62. Yule, G. U. (1927). VII. On a method of investigating periodicities disturbed series, with special reference to Wolfer's sunspot numbers. Philosophical Transactions of the Royal Society of London. Series A, Containing Papers of a Mathematical or Physical Character, 226(636-646), 267-298. DOI: https://doi.org/10.1098/rsta.1927.0007
63. Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics, 16*(3), 289-326. https://www.jstor.org/stable/2678547
64. Nguyen, T. L. A., Luong, H. G., & Xuan, V. N. (2025). The link between GDP, FDI, inflation, trade openness, CO2 emissions, and renewable energy in the Czech Republic: New evidence from the ARDL method. Energy Conversion and Management X, 29, 101451. DOI: https://doi.org/10.1016/j.ecmx.2025.101451
65. Xuan, V. N., Hoa, P. X., & Thu, N. T. P. (2025). Relationship between R&D investment, financial development, energy use, and carbon dioxide emissions in USA: New insights from ARDL methodology. Cleaner Environmental Systems, 19, 100362. DOI: https://doi.org/10.1016/j.cesys.2025.100362
66. Amin, A., Peng, S., Mohamed Yusoff, N. Y., Magazzino, C., Sharif, A., & Kamran, H. W. (2025). Driving sustainable development: The impact of energy transition, eco-innovation, mineral resources, and green growth on carbon emissions. Renewable Energy, 238, 121879. DOI; https://doi.org/10.1016/j.renene.2024.121879
67. Nguyen Dang, H.-A., Khan, A., Ibbett, N., & Doan, A.-T. (2025). Investigating the social impact of green innovation: an exploratory study of Vietnamese organisations using "concept cards" interviewing. *Journal of Asian Business and Economic Studies, 32*(3), 160-173.
68. Xuan, V. N. (2025). Nexus of GDP, FDI, inflation, exchange rate, renewable energy, trade openness, and open innovation in Singapore: New evidence from the ARDL method. *Sustainable Futures*, 9, 100628. DOI: https://doi.org/10.1016/j.sftr.2025.100628
69. Kassi, D. F., Li, Y., Gnangoin, Y. T. B., N'Drin, M. G.-R., Gnahe, F. E., & Edjoukou, A. J. R. (2023). Investigating the finance-energy-growth trilogy in Sub-Saharan Africa: Evidence from the NARDL framework. *SAGE Open, 13*(1). DOI: https://doi.org/10.1177/21582440221149714
70. Olaoye, O. O., Orisadare, M., Okorie, U. U., & Abanikanda, E. (2020). Re-examining the government expenditure–growth nexus in ECOWAS countries. *Journal of Economic and Administrative Sciences, 36*(4), 277-301. DOI: https://doi.org/10.1108/JEAS-12-2018-0140
71. Udeagha, M. C., & Breitenbach, M. C. (2023). On the asymmetric effects of trade openness on CO2 emissions in SADC with a nonlinear ARDL approach. *Discover Sustainability, 4*(1), 2. DOI: https://doi.org/10.1007/s43621-022-00117-3
72. Trejo-García, J. C., Valencia-Romero, R., Soto-Rosales, M. D. L., & Venegas-Martínez, F. (2024). On the asymmetric relation between inflation and growth in Mexico: A NARDL approach. *Economies, 12*(1), 21. DOI: https://doi.org/10.3390/economies12010021
73. Shin, Y., Yu, B., & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In Sickles, R., Horrace, W. (eds.). Festschrift in honor of Peter

Schmidt, Springer. (pp. 281-314).
DOI: https://doi.org/10.1007/978-1-4899-8008-3_9
74. Arebo, M. J. (2025). Asymmetric analysis of financial inclusion–growth nexus: A NARDL approach. Research in Globalization, 11, 100316.
DOI: https://doi.org/10.1016/j.resglo.2025.100316
75. Sadraoui, T., Zarai, S., & Azouzi, M. A. (2026). Exploring the interconnectedness of oil, gold, cryptocurrencies, and economic growth in geopolitical uncertainty: An econometric analysis. *Social Sciences & Humanities Open*, 13, 102292.
DOI: https://doi.org/10.1016/j.ssaho.2025.102292
76. Adeniyi, A. P., & Olasunkanmi, A. O. (2019). Impact of exchange rate volatility on economic growth in Nigeria (1980-2016). *International Journal of Management Studies and Social Science Research, 1*(4), 6-14.
https://www.ijmsssr.org/paper/IJMSSSR0037.pdf
77. Frimpong, J. M., & Oteng-Abayie, E. F. (2010). When is inflation harmful? Estimating the threshold effect for Ghana. *American journal of economics and business administration, 2*(3), 232-239.
DOI: https://doi.org/10.3844/ajebasp.2010.232.239
78. Perron, P. (1989). The great crash, the oil price shock, and the unit root hypothesis. *Econometrica, 57*(6), 1361-1401.
DOI: https://doi.org/10.2307/1913712
79. Hamilton, J. D. (2009). Causes and Consequences of the Oil Shock of 2007-08. Brookings Papers on Economic Activity. https://www.researchgate.net/publication/227370279_Causes_and_Consequences_of_the_Oil_Shock_of_2007-08
80. Fuhrer, J. C. (2000). Habit formation in consumption and its implications for monetary-policy models. *American economic review, 90*(3), 367-390.
DOI: 10.1257/aer.90.3.367
81. Taylor, J. B. (2000). Low inflation, pass-through, and the pricing power of firms. *European Economic Review, 44*(7), 1389-1408.
DOI: https://doi.org/10.1016/S0014-2921(00)00037-4
82. Choudhri, E. U., & Hakura, D. S. (2006). Exchange rate pass-through to domestic prices: does the inflationary environment matter? Journal of international Money and Finance, 25(4), 614-639.
83. Coulibaly, D., & Kempf, H. (2010). Does inflation targeting decrease exchange rate pass-through in emerging countries? SSRN.
DOI: https://dx.doi.org/10.2139/ssrn.1706025
84. Mishkin, F. S. (2016). 2% forever? Rethinking the inflation target. In Central banking in times of change (pp. 92–101). Oesterreichische National bank.
85. Kilian, L. (2008). The economic effects of energy price shocks. Journal of economic literature, 46(4), 871-909. DOI:10.1257/jel.46.4.871
86. Bacon, R. W. (1991). Rockets and feathers: the asymmetric speed of adjustment of UK retail gasoline prices to cost changes. *Energy Econ, omics, 13*(3), 211-218.
DOI: https://doi.org/10.1016/0140-9883(91)90022-R
87. Balke, N. S., Brown, S. P., & Yücel, M. K. (2002). Oil price shocks and the US economy: Where does the asymmetry originate? *The Energy Journal, 23*(3), 27-52.
DOI: https://doi.org/10.5547/ISSN0195-6574-EJ-Vol23-No3-2
88. Chukwu, C. (2025). The Dual Impact of the Informal Economy on Formal Growth in Nigeria: Evidence from ARDL Bounds Testing. *Journal of Economics, Business, and Commerce, 2*(2), 101-111.
DOI: https://doi.org/10.69739/jebc.v2i2.931
89. Woodford, M., & Walsh, C. E. (2005). Interest and prices: Foundations of a theory of monetary policy. *Macroeconomic Dynamics, 9*(3), 462-468.
DOI: https://doi.org/10.1017/S1365100505040253