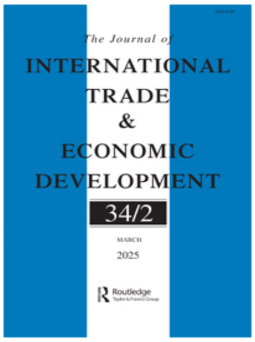

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Quantifying the heterogeneous effects of oil price shocks on domestic inflation of oil-rich countries in sub-Saharan Africa

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ABSTRACT

The study investigates the impact of oil price shocks on inflation components in Nigeria Congo, Angola, and Equatorial Guinea using non-linear and threshold non-linear autoregressive distributed lag models. In the long run, positive oil price shocks significantly influenced core and headline inflation in Nigeria and Angola, while negative shocks had stronger effects in Equatorial Guinea and the Republic of Congo, particularly energy and fold inflation. Mild positive shocks increased inflation in Angola and the Republic of Congo but reduced inflation in Equatorial Guinea. Mild negative shocks reduced inflation in Equatorial Guinea but raised inflation in the Republic of Congo. Moderate shocks had mixed effects, with positive shocks increasing inflation. In the long run, large positive shocks generally raised inflation, while moderate and mild shocks had mixed or insignificant effects. The study recommends for diversification of economic sectors and strengthening of inflation targeting framework to stabilize prices.

KEYWORDS Inflation; oil price shocks; MTNARDL SSA; crude oil

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1. Introduction

Crude oil has significant prominence as an essential input material. It dominates the commodities sector with the most extensive market presence, representing approximately 40% of the world's total energy consumption (Sun and Wang 2021). This establishes its pivotal position as a fundamental energy reservoir, catering to the energy needs of transportation, electricity generation, and diverse industrial processes. Its significance transcends economic boundaries, encompassing both oil-importing and exporting nations. Consequently, it holds considerable sway over economic activities on

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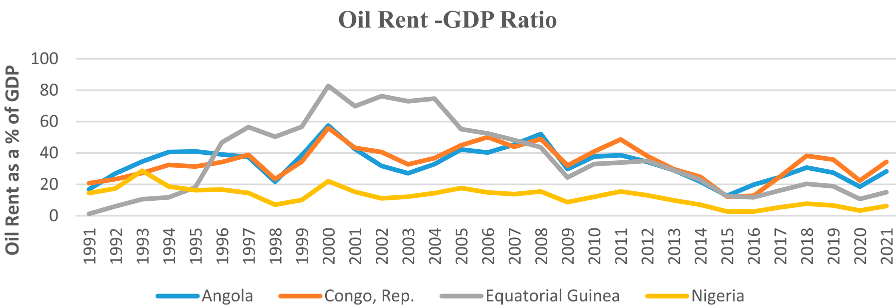

Figure 1. Oil rent as a ratio of GDP. World Bank development indicators database (2022).

a global scale, thereby emerging as a key determinant of macroeconomic performances across countries (Bawa et al. 2020; Mukhtarov, Aliyev, and Zeynalov 2020).

Crude oil contributes significantly to the economies of the four largest oil producers in sub-Saharan Africa (SSA): Nigeria, Angola, Congo Republic, and Equatorial Guinea (Adesina 2023). For instance, the oil sector accounted for 51% of federal government revenue and 41.6% of total exports in Nigeria in 2020 (CBN Statistical Bulletin 2022). In Angola, crude oil and oil products made up approximately 96% of total exports, 56% of fiscal revenues, and 34% of real gross domestic production in 2021 (IMF 2022). Similarly, in the Congo Republic, oil constitutes more than 80% of exports (IMF 2023) and contributed 45.3% to the country's economic growth in 2022 (African Economic Outlook 2023). Meanwhile, Equatorial Guinea saw its oil revenue grow by 150%, while the Congo Republic, Angola, and Nigeria experienced growth rates of 50%, 46%, and 26%, respectively (U.S. Energy Information Administration Short-Term Energy Outlook, June 2023).

The economic reliance on oil is further shown by the contribution of oil rent to GDP in the four largest oil-producing countries in SSA (see Figure 1).

The oil rent-GDP ratio is high for most of the countries in the graph, particularly Equatorial Guinea, Angola, and the Republic of Congo, where oil rents contribute significantly to GDP, often exceeding 20% and even surpassing 80% in Equatorial Guinea during peak periods.

Due to the dominance of oil, these nations constitute some of the most commodity-dependent economies globally, ranking poorly in diversification. For instance, Nigeria, Angola, Equatorial Guinea, and Congo were ranked 130, 177, 178, and 180, respectively, out of 190 countries in the 2020 diversification ranking (Augé 2021). This heavy reliance on oil for exports and revenue renders them highly vulnerable to market volatility, particularly oil price shocks. Such volatility has had tangible impacts on sub-Saharan economies. Some of the major economies of SSA have experienced declines in GDP and economic growth over the past decade, particularly during the oil price crises of 2014–2016 and 2020. For example, Equatorial Guinea's GDP halved from \$22 billion to \$11 billion between 2014 and 2019, contracting by an additional 6% in 2020. Similarly, faced economic contractions, with growth rates of −4.3% and −6.4%, respectively (Augé 2021).

This susceptibility to oil price volatility underscores the broader economic impacts of crude oil. Fluctuations in oil prices not only influence GDP but also affect inflation, a key macroeconomic indicator. Inflation has garnered considerable attention due to its

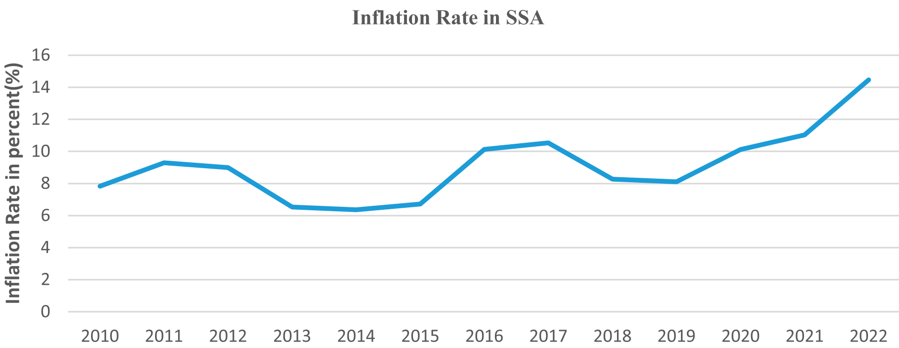

Figure 2. Trend of inflation rate. Source: Ha, Kose, and Ohnsorge (2021).

potential to disrupt economic stability, incur welfare costs, and impede resource allocation (Mordi et al. 2007). Consequently, maintaining price stability remains a central objective for many central banks, both in advanced economies and emerging markets and developing economies (EMDEs). Studying oil price-inflation links is fundamental due to a comovement observed globally between them at various times. In the wake of two major oil crises – the quadrupling of oil prices in 1973 and the doubling of oil prices in 1979–1980 occurred alongside the tripling of the global median inflation from 4.4% in 1970 to 13.6% in 1980 (Ha, Kose, and Ohnsorge 2021). The rise in the core inflation rate from 2.5% in 1972 to 10.9% in 1974 coincided with the Organization of Oil Producing Countries (OPEC) oil embargo in 1973 and its further rise beyond 11% was attributed to the subsequent surge in oil prices in 1979 (Bachmeier and Cha 2011). Therefore, it may not be out of place to attribute the rise in inflation rate in different countries, especially in rich oil-resource sub-Saharan African countries to oil price changes.

SSA's inflation trends exemplify the broader macroeconomic repercussions of oil price fluctuations, given the region's reliance on oil as a revenue source. In Nigeria, the largest country in SSA, inflation surged to a 17-year peak at 21.34%, while in South Africa, the second largest country, the inflation rate has reached a 13-year high of 7.5% since 2009. Ghana, on the other hand, witnessed inflation rise for the 11th consecutive month, reaching an all-time high of 31.7%, the highest level since November 2003 (Olaoye et al. 2023). Angola, the second largest producer of oil after Nigeria recorded an inflation rate of 23.8% in 2020, a much lower rate compared to the thousand rates recorded in the mid-1990s (Kose and Unal 2024). Since the recent COVID-19 pandemic, inflation has been increasing in SSA. As of July 2022, median inflation has risen to nearly 9%, which was significantly higher than the pre-pandemic average of slightly over 5% from 2009 to 2019. Despite this, it is important to note that current median inflation, although the highest in a decade, is still lower than the peak of 12% seen during the global financial crisis in the region (IMF 2022). Inflation in SSA has been upward trending over the years. As shown in Figure 2, from 10.1% in 2016, inflation increased to 10.5% in 2017 and fluctuated downwards between 8.3% and 8.1% until early 2019. It rose to 10.1% in 2020 occasioned by the COVID-19 pandemic, and further to 14.5% in 2022, and it is expected to worsen in the future following the predictions of International Monetary Fund (IMF) and World Bank.

The impact of oil price shocks on inflation, however, can be contingent on the structural attributes of the economy and the potency of monetary policy in mitigating it.

Consequently, the existing body of literature suggests that oil price shocks differ in scale. Notably, Bernanke et al. (1997) exclusively discussed the three significant oil price shocks – OPEC 1, OPEC 2, and the Iraqi invasion of Kuwait in their analysis of oil price shocks, stating how each had a different impact on output and commodity prices. Kilian (2010), on the other hand, identified major shocks including the oil price increases in 1973/1974, 1979/1980, and 1990, as well as those occurring between 2003 and mid-2008, and how they differently impacted inflation and output. Additionally, Pal and Mitra (2019) observed varying responses in purchasing power to minor and major oil price fluctuations. These portray an assertion that all oil price shocks are not the same (Kilian 2009).

To this end, a lot of studies have recognized this and hence explored the different sign effects of oil price shocks on inflation – dichotomizing between positive and negative shocks on both the aggregate and disaggregated inflation (see Ali 2021; Anyars and Adabor 2023; Babuga and Naseem 2020; Bala and Chin 2018; Bawa et al. 2020; Goh, Law, and Trinugroho 2022; Goh, Law, and Trinugroho 2022; Kelesbayev et al. 2022; Lacheheb and Sirag 2019; Nnadozie, Emediegwu, and Raifu 2022; Shitile and Usman 2020). Furthermore, some studies have tried to differentiate among the inflation response to mild, moderate, and large crude oil price fluctuations, capturing the nonlinearity and asymmetric transmission of crude oil shocks to inflation. Li and Guo (2022) and Pal and Mitra (2016) have investigated how aggregate inflation responds to various magnitudes of price shocks, including minor, moderate, and large shocks using multiple threshold nonlinear autoregressive distributed lag (MTNARDL).

However, they focus on the impact of the various sizes and signs of oil price shocks on aggregate inflation, neglecting their impacts on the various inflation components. Disaggregating inflation into their various inflation components to assess their responses to oil price shocks is very crucial to enable the monetary authorities to react appropriately to different components. However, what constitutes the appropriate inflation components has been a subject of debate for a long time because inflation comprises the transitory and persistent components (Atuk and Ozmen 2009). The transitory components, rather called headline inflation is being alluded to include more volatile items such as energy and food prices while the persistent components, or core inflation exclude these items (Giri 2022). Roger (1998) is his study argued that aggregate inflation reflects all price changes including shocks or volatile items, which are not influenced by monetary policy, and hence have limited predictive values. The study further argued that the only way to minimize the impact of some parts of inflation with limited predictive value is to decompose them into their various components. Through this, monetary authorities will be able to react differently to different types of price changes. In doing so, monetary authorities can avoid reacting uniformly to disparate price fluctuations, which could lead to inaccurate assessments and suboptimal outcomes (Odo, Odionye, and Ojike 2016). The emphasis in considering different inflation components is further re-enforced by the fact that in some countries, particularly within middle and low-income countries, some components of inflation are not effective (Anand and Prasad 2010). Thus, studying the impact of oil price shocks on different components will reveal the component that is not impacted by oil price shock and this will ensure targeted policies. Bawa et al. (2020) in further support of disaggregating inflation argued that oil price increases may have a larger impact on the core than food measure of inflation especially in Africa where most of the food consumed is produced locally and thus, its prices are largely immune from oil price-induced inflation. This is an indication that core inflation and food inflation should be treated differently. More so, Ibarra (2012) pointed out that the use of disaggregated data also helps to forecast inflation Thus, breaking headline consumer inflation data into categories like food or non-core, core, and energy helps to better discern the direct effects of oil price fluctuations on inflation (Shitile and Usman 2020).

Furthermore, the diverse effects of oil price shocks on various inflation components may not be the same across countries. This prompted the study of the effects of oil price shocks across individual oil exporting countries in Africa. Hirschman (1981) emphasized the importance of considering heterogeneous effects in his essay as he criticized one-size fit-all development economic policies. He argued that the idea of a 'unified body of analysis and recommendations' for all underdeveloped countries was fundamentally flawed because it failed to account for the diverse and uneven nature of development experiences across countries. He further recommended understanding local contexts and designing policies leveraging each country's strengths, challenges, and opportunities. Guerrero and Castañeda (2021) added that policy-making should be modeled to account for the institutional context of each country to elicit desired outcomes. More so, Castañeda, Chávez-Juárez, and Guerrero (2018) in one of their studies find that country-specific factors are fundamental in determining how well policy priorities achieve their intended goals. Rodrik and Rosenzweig (2010) recommended context specificity for policy to produce desirable results. Thus, integrating general principles with context-specific adaptations enables policies to address the complexities of underdevelopment and the achievement of sustainable economic growth peculiar to countries. Therefore, the impacts of different sizes and signs of oil price shocks on the different inflation components still lack clarity. The study adopts the innovative MTNARDL approach to investigate the impacts of different sizes and signs of oil price shocks including, mild, moderate, and large on various inflation components in selected sub-Saharan countries. This will extend the studies by Li and Guo (2022) and Pal and Mitra (2016) who investigated aggregate inflation responds to various magnitudes of price shocks, including minor, moderate, and large shocks, by considering the extent to various inflation components(disaggregated inflation) respond to minor, moderate, and large shocks.

This research is distinguished by its application of the MTNARDL model to disaggregated inflation measures, including the core, headline, energy, and food consumer price indices to ascertain the heterogeneity of oil price shocks across countries. It offers the advantage of indicating both the degree as well as the trajectory of extreme (minor/major) positive and extreme (minor/major) negative oil price shocks on the diverse components of inflation in the context of SSA countries. This knowledge is crucial as not all oil price shocks (negative or positive) will prompt a shift in input costs; however, certain shocks will influence consumer prices via transportation cost, energy cost, and hence impacting firms' production cost.

2. Literature review

Oil prices have been identified as leading drivers and indicators of inflation as they translate to higher consumer prices through various channels. The first-round direct channel refers to a one-off increase in oil price through the demand side (Asghar and Naveed 2015), which occurs as people try to substitute oil with other forms of energy, such as natural gas when oil prices rise, leading to price increases in those alternatives as well. In other words, the oil price shocks have a direct effect on inflation through energy components (Sun, Wang, and Jia 2022). The first-round indirect channel occurs through their impact on the firms' input costs via the supply side (Asghar and Naveed 2015). Another way through which oil prices can be translated into the high prices of goods and services is through the impact on the cost of transportation. When transportation costs increase due to higher oil prices, these costs are passed on to the consumer. All these negatively affect the supply of goods and services by escalating energy costs, thereby diminishing the availability of essential inputs required for production, ultimately contributing to an increase in inflation. The first-round impact, whether directly or indirectly related to a one-off oil price jump, only elevates the price level temporarily and does not induce lasting inflation (European Central Bank [ECB] 2010). The second-round effects involve the actions of wage and price setters in response to initial price shock impacts, seeking to keep their real earnings and profits stable. In other words, the initial rise in prices of goods and services makes workers demand for higher wages to compensate the decline in real income which may lead to an increase in cost-push inflation. The fact that wage impacts are magnified by further price level pressures makes indirect first and second-round effects interdependent and hard to disentangle (ECB 2010).

2.1. Empirical review

Several studies investigated the linear impact of oil prices on inflation. Mien (2022) revealed for Central African Economic and Monetary Community (CEMAC) countries using dynamic ordinary least squares and autoregressive distributed lag (ARDL) models, a positive impact of oil price on inflation, though the impacts were not significant for all countries. Ding et al. (2023) did a similar study for China using vector autoregressive (VAR) model and a mixed data sampling framework. They investigated the mediating effect of five RMB exchange rates (CAD/RMB, EURO/RMB, RUB/RMB, GBP/RMB, and USD/RMB) on the link between the two variables, providing evidence of a significant effect of oil price on inflation. The findings from Kelesbayev et al. (2022) for Kazakhstan contradicted other studies as the study revealed using VAR estimation that oil price was found inconsequential to changes in inflation. The study by Odionye, Ukeje, and Odo (2019) for Nigeria via local projection impulse response function appeared rather mixed as the evidence showed that within two periods, oil price shock had a detrimental effect on inflation, and afterward, oil price shocks increased inflation which persisted over a more extended period. Xuan and Chin (2015) considered the impact of oil price pass-through on consumer prices in the context of Malaysia using ARDL estimation procedure. The study's outcome revealed a substantial link between the investigated series. In another related study in Malaysia, Wong, Chin, and Wong (2019) investigated how the country's food prices respond to climate change and economic factors utilizing error correction model approach. The study's result demonstrates that both climate change and real GDP largely drive the investigated country's food prices. Furthermore, it revealed that the link between climate change and food prices is nonlinear U-shaped. In the context of ASEAN-4 nations, Ramzi investigated the susceptibility of inflation to oil price shocks. The study adopted the structural VAR estimation approach and concluded that oil price is a major driver of price changes in the nations.

Furthermore, other studies considered the nonlinear effect of oil prices on inflation. According to the findings from Lacheheb and Sirag (2019) using the non-linear autoregressive distributed lag (NARDL) approach, positive short-run and long-run shocks to oil prices increased the inflation rate whereas negative shocks albeit having an insignificant coefficient in the short-run are negatively related to inflation in Algeria. The same results were found for Egypt following the NARDL estimation by Ali (2021), except that the long-run positive shock to oil prices could not explain inflation. Nnadozie, Emediegwu, and Raifu (2022) and Goh, Law, and Trinugroho (2022) studies had similar findings with all coefficients significant, indicating that positive and negative shock increased and decreased inflation respectively in Nigeria and Indonesia. The study by Bala and Chin (2018) based on the nonlinear version of pooled mean group (PMG) of NARDL was a little different from the preceding study as it showed evidence of both negative and positive shocks increasing inflation in Algeria, Angola, Libya, and Nigeria. Babuga and Naseem (2020) applying heterogeneous nonlinear panel ARDL also showed that both positive and negative shocks to oil prices had a significant and positive influence on inflation, but exclusively in the long run. The asymmetric dynamic conditional correlation generalized autoregressive conditional heteroscedasticity (GARCH) (DCC-GARCH) version of the study by Balcilar, Uwilingiye, and Gupta (2018) revealed that positive shocks in oil prices have a higher impact on inflation volatility than negative shocks of the same scale. In a similar study, the threshold version of cointegration approach was used by Belke and Dreger (2015) to examine the effect of international oil and food price shocks on consumer prices in the context of Middle-East and North Africa nations. The study revealed that both international oil price and food price shocks are major determinants of changes in consumer prices of the investigated countries.

Some studied the nonlinear effects of oil prices on the various components of inflation. Anyars and Adabor (2023) who focused on Ghana found an asymmetric effect on the inflation rate in disaggregated forms including food consumer price index (FCPI), energy consumer price index (ECI), core consumer price index (CCPI), and transport consumer price index (TCPI) as well as in the aggregated form. This aligned with Bawa et al. (2020), who found that the oil price increase was found to significantly raise the inflation rate when we consider headline and core inflation but not food inflation while negative shocks albeit having positive coefficients explained none of the components of inflation in Nigeria. Shitile and Usman (2020) also found for Nigeria that positive oil price shocks have a significant positive impact on FCPI, ECPI, ECPI, and the core inflation CPI while the negative changes in oil price were found to be negative but non-statistically significant.

Considering the signs and sizes of the effects of oil price shocks, a study by Pal and Mitra (2016) using the MTNARDL model of India showed that quintile and decile decomposition of the oil price effects revealed heterogeneous effects of oil price shocks on inflation. Li and Guo (2022) conducted a study using MTNARDL and disintegrated oil price shocks into supply, demand, and risk-related shocks. The study obtained the asymmetric effects of these various shocks on inflation in the Brasil, Russia, India, China and South Africa (BRICS) countries. Wen, Zhang, and Gong (2021) used the same methodology for G7 nations dissecting oil price shocks into supply shocks, demand shocks, and risk shocks. A dynamic connectedness approach shows that nearly all countries witnessed a substantial rise in connectedness from risk shocks to CPI during the financial crisis.

3. Data and econometric model

3.1. Data

The study's primary focus is on investigating the inflationary consequences of oil price shocks within specific oil-exporting sub-Saharan African countries, namely Nigeria, Angola, Congo Republic, and Equatorial Guinea using quarterly data between 2005 and 2022. The selection of these countries aligns with the IMF's categorization of sub-Saharan African countries into three distinct groups: oil exporters, other resource-intensive nations, and non-resource-intensive nations. Within the IMF's designation of seven oil-exporting countries in SSA, including Angola, Cameroon, Chad, Congo Republic, Equatorial Guinea, Gabon, and Nigeria, this study concentrated on the four largest oil producers. These countries' heavy reliance on oil as a single commodity for exports and revenue, renders them highly vulnerable to market volatility, particularly during oil price shocks.

The susceptibility is further compounded by these countries' dual status as a net exporter of crude oil and a net importer of petroleum products (African Union Energy Commission 2020). Thus, fluctuations in oil prices can have significant repercussions on inflation in these countries. Furthermore, these countries fall within the middle-income category according to the IMF's income level classification. Notably, these chosen countries are also members of the OPEC. The above commonalities provide the rationale for investigating how oil price shocks impact inflation dynamics in these countries.

The data were obtained from various sources as contained in Table 1. Among the data, output gap and oil price volatility were computed by the authors. The output gap was estimated using Hodrick and Prescott filter trend while oil price volatility measured using the standard deviation of oil price which was computed using 5-year rolling window (Odo, Urama, and Odionye 2024).

3.2. Econometric model

The new Keynesian Phillips curve (NKPC) is widely accepted as the primary model for understanding inflation (Bawa et al. 2020; Renou-Maissant 2019). According to Calvo (1983), the basic NKPC model is stated as follows:

$$\pi_t = \theta E_t \pi_{t+1} + \vartheta mc_t \tag{1}$$

where π_t is the inflation rate, $E_t \pi_{t+1}$ is the expected inflation, and mc_t is the deviation of real marginal cost from its steady state within the period.

The above model is difficult to estimate because there are no observed data on real marginal cost, and the variable $E_t \pi_{t+1}$, representing expected inflation for the next period, cannot be directly observed. To overcome these challenges, Cevik and Teksoz (2013) suggested the use of past inflation values and monetary aggregate to replace inflation expectation while the real marginal cost could be replaced by output gap as they are proportionately related. Adding these variables to Equation (1), we have the equation below:

$$\pi_t = \beta_1 + \beta_2 \pi_{t-1} + \beta_3 ms_{t-1} + \beta_4 y_t \tag{2}$$

where π_{t-1} is first-period lagged inflation, m_{t-1} is lagged money supply (MS) growth, and the output gap $(y_t) = y^a - y^p$ with y^a as the actual output and y^p is the potential output. Thus, output gap is the difference between actual output and potential output – the maximum level of output that could be achieved while maintaining stable inflation over a given time horizon (Murray 2014). Among various methods of estimating the output gap, including the linear method, the Hodrick-Prescott (HP) filter trends method, multivariate HP filter trends, unobservable component models, and the production function

Table 1. Data description.

Variable	Definition	Source
Olp	Quarterly price of Brent Oil	investing.com
ECPI	Energy core consumer index (ECPI) measures the price variations of residential energy items used for heating, cooling, lighting, cooking, and other appliances and household equipment	Ha, Kose, and Ohnsorge (2021) Global Database of Inflation
FCPI	The food consumer price index (FCPI) is the changes over time in the prices of a basket of food items consumed by households	Ha, Kose, and Ohnsorge (2021) Global Database of Inflation
CCPI	The core consumer price index (CCPI) measures the changes in the price of goods and services, excluding food and energy	Ha, Kose, and Ohnsorge (2021) Global Database of Inflation
HCPI	The headline consumer price index (HCPI) measures changes in prices paid by urban consumers for a comprehensive basket of goods and services over time.	Ha, Kose, and Ohnsorge (2021) Global Database of Inflation
GINF	Global inflation is the cross-country median of inflation in a balanced set of 155 countries, of which 126 are EMDEs. The median is chosen to control for several episodes of hyperinflation, especially in the 1980s and 1990s	Ha, Kose, and Ohnsorge (2021) Global Database of Inflation
EXR	The country's nominal exchange rate vis-à-vis the US Dollars (National Currency/USD) – measured in direct quotation	World Bank, WDI
OUTPUT GAP	The output gap was derived from each country's GDP as the difference between actual output and potential output	World Bank, WDI
FSD-GDPR	This is measured fiscal deficit (Difference between government revenue and expenditure) as a ratio of GDP	World Bank, WDI
WGDP-GR	The growth rate of world GDP	United Nations Conference on Trade and Development
Oil price volatility	The standard deviation of oil price	Computed by the authors
MS	Money supply (MS) is the sum of currency outside banks; demand deposits other than those of the central government; the time, savings, and foreign currency deposits of resident sectors other than the central government; bank and traveler's checks; and other securities such as certificates of deposit and commercial paper as the ratio of GDP	World Bank, WDI

method (Barigozzi and Luciani 2023; De Brouwer 1998), this study utilized the Hodrick-Prescott method to estimate the output gap due to its advantages of ensuring stationarity of the output gap and allowing trend to change overtime (De Brouwer 1998).

The NKPC has been criticized for ignoring the supply-side shocks, such as the impact of import prices and fuel prices (Hayashi, Wickremasinghe, and Jayakody 2015). In line with Hayashi, Wickremasinghe, and Jayakody (2015) and Renou-Maissant (2019) in their study augmented Equation (2) with supply-side shocks variables such as crude oil prices and exchange rate. Aside from the inclusion of the exchange rate as a supply shocks variable, Cevik and Teksoz (2013) argued for the inclusion of both global inflation and the exchange rate in the model when imports represent a substantial part of consumption and intermediate goods. These variables are relevant, especially for selected countries as they are both importers of petroleum products and exporters of crude oil.

In light of that, the study models NKPC following Cevik and Teksoz (2013) and Bala and Chin (2020).

The model is specified as follows:

$$\pi_t = \beta_1 + \beta_2\pi_{t-1} + \beta_3 ms_{t-1} + \beta_4 y_t + \beta_5 olp_t + \Pi\boldsymbol{X} + \boldsymbol{\mu_t} \quad (3)$$

where olp_t is the crude oil price and $\boldsymbol{X}$ is a vector of other control variables that impact domestic inflation such as the exchange rate (exr) and global inflation (*ginf*).

The conceptual model of consumer price inflation can be stated as

$$\pi_t = \beta_1 + \beta_2\pi_{t-1} + \beta_3 ms_{t-1} + \beta_4 y_t + \beta_5 olp_t + \alpha_1\boldsymbol{exr_t} + \alpha_2\boldsymbol{ginf_t} + \boldsymbol{\mu_t} \quad (4)$$

The study models MTNARDL through the ARDL as propounded by Pesaran, Shin, and Smith (2001) as follows:

$$\Delta\Pi_t = \beta_1 + \beta_2\boldsymbol{X} + \chi ECT_{t-1} + \sum_{j=1}^{q}\delta_i\Delta\Pi_{t-j} + \sum_{j=0}^{p}\delta_i\Delta\boldsymbol{X}_{t-j} + \mu_t \quad (5)$$

where Π is a vector of the headline consumer price index (HCPI) and other indexes, namely core consumer price index (CCPI), ECPI, and FCPI, and $\boldsymbol{X}$ is a vector of explanatory variables including oil price (*olp*), MS, exchange rate (exr), output gap (y) as already defined. The ECT indicates the degree of convergence to equilibrium; χ and δ_i are the long-term and short-term coefficients, respectively.

Equation (6) re-specified explicitly Equation (5) by including the oil price as follows:

$$\Delta\Pi_{i,t} = \psi_{i,1} + \psi_{i,2}\boldsymbol{X_{i,t}} + \psi_{i,3} olp_{\boldsymbol{i.t}} + \chi_i ECT_{t-1} + \sum_{\omega=1}^{p}\phi_i\Delta\Pi_{i,t-\omega}$$
$$+ \sum_{\omega=0}^{q}\phi_i\Delta olp_{i,t-\omega} + \sum_{\omega=0}^{q}\Delta\phi_i\boldsymbol{X_{i,t-\omega}} + \varepsilon_{i.t} \quad (6)$$

where i represents ith selected sub-Sahara African countries, ϕ_i measures the short-run coefficients, ψ denotes the long-run coefficients, ε is the error term, Δ is the difference operator, and p and q are the maximum lag value. The coefficient of ECT measures the speed of adjustment to equilibrium. Oil price is disintegrated into three diverse changes, namely minor (olpMIS) moderate (olpMOS), and large shocks (olpLAS), respectively.

Introducing the asymmetric parts in Equation (6), we dichotomize the explanatory variables *olp* into positive and negative components in line with Shin, Yu, and Greenwood-Nimmo (2014). Thus, the positive and negative *olp* are expressed in Equations (7) and (8) as follows:

$$olp^{+}_{i,t} = \sum_{j=1}^{p}\Delta olp^{+}_{i,t-j} = \sum_{j=1}^{q}\max(\Delta olp_{ij,0}) \quad (7)$$

$$olp^{-}_{i,t} = \sum_{j=1}^{p}\Delta olp^{-}_{i,t-j} = \sum_{j=1}^{q}\min(\Delta olp_{ij,0}) \quad (8)$$

The NARDL model is therefore specified as Equation (9) after the substitution of Equations (7) and (8) into Equation (6) as follows:

$$\Delta\Pi_{i,t} = \psi_{i,1} + \psi_{i,2}\boldsymbol{X_{i,t}} + \psi_{i,3}\boldsymbol{olp^{+}_{i,t}} + \psi_{i,4}\boldsymbol{olp^{-}_{i,t}} + \chi_i ECT_{t-1} + \sum_{\omega=0}^{q}\Delta\phi_i\boldsymbol{X_{i,t-\omega}} + \sum_{\omega=1}^{p}\phi_i\Delta\Pi_{i,t-\omega} + \sum_{\omega=0}^{q}\phi_i olp^{+}_{i,t-w} + \sum_{\omega=0}^{q}\phi_i olp^{-}_{i,t-w} + \varepsilon_{i.t} \tag{9}$$

The first four terms on the right-hand side are the long-run asymmetric parameters, the fifth term is the error correction component and the last four terms are the short-term asymmetric parameters. The short-run and the long-run asymmetric can be examined using the standard Wald test. There is no long-run asymmetric effect if $\psi_3 = \psi_4 == 0$. The bound test is used to determine the presence of cointegration.

3.3. Multiple thresholds

In this study, the MTNARDL model, originally put forward by Pal and Mitra (2015, 2016), was chosen over the one-threshold approach proposed by Shin, Yu, and Greenwood-Nimmo (2014). This decision was made because the MTNARDL model offers distinct advantages, such as breaking down the explanatory variable (OLP) into various quantiles. This allows for the examination of the variable's asymmetric effects in response to mild, moderate, and large shocks. In this research, two thresholds were introduced at the 25th and 75th quantiles, effectively dividing the oil variable into three separate sums, as outlined in Equation (7).

$$olp_{i,t} = olp^{0}_{i,t} + olp^{mis}_{i,t} + olp^{mos}_{i,t} + olp^{las}_{i,t} \tag{10}$$

where *mis*, *mos*, and *las* represent minor or mild, moderate, and large shocks, respectively. The right-hand components of Equation (10) are the partial sum estimated as follows:

$$olp^{mis}_{i,t} = \sum_{j=1}^{p}\Delta olp^{mis}_{i,j} = \sum_{j=1}^{p}\Delta olp^{mis}_{i,j}(olp_{i,j\le 25}) \tag{11}$$

$$olp^{mos}_{i,t} = \sum_{j=1}^{p}\Delta olp^{mos}_{i,j} = \sum_{j=1}^{p}\Delta olp^{m0s}_{i,j}(olp_{i,j\le 75}) \tag{12}$$

$$olp^{las}_{i,t} = \sum_{j=1}^{p}\Delta olp^{las}_{i,j} = \sum_{j=1}^{p}\Delta olp^{las}_{i,j}(olp_{i,j>75}) \tag{13}$$

In this context, the symbol I(·) serves as a dummy variable, meeting the necessary condition when it equals one and taking on a value of zero otherwise.

The multiple thresholds NARDL model, as expressed in Equation (14), encompasses various components. The first two terms on the right-hand side represent the asymmetric long-run aspects, divided into positive (*po*) and negative (*ne*).

$$\Pi_{i.t} = \sum_{j=1}^{3} olp_{i,t}^{\tau_i}(po) + \sum_{j=1}^{3} olp_{i,t}^{\tau_i}(ne) + \Gamma_i ECT_{t-1} + \sum_{m=1}^{p} \varpi_{i,t} \Delta inf_{t-m} + \sum_{j=1}^{3}\sum_{m=0}^{q} \phi_{i,t} \Delta olp_{i,t-m}^{\tau_i}(po) + \sum_{j=1}^{3}\sum_{m=0}^{q} \phi_{i,t} \Delta olp_{i,t-m}^{\tau_i}(ne) + \varepsilon_{i,t} \quad (14)$$

ECT signifies the speed at which the system adjusts to equilibrium, while the final two terms gauge the positive (*po*) and negative (*ne*) short-term coefficients. In this context, λ represents the impact of an oil price shock, with the subscript j denoting the magnitude of the shock ($j = 1, 2$, and 3). Specifically, 1 stands for a minor shock (*mis*), characterized by changes below or equal to the 25th percentile change; 2 corresponds to a moderate shock (*mos*), signifying changes above the 25th percentile but below or equal to the 75th percentile changes; and 3 relates to a large shock (*las*), defined by changes above the 75th percentile. Additionally, p and q denote the maximum lag length, and ε represents the error term with an independent and identically distributed (i.i.d) property.

The null hypothesis, expressed as $\phi 1 = \phi 2 = \phi 3 = 0$, signifies the absence of cointegration. Rejecting this hypothesis indicates a long-term relationship within the model. The study employs the Wald test to investigate symmetry in both the short and long terms. The MTNARDL model has recently gained popularity due to its numerous benefits over other heterogeneous estimation procedures, as it allows for the examination of the asymmetrical implications of varied shocks on response variables (Li and Guo 2022; Odionye et al. 2024; Odionye and Chukwu 2023; Pal and Mitra 2015, 2016). The prerequisite for estimating MTNARDL is that the order of integration of the series must not surpass 1.

4. Empirical findings and discussion

Summary statistics were applied to the series, unveiling the characteristics of distributions and behavioral patterns within the series, among other features. Notably, descriptive statistics serve to establish confidence in the series as evidenced by the test results presented in Table 2. The descriptive statistics were carried out before any transformation was performed on the series to enable the study to ascertain their true behavioral patterns. For the global series, the mean of the different sizes of oil price shocks shows that the large oil shock (OILP_LAS) has the largest mean of 4.22, followed by moderate oil price shock (OILP_MOS), with a mean of 3.00 and mild oil shock(OILP_MIS) with mean of 2.94.

In terms of their volatility measured using standard deviation, OILP_LAS expectedly is the most volatile, with a value of 0.32, while the OILP_MOS is less volatile with a value of 0.25 compared to OILP_MIS with a value of 0.27. Among all the global series, the Jarque-Bera statistics demonstrate the rejection of the null hypothesis of normal distribution across all examined sample series except for the global inflation (GINF).

The country-specific series shows that among the components of inflation, the FCPI for Nigeria has the largest mean value of 200.84, and greater than the FCPI, the largest value (123.57) of inflation components for Equatorial Guinea. For Angola, HCPI with a mean value of 225.44 is the largest inflation component and greater than the largest

Table 2. Descriptive statistics.

Variables	Mean	Maximum	Std.Dev.	Skewness	Kurtosis	J-B Stat.
Global						
OILP	71.29	125.01	21.96	0.30	2.20	3.01
OILP_LAS	4.22	4.83	0.32	−0.27	2.47	1.74
OILP_MOS	3.00	3.52	0.25	−0.01	2.71	0.25
OILP_MIS	2.94	3.46	0.27	−0.03	2.68	0.32
GINF	5.12	10.04	1.88	1.57	4.66	37.72***
OILP_Vol.	10.3	7.05	7.59	1.69	5.82	57.5***
WGDP_GR	2.88	6.24	2.04	−1.46	5.33	42.0***
Nigeria						
CCPI	174.7	405.97	90.74	0.81	3.65	8.20**
ECPI	185.15	396.93	96.82	0.54	2.08	6.09**
HCPI	173.08	432.59	103.06	0.91	2.81	10.15***
FCPI	200.84	551.27	132.46	1.05	3.09	13.31***
EXR	221.19	425.98	100.69	0.76	2.10	9.29***
OUTPUT-GAP	−0.0001	0.039	0.02	0.09	2.34	1.41
MS	22.68	27.39	4.38	−1.74	4.98	48.2***
FD_GDPR	−2.01	8.76	4.29	1.27	3.44	19.88**
Equatorial Guinea						
CCPI	106.89	135.88	17.25	−0.46	1.89	6.17**
ECPI	123.37	157.57	24.39	0.06	1.39	7.79**
FCPI	123.57	138.22	72.20	−0.76	−0.76	9.99***
HCPI	109.08	115.21	17.61	−0.45	1.89	0.17**
EXR	531.59	632.76	51.15	0.09	1.77	4.61*
OUTPUT-GAP	–	−0.0003	0.002	0.32	2.83	1.35
MS	0.000002	15.4	2.900	−0.58	2.10	6.42**
FD_GDPR	11.1	21.8	10.7	0.51	2.10	5.57**
	1.72					
Angola						
CCPI	87.18	121.18	25.75	−1.03	2.82	12.86***
ECPI	94.44	167.55	26.50	−0.30	3.98	3.93
FCPI	98.84	127.18	23.35	−1.24	3.52	19.37***
HCPI	225.44	718.88	188.21	1.26	3.47	19.73***
EXR	200.68	631.44	178.14	1.41	3.51	24.63***
OUTPUT-GAP	−0.00000	0.003	0.001	0.12	3.54	1.07
MS	6	45.61	8.52	−0.55	2.58	4.18
FSB_GDPR	31.18	29.82	16.06	0.027	1.94	3.41
	1.75					
Congo						
CCPI	96.90	113.82	8.52	−0.03	1.99	3.08
ECPI	91.47	111.15	12.69	−0.38	1.93	5.23*
FCPI	108.26	134.33	8.42	1.23	4.44	24.62***
HCPI	110.23	133.67	14.84	−0.23	1.87	4.49
EXR	531.59	632.76	51.15	0.09	1.77	4.61*
OUTPUT-GAP	−0.000002	0.003	0.002	−0.10	2.28	1.69
MS	24.35	34.12	6.17	−0.25	2.18	2.75
FD_GDPR	−0.28	1.76	1.37	−0.37	2.50	2.42

Source: Authors' computation using Eviews 13.

*** (**) [*] signify the decline of the null hypothesis of normal distribution at 1% (5%) [10%] level of significance respectively, OILP represents oil price, OILP_LAS, stands for the large shock to the oil price, OILP_MIS means a mild shock to the oil price, OILP_MOS denotes moderate shock to the oil price, GINF signifies global inflation, CCPI is core consumer price index, ECPI stands for energy consumer price index, FCPI means food consumer price index, HCPI denotes headline consumer price index and EXR represents each country's USA dollar exchange rate, OUTPUT-GAP is output gap, MS is MS, respectively, FD_GDPR represents the fiscal deficit as a ratio of GDP, WGDP_GR is world GDP growth while OILP_Vol. is oil price volatility.

HCPI value of 110.23 for the Congo Republic. Regarding their volatilities, in Nigeria and Equatorial Guinea, FCPI is the most volatile compared to other components while HCPI is the most volatile in Angola and Congo Republic. The Jarque-Bera statistics show that all the inflation components are nonlinear for Nigeria and Equatorial Guinea, but for Angola, the study shows that all the components are nonlinear except energy inflation (CCPI) while for the Republic of Congo, ECPI and FCPI are nonlinear.

4.1. Brock, Dechert, Scheinkman, and LeBaron (BDS) test

The assessment of nonlinearity in the data series also utilized the Brock et al. (1996) estimator, commonly denoted as the BDS test. The null hypothesis assumes independence and identical distribution (i.i.d) of the series, while the alternative hypothesis suggests nonlinearity in the series. Table 3 summarizes the outcomes of the BDS test which shows that all the series are nonlinear. This demonstrates the appropriateness of employing a nonlinear model as opined in Odionye et al. (2023).

4.2. Unit root test

The stationarity attributes of the series were examined to ascertain the series' order of integration. The study employed the Augmented Dickey–Fuller (ADF) breakpoint and Zivot and Andrew structural break unit root tests to examine the stationarity properties of all the variables. The tests were carried out with the choice of the optimal lag for each of the series being guided by information criteria.

As depicted in Table 4, both the level and first difference forms of the variables underwent testing. The results in Table 4 indicate that MacKinnon's approximate p-values for the t-value fall between 1% and 5% for most series, with a few exceptions at the 10% level. For global variables, the Dickey–Fuller break point test results reveal that only the oil price (oilp) and world GDP growth (Wgdp_GR) are stationary at the level form, whereas the others are stationary at the first difference. Conversely, the Zivot and Andrew break point test shows that oil price (OILP), volatility of oil price (OILP_Vol), and mild oilp price shock (OILP_MIS) are stationary at level form, while the others are stationary at first difference.

For country-specific series, the Dickey–Fuller break point test results for Nigeria indicate that all variables are free of a unit root at the first difference form except the world GDP growth and the output gap. The Zivot and Andrew break point results are similar, except that fiscal deficit as a ratio of GDP which is stationary at the level form is stationary at the first difference and exchange rate which is stationary at the first difference is stationary at the level form. In Equatorial Guinea and Angola, the Dickey–Fuller break point test results show that only FCPI and exchange rate are stationary at the level form, with other variables stationary at the first difference form while Zivot and Andrew break point results indicated that ECPI and FCPI are stationary at the level form, with other variables stationary at the first difference form. In the Republic of Congo, only FCPI and exchange rate are stationary at the level form, with other variables stationary at the first difference form, but Zivot and Andrew break point results show that all the variables are stationary level forms except CCPI, fiscal deficit as a ratio of GDP and exchange rate. The analysis demonstrates a mixture of variable integration levels, highlighting the necessity for using the ARDL version of the model.

Table 3. Summary of the BDS test results.

Global								
Dimension	OILP	OILP_V	OILP_MOS	OILP_LAS	WGDP_GR	OILP_MIS	GINF	
$M=2$	0.11***	0.12***	0.13***	0.11***	0.16***	0.14***	0.13***	
$M=3$	0.17***	0.18***	0.22***	0.17***	0.26***	0.24***	0.19***	
$M=4$	0.19***	0.21***	0.27***	0.17***	0.31***	0.28***	0.22***	
$M=5$	0.18***	0.23***	0.29***	0.20***	0.34***	0.31***	0.21***	
$M=6$	0.19***	0.23***	0.30***	0.19***	0.35***	0.32***	0.24***	
Nigeria								
Dimension	CCPI	ECPI	FCPI	HCPI	FS_GDP	EXR	Outpput_gap	MS
$M=2$	0.19***	0.20***	0.20***	0.20***	0.16***	0.19***	0.19***	0.06***
$M=3$	0.33***	0.33***	0.32***	0.33***	0.27***	0.31***	0.32***	0.07***
$M=4$	0.42***	0.43***	0.42***	0.43***	0.33***	0.40***	0.41***	0.07***
$M=5$	0.48***	0.50***	0.48***	0.49***	0.59***	0.45***	0.47***	0.08***
$M=6$	0.52***	0.55***	0.53***	0.54***	0.39***	0.48***	0.50***	0.11***
Equatorial Guinea								
$M=2$	0.20***	0.19***	0.20***	0.20***	0.18***	0.16***	0.08***	0.19***
$M=3$	0.35***	0.33***	0.33***	0.34***	0.30***	0.25***	0.11***	0.32***
$M=4$	0.45***	0.42***	0.43***	0.45***	0.38***	0.29***	0.13***	0.40***
$M=5$	0.52***	0.48***	0.50***	0.52***	0.43***	0.32***	0.13***	0.46***
$M=6$	0.57***	0.53***	0.55***	0.57***	0.47***	0.35***	0.14***	0.49***
Angola								
$M=2$	0.20***	0.19***	0.20***	0.20***	0.15***	0.19***	0.08***	0.17***
$M=3$	0.35***	0.31***	0.34***	0.33***	0.23***	0.31***	0.11***	0.29***
$M=4$	0.44***	0.41***	0.45***	0.42***	0.27***	0.39***	0.14***	0.36***
$M=5$	0.51***	0.48***	0.52***	0.49***	0.27**	0.44***	0.16***	0.40***
$M=6$	0.56***	0.54***	0.56***	0.52***	0.28***	0.47***	0.18***	0.43***

(*continued*).

Table 3. Continued.

Republic of Congo								
Dimension	OILP	OILP_V	OILP_MOS	OILP_LAS	WGDP_GR	OILP_MIS	GINF	
$M=2$	0.20∗∗∗	0.18∗∗∗	0.12∗∗∗	0.19∗∗∗	0.15∗∗∗	0.16∗∗∗	0.08∗∗∗	0.08∗∗∗
$M=3$	0.34∗∗∗	0.31∗∗∗	0.19∗∗∗	0.32∗∗∗	0.24∗∗∗	0.25∗∗∗	0.11∗∗∗	0.11∗∗∗
$M=4$	0.43∗∗∗	0.40∗∗∗	0.23∗∗∗	0.42∗∗∗	0.29∗∗∗	0.29∗∗∗	0.13∗∗∗	0.13∗∗∗
$M=5$	0.51∗∗∗	0.46∗∗∗	0.27∗∗∗	0.49∗∗∗	0.31∗∗∗	0.32∗∗∗	0.13∗∗∗	0.13∗∗∗
$M=6$	0.56∗∗∗	0.51∗∗∗	0.28∗∗∗	0.54∗∗∗	0.32∗∗∗	0.35∗∗∗	0.13∗∗∗	0.13∗∗∗

Source Authors' computation using Eviews 13.
∗∗∗ and ∗∗ stand for the refutation of the null hypothesis of linearity at 1% and 5% level of significance. Statistics in parentheses are the *p*-values. The aloofness rate chosen by the test is 0.7.

Table 4. Unit roots test (URT) result.

Global	Variable	oilp	OILP_VOL	oilp_mos	oilp_las	Wgdp_GR	oilp_mis	ginf	
	ADF min-t	−4.34* I[0]	−7.36*** I[1]	−9.87*** I[1]	−10.9*** I[1]	−4.70** I[0]	−8.20*** I[1]	−10.6*** I[1]	
	Zaunit	−4.3* I[0]	−5.58*** I[0]	−9.94*** I[1]	−5.85*** I[1]	−7.41 I[1]	−5.18*** I[0]	−9.04*** I[1]	
	Variable	CCPI	ECPI	FCPI	HCPI	FD_GDPR	EXR	OUTPUT-GAP	MS
Nigeria	ADF min-t	−6.59*** I[1]	−15.4*** I[1]	−4.34* I[1]	−4.44* I[1]	−0.48*** I[0]	−9.3*** I[1]	−6.36*** I[0]	−6.38*** I[0]
	Zaunit	−5.6*** I[1]	−4.4*** I[1]	−5.35*** I[1]	−4.9* I[1]	5.54*** I[1]	−5.17*** I[0]	−4.8** I[0]	8.98** I[1]
Equatorial Guinea	ADF min-t	−6.59*** I[1]	−15.4*** I[1]	−5.11*** I[0]	−6.6*** I[1]	−11.5*** I[1]	−4.46** I[0]	−10.7*** I[1]	−9.18*** I[1]
	Zaunit	−5.3*** I[1]	−12.7*** I[0]	−6.8*** I[0]	−5.3*** I[1]	−6.10*** I[1]	−8.8*** I[1]	−6.2*** I[1]	−6.1*** I[1]
Angola	ADF min-t	−10.9*** I[1]	−8.19*** I[1]	−5.11*** I[0]	−6.6*** I[1]	−11.49 I[1]	−4.46** I[0]	−10.7*** I[1]	−9.7*** I[1]
	Zaunit	−5.3*** I[1]	−12.7*** I[0]	−6.7**** I[0]	−5.3* I[1]	−7.0*** I[1]	−8.8*** I[1]	−6.22** I[1]	−6.1*** I[1]
Republic of Congo	ADF min-t	−11.6*** I[1]	−10.8*** I[1]	−5.04*** I[0]	−9.2*** I[1]	−9.3*** I[1]	−4.44** I[0]	−10.1*** I[1]	−10.3*** I[1]
	Zaunit	−5.73*** I[1]	−5.9*** I[0]	−7.5*** I[0]	−4.9** I[0]	−8.42** I[1]	−8.8** I[1]	−4.9** I[0]	−4.83** I[0]

Source*: Author's computation* URT stands for unit root test.
***, ** and * signify that the series is stationary at 1% 5%, and 10% significance levels respectively. I[·] represents the series' order of integration, ADF min-t represent Dickey Fuller break point unit root and Zaunit is the Zivot and Andrew break point unit root.

Table 5. Bound cointegration test results.

Model	Nigeria	Equ. Guinea	Angola	Congo Rep
Core Consumer Price Index (CCPI)				
NARDL	3.60*	2.81**	3.26*	6.79***
MTNARDL	3.73**	3.62**	3.35**	5.35**
Energy Consumer Price Index (ECPI)				
NARDL	4.52**	3.32*	4.03**	3.31*
MTNARDL	2.94*	3.48***	4.42***	3.25**
Food Consumer Price Index (FCPI)				
NARDL	3.98**	4.61*	7.21***	3.42*
MTNARDL	2.97*	2.97*	3.86***	3.25**
Headline Consumer Price Index (HCPI)				
NARDL	4.10**	3.30*	9.05***	3.82**
MTNARDL	3.76**	3.62**	6.01***	2.95*

Source Authors' computation using Eviews 13.
*** (**) [*] signify refutation of no cointegration at 1% (5%) [10%] level of significance.

4.3. Cointegration test

After conducting unit root tests, a bound cointegration test was employed to examine the presence of a long-term equilibrium relationship among the estimated model variables. Assessment of bound cointegration was carried out within the NARDL and MTNARDL model frameworks, and the resulting summary of the findings is presented in Table 5.

In Table 5, it is evident that in all the countries used for the study, there was a sustained long-term relationship between oil prices and all the components of the consumer price index, as used in the study in the MNARDL. This was also the case with the NARDL model, results.

4.4. Main findings

4.4.1. NARDL model estimation of the impact of oil price shocks on HCPI and CCPI

The evidence in Table 6 shows that in the short-run, only positive shocks to oil price impacted HCPI in Nigeria, increasing it by 0.04% for 1% positive shocks to the oil price, while 1% positive and negative shocks to oil price impacted CCPI positively (negatively), increasing (decreasing) it by 0.027% (0.08%). Similarly, both positive and negative oil price shocks impacted CCPI in the Republic of Congo, with 1% positive (negative) shocks to oil prices increasing (decreasing) CCPI by 0.02%(0.01%). Only a negative shock to oil price significantly impacted HCPI, reducing it by 0.044% for a 1% negative shock to the oil price. For Angola as it is for the Republic of Congo, only negative shocks to oil price impacted HCPI significantly, by increasing it by 0.08% for 1% negative shocks to oil price; while positive shocks only impacted CCPI significantly, increasing it by 0.10% for any 1% positive shocks to oil price. For Equatorial Guinea, only positive shocks to oil prices impacted HCPI and CCPI, decreasing HCPI by 0.03% and CCPI by 0.02%. The evidence shows that for Nigeria and Equatorial Guinea, only positive changes in oil prices significantly impact HCPI.

In contrast, only negative oil price shocks impacted HCPI significantly in Angola and the Republic of Congo. This evidence shows that a change in oil price in one direction only, impacts headline inflation in each country, aligning with Lacheheb and Sirag (2019). However, this contradicts the findings by Bala and Chin (2018) that both the

Table 6. Summary of HCPI and CCPI NARDL results.

Variables	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI
Panel A: Short-run results								
D(LHCPI(−1))	−0.31**				0.2		−0.003	
D(LCCPI(−1))						0.28		−0.57***
D(GINF)	−0.0007	0.002*	0.0002	0.02***	−0.0004	0.0005	0.012	0.00006
D(GINF(−1))	0.05**		0.002					
D(LEXR)	−0.01	0.01*	0.0008	−0.004	−0.008	−0.013	0.04	0.024*
D(EXR(−1))	−0.05		−0.007					
D(LMS)	0.02**	0.033***	0.03	0.23***	0.001	0.014	−0.004	0.01*
D(LMS(−1))			−0.009		−0.03			0.015***
D(OUTPUT_GAP)	0.34	0.061	0.57	2.57		1.47	0.91	−0.4
D(OUTPUT_GAP(−1))			−2.13		0.04		−2.78	
D(LOILP_POS)	0.03	0.027***	0.02	0.10*	−0.02	−0.005	−0.03	0.02***
D(LOILP_POS(−1))	0.04*		−0.02		−0.03*	−0.02*		
D(LOILP_NEG)	−0.004	−0.018*	−0.02	0.04	−0.001	−0.001	−0.044***	0.003
D(LOIP_NEG(−1))			0.08***					−0.01**
ECT(−1)	−0.08**	−0.11***	−0.07***	−0.30***	−0.24***	−0.20***	−0.14*	−0.18***
Panel B: Long-run results								
GINF	0.009	0.02	0.03	−0.006	−0.002	−0.002**	−0.0004	0.0004
LEXR	0.64*	0.09	0.34***	−0.09	−0.03	−0.032	0.088	0.28***
LMS	0.4	−0.30***	0.12	0.46	0.17***	0.17	−0.025	0.1
OUTPUT_GAP	1.55	0.56	11.2	48.36	6.43	6.43	4.73	−2.47
LOILP_POS	0.21*	0.25***	−0.39	0.36***	0.09***	0.087***	0.09	0.13***
LOILP_NEG	−0.04	−0.17**	−0.83**	0.12	−0.004	−0.004	0.004	0.07***
F-Stat.	3.36***	3.6***	8.14***	5.00***	10.3***	1.89*	3.25***	6.17***
R^2	0.62	0.69	0.66	0.67	0.69	0.59	0.44	0.59

(continued).

Table 6. Continued.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI
Panel C: Robustness test results								
J-B Test	20.93***	33.54***	55.71	605.65***	57.34***	57.33***	0.19	8.30**
B-G-S_Test	0.85	1.64	4.41**	0.1	0.36	0.36	0.17	1.022
B-*P*-GH_Test	2.13**	4.83***	1.77*	2.13**	1.04	3.13**	1.58	0.91
R-R_Test	1.64	1.54	0.99	6.28***	0.64	0.64	2.27	0.42
Cusum	Stable	Stable	Stable	Unstable	Stable	Stable	Stable	Stable
Cusum sqr	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable	Unstable
LR-Wald	0.72	7.82***	3.43*	4.05**	10.34***	10.34***	2.85	9.16***
SR-Wald	0.005	0.37	1.05	0.14	0.027	0.027	1.43	0.75

Source: Authors' computation using Eviews 13e shocks in the exchange rat

***,**, and * show rejection of the null hypothesis at a 1%, 5%, and 10% level of significance respectively, Arch LM test represents a test of the ARCH effect, the B-Serial test represents q-order serial autocorrelation, B-P-G – Het is a test for constant variance, R-RESET represents a test of model specification, J-B test is the Jarque-Bera normality test, SR_Wald represents the short-run Wald symmetry test; LR _Wald is the long-run symmetry test. POS is positive (oil price increase) while NEG means negative (oil price decrease).

positive and negative oil price changes positively influenced inflation. This goes further to buttress that shocks to oil prices affect countries differently (Kudabayeva et al. 2024).

Considering only the magnitude of shocks to the oil price, positive shocks elicited a smaller effect on the HCPI compared with the negative shocks. For instance, in Nigeria and Equatorial Guinea, 1% positive shocks to oil prices changed inflation by 0.04% and 0.03%, respectively.

In comparison, the same magnitude of negative shocks to oil prices changed inflation by 0.08% and 0.044%, respectively in Angola and Congo. This corroborates the findings by Li and Guo (2022), Bala and Chin (2018), and Donayre and Wilmot (2016) that an oil price decrease leads to a rise in inflation faster, while an increase in oil price will cause slight deflation. However, considering CCPI models, the evidence is that positive changes outweighed negative changes, as reflected for Nigeria with positive and negative changes equivalent to 0.027% and 0.018% and the Republic of Congo to 0.02% and 0.01% positive and negative, respectively. This implies that the component of inflation matters regarding the effect of oil price shocks. This does not align with the finding by Ali (2021) of an asymmetric impact of a shock to oil price on inflation in the short run. The scenario extends to the long run for Nigeria and the Republic of Congo, respectively, where a positive shock to oil price changes CCPI by a larger percentage (0.25 and 0.13) than the negative shock (0.017% and 0.07%). However, a 0.83% change of HCPI in Angola resulting from a 1% negative shock to oil prices outweighs 0.21 and 0.09 percentage changes due to 1% positive shocks to oil prices in Nigeria and the Republic of Congo, respectively. This validates the short-run results showing a negative change outweighs positive change. However, oil price shocks were inconsequential to the changes in HCPI in the Republic of Congo. These results, however, could not substantiate the findings of Balcilar, Uwilingiye, and Gupta (2018), Goh, Law, and Trinugroho (2022), Pal and Mitra (2016), and Goh, Law, and Trinugroho (2022).

For other covariates, a 1% rise in global inflation (GINF) increased HCPI and CCPI by 0.05% and 0.02%, respectively, for Nigeria, and CCPI by 0.02% for Angola. The exchange rate impacted CCPI by 0.01% and 0.024% for Nigeria and the Republic of Congo, respectively. MS contradicted the theory of positive impact on CCPI in Nigeria but aligned with the theory by raising CCPI for Angola and the Republic of Congo, but inconsequential to the changes in CCPI in Equatorial Guinea. For all the countries, the output gap could not explain changes in both HCPI and CCPI. This implies that, in the CCPI and HCPI models, the output gap was not important in explaining their changes.

The J-B test indicated the existence of normality problems in Nigeria and Equatorial Guinea in both the HCPI and CCPI models and in the CCPI model for both Angola and the Republic of Congo. The autocorrelation of the errors was found only in the HCPI for Angola and heteroscedasticity was found in both the HCPI and CCPI models for Nigeria and Angola and the CCPI model for Equatorial Guinea. For all the countries, no model specification problem was observed according to Ramsey reset test, except in the CCPI model for Angola. Similarly cumulative sum (CUSUM) test confirmed the coefficient stability for all the countries in both CCPI and HCPI models except for Angola where CCPI was found unstable, but the CUSUM square shows coefficient stability for none of the countries. Furthermore, in the short-run, the Wald test could not reject the null hypothesis for the symmetric impact of oil price change on HCPI and CCPI in all the countries, while the long-run Wald test results showed the asymmetric impact of oil price on HCPI and CCPI for Angola and Equatorial Guinea and CCPI for Nigeria and the Republic of Congo. These findings differ from the study by Ali (2021) that established both long-run and short-run asymmetry. However, it agrees with Babuga and Naseem (2020) of the long-run instead of the short-run asymmetric relationship.

Ball and Mankiw (1994) explained that asymmetric relationship is driven by how firms' response to oil price shocks. Positive oil price shocks impose menu costs, prompting firms to adjust their prices upward more frequently and by larger amounts. In contrast, negative oil price shocks do not incur extra costs for lowering prices, as inflation naturally reduces relative prices over time. This explains why oil price increases due to shocks tend to have a stronger and faster impact on inflation than price decreases, reinforcing the asymmetric nature of the oil price-inflation dynamics. It was further expatiated by Bernanke et al. (1997) and Hooker (2002) that the asymmetric impact of oil price shocks on inflation is a reflection of the diverse responses of monetary authority to changes in oil price. They argued that oil price increases elicits aggressive tightening of monetary policy while easing of the monetary policy in response to oil price declines is often less pronounced. This asymmetry can amplify the impact of oil price increases on inflation and economic activity while muting the effects of price decreases. Hooker (2002) in the same study interpreted the asymmetric effects of oil price changes using inflation expectation. He stated that oil price rise can lead to increased inflation expectations, prompting workers to demand higher wages and firms to raise prices, thereby reinforcing the inflationary effect. On the other hand, oil price decreases may not lead to a corresponding downward adjustment in inflation expectations, resulting in a muted impact on inflation. Rotemberg and Woodford (1996) argued that asymmetric inflation responses can be caused by firms having market powers. Such firms are less responsive to decreases in energy prices compared to increases because when energy prices rise they can pass these higher costs onto consumers, leading to increased prices and inflation. However, when energy prices fall, they may be reluctant to reduce their prices proportionally, especially if they anticipate future cost increases or if their pricing strategies are influenced by factors other than current input costs. This behavior results in a slower or less complete reduction in prices, contributing to asymmetric inflation responses.

4.4.2. MTNARDL model estimation of the impact of oil price shocks on HCPI and CCPI

Table 7 captures the sizes and signs effects of oil price shocks on the CCPI and HCPI in the four countries under investigation. It showed that in the short-run, large positive shocks to oil prices significantly impacted CCPI and HCPI, increasing them by 0.05% and 0.04% in Nigeria and 0.05% and 0.31% in Angola, respectively. Large positive shocks to oil prices impacted neither HCPI nor CCPI in Equatorial Guinea and the Republic of Congo. On the other hand, large negative shocks to oil prices had no impact on HCPI and CCPI in Nigeria, CCPI in Angola, and HCPI in the Republic of Congo, but in Equatorial Guinea, it impacted positively HCPI and CCPI by 0.32% and 0.21%, respectively, and negatively HCPI for Angola by 0.40, and mixed on CCPI for the Republic of Congo, reducing it by 0.06% at lag zero and increasing by 0.09%.

Regarding the mild shocks, positive shock impacted CCPI positively in Angola by 0.08%, CCPI and HCPI in the Republic of Congo by 0.03% and 0.02%, respectively, and CCPI and HCPI negatively in Equatorial Guinea by 0.04% and 0.02%. The impact of mild positive shocks did not affect CCPI and HCPI in Nigeria, and HCPI in Angola. Mild negative shocks impacted only CCPI in Nigeria, reducing it by 0.20% and CCPI and HCPI in the Republic of Congo, reducing them by 0.06% and 0.02%, respectively. Moderate positive shocks impacted HCPI for Angola, reducing it by 0.3% and HCPI and CCPI, for

Table 7. Summary of HCPI and CCPI MTNARDL results.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI
Panel A: Short-run results								
D(LCCPI(−1))								−0.53***
D(GINF)	0.00002	0.0004	0.0008	0.014	0.002	0.02	0.0003	0.0004
D(GINF(−1))					0.004**	0.002**		
D(LEXR)	0.05	−0.005	0.015	0.008	−0.07	−0.02	−0.06	−0.004
D(LMS)	−0.01	−0.04***	0.0006	0.20*	0.04	0.34*	−0.007	0.009
D(LMS(−1))				8.9		−0.045		0.021***
D(OUTPUT_GAP)	0.06	0.06	−1.03		−0.04		1.46	−16.0
D(OUTPUT_GAP(−1))							−4.30***	
D(OILP_LAS_POS)	0.05*	0.04***	0.31***	0.059***	−0.03	0.027	0.16	−0.026
D(OILP_LAS_NEG)	0.007	−0.01	−0.40***	−0.02	0.32***	0.21***	0.05	−0.08**
D(OILP_LAS_NEG(-))								0.09***
D(OILP_MIS_POS)	−0.07	−0.07	−0.021	0.08*	−0.03	−0.13	0.03**	0.02***
D(OILP_MIS_POS(−1))					−0.04**	−0.02**		0.0002
D(OILP_MIS_NEG)	−0.17	−0.20*	0.006	0.03	−0.004	−0.007	−0.06***	0.002
D(OILP_MIS_NEG(−1))								−0.02***
D(OILP_MOS_POS)	0.13	0.09	−0.30***	0.008	−0.062	−0.06	−0.17***	0.04*
D(OILP_MOS_NEG)	0.12	0.17	0.31***	0.003	−0.32***	−0.22***	−0.01	0.08**
D(OILP_MOS_NEG(−1))					−0.08***	−0.02***	0.05*	−0.06**
ECT(−1)	−0.20***	−0.18***	−0.03***	−0.27***	−0.39***	−0.33***	−0.31***	−0.12*
Panel B: Long-run results								
GINF	−0.007	0.003	0.045	−0.04	−0.01**	−0.01**	−0.001	−0.003
LEXR	0.151	−0.027	0.92	−0.009	−0.18*	−0.16*	0.06	0.25*
LMS	0.08	−0.21**	0.83	0.35	0.11**	0.12**	−0.02	−0.02
OUTPUT_GAP	1.33	0.32	70.08	93.13	−0.12	−0.11	5.53	−1.33
OILP_LAS_POS	0.14***	0.20***	3.51	1.92	0.21	0.22	−0.27	−0.46
OILP_LAS_NEG	−0.03	−0.08	9.78	1.51	1.27**	0.27***	0.17	−1.34
OILP_MIS_POS	−0.27	−42	−0.51*	0.48**	0.01***	−0.10***	0.10**	0.16**
OILP_MIS_NEG	−0.43	−1.13	−0.31	0.09	−0.01	−0.01	0.005	0.08*

(continued).

Table 7. Continued.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI
OILP_MOS_POS	0.44	0.54	−4.93	−1.89	−0.16	−0.16	0.22	0.33
OILP_MOS_NEG	0.22	0.95	8.1	−1.1	−1.25***	−1.21***	−0.25	1.28
F-Stat.	2.54**	2.73***	13.37***	3.25***	2.91***	2.01***	3.84	4.53**
R^2	0.73	0.64	0.72	0.58	0.53	0.50	0.67	0.68
Panel C: Robustness test								
J-B Test	72.75	43.09***	25.64***	517.41***	30.36***	33.36***	0.45	1.58
B-G-S_Test	3.83**	2.92	1.72	1.33	0.29	0.19	2.03	1.86
B-P-GH_Test	1.6	1.66*	1.80**	1.2	0.99	0.89	1.2	1.08
R-R_Test	1.36	0.33	1.26	8.1	0.88	0.81	2.49**	0.18
Cusum	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
Cusum sqr	Stable	Unstable	Unstable	Unstable	Unstable	Unstable	Stable	Unstable
LR-Wald(OILP_LAS)	1.38	9.03***	6.62**	0.02	3.73**	7.13**	2.13	7.1**
LR-Wald(OILP_MIS)	0.02	0.2	0.12	1.57	5.79*	7.13**	2.93*	3.86**
LR-Wald(OILP_MOS)	0.03	1.13E-05.	8.30***	0.08	3.44*	7.01***	2.27	6.97**
SR-Wald(OILP_LAS)	0.4	0.31	18.07***	0.009	3.57*	5.60**	1.37	0.25
SR-Wald(OILP_MIS)	0.15	0.49	0.51	0.087	1.71	3.06*	0.43	8.09***
SR-Wald(OILP_MOS)	0.002	0.03	15.85***	0.0002	4.06*	7.64***	2.57	0.47

Notes: Author's computation. Using Eviews 13.
***, **, and *show rejection of the null hypothesis at a 1%, 5%, and 10% level of significance respectively, J-B test represents the normality test, the B-G-S test represents q-order serial autocorrelation, B-P-G-Het is a test for constant variance, R-RESET represents a test of model specification. SR_Wald represents the short-run Wald symmetry test; LR _Wald is the long-run symmetry test. POS is positive (oil price increase) while NEG means negative (oil price decrease). OILPT_MIS is mild shocks in the exchange rate, OILP_MOS depicts moderate shocks in the oil price; OILP_LAS represents large shocks in the exchange rate.

the Republic of Congo, reducing it by 0.17% and increasing it by 0.04. Moderate positive shocks did not impact CCPI and HCPI in Nigeria, and CCPI in Angola and Equatorial Guinea. The several insignificant coefficients compare with Chuku (2012) who found that symmetric and asymmetric impacts of oil price changes do not lead to changes in inflation and Sarmah and Bal (2021) who found that negative oil price changes do not impact significantly inflation in India. In the same vein, Shitile and Usman (2020) found that for the transport sector, negative oil price changes do not significantly impact the inflation in that sector.

The long-run estimates show that large positive shocks to oil prices impacted HCPI and CCPI in Nigeria only, increasing them by 0.14% and 0.20%, respectively, while large negative shocks impacted HCPI and CCPI in Equatorial Guinea only, increasing them by 1.27% and 0.27%, respectively. Mild positive shocks impacted most countries, reducing HCPI by 0.51% in Angola, increasing it by 0.01% and 0.10%, respectively in Equatorial Guinea and the Republic of Congo and increasing CCPI by 0.48% and 0.16% in Angola and the Republic of Congo, while decreasing CCPI in Equatorial Guinea by 0.10%. In Nigeria, mild positive shocks impacted neither CCPI nor HCPI. Mild negative shock impacted the Republic of Congo only increasing CCPI by 0.08%. Moderate positive did not significantly impact any inflation components, while moderate negative shocks reduced HCPI and CCPI by 1.25% and 1.12%, respectively. The evidence shows the variations of the impact of oil price shocks in terms of signs and magnitudes across countries, hence supporting an assertion that all oil price shocks are not the same (Kilian 2009).

Global inflation impacted HCPI and CCPI in Equatorial Guinea in the short-run and long-run, respectively. However, while the impacts were positive in the short-run, they were negative in the long-run. While the exchange rate impacted HCPI and CCPI negatively in Equatorial Guinea, and CCPI positively in the Republic of Congo in the long-run, its effects were not significant in the short-run for all countries. The negative impact of MS on CCPI in Nigeria in the short-run and long-run contradict the theory, while in the short-run, it increased CCPI in Equatorial Guinea and the Republic of Congo. It also impacted positively CCPI in Equatorial Guinea in the long-run. Its effects on HCPI across the four countries were not significant. The output gap decreased only CCPI for the Republic of Congo in the short-run, exacting no long-run effect on either CCPI or HCPI in the long-run for all the countries.

The diagnostic tests showed a statistically significant joint effect (F-statistics) of all covariates on HCPI and CCPI for all countries, validated by the high R^2 values. The J-B test results confirmed the normality of residuals for the HCPI model in Nigeria and both HCPI and CCPI models in the Republic of Congo. Autocorrelation tests were passed for all countries except Nigeria's HCPI model, and heteroscedasticity tests were valid for all countries, save HCPI in Nigeria and Angola. CUSUM tests indicated stable coefficients across all models, with CUSUM square confirming stability only for Nigeria's and the Republic of Congo's HCPI models. Wald asymmetric test results indicated no asymmetric relationship for large shocks in Nigeria's and the Republic of Congo's HCPI models, and Angola's CCPI model in the short term, while in the long term, large shocks showed asymmetry in Angola's CCPI and both HCPI and CCPI for Equatorial Guinea. Mild shocks had asymmetric impacts on HCPI and CCPI in Equatorial Guinea and the Republic of Congo in the long term, and CCPI in Equatorial Guinea and the Republic of Congo in the short term. Moderate shocks did not show asymmetry for HCPI and CCPI in Nigeria, CCPI in Angola for both the short and long terms, HCPI in the Republic of

Congo in the long-run, and both HCPI and CCPI in the Republic of Congo for both the short and long terms.

4.4.3. NARDL model estimation of the impact of oil price shocks on ECPI and FCPI

According to Table 8, positive oil price shocks impacted FCPI in the short-run but not ECPI in Nigeria, increasing FCPI by 0.06%, ECPI and FCPI in Angola and Equatorial Guinea, increasing and reducing them by 0.21% and 0.17% and 0.09% and 0.04%, respectively. Negative oil price shocks could only explain a 0.03% rise in FCPI for the Republic of Congo. The increase in energy inflation resulting from oil price shocks supports the finding by Anyars and Adabor (2023) for Ghana that an increase in oil price increases energy inflation.

However, a positive oil price shock in the long-run could only explain ECPI but not FCPI in Nigeria, both ECPI and FCPI in Angola, and FCPI in Equatorial Guinea but neither in the Republic of Congo. More so, negative shocks to oil prices could only explain changes in ECPI in Angola and FCPI in Equatorial Guinea. This corroborates the finding by Shitile and Usman (2020) that an increase in oil price significantly increases energy price; however, we could not establish a significant impact of negative shocks to oil prices on inflation in most countries under investigation.

In the context of short-run covariates, global inflation exhibited a significant positive impact on FCPI in Equatorial Guinea and on HCPI and CCPI for the Republic of Congo. Conversely, in the long-run, global inflation positively influenced only FCPI in the Republic of Congo. The exchange rate was found a determinant for ECPI in both the short-run and long-run in Equatorial Guinea and for ECPI in the Republic of Congo. MS was identified as a significant factor affecting inflation in the majority of the countries, with the exceptions of ECPI and FCPI in the Republic of Congo and ECPI in Angola in the short-run. However, it exerted a positive influence on ECPI in the Republic of Congo and FCPI in Angola, and on both HCPI and CCPI in Equatorial Guinea in the long-run. The output gap led to a decrease in FCPI in Equatorial Guinea and an increase in ECPI in Angola in the short-run, whereas in the long-run, it affected two countries by increasing FCPI in Angola and decreasing it in Equatorial Guinea.

In the robustness results, the normality of residuals in only ECPI models was established for Nigeria, Angola, and the Republic of Congo. No autocorrelation was found in both ECPI and ECPI for all the countries while no heteroscedasticity was valid in ECPI for Equatorial Guinea and the Republic of Congo and in FCPI for Nigeria. The problem of model specification was found in ECPI and FCPI for Nigeria and Angola, respectively. Regarding the stability test, CUSUM statistics show stability only in ECPI and FCPI for Nigeria and ECPI for Angola, with CUSUM in FCPI for Angola and ECPI for the Republic of Congo. Long-run asymmetric was observed in FCPI for Angola and Equatorial Guinea but in ECPI for Angola and the Republic of Congo.

4.4.4. MTNARDL model estimation of the impact of oil price shocks on energy (ECPI) and FCPI

In the short-run, large positive shocks to oil prices significantly impacted FCPI and ECPI increasing FCPI by 0.10% for Nigeria and ECPI by 0.11 for the Republic of Congo, while large negative shocks impacted ECPI for Nigeria reducing it by 0.03%, FCPI for Equatorial Guinea, increasing it by 0.20% and both ECPI and FCPI for the Republic of Congo, reducing them by 0.20% and 0.47%, respectively. Mild positive shocks to price explained

Table 8. Summary of ECPI and FCPI NARDL results.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI
Panel A: Short-run results								
D(LECPI(−1))	0.33***							
D(LFCPI(−1))		0.30**		0.04		−0.17		
D(GINF)	−0.003	0.0006	0.005	0.0003	0.004	0.01**	−0.008***	0.009**
D(GINF(−1))				−0.004		0.008**		
D(LEXR)	0.03	0.05	−0.06	0.003	0.05	−0.160**	0.26***	−0.09
D(LEXR(−1))				0.01				
D(LMS)	0.08**	−0.07*	−0.07	0.1	0.03	0.15***	0.144	0.01
D(LLMS(−1))	0.10**			−0.17***	−0.06*			
D(OUTPUT_GAP)	0.2	−0.1	10.2*	2.0	−3.59	−5.32**	−1.66	5.14
D(OUTPUT_GAP(−1))				−32.18***				
D(LOILP_POS)	0.02	0.045	0.21***	0.17*	−0.03	−0.05	−0.09***	−0.023
D(LOILP_POS(−1))		0.06*		−0.04	−0.09**	−0.07*		
D(LOILP_NEG)	0.001	−0.003	−0.74	0.09	−0.02	0.03*	0.04	0.06
D(LOILP_NEG(−1))				0.02	0.06			
ECT(−1)	−0.08**	−0.08**	−0.17***	−0.49***	−0.21***	−0.29***	−0.20***	−0.29***
Panel B: Long-run results								
GINF	−0.3	−0.008	0.04	0.01	0.02	−0.001	−0.009	0.03**
LEXR	0.4	0.65	−0.14	−0.008	0.22	−0.53**	0.52**	−0.32
LMS	0.15	−1.21	0.1	0.47***	0.22*	0.50***	0.29***	0.04
OUTPUT_GAP	2.31	23.4	50.7	72.57***	6.91	−18.07**	−6.69	17.86
LOILP_POS	0.29**	0.25	0.59***	0.33***	−0.15	0.20***	0.04	−0.08
LOILP_NEG	0.02	−0.04	0.34**	0.16	−0.23	0.09*	0.02	−0.08
F-Stat.	8.73***	4.24***	7.94***	5.40**	2.32**	2.97***	4.25***	9.47**
R^2	0.56	0.45	0.47	0.56	0.78	0.79	0.52	0.55

(*continued*).

Table 8. Continued.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI
Panel C: Robustness test								
J-B Test	26.24	66.22***	79.9	574.53***	370.88***	430.76***	1.81	11065.4***
B-G-S_Test	1.06	1.61	1.15	2.27	0.33	1.9	1.2	0.28
B-P-GH_Test	2.88***	1.29	3.83***	2.83***	2.11	4.55**	0.81	3.18**
R-R_Test	1.84*	0.922	0.63	14.31***	1.18	1.2	0.85	1.03
Cusum	Unstable	Unstable	Unstable	Stable	Stable	Stable	Stable	Stable
Cusum sqr	Unstable	Unstable	Unstable	Stable	Unstable	Unstable	Stable	Unstable
LR-Wald	2.05	0.07	1.95	5.56**	2.57	13.21***	0.4	0.037
SR-Wald	2.06	0.17	5.07**	0.012	2.68	0.5	5.96**	1.24

Source: Authors' computation. Using Eviews 13.

***, **, and * show rejection of the null hypothesis at a 1%, 5%, and 10% level of significance respectively, Arch LM test represents a test of the ARCH effect, the B-Serial test represents q-order serial autocorrelation, B-P-G – Het is a test for constant variance, R-RESET represents a test of model specification. SR_Wald represents the short-run Wald symmetry test; LR_Wald is the long-run symmetry test. POS is positive (oil price increase) while NEG means negative (oil price decrease).

ECPI in all countries, accounting for 0.21% and 0.12% rise in ECPI and FCPI, respectively, in Angola, reducing ECPI by 0.13% and 0.1%, respectively, in the Republic of Congo and Equatorial Guinea while increasing FCPI by 0.02% in the Republic of Congo. However, mild positive shocks to oil prices could not explain changes in ECPI and FCPI in Nigeria and FCPI in the Republic of Congo.

Mild negative shocks explained ECPI in Nigeria, reducing it by 0.27%, and FCPI in Angola, reducing it by 0.13% and increasing it by 0.16% and 0.04%, respectively, in Equatorial Guinea and the Republic of Congo. In the same vein, among all the countries, moderate positive shocks only accounted for a 0.25% fall in ECPI in the Republic of Congo but negative shocks increased ECPI and FCPI by 0.34% and 0.48%, respectively, in Congo. In the long-run, large positive shocks to oil prices could only impact FCPI in Nigeria and Angola, increasing it by 0.8% in 0.07%, respectively, leaving neither ECPI nor FCPI in Equatorial Guinea and the Republic of Congo, while large negative shocks impacted ECPI negatively, by decreasing it by 0.62% in the Republic of Congo only. Similar to the short-run, mild positive shocks to oil prices could not explain changes in ECPI and FCPI in Nigeria and FCPI in the Republic of Congo in the long-run. Mild negative shocks to oil prices reduce FCPI by 0.73% and ECPI by 0.20% in Equatorial Guinea, but increased ECPI by 0.047% in the Republic of Congo in the long-run. While moderate positive shocks to oil prices impacted only ECPI, decreasing by 0.28% in the Republic of Congo, moderate negative shocks increased ECPI in the Republic of Congo by 0.39% but decreased FCPI in Equatorial Guinea by 0.52%.

The control variables include global inflation while it reduced ECPI in the short-run by 0.009% in the Republic of Congo, and FCPI by 0.28% in Equatorial Guinea, it increased it by 0.01% in Equatorial Guinea. The exchange rate reduced FCPI in Equatorial Guinea by 0.22% and increased ECPI in the Republic of Congo by 0.18% while MS pushed up ECPI by 0.06% and 0.14%, respectively, in Nigeria and the Republic of Congo, it increased ECPI and FCPI in Equatorial Guinea by 0.13% and 0.17%, respectively. While the output gap reduced ECPI and FCPI in Equatorial Guinea by 0.8.16% and 9.02%, respectively, it increased ECPI in Angola by 19.05%. The long-run impact of the control variables indicated that as in the case of the short-run, only Equatorial Guinea and the Republic of Congo were impacted by global inflation, with the exchange rate impacting only ECPI for Equatorial Guinea. Furthermore, the MS and output gap could impact both ECPI and FCPI in Nigeria. Moderate positive shocks to oil prices impacted only ECPI negatively though, while moderate negative shocks to oil prices could only impact the Republic of Congo, increasing ECPI and FCPI by 0.34% and 0.38%, respectively.

The study established evidence of normality of the residuals in ECPI for Nigeria, and the Republic of Congo, and in FCPI for Equatorial Guinea, while autocorrelation was identified only in FCPI for Equatorial Guinea. In the case of heteroscedasticity, evidence identified it in ECPI and FCPI for Angola, and FCPI for Equatorial Guinea and the Republic of Congo. While ECPI and FCPI for Nigeria were established to be well specified, the same occurred in ECPI for the Republic of Congo. The CUSUM test shows that for all countries, ECPI and FCPI are stable, but CUSUM square could not confirm that for FCPI for the Republic of Congo Angola and FCPI for Equatorial Guinea.

An asymmetric relationship was observed between FCPI and large shock in Nigeria only in the long-run, while an asymmetric relationship in FCPI was also found in long-run mild shocks for Angola. Moderate shocks in the long-run have an asymmetric relationship with FCPI for Angola and Equatorial Guinea. In the short-run, no asymmetry was found in large and moderate shocks to both ECPI and FCPI for all the countries, while mild shocks showed an asymmetric relationship with ECPI for Angola and Equatorial Guinea, and both ECPI and FCPI for the Republic of Congo.

4.4.5. Sensitivity tests

The study conducted robustness checks on the MTNARDL benchmark results by including oil price volatility, world GDP growth and fiscal deficit as the ratio of GDP as additional covariates. The results are displayed on Tables 9 and 10.

Just as in the benchmark results of Table 7, large positive shocks to oil prices have limited impacts on HCPI and CCPI across countries as show in Table 9. For instance, Nigeria consistently shows positive impact on HCPI, while impacts in other countries are mostly insignificant. Furthermore, large negative shocks have isolated impacts. For example, CCPI in Nigeria and Equatorial Guinea is positively affected in both results, while other countries generally experience no significant impacts.

Mild positive shocks tend to increase CCPI or HCPI in specific countries like Nigeria, Angola, and Congo, while negatively impacting HCPI in Equatorial Guinea, that mild negative shocks mostly reduce HCPI in Nigeria, Angola, and Congo, with limited or no significant effects on CCPI in these countries in both results. There are mixed effects of moderate shocks. Moderate positive shocks tend to reduce HCPI in some countries (e.g. Nigeria and Congo), while moderate negative shocks often reduce HCPI and CCPI selectively (e.g. in Nigeria and Equatorial Guinea), and this align with the benchmark results. Global inflation has a significant impact on CCPI and HCPI in Equatorial Guinea, often showing positive effects in the short-run and negative effects in the long-run, displaying the similarities with the benchmark results.

Varying impacts of exchange rate and MS, with significant effects were observed primarily in CCPI for Nigeria, Angola, and Congo, similar to the benchmark results.

As shown in Table 10, after controlling for oil prices volatility, world GDP and fiscal deficit as the ratio of GDP, evidence shows a similarity of results compared to the benchmark results of Table 11. Large positive shocks primarily affect FCPI, particularly in Nigeria and Equatorial Guinea. In Nigeria, large positive shocks increase FCPI (by 0.10% in the benchmark and 0.45% in Table 9), while in Equatorial Guinea, they either have a small or no effect on ECPI, and in some cases, a small negative effect on FCPI. Furthermore, similar to the benchmark, large negative shocks reduced ECPI in Nigeria, and increase FCPI in Equatorial Guinea. In the Republic of Congo, large negative shocks impact both ECPI and FCPI, but with differing magnitudes. Both tables also note that large negative shocks have no effect on Angola's ECPI and FCPI.

Regarding positive moderate shocks, it decreased FCPI in Nigeria and increases it in Angola, while negative shocks reduce FCPI in Nigeria, Angola, and Equatorial Guinea. Both results highlight that moderate negative shocks impact ECPI in Equatorial Guinea, reducing it, while they have little effect on other countries. Global inflation impacts FCPI in Nigeria, Equatorial Guinea, and the Republic of Congo, while it reduces ECPI in Nigeria and the Republic of Congo. Exchange rate shocks reduce FCPI in Equatorial Guinea and ECPI in Nigeria. The MS influences ECPI and FCPI in most countries, and the output gap shows significant effects in Equatorial Guinea and Angola.

Thus, there exist consistent findings in terms of the general effects of oil price shocks (large, mild, and moderate) on ECPI, FCPI, HCPI, and FCPI, with some variation in the magnitudes of impacts across countries after controlling for oil price volatility, world

Table 9. Summary of HCPI and CCPI MTNARDL results.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI
Panel A: Short-run results								
D(LCCPI(−1))	−0.36***		0.51***					
D(GINF)	0.0005	−0.002	0.0003	0.024***	0.006**	0.008***	0.002	−0.0009
D(GINF(−1))					0.004**			
D(LEXR)	0.03	0.04	0.004	−0.06	−0.081*	−0.08*	−0.029	0.011
D(LEXR(−1))	0.086**							
D(LMS)	−0.02	0.004	0.002	0.36***	0.03	0.01	−0.0001	0.02**
D(OUTPUT_GAP)	0.25*	0.19**	−0.32	−2.1***	−1.76	−3.5**	0.10	−0.57
D(OUTPUT_GAP(−1))	−0.19*							
D(OILP_LAS_POS)	0.3***	0.09	0.002	−0.33	−0.092	−0.133	0.10	−0.049
D(OILP_LAS_NEG)	0.20	0.19*	0.005	0.153	0.28**	0.16	0.02	−0.05
D(OILP_MIS_POS)	0.08***	0.04***	0.004	0.14**	−0.03*	−0.004	−0.01	0.02***
D(OILP_MIS_POS(−1))	0.10***		0.011***		−0.05**			
D(OILP_MIS_NEG)	−0.03***	−0.01	−0.01***	−0.03	−0.007	−0.001	−0.06***	−0.007
D(OILP_MOS_POS)	−0.25***	−0.08	−0.007	0.36	0.05	0.10	−0.11***	0.05*
D(OILP_MOS_NEG)	−0.20*	−0.19**	−0.006	−0.07	−0.29**	−0.17	−0.04	0.05
D(OILP_MOS_NEG(−1))	0.12***		−0.008*		−0.07**		0.05*	
D(FSD_GDPR)	0.0006	0.004***	8E-5***	−0.0008	−0.002*	−0.003***	0.003	0.0009
D(OILP_VOL)	0.002**	−0.0001	2E-4***	0.001	−0.0002	0.001**	−0.0003	0.00005
D(OILP_VOL(−1))		−0.0008*						
D(WGDP_GR)	−0.0005	−0.0009	0.0003	0.008	−0.0007	−0.0004	−0.0006	−0.0001
D(WGDP_GR(−1))			4E-4***					
ECT(−1)	−0.27***	−0.16***	−0.05***	−0.55***	−0.45***	−0.46***	−0.32***	−0.33***
Panel B: Long-run results								
GINF	0.002	−0.013	0.016	0.02*	−0.00002	0.08***	0.005	−0.003
LEXR	0.048	0.24	0.07	−0.11	−0.18**	−0.18*	−0.09	0.15**
LMS	0.26*	0.03	0.13	0.66***	0.07**	0.12**	−0.0003	0.06***
OUTPUT_GAP	2.58**	1.21*	−19.7	35.7	−3.9	0.11*	−0.31	−1.71

(*continued*).

Table 9. Continued.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI	HCPI	CCPI
OILP_LAS_POS	0.54	0.58	−0.60	−.604	−0.06	−0.29	−0.54	−0.15
OILP_LAS_NEG	0.75	1.24*	0.09	0.28	0.61**	0.15	0.06	−0.16
OILP_MIS_POS	0.11**	0.27***	−0.09	0.26***	0.052	−0.10	0.05	0.07***
OILP_MIS_NEG	−0.13**	−0.09	−0.12	−0.06	0.02	−0.05	−0.05	0.042**
OILP_MOS_POS	−0.32	−0.49	0.65	0.66	0.11	0.37*	0.5	0.15*
OILP_MOS_NEG	−0.88*	−1.22	−0.12	−0.13	−0.71***	−0.38	−0.12	0.11
FSD_GDPR	0.015**	0.026**	−0.002	0.001	−0.003**	−0.006***	0.009	0.003
OILP_VOL	−0.01***	−0.005	−0.003	−0.009***	−0.0005	−0.002**	−0.001	0.0001
WGDP_GR	−0.002	−0.006	0.021	.015	−0.005	−0.0008	−0.002	−0.0005
F-Stat.	7305**	2.47***	9.13***	2.2***	2.05**	3.01***	2.23	5.23***
R^2	0.99	0.43	0.85	0.44	0.48	0.52	0.45	0.72
Panel C: Robustness test								
J-B Test	0.23	8.96**	0.47	125.2***	45.4***	36.24***	1.2	2.99
B-G-S_Test	0.009	2.76	0.90	0.66	1.15	0.48	1.05	21.25
B-*P*-GH_Test	0.80	3.53***	1.24	5.07***	0.64	0.31	1.31	1.42
R-R_Test	0.49	1.42	1.56	1.6	0.74	0.62	2.77***	1.75*
Cusum	Stable	Unstable	Stable	Stable	Stable	Stable	Stable	Stable
Cusum sqr	Stable	Stable	Unstable	Unstable	Unstable	Unstable	Stable	Stable
LR-Wald(OILP_LAS)	1.12	2.03*	5.34**	0.22	4.81***	5.10*	1.33	5.2**
LR-Wald(OILP_MIS)	0.07	0.7	3.10	1.47	6.19**	2.8	3.45*	3.1**
LR-Wald(OILP_MOS)	0.13	0.054.	2.15	0.1	4.33*	4.0**	3.07*	7.27***
SR-Wald(OILP_LAS)	0.8	4.31*	10.07***	0.9	6.79***	4.35*	2.31	0.35
SR-Wald(OILP_MIS)	0.19	1.49	4.51*	0.734	4.68	6.00*	0.81	4.09**
SR-Wald(OILP_MOS)	0.2	0.09	5.85**	0.28	2.01*	4.36***	3.58*	5.7***

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10. Summary of ECPI and FCPI MTNARDL results.

Variables	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI
Panel A: Short-run results								
D(LECPI(−1))	0.21*	−0.25**		0.17	−0.14		−0.18	
D(GINF)	−0.005*	−0.003	0.002	0.001	0.02***	0.02***	−0.008**	0.014**
D(GINF(−1))		0.006*		−0.01				
D(LEXR)	0.08*	−0.009	−0.09	−0.03	−0.23**	−0.22**	0.144	−0.02
D(LEXR(−1))					0.22**			
D(LMS)	0.14***	−0.11***	0.042	0.16	0.09**	0.20***	0.23***	0.021
D(LMS(−1))		−0.10***		−0.17**				
D(OUTPUT_GAP)	0.30*	0.33**	21.4***	13.2	−11.8***	−10.1***	−2.0	4.2
D(OUTPUT_GAP(−1))		−0.33**		−41.2		5.9**		
D(OILP_LAS_POS)	−0.01	0.45***	−0.13	−0.15	−0.15	0.14	0.09	−0.27
D(OILP_LAS_POS(−1))		0.08				−0.14**		
D(OILP_LAS_NEG)	−0.10*	0.15	0.07	0.30	0.21	0.50*	0.02	−0.29
D(OILP_LAS_NEG(−1))		0.15***						
D(OILP_MIS_POS)	0.03*	0.16***	0.32***	0.29	−0.16***	−0.24***	−0.04	−.008
D(OILP_MIS_POS(−1))		0.12***			−0.13***	−0.10**		
D(OILP_MIS_NEG)	−0.01	−0.06***	−0.20***	−0.01	0.047	0.19***	−0.03	0.03
D(OILP_MIS_NEG(−1))					0.19****			
D(OILP_MOS_POS)	−0.003	−0.25**	0.08	0.29	0.046	−0.12	−0.19	0.25
D(OILP_MOS_POS(−1))				0.33**				
D(OILP_MOS_NEG)	0.05	−0.26***	0.14	0.38	−0.43*	−0.75**	−0.01	0.35
D(OILP_MOS_NEG(−1))				−0.21*				
D(FD_GDPR)	0.005***	−0.0003	0.0009	0.0007	−0.003	−0.001	0.004	−0.006
D(FD_GDPR(−1))		−0.006***			0.002**	0.005***		
D(OILP_VOL)	0.001**	0.001**	0.002**	−0.0009	−0.0002	0.004***	−0.0008	−0.001
D(OILP_VOL(−1))		0.001**		0.004**		−0.001		
D(WGDP_GR)	−0.0008	0.002*	0.002***	−0.005	0.003	0.005	0.008***	0.0006
D(WGDP_GR(−1))					0.003*			
ECT(−1)	−0.22***	−0.48***	−0.28***	−0.71***	0.54***	−0.43***	−0.77***	−0.35***

(*continued*).

Table 10. Continued.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI
Panel B: Long-run results								
GINF	−0.02*	−0.004	0.007	0.02*	0.04***	0.04***	−0.004	0.04**
LEXR	0.34	−0.018	−0.30	−0.05**	−0.77***	−0.52**	−0.008	0.05
LMS	0.45***	0.011	0.15	0.46***	0.17**	0.20*	0.17***	0.06
OUTPUT_GAP	2.4*	2.14***	107.1**	85.9***	−9.9*	−39.5***	2.58	11.9
OILP_LAS_POS	−0.05	0.28	1.87	−0.22	−0.68	0.12	0.11	−0.77
OILP_LAS_NEG	−0.43	0.41	0.23	−0.42*	0.39	1.17*	−0.13	−0.81
OILP_MIS_POS	0.15	0.17***	0.54***	0.37***	−0.33***	−0.13*	0.019	−0.02
OILP_MIS_NEG	−0.05	−0.12***	−0.05	−0.02	−0.27***	0.28**	−0.05	−0.13
OILP_MOS_POS	−0.01	−0.03	−1.71	0.15	0.70*	0.29	−0.25	0.70
OILP_MOS_NEG	0.20	−0.54	0.49	0.73	−0.81*	−1.75**	−0.01	1.00
FSD_GDPR	0.023**	0.014***	0.003	0.001	−0.002	−0.02***	0.005	−0.017
OILP_VOL	−0.005**	−0.004	−0.008*	−0.008***	−0.0004	0.005	−0.002***	−0.003
WGDP_GR	−0.003	−0.005*	0.008	−0.008	0.004	−0.002	0.005**	0.002
F-Stat.	2.21**	6.78***	3.71***	3.36***	1.57*	2.54***	5.08***	3.21***
R^2	0.44	0’86	0.59	0.69	0.52	0.65	0.69	0.58
Panel C: Robustness test								
J-B Test	4.60	25.4***	15.21	114.7***	18.04***	4.45	2.05	980.41***
B-G-S_Test	1.17	0.92	1.4.	0.60	0.81	0.13	0.10.	0.94
B-P-GH_Test	3.96***	0.73	4.03***	4.39***	2.06*	2.49***	0.74	2.06**
R-R_Test	0.15	1.14	1.08	2.8***	0.55	0.30	0.30	0.26
Cusum	Stable	Stable	Unstable	Stable	Stable	Stable	Stable	Stable
Cusum sqr	Unstable	Stable	Stable	Unstable	Stable	Unstable	Stable	Unstable
LR-Wald(OILP_LAS)	4.31**	4.08*	3.47	0.24	1.71	2.51*	2.41	3.43*
LR-Wald(OILP_MIS)	1.03	0.17	3.54*	2.78*	0.61	2.04	0.03	0.33
LR-Wald(OILP_MOS)	3.22*	0.031	3.03*	1.22	4.43**	4.48**	1.71	3.01*
SR-Wald(OILP_LAS)	0.57	2.07	0.21	0.08	2.48	1.26	4.43**	0.87
SR-Wald(OILP_MIS)	0.11	0.90	5.42**	0.73	8.32***	0.45	7.10***	3.21*
SR-Wald(OILP_MOS)	0.31	0.033	0.53	0.64	0.57	0.43	0.43	0.63

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 11. Summary of ECPI and FCPI MTNARDL results.

	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
Variables	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI
Panel A: Short-run results								
D(LECPI(−1))							−0.18	
D(GINF)	0.0005	−0.001	0.0006	0.001	0.01***	−0.28***	−0.009***	0.007
D(GINF(−1))					0.006**			
D(LEXR)	0.02	0.07	−0.07	−0.03	−0.14	−0.22**	0.18*	0.08
D(LMS)	0.06*	−0.09	−0.07	0.13	0.13***	0.17***	0.14***	0.026
D(LMS(−1))							−0.13	
D(OUTPUT_GAP)	−0.011	−0.02	19.05***	−2.49	−8.16***	−9.02***	−2.39	1.64
D(OILP_LAS_POS)	−0.02	0.10**	−0.19	0.31	−0.04	0.09	0.23	−0.1
D(OILP_LAS_POS(−1))							0.11**	
D(OILP_LAS_NEG)	−0.03*	−0.01	0.03	−0.15	0.06	0.20*	−0.47**	−0.42**
D(OILP_MIS_POS)	−0.02	−0.11	0.21***	0.12**	−0.17	−0.04	−0.10***	0.02***
D(OILP_MIS_POS(−1))					−0.13***		−0.123***	
D(OILP_MIS_NEG)	0.07	−0.27**	−0.13***	0.013	0.03	0.04	0.04**	0.008
D(OILP_MIS_NEG(−1))					0.16***			
D(OILP_MOS_POS)	−0.06	0.27	0.17	−0.16	0.03	−0.16	−0.25*	0.1
D(OILP_MOS_NEG)	−0.15	0.17	0.05	−0.012	−0.29	−24	0.34*	0.48***
ECT(−1)	−0.14***	−0.42***	−0.24***	−0.45***	0.55***	−0.28***	−0.90***	−0.36***
Panel B: Long-run results								
GINF	0.009	−0.01	−0.008	0.012	0.02**	0.007	−0.01**	0.02
LEXR	0.21	−0.009	−0.32	−1.13	−0.75***	−0.63	−0.08	0.21
LMS	0.33	−0.07	0.014	0.46***	0.28***	0.41	0.24***	0.07
OUTPUT_GAP	0.45	0.62	93.87*	17.76	−8.45**	−23.34	−2.66*	4.57
OILP_LAS_POS	0.02	0.18*	1.28	0.07***	−0.08	−0.51	0.16	−0.28
OILP_LAS_NEG	−0.09	−0.02	−2.41	0.85	0.1	0.81	−0.62**	−1.18
OILP_MIS_POS	1.33	−0.32	0.56**	0.32*	−0.26***	0.22*	0.03	0.04
OILP_MIS_NEG	2.81	−0.73*	0.106	0.15	−0.20***	0.1	0.047**	0.02

(continued).

Table 11. Continued.

Variables	Nigeria		Angola		Equatorial Guinea		Republic of Congo	
	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI	ECPI	FCPI
OILP_MOS_POS	−1.65	0.59	−1.2	0.08	0.05	0.47	−0.28**	0.27
OILP_MOS_NEG	−3.45	0.51	2.94	−0.82	−0.52*	−0.93	0.39*	1.33
F-Stat.	2.03**	3.32***	6.96***	2.42***	1.70*	4.64***	3.61***	9.80***
R^2	0.58	0.69	0.57	0.51	0.51	0.47	0.6	0.6
Panel C: Robustness test								
J-B Test	9.4	183.47***	53.06***	1570.82***	92.62***	371.23	0.63	971.56***
B-G-S_Test	2.73	2.06	0.70.	0.3	0.49	3.10*	2.12	0.92
B-*P*-GH_Test	1.63*	1.45	2.57***	1.67*	1.53	1.82**	0.72	2.68***
R-R_Test	1.42	2.08	2.51**	6.68***	1.78*	10***	2.96***	0.45
Cusum	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
Cusum sqr	Stable	Stable	Stable	Unstable	Unstable	Stable	Stable	Unstable
LR-Wald(OILP_LAS)	0.43	3.38*	2.67	0.2	1.71	1.35	2.41	1.85
LR-Wald(OILP_MIS)	0.53	0.29	2.85*	0.78	0.61	1.01	0.03	0.001
LR-Wald(OILP_MOS)	0.77	0.011	3.73*	0.29	3.18*	1.48	1.71	0.25
SR-Wald(OILP_LAS)	0.41	1.48	0.14	0.3	0.044	0.82	2.28	0.08
SR-Wald(OILP_MIS)	0.09	0.19	6.36**	0.27	10.23***	0.71	6.48**	2.7*
SR-Wald(OILP_MOS)	0.072	0.073	0.047	0.034	0.46	0.06	2.17	0.026

Notes: Author's computation. Using Eviews 13.
***, **, and *show rejection of the null hypothesis at a 1%, 5%, and 10% level of significance respectively, J-B test represents the normality test, the B-G-S test represents q-order serial autocorrelation, B-P-G-Het is a test for constant variance, R-RESET represents a test of model specification. SR_Wald represents the short-run Wald symmetry test; LR _Wald is the long-run symmetry test. POS is positive (oil price increase) while NEG means negative (oil price decrease). OILPT_MIS is mild shocks in the exchange rate, OILP_MOS depicts moderate shocks in the oil price; OILP_LAS represents large shocks in the exchange rate.

GDP and fiscal deficit as ratio of GDP. Additionally, the influence of control variables like global inflation, exchange rates, MS, and output gaps is similarly reflected.

5. Conclusion and policy implication

The study investigates the impact of oil price shocks on inflation components (HCPI, CCPI, ECPI, and FCCI) across Nigeria, Angola, the Republic of Congo, and Equatorial Guinea, using NARDL and MTNARDL models. The estimates indicate that oil price shocks have differing short- and long-term effects on inflation indices across these countries. In the short-run, large positive shocks led to an increase in all inflation indices in Nigeria, Angola, and the Republic of Congo, while large negative shocks reduced ECPI in Nigeria and the Republic of Congo, but increased FCPI, CCPI, and HCPI in Equatorial Guinea. Mild shocks had mixed effects on different indices across countries, with some lowering and others raising inflation measures. Moderate shocks showed no significant impact on most indices except for mixed results in the Republic of Congo. Long-term effects revealed that large positive shocks increased FCPI in Nigeria and Angola, while negative shocks had differing impacts on ECPI, FCPI, CCPI, and HCPI across countries. Overall, the study highlights that oil price shocks have significant and varied effects on different inflation components, with the magnitude and direction of shocks influencing inflation differently across countries.

Based on these findings, the study recommends the strengthening of fiscal and monetary policies in Nigeria, by saving in sovereign funds during high oil price and adjusting the interest rate, respectively to stabilize inflation and ensure more predictable economic conditions. Regarding Congo, the study recommends for enhanced economic diversifications to reduce dependency on oil, by leveraging agriculture, manufacturing, and services to reduce vulnerability to fluctuation in global oil price. Furthermore, for Angola, focusing on inflation targeting to manage the mixed effect of oil price shocks on inflation components is recommended. This will help the country weather the short-run fluctuations caused by oil price volatility. Finally, the study recommends that Equatorial Guinea should strengthen the social protection programs to cushion the effects of oil price shocks on consumer prices. This could be in the form of subsidies or direct transfers which will act as a buffer against a rise in consumer prices occasioned by oil price shocks.

6. Limitations and suggestions for further study

The study employed the MTNARDL model to examine the impact of aggregate oil price shocks on the different components of inflation, including the core, headline, energy, and food consumer price indices. This study specifically focused on how the signs (positive or negative) and sizes (magnitude) of aggregate oil price shocks affect various inflation components. It failed to capture how the signs (positive or negative) and sizes (magnitude) of distinct types of oil price shocks: supply shocks, demand shocks, and risk shocks impact various inflation components to provide a more nuanced understanding. Further studies can focus on this by analyzing the impact (in terms of the signs [positive or negative] and sizes [magnitude]) of diverse types of oil price shocks on various components of inflation using the MTNARDL model.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data that supports the findings of this study are available from the corresponding author upon reasonable request.

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References

Adesina, A. 2023. "Mobilising Private Sector Financing for Climate and Green Growth in Africa." May 30. https://newafricanmagazine.com/29682/.

African Economic Outlook. 2023. "Mobilizing Private Sector Financing for Climate and Green Growth in Africa." https://www.afdb.org/en/knowledge/publications/african-economic-outlook.

African Union Energy Commission. 2020. "The Impact of COVID-19 on African Oil Sector: A Special Report by AFREC on the Implications on African Countries." https://au.int/en/documents/20200528/impact-covid-19-african-oil-sector-special-report-afrec.

Ali, I. 2021. "Asymmetric Impacts of Oil Prices on Inflation in Egypt: A Nonlinear ARDL Approach." *Journal of Development and Economic Policies* 23 (1): 5–28.

Anand, R., and E. S. Prasad. 2010. "Optimal Price Indices for Targeting Inflation Under Incomplete Markets." National Bureau of Economic Research No. 16290.

Anyars, S. I., and O. Adabor. 2023. "The Impact of Oil Price Changes on Inflation and Disaggregated Inflation: Insights from Ghana." *Research in Globalization* 6:1–12.

Asghar, N., and T. A. Naveed. 2015. "Pass-through of World Oil Prices to Inflation: A Time Series Analysis of Pakistan." *Pakistan Economic and Social Review* 53 (2): 269–284.

Atuk, O., and M. Ozmen. 2009. "A New Approach to Measuring Core Inflation for *Turkey:Satrim*." *Iktisat Isletme ve Finans* 24 (285): 73–88.

Augé, B. 2021. "The Economic and Political Consequences of Falling Oil Production in Sub-Saharan Africa by 2030." Erişim Adresi. https://www.ifri.org/sites/default/files/atoms/files/.

Babuga, U. J., and N. A. M. Naseem. 2020. "Asymmetric Effect of Oil Price Change on Inflation: Evidence from sub-Saharan Africa Countries." *International Journal of Energy Economics and Policy* 11 (1): 448–458. https://doi.org/10.32479/ijeep.10764

Bachmeier, L. J., and I. Cha. 2011. "Why Don't Oil Shocks Cause Inflation? Evidence from Disaggregate Inflation Data." *Journal of Money, Credit and Banking* 43 (6): 1165–1183. https://doi.org/10.1111/j.1538-4616.2011.00421.x

Bala, U., and L. Chin. 2018. "Asymmetric Impacts of Oil Price on Inflation: An Empirical Study of African OPEC Member Countries." *Energies* 2018 (11): 1–21.

Bala, U., and L. Chin. 2020. "Asymmetric Impacts of Oil Price Shocks on Malaysian Economic Growth: Nonlinear Autoregressive Distributed Lag Approach." *Iranian Economic Review* 24 (4): 959–981.

Balcilar, M., J. Uwilingiye, and R. Gupta. 2018. "The Dynamic Relationship between Oil Price and Inflation in South Africa." *The Journal of Developing Areas* 52 (2): 73–93. https://doi.org/10.1353/jda.2018.0023

Ball, L., and N. G. Mankiw. 1994. "Asymmetric Price Adjustment and Economic Fluctuations." *The Economic Journal* 104 (423): 247–261. https://doi.org/10.2307/2234746

Barigozzi, M., and M. Luciani. 2023. "Measuring the Output Gap Using Large Datasets." *Review of Economics and Statistics* 105 (6): 1500–1514. https://doi.org/10.1162/rest_a_01119

Bawa, S., I. S. Abdullahi, D. Turkur, S. I. Barda, and Y. J. Adams. 2020. "Asymmetric Impact of Oil Price on Inflation in Nigeria." *CBN Journal of Applied Statistics* 11 (2): 85–113.

Belke, A., and C. Dreger. 2015. "The Transmission of Oil and Food Prices to Consumer Prices: Evidence for the MENA Countries." *International Economics and Economic Policy* 11 (3): 413–430. https://doi.org/10.1007/s10368-013-0241-z

Bernanke, B. S., M. Gertler, M. Watson, C. A. Sims, and B. M. Friedman. 1997. "Systematic Monetary Policy and the Effects of Oil Price Shocks." *Brookings Papers on Economic Activity* 1997 (1): 91–157. https://doi.org/10.2307/2534702

Brock, W. A., W. D. Dechert, J. A. Scheinkman, and B. LeBaron. 1996. "A Test for Independence Based on the Correlation Dimension." *Econometric Reviews* 15 (3): 197–235. https://doi.org/10.1080/07474939608800353.

Calvo, G. A. 1983. "Staggered Prices in a Utility-Maximizing Framework." *Journal of Monetary Economics* 12 (3): 383–398. https://doi.org/10.1016/0304-3932(83)90060-0.

Castañeda, G., F. Chávez-Juárez, and O. A. Guerrero. 2018. "How do Governments Determine Policy Priorities? Studying Development Strategies Through Spillover Networks." *Journal of Economic Behavior & Organization* 154:335–361. https://doi.org/10.1016/j.jebo.2018.07.017.

Central Bank of Nigeria Statistical Bulletin. 2022. https://www.cbn.gov.ng/documents

Cevik, S., and K. Teksoz. 2013. "Hitchhiker's Guide to Inflation in Libya." IMF Working Paper N0 78.

Chuku, C. A. 2012. "Linear and Asymmetric Impacts of Oil Price Shocks in an Oil-Importing and –Exporting Economy: The Case of Nigeria." *OPEC Energy Review* 36:413–443. https://doi.org/10.1111/j.1753-0237.2012.00220.x.

De Brouwer, G. 1998. "Methods of Estimating the Output Gap| RDP 9809: Estimating Output Gaps." Reserve Bank of Australia Research Discussion Papers, August.

Ding, S., D. Zheng, T. Cui, and M. Du. 2023. "The Oil Price-Inflation Nexus: The Exchange Rate Pass-Through Effect." *Energy Economics* 125:1–13.

Donayre, L., and N. A. Wilmot. 2016. "The Asymmetric Effects of Oil Price Shocks on the Canadian Economy." *International Journal of Energy Economics and Policy* 6 (2): 167–182.

European Central Bank. 2010. "Annual Report 2010." https://www.europa.eu/pub/pdf/annrep/ar.

Giri, F. 2022. "The Relationship between Headline, Core, and Energy Inflation: A Wavelet Investigation." *Economics Letters* 210:110214. https://doi.org/10.1016/j.econlet.2021.110214.

Goh, L. T., S. H. Law, and I. Trinugroho. 2022. "Do Oil Price Fluctuations Affect the Inflation Rate in Indonesia Asymmetrically?" *The Singapore Economic Review* 67 (04): 1333–1353. https://doi.org/10.1142/S0217590820460030.

Guerrero, O. A., and G. Castañeda. 2021. "Quantifying the Coherence of Development Policy Priorities." *Development Policy Review* 39 (2): 155–180. https://doi.org/10.1111/dpr.12498.

Ha, J., M. A. Kose, and F. Ohnsorge. 2021. "One-Stop Source: A Global Database of Inflation." Policy Research Working Paper 9737. Report No. 22/12. Washington, DC: World Bank. https://www.elibrary.imf.org/view/journals/002/2022/012/article-A001-en.xml.

Hayashi, T., N. H. Wickremasinghe, and S. Jayakody. 2015. "Application of the New Keynesian Phillips Curve Inflation Model in Sri Lanka."

Hirschman, A. O. 1981. *Essays in Trespassing: Economics to Politics and Beyond*. Cambridge: Cambridge University Press.

Hooker, M. A. 2002. "Are Oil Shocks Inflationary? Asymmetric and Nonlinear Specifications Versus Changes in Regime." *Journal of Money, Credit and Banking* 34:540–561. https://doi.org/10.1353/mcb.2002.0041

Ibarra, R. 2012. "Do Disaggregated CPI Data Improve the Accuracy of Inflation Forecasts?" *Economic Modelling* 29 (4): 1305–1313. https://doi.org/10.1016/j.econmod.2012.04.017.

IMF. 2022. "Angola Selected Issues." IMF Country Report No. 22/12. https://www.elibrary.imf.org/view/journals/002/2022/012/article-A001-en.xml.

IMF. 2023. "Republic of Congo. Fourth Review under the Three-Year Arrangement under the Extended Credit Facility, Requests for Modification of Performance Criteria, Waivers of Non-Observance of Performance Criteria, and Financing Assurances Review—Debt Sustainability Analysis." https://www.elibrary.imf.org/view/journals/002/2024/002/article-A002-en.xml.

Kelesbayev, D., K. Myrzabekkyzy, A. Bolganbayev, and S. Baimaganbetov. 2022. "The Effects of the Oil Price Shock on Inflation: The Case of Kazakhstan." *International Journal of Energy Economics and Policy* 12 (3): 477–481. https://doi.org/10.32479/ijeep.13061.

Kilian, L. 2009. "Not All Oil Price Shocks are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market." *American Economic Review* 99 (3): 1053–1069. https://doi.org/10.1257/aer.99.3.1053.

Kilian, L. 2010. "Oil Price Volatility: Origins and Effects (No. ERSD-2010-02)." WTO Staff Working Paper 5.

Kose, K., and E. Unal. 2024. “The Effects of the Oil Price and Temperature on Food Inflation in Latin America.” *Environment, Development and Sustainability* 26:3269–3295. https://doi.org/10.1007/s10668-022-02817-2.

Kudabayeva, L., A. Abubakirova, A. Zurbayeva, G. Mussaeva, and G. Chimgentbayeva. 2024. “The Relationship between Oil Prices and Inflation in Oil İmporting Countries (1980–2022).” *International Journal of Energy Economics and Policy* 14 (1): 359–364. https://doi.org/10.32479/ijeep.15060.

Lacheheb, M., and A. Sirag. 2019. “Oil Price and Inflation in Algeria: A Nonlinear ARDL Approach.” *The Quarterly Review of Economics and Finance* 73:217–222. https://doi.org/10.1016/j.qref.2018.12.003.

Li, Y., and J. Guo. 2022. “The Asymmetric Impacts of Oil Price and Shocks on Inflation in BRICS: A Multiple Threshold Nonlinear ARDL Model.” *Applied Economics* 54 (12): 1377–1395. https://doi.org/10.1080/00036846.2021.1976386.

Mien, E. 2022. “Impact of Oil Price and Oil Production on Inflation in the CEMAC.” *Resources Policy* 79:103010. https://doi.org/10.1016/j.resourpol.2022.103010.

Mordi, C. N. O., E. A. Essien, P. N. Adenuga, M. C. Ononugbo, A. A. Oguntade, M. O. Abeng, and O. M. Ajao. 2007. “The Dynamic of Inflation in Nigeria.” Occasional Paper, 32.

Mukhtarov, S., S. Aliyev, and J. Zeynalov. 2020. “The Effects of Oil Prices on Macroeconomic Variables: Evidence from.” *Journal of Energy Economics and Policy* 10 (1): 72–80.

Murray, J. P. 2014. “Output Gap Measurement: Judgement and Uncertainty.” Office for Budget Responsibility Working Paper.

Nnadozie, O. O., L. E. Emediegwu, and I. A. Raifu. 2022. “Examining the Response of Inflation to the Boom-Bust Cycle of Oil. Evidence from Nigeria. Development Bank of Nigeria.” *Journal of Economics and Sustainable Growth* 5 (1): 1–31.

Odionye, J. C., and J. O. Chukwu. 2023. “Asymmetric Reactions of Stock Prices and Industrial Output to Exchange Rate Shocks: Multiple Threshold Nonlinear Autoregressive Distributed Lag Framework.” *Economic Annals* 68 (237): 165–191. https://doi.org/10.2298/EKA2337165C.

Odionye, J. C., O. N. Emmanuel, A. C. Odo, U. S. Ugwuegbe, and C. N. Uba. 2023. “Asymmetric Impact of Multifarious Exchange Rate Shocks on Stock Prices: Fresh Insights from Multiple Thresholds Nonlinear Autoregressive Distributed-Lag Approach.” *The Journal of International Trade & Economic Development* 33 (5): 1–35.

Odionye, J. C., A. C. Odo, A. Orji, A. Ndubuisi, V. A. Ihezukwu, R. O. Ojike, and R. M. Okparra. 2024. “Threshold-Based Influence of Currency Devaluation on External Deb Sustainability: Insights Form Smooth Transition Regression and Multiple Thresholds Nonlinear ARDL Approaches.” *The Journal of International Trade and Ecoomic Development*, 1–34. https://doi.org/10.1080/09638199.2024.2389873.

Odionye, J. C., O. S. Ukeje, and A. C. Odo. 2019. “Oil Price Shocks and Inflation Dynamics in Nigeria: Sensitivity of Unit Root to Structural Breaks.” *International Journal of Business and Economics Research* 8 (2): 58–64. https://doi.org/10.11648/j.ijber.20190802.13

Odo, A. C., J. K. Odionye, and R. O. Ojike. 2016. “Inflation Dynamics in Nigeria: Implications for Monetary Policy Response.” *Journal of Economics and Sustainable* 7 (8): 243–248.

Odo, A. C., N. E. Urama, and J. C. Odionye. 2024. “Volatile Capital Flows and Economic Growth in Sub-Saharan Africa: The Role of Transparency.” *Empirical Economics*, 1–27.

Olaoye, O. O., O. J. Omokanmi, M. I. Tabash, S. O. Olofinlade, and M. O. Ojelade. 2023. “Soaring Inflation in Sub-Saharan Africa: A Fiscal Root?” *Quality & Quantity* 58 (1): 1–23.

Pal, D., and S. K. Mitra. 2015. “Asymmetric Impact of Crude Price on Oil Product Pricing in the United States: An Application of Multiple Threshold Nonlinear Autoregressive Distributed Lag Model.” *Economic Modelling* 51:436–443. https://doi.org/10.1016/j.econmod.2015.08.026

Pal, D., and S. K. Mitra. 2016. “Asymmetric Oil Product Pricing in India: Evidence from a Multiple Threshold Nonlinear ARDL Model.” *Economic Modelling* 59:314–328. https://doi.org/10.1016/j.econmod.2016.08.003

Pal, D., and S. K. Mitra. 2019. “Asymmetric Oil Price Transmission to the Purchasing Power of the US Dollar: A Multiple Threshold NARDL Modeling Approach.” *Resources Policy* 64:101508. https://doi.org/10.1016/j.resourpol.2019.101508

Pesaran, M. H., Y. Shin, and R. J. Smith. 2001. “Bounds Testing Approaches to the Analysis of Level Relationships.” *Journal of Applied Econometrics* 16 (3): 289–326.

Renou-Maissant, P. 2019. “Is Oil Price Still Driving Inflation?” *The Energy Journal* 40 (6): 199–220. https://doi.org/10.5547/01956574.40.6.pren

Rodrik, D., and M. R. Rosenzweig, eds. 2010. “Preface: Development Policy and Development Economics: An Introduction.” In *Handbook of Development Economics*, Vol. 5, 15–27. Oxford: North-Holland.

Roger, S. 1998. “Core Inflation: Concepts, Uses, and Measurement.” Reserve Bank of New Zealand Discussion Paper, G98/9.

Rotemberg, J. J., and M. Woodford. 1996. “Imperfect Competition and the Effects of Energy Price Increases on Economic Activity.” NBER Working Paper w5634.

Sarmah, A., and D. P. Bal. 2021. “Does Crude Oil Price Affect the Inflation Rate and Economic Growth in India? A New Insight Based on Structural VAR Framework.” *The Indian Economic Journal* 69 (1): 123–139. https://doi.org/10.1177/0019466221998838

Shin, Y., B. Yu, and M. Greenwood-Nimmo. 2014. “Modeling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework.” In *Festschrift in Honor of Peter Schmidt*, edited by R. Sickles and W. Horrace, 281–314. New York: Springer. https://doi.org/10.1007/978-1-4899-8008-3_9.

Shitile, T. S., and N. Usman. 2020. “Disaggregated Inflation and Asymmetric Oil Price Pass-through in Nigeria.” *Journal of Energy Economics and Policy* 10 (1): 255–264.

Sun, L., and Y. Wang. 2021. “Global Economic Performance and Natural Resources Commodity Prices Volatility: Evidence from pre and Post COVID-19 Era.” *Resources Policy* 74:102393. https://doi.org/10.1016/j.resourpol.2021.102393

Sun, Q., Z. Wang, and N. Jia. 2022. “Revisiting the Dynamic Response of Chinese Price Level to Crude Oil Price Shocks Based on a Network Analysis Method.” *Entropy* 24 (7): 944. https://doi.org/10.3390/e24070944

U.S. Energy Information Administration Short-Term Energy Outlook. 2023. *Database*.

Wen, F., K. Zhang, and X. Gong. 2021. “The Effects of Oil Price Shocks on Inflation in the G7 Countries.” *North American Journal of Economics and Finance* 57:1–25.

Wong, K., L. Chin, and W. L. Wong. 2019. “Impact of Climate Change and Economic Factors on Malaysian Food Prices.” *Journal of the International Society for Southeast Asian Agricultural Sciences* 25 (1): 32–499.

Xuan, P. P., and L. Chin. 2015. “Pass-through Effect of Oil Price into Consumer Price: An Empirical Study.” *International Journal of Economics and Management* 9:143–161.