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Asymmetric Pass-through Effects of Oil Price Shocks and Exchange Rates on Inflation in Nigeria: Evidence from a Nonlinear ARDL Model

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Abstract

This paper employs the linear autoregressive distributed lag (ARDL) model, the asymmetric nonlinear ARDL (NARDL) model developed by Shin, et al (2014) to examine the asymmetric effect of oil price and exchange rates pass-through on inflation in Nigeria over a period of 1970 to 2020. The result of the asymmetric test revealed the existence of asymmetries among the variables of the study, suggesting that there is a nonlinear interaction among the variables used in the study. This validates the choice of a non-linear ARDL model for the study. Results of the long-run estimates show that rising (Positive) oil price shocks have a greater impact on inflation than falling (negative) oil price shocks. Furthermore, it is evident from the result that the depreciation of the exchange rate has a much and significant effect on inflation than the appreciation of the exchange rate in Nigeria. However, a rising

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interest rate increases inflation by 0.84 per cent while a falling interest rate increases inflation by 0.85 per cent. This implies that the effect of negative interest rate on inflation is higher than its positive effect on inflation, though, by a smaller amount of about 0.01 per cent. Again, the short-run dynamic model revealed a high speed of convergence of more than 90% from the short-run disequilibrium. During the study period, the oil price fluctuations showed a significant and incomplete pass-through to both exchange rates and inflation in Nigeria. Moreover, the results suggest that positive oil price changes have a larger impact than the negative ones, that the effect of an oil price shock on inflation and exchange rates is larger in the long-run than in the short-run, and that there is incomplete pass-through effect of oil price on domestic inflation and exchange rates. Based on the findings, the study recommends policies that set oil prices and exchange rates within reasonable limits to check inflation in Nigeria and should diversify its economy as well as withdraw the current subsidy regime completely.

Keywords: Non-linear Autoregressive Distributed Lag (NARDL), asymmetric pass-through, oil price shock, exchange rates, and inflation

1. Introduction

The sharp and persistent volatility of international oil prices over the last five decades has piqued the interest of researchers and policymakers alike, owing to the significant impact oil price fluctuations have had on exchange rates and domestic inflation in oil-consuming and oil-producing countries. This phenomenon has sparked several studies on the potential influence of oil price shocks on macroeconomics, primarily in developed OECD nations, with a few studies in developing non-OECD nations, though there is disagreement on whether oil price shocks cause economic downturns. According to empirical evidence, oil price shocks affect domestic inflation and exchange rates in both oil-consuming and oil-producing economies.

According to López-Villavicencio and Pourroy (2019), the impact of oil price shocks on domestic inflation and exchange rate happens via two channels: the direct channel and the indirect channel. The direct channel is related to variations in the cost of production of a firm induced by an increase or decrease in energy resources; while the indirect channel is associated with to the fluctuations in exchange rates caused by rising and falling oil prices.

However, the oil-consuming and oil-exporting nations are more likely to benefit from the indirect channel, disproportionately. The Central Bank of Nigeria relies on a thorough understanding of the empirical linkage between oil price shocks, domestic inflation, and exchange rates to formulate a comprehensive policy. In the advent of disruptions caused by fluctuations in oil prices in both oil-consuming and oil-producing countries, the monetary

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policy framework can play a critical role in exchange rate policies and inflation targeting. According to Bernanke, et al (1997), tighter monetary policy in response to fluctuations in oil prices in the global oil market may instigate an unnecessary economic recession.

Understanding the actual response of exchange rate and domestic inflation to the shock of oil prices will guide the monetary policymakers to design a sound and suitable policy to guard against any negative shocks of prices on a country's macroeconomy. When there is a sudden and unexpected increase in oil prices, which may result in an increase in domestic production costs, which may be passed on to domestic consumer prices, monetary policymakers may change their course to achieve the desired outcome. Monetary policy's emphasis may shift to regulating inflation from the wonky handling of the exchange rate or output.

Many studies have attempted to explore the dynamic of oil prices and the macroeconomy nexus in developed and developing countries using various data sets and methodologies. This paper is interested in López and Pourroy's research (2019) because they used the state-space model to evaluate the pass-through from changes in prices of crude oil to inflation from 1970-2017 in a large sample of countries. Therefore, how can an all-encompassing monetary policy formulation be implemented in Nigeria in response to the likely negative influences of oil price pass-through on domestic inflation and exchange rates? Is there a difference in how exchange rates and inflation react when international oil prices rise or fall? If this is the case, how can monetary policy be designed to cushion the likely unexpected transmission of shocks when oil prices rise or fall?

These questions appear necessary in the context of discussions about the Central Bank of Nigeria's policy, particularly on inflation control, because the Nigerian economy is heavily reliant on oil exports (and, to a large extent, imports of oil products), and the economy's reaction to changes oil price shock may be strong. According to Kartaev and Luneva (2018), the target function of the Central Bank in pure inflation targeting policy may include, when the inflation diverts from the actual target. However, the central bank does not intercede for the foreign exchange market (except in emergencies) and is less likely to achieve monetary policy goals through the interest rate.

As a result, aiming hyperinflation may necessitate the use of the monetary policy device which is the exchange rate together with the interest rates. As a result, anti-inflationary policies and monetary authority credibility are critical factors in reducing oil price pass-through and changes in exchange rate into consumer price inflation. In line with this, this paper attempts to add to the existing writings by conducting a methodical exploration of the impact of socks on global oil prices on Nigerian exchange rates and domestic inflation from 1970 to 2020. The study attempted to specifically examine the

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asymmetric response of shocks in global oil prices on exchange rates and domestic inflation, also, with the effect of pass-through of global oil prices on exchange rates and domestic inflation.

In-depth knowledge of the connection between exchange rates, oil prices, and domestic inflation, may help policymakers form a more accurate assessment of inflation risk and exchange rate misalignment. This is likely to accompany oil price shocks and respond appropriately to international oil price shocks that may affect these variables and transmit into the workings of the Nigerian economy. The paper adds to the existing literature in developing countries by investigating the oil price pass-through effects on exchange rates and inflation in Nigeria, as well as the impact of (A) symmetric oil price deviations on domestic inflation and exchange rates using non-linear Autoregressive Distributed Lags Models.

The second section of this paper examines the movements of the exchange rate, domestic inflation, and global oil prices. Section three examines the existing studies on the linkage between global oil prices, exchange rates, and domestic inflation. The empirical methodology is in Section four, while section five is the empirical findings and discussions. The sixth section is the conclusion and policy implication of the findings.

2. A Review of Nigerian Oil Price, Exchange Rate, and Inflation Developments

Nigeria has the largest economy in Africa and one of the top ten oil producers in the world. The Nigerian economy, on the other hand, is both resource-rich and resource-dependent. Nigeria's economy is heavily reliant on the fortunes of oil. Since the early 1970s, oil has been responsible for large macroeconomic fluctuations in Nigeria, which have had an impact significantly on the overall feat of the economy. The high volatility of international oil prices, which was transmitted into the Nigerian economy, was the major contributing factor accounting for the business cycle in the Nigerian economy during that period. Figure 1(a) shows that the price of oil increased by more than 400% in 1974, from $1.90 in 1972 to $10.41 in 1974. The price of oil increased further in 1980, reaching $102.62 in 1980 and $111.67 in 2012.

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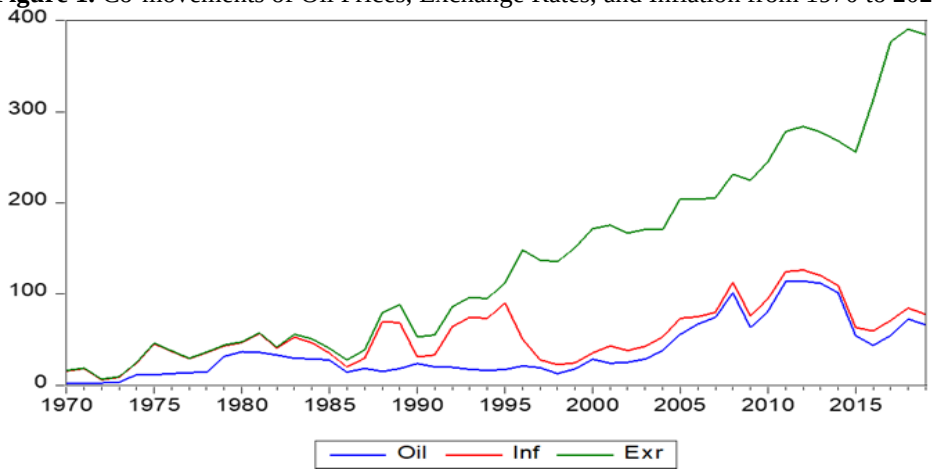
Figure 1. Co-movements of Oil Prices, Exchange Rates, and Inflation from 1970 to 2020

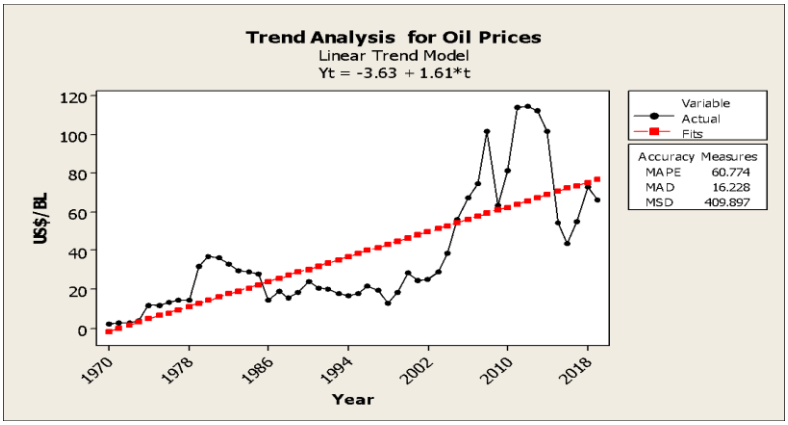


However, most increases in oil prices resulted in a downward trend; for example, the collapse of the international oil market during the 1980s saw oil prices fall to $17.91 in 1988 from their early 1980 levels. Despite a price recovery in 2012, prices eventually fell to $52.39 in 2015.

One of the recent developments in the International Oil Market (IOM) is the current Covid-19 pandemic, which has resulted in global lockdown measures to contain the spread of COVID-19, causing an unprecedented shock to global oil demand. The drop in global oil demand caused the IOM to fail, resulting in a drop in international oil prices from $18/barrel to a historic minus $37/barrel.

Figure 2. Trends in Oil Prices, Exchange Rates, and Inflation from 1970 to 2020

(A)



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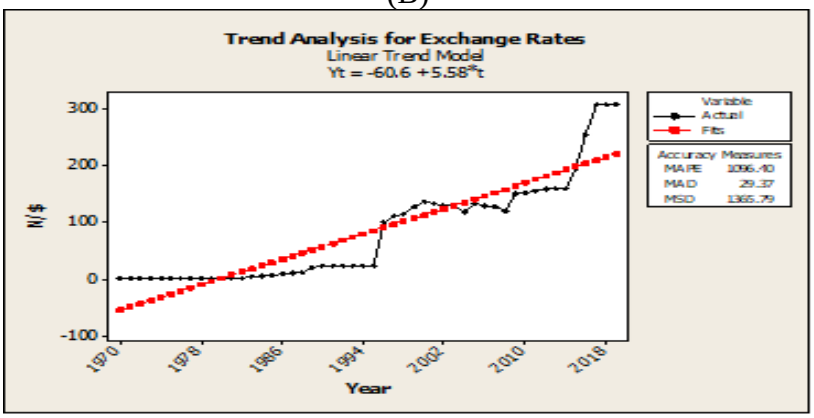
(B)



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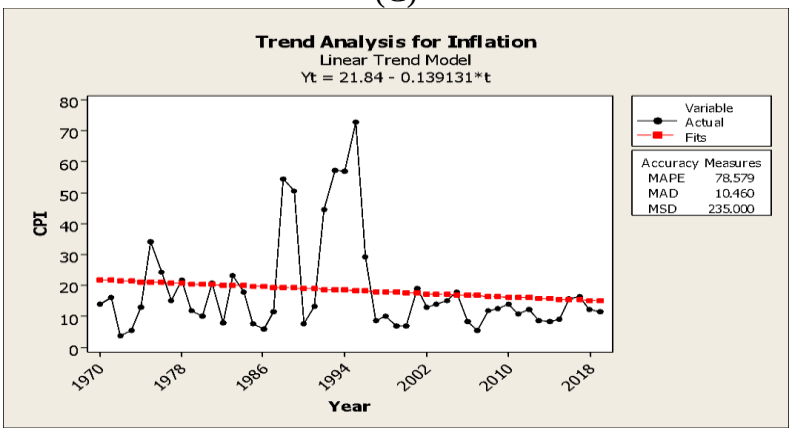

Source: Authors' computation via Minitab 16

These historical swings in international oil prices caused a spillover from the oil sector into the rest of the Nigerian economy, including a large transfer of wealth in dollars from oil exports, which also resulted in high real exchange rate appreciation and a high rate of inflation. Nigeria maintained a fixed exchange rate regime to protect the naira from exchange rate fluctuations from its independence in 1960 until the introduction of the Structural Adjustment Program (SAP) in 1986. Figure 1(b) depicts an average of N 0.85 / $1.00 during the pre-adjustment period from 1970 to 1985 when the nominal value of the Nigerian naira was stronger than the US dollar. The influx of foreign exchange from oil sales contributed to the naira's strong value. Even during the early 1980s economic crisis, which resulted in a sharp decline in foreign exchange earnings, Nigerian policymakers did not see devaluation as a viable option. The 1982 economic crisis accorded with the escalation of

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parallel markets, resulting in Nigeria having a prohibited floating rate in parallel markets coexisting with an official rate (Pinto, 1987).

As the economic crisis worsened, the government resorted to abandoning the previous fixed exchange rate regime to implement a market-determined regime. As a result of this policy, the naira fell to N2.413/$1.00 and then to N 7.901 against the US dollar in 1987 and 1990. The government later implemented a deregulation policy which nailed the Naira at N21.886 against the dollar; additionally, the Naira was devalued to N86.322 and N131.5 to the dollar between 1999 and 2008, and by early 2017, the nominal value of the Naira had depreciated to around N350.00/dollar. However, the crash of the international oil market during the Covid-19 crisis in international oil prices caused the Nigerian exchange rate to depreciate further from around N360/$1.00 to over N500/$1 and the rate of inflation to rise from 11.4 per cent in 2019 to 13.39 per cent in 2020. (CBN, 2020).

The combined effects of fluctuating oil prices, which resulted in an influx of petrodollar oil revenue, and an overvaluation of the domestic currency also had an impact on domestic prices of goods and services in Nigeria during the period under review. According to Figure 1(c), the combination of these factors resulted in an increase in inflation from about 10% in 1970 to about 33.7 per cent in 1975, indicating the effect of the 1974 oil crisis, which brought a large amount of petrodollar to Nigeria, resulting in an increase in domestic money supply through the Udoji Salary Awards and a construction boom in the face of insufficient commodity supply due to an unprecedented rise in aggregate demand. Inflation, on the other hand, fell to 22 per cent in 1978 and peaked at 72.8 per cent in 1994. Despite a significant decline over the last decade, the CBN's single-digit inflation target has remained elusive. For example, inflation rates in 2000, 2002, 2010, and 2011 were 15.4, 12.2, 12.1, and 10.3 per cent, respectively (Zubair, A., et al, 2013), rising to 16 per cent in 2017 and dropping to 11 per cent in 2019. By 2020, the inflation rate was around 17 per cent.

Overvaluation of the naira and large influx of oil revenues during the pre-adjustment period resulted in the crowding out of investable resources from real tradable sectors to non-tradable service sectors, resulting in a "Dutch disease" in Nigeria. According to Pinto, (1987) overvaluing the Naira relative to price changes will result in factors of production budging away from the resource-based sector (the resource-movement effect) which increase the demands of the non-tradable good (spending effect), and favors the appreciation of real exchange rate.

Throughout the period of this study, the movement of inflation in Nigeria has been erratic. The trends in inflation are, arguably, a reflection of multiple factors. For example, during the initial period of the study, the economy was monetized as a result of an influx of crude oil revenues during

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three successive global oil shocks led to an increase in the supply of money in the economy. This results in crowding out of investments from tradable to non-tradable sectors, as well as the migration of labour from rural agrarian sectors to urban service sectors, drawing out resources from the tradable sector to the non-tradable sector, causing the non-tradable output to rise while tradable output to fall. The resulting decline in the tradable sector is known as "All of this created an excess demand for tradable goods, but the supply of goods from the weak manufacturing sector could not adjust to meet the excess demand, resulting in a sharp rise in prices. Furthermore, since the late 1980s, the domestic productive capacity of Nigerian refineries has declined significantly; by 2019, nearly 90 per cent of the domestic consumption of petroleum in Nigeria was imported.

The depreciation of the naira during and after the Structural Adjustment period raises the prices of mostly imported intermediate and final goods (exchange rates pass through domestic prices); arguably, in addition to oil prices, nominal exchange rate depreciations are likely to be an additional factor that accelerates inflation in Nigeria. From the above analysis, it is clear that oil prices, exchange rates, and inflation are important factors for domestic economies, especially for Nigeria. The volatility of oil prices and exchange rate fuelled domestic prices and made Nigeria's economy both fiscally and externally vulnerable, apart from the influx of petrodollar to Nigeria during the oil price increase, the performance of Nigeria's terms of trade has also become synonymous with the movements of international oil prices; in most cases except during and years immediately follows oil price shocks, the country has recorded balance of payment deficits.

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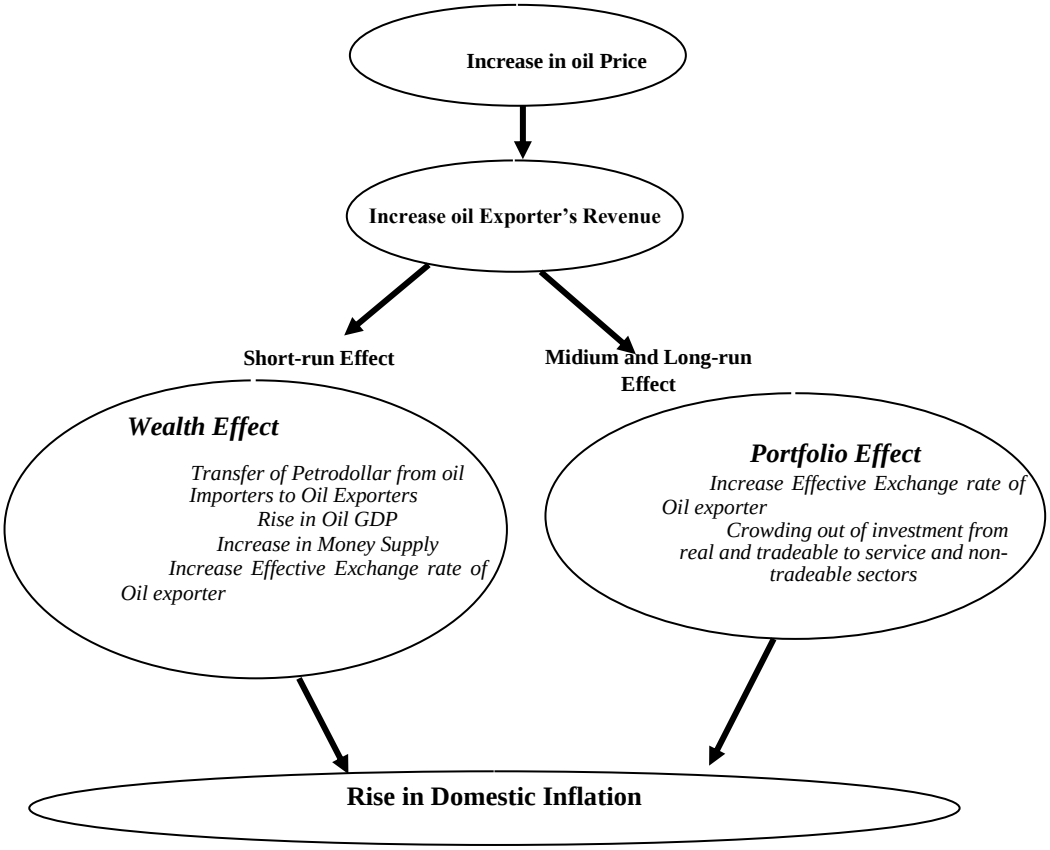

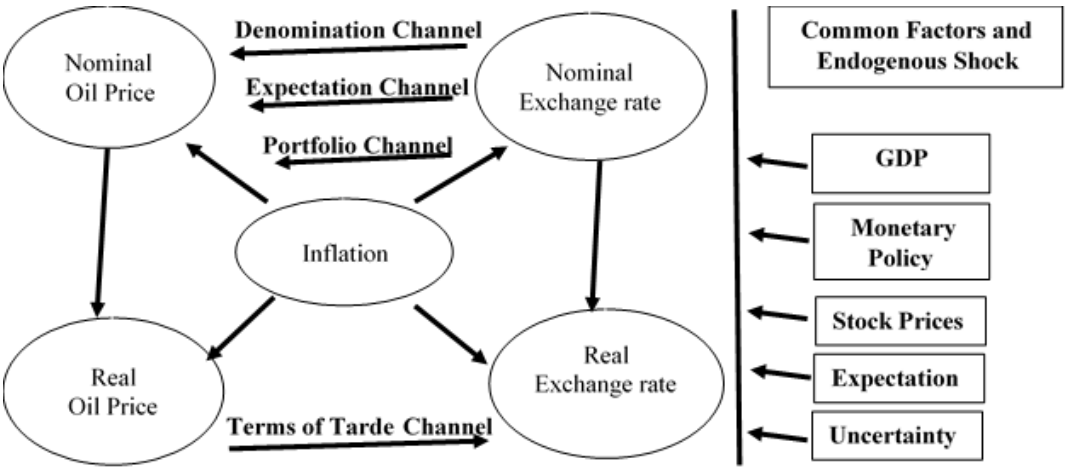

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Figure 3 a & b. Frameworks for Examining the Effects of Rising Oil Prices on Nigerian Exchange Rates and Inflation

A considerable number of literature backs the theoretical prediction of supply-side shock models that growing oil prices lead to rising domestic inflation and lower output. According to Kilian, (2014), the two transmissions mechanism through which crude oil prices impact economic activities such as exchange rate regimes and domestic inflation in both oil-consuming and producing countries are the supply and demand channel. Interestingly, Nigeria has been one of Africa's major crude oil exporters for nearly three decades, importing approximately 70% of its domestic requirements for refined petroleum products. In essence, the analysis of the effects of oil price shocks on the Nigerian economy must be done with caution.

Review of the Empirical Literature

More than a few studies have attempted to analyze the effect of oil prices on fluctuations in the exchange rate and inflation in both oil-producing and oil-consuming countries (see Joscha, et al., 2020; Ahmad, et al., 2020; Alley, 2018; Wena, et al., 2020; Shangle & Solaymani, 2020). The dynamic connection between the fluctuations in the prices of goods and the variability in the exchange rate in an open economy has piqued the curiosity of researchers and policymakers alike. The theoretical linkages between the prices of crude oil and the exchange rates are the terms of the trade conduit introduced by Amano and van Norden (1998a,b) and (Bénassy-Quéré et al., 2007) is intended to link oil prices with exchange rates. First, disposable income is positively influenced by an increase in commodity prices, resulting in a rise in the demand for tradable and non-tradable commodities and raising the exchange rate; it will also lead to rising demand for imports. Second, the surplus in Balance-of-payment and accrued foreign reserve tends to be positively influenced by an increase in commodity prices. Mandoza (1995, and Chen, (2004). observed that terms-of-trade shocks account for about 45% to 65% of the observed change in GDP and exchange rates in developing countries. Also, Chen and Rogoff, (2002) also state that shows that a rise in the global price of a country's commodity exports will put forth upward pressure on its real exchange rate via its impact on wages and demand for non-traded goods. In the words of Armano and Norden (1998, 2010), government expenditure rises due to a rise in petro-dollar revenue, money supply increases, and demand for real money balance also increases leading to an increase in income distribution. However, inflation prevails only when the quantity of money supplied is larger than the quantity of money demanded. Also, Armano and Norden (1998) discovered a long-run relationship between exchange rate and oil prices and a Uni-directional causality running from crude oil prices to

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exchange rate. After examining the exchange rate and oil prices nexus in Nigeria, Osuji (2015) found oil prices affecting the exchange rate significantly, and evidence of Uni-directional causality running from crude oil prices to the exchange rate, and to foreign reserve. And that implies that the exchange rate appreciates, and foreign reserve boost after a unit increase in oil prices. In Nigeria, movements in real oil prices and real and effective exchange rates have a positive linkage; in which a unit increase in crude oil prices has a positive and significant impact on the real and effective exchange rate in Nigeria (Olomola & Adejumo). Moreover, after employing the threshold and momentum threshold model in studying the connection and asymmetric adjustment between real oil prices and a bilateral real exchange rate in 12 countries; Ahmad and Ricardo (2013) found the variables cointegrated in 6 of the countries, while 4 countries proved cointegration as well as asymmetric adjustment.

The impact of the nominal oil price on inflation

When the crude oil price increases in the international oil market, retail oil marketers will swiftly raise the pump price in order to uphold their habitual profit margin and avoid losses. Because refined oil is assumed to be one of the factors of production for industrial products. Therefore, an increase in oil prices will lead to an increase in the cost of production and quite a number of products will rise, hiking the producer and consumer prices (PPI and CPI, respectively). Energy (oil), along with labor and capital, is considered a key input into the production process that transforms factors of production into goods and services (Nordhaus, 1980). As a result, a unit increase in the cost of energy will pass through to production costs, to domestic prices of finished goods. The effects of crude oil price shocks can be replicated to some magnitude by the reactions of raw material procurement costs and product ex-factory prices to variations in oil prices (Huiming, & Xiuyun, 2019). Furthermore, theories assert that if all things are equal, higher or lower crude oil prices will result in a higher or lower cost of operation in many industrial enterprises, and the rise in production costs will be passed on to finished goods prices. Exorbitant prices of oil in the global market translate to increases in production costs, leading to a shortage in the aggregate supply of goods and services, resulting in inflation a and fall in production.

Furthermore, rising oil prices, whether sudden or expected, will increase oil-based revenues for oil-producing economies, which will consequently, increase the money supply, which increases government expenditure due to an increase in petro-dollar revenue, which will lead to an increase in money supply and real income in the system, then translate to inflation (Pinto, 1987). (2016). Similarly, Choi et al. (2018) state that Nigeria is supposed to have the lesser impact of fluctuations in the world oil prices on

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domestic inflation because of the huge energy subsidy it used to give. Researchers discovered oil price dynamics to be the reason for economic slumps and inflation in many countries over the last few decades (Lu, Carib, & Hamonic). As a result, a unit increase in the prices of crude oil will pass through to the cost of production and transportation of raw materials and finished goods, and this will invariably be passed onto prices of finished goods, particularly when demand for such products is inelastic (Humming, & Chen, 2019).

All things being equal, increases or decreases in the prices of crude oil will result in rising or fall in the cost of operation in most industries. The increase in production costs will be passed on to finished goods prices. Hikes in the cost of production are related to increases in the prices of crude oil in the international oil market, which reduces aggregate supply, and results in inflation and falling output (Nusair, 2019). In line with theoretical postulations, Sirag (2018) used the NARDL approach to detect asymmetries in the correlation between oil prices and inflation. The findings showed a significant nonlinear impact of oil prices on inflation, but the negative oil price showed no significant effect on inflation. The NARDL model was used by Davari and Kamalian, (2018); Nusair, (2019); Bala and Chin, (2018); Renou-Maissant, (2019); Shitile and Usman, (2020); Agboola et al., (2020) to examine the relationship between crude oil price shocks and inflation rate. The results revealed an asymmetric effect of crude oil price shock on inflation, and the effect of rising crude oil prices is larger than the effect of falling crude oil prices on inflation. Wang et al., 2019 used the New Keynesian DSGE model on the Chinese economy, consisting of oil demand to examine the impact of crude oil price shocks on the business cycle in China. The model revealed oil prices have a significant influence on income and investments in China. Chen, (2020) used the TVP-SVAR-SV model to disintegrate the shocks of crude oil price fluctuations into four parts, and the result showed that the pass-through effects of the four fluctuations of oil price shocks on inflation in China at each stage are time-varying, with significant variations at different time horizons.

4. Empirical Methodology and Data

Where the *inf* is inflation (proxied by a consumer price index), *oil* is the bonny light oil price, while *exr*, stance for the nominal exchange rate (N/US$). The *exr* is included becuse, it is dynamic has a significant connection with macroeconomic variables (Udeaja and Isah, 2019; Ha, Stocker and Yilmazkuday, 2019); and Nigeria is an inflation targeting and open economy adopting the flexible exchange rate regime. Furthermore, the study included *r* as for interest rate because, high-interest rates induce inflation, as such equation (1) is re-specified in equation (2)

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$$inf = f(oil, exr, r) \tag{2}$$

First, we look at the linear ARDL model because, before specifying the NARDL model, it is ideal to specify the linear ARDL model. After the bounds testing process (Pesaran & Shin, 1998; Pesaran *et al*., 2001), the linear ARDL specification of the linear ARDL models can be pictured as follows and note that all variables are in log forms (*L*):

$$\Delta LINF_t = \mu + \alpha_1 LINf_t + \alpha_2 LEXR_{t-1} + \alpha_3 LR_t + \alpha_4 LOIL_{t-1} + \sum_{t=1}^{p-1} \gamma_1 \Delta LINf_{t-1} + \sum_{t=1}^{q-1} \gamma_2 \Delta LEXR_{t-1} + \sum_{t=1}^{q-1} \gamma_3 \Delta LR + \sum_{t=1}^{p-1} \gamma_4 \Delta LOIL_{t-1} + \epsilon_1 \tag{3}$$

In which; α_1, α_2, α_3, and α_4 represent long-run equations while, γ_1, γ_2, γ_3, and γ_4 are the short-run equations of Δ*LINF*, Δ*LEXR*, Δ*LR* and Δ*LOIL*, respectively, for inflation, exchange rate, interest rate and oil prices. μ represents the constant term, *p* and *q* are lag orders of the dependent and 0…d independent variables. The long-run cointegration in the ARDL model is selected using the optimal lag length which is based on *Akaike, Schwartz or Hannan Quin criteria.* The null hypothesis (H_0) of no levels relationship is defined as H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$. Therefore, equation (3) can be re-specified in order to capture the error correction mechanism in equation (4).

$$\Delta LINF_t = \delta + \mu\lambda_{t-1} + \sum_{t=1}^{p-1} \gamma_1 \Delta LINF_{t-1} + \sum_{t=1}^{q-1} \gamma_2 \Delta LEXR_{t-1} + \sum_{t=1}^{q-1} \gamma_3 \Delta LIR_{t-1} + \sum_{t=1}^{q-1} \gamma_4 \Delta LOIL_{t-1} + \epsilon_1 \tag{4}$$

Where δ stance as the constant term, μ is the linear parameter of speed of adjustment and λ_{t-1} is the error correction model. However, equations (3) and (4) represent the symmetry ARDL. Before carrying on with the NARDL specification, it is fitting to introduce a nonlinear long-run cointegrating equation which is presented in equation (5) and the partial positive and

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negative sum decomposition for rising and falling effects within the variables are presented in equations (6) and (7).

$$y_t = \beta^+ X_t^+ + \beta^- X_T^- + \mu_1 \tag{5}$$

For the positive partial sum

$$X_t^+ = \sum_{t=1}^{t} \Delta x_t^+ = \sum_{t=1}^{t} \Delta x_t^+ \, max(\Delta x_{t,} 0) \tag{6}$$

And for negative partial sum

$$X_t^- = \sum_{t=1}^{t} \Delta x_t^- = \sum_{t=1}^{t} \Delta x_t^- \, min(\Delta x_{t,} 0) \tag{7}$$

The nonlinear ARDL can be re-specified to capture asymmetries (NARDL) as indicated in the following equations.

$$\begin{aligned} \Delta LINF_t = {} & \mu + \partial LINF_{t-1} + \varphi_1^+ LEXR_{t-1}^+ + \varphi_1^- LEXR_{t-1}^- + \varphi_1^+ LOIL_{t-1}^+ \\ & + \varphi_1^- LOIL_{t-1}^- + \varphi_3^+ + \varphi_3^- LR_{t-1}^- + \sum_{t=1}^{p-1} \gamma_1 \, LINF_{t-1} \\ & + \sum_{t=1}^{q-1} \delta_t^+ \, \Delta LOIL_t^+ + \sum_{t=1}^{q-1} \delta_t^- \, \Delta LOIL_t^- + \sum_{t=1}^{q-1} \partial_t^+ \, \Delta LEXR_t^+ \\ & + \sum_{t=1}^{q-1} \partial_t^- \, \Delta LEXR_t^- + \sum_{t=1}^{q-1} \varphi_t^+ \, \Delta LR_t^+ + \sum_{t=1}^{q-1} \varphi_t^- \, \Delta LR_t^- \\ & + \epsilon_1 \end{aligned} \tag{8}$$

Note in equation (8), only the independent variables are structured into X_t^+ and X_t^- but the dependent variable is in a single form. However, equation (8) will be re-specified to introduce the error correction model in equation (9).

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$$\Delta LINF_t = \mu + \partial\eta_{t-1} + \sum_{t=1}^{p-1} \gamma_1 \, LINF_{t-1} + \sum_{t=1}^{q-1} \delta_t^+ \, \Delta LOIL_t^+ + \sum_{t=1}^{q-1} \delta_t^- \, \Delta LOIL_t^- + \sum_{t=1}^{q-1} \partial_t^+ \, \Delta LEXR_t^+ + \sum_{t=1}^{q-1} \partial_t^- \, \Delta LEXR_t^- + \sum_{t=1}^{q-1} \varphi_t^+ \, \Delta LR_t^+ + \sum_{t=1}^{q-1} \varphi_t^- \, \Delta LR_t^- + \epsilon_1 \quad (9)$$

In which μ stance for the constant term, while η_{t-1} is the asymmetry error correction model and ∂ is the coefficient of the speed of adjustment. The pretesting of the long-run cointegration is similar to that of linear ARDL using the F-distributed bound test. Though, the NARDL test of asymmetries (to find out whether the independent variables have a nonlinear relationship with the dependent variable in both the long and the short run) is carried out using F_{pss} of Pesaran, et, al. (2001) which conduct the hypothesis of no-co-integration (H_0: $p = \pi^+ = \pi^{--} = 0$). The t_{BDM} test is used to for asymmetries in long-run and short-run terms which is conducted by testing the null hypothesis of no long-run asymmetries ($\delta^+ = \delta^{--}$, *where* $\delta^+ = -\pi^+/p$, *and* $\delta^- = -\pi^-/p$); and the null hypothesis for short-run asymmetries ($\sum_{J=1}^{n_1} \delta_t^+ = \sum_{J=1}^{n_1} \delta_t^-$).

The previous dissimilarity between positive and negative changes is essential for at least two reasons. First, the impact on inflation is not necessarily of the same amount as positive and negative changes. Second, oil price increases and decreases are not understood in the same way by monetary authorities.

Empirical Data

The variables used in arriving at the analysis of the oil pass-through are: (i) Consumer Price Index (P), (ii) the Bonny light Oil price, and (iii) the nominal and effective exchange rate defined as naira per unit of US dollar. The data are sourced from the International Monetary Fund (IMF) *International Financial Statistics (IFS), 2021*edition.

Descriptive Statistics for the Oil price, Exchange rates and inflation

A	B	C

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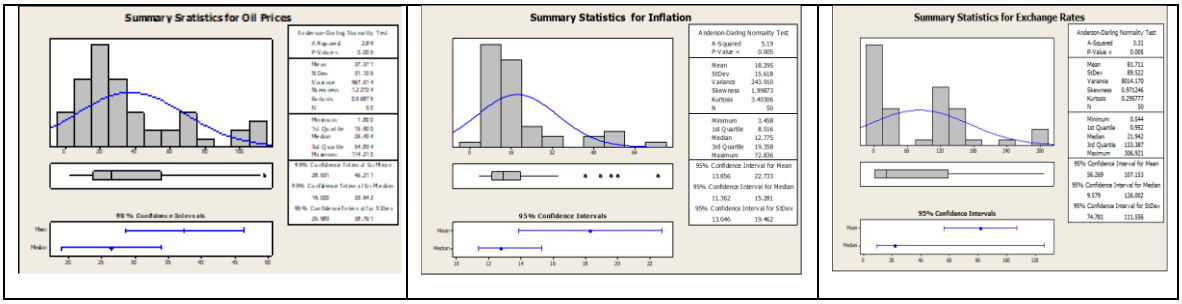

Figure 4.
Source: Authors' computation

Figure (a, b & c) showed the synopsis of statistics for the data utilized in the study. All the variables (OIL, EXR and INF) have high small mean values, implying a quite robust distribution. Also, the corresponding standard deviations for all the variables, except EXR, are quite small, indicating that the analysed values of the variables are quite close to their true values. Besides, the skewness of the distribution for all the variables is inside the acceptable limit of -3 to +3. Again, the skewness measures shows that all the variables are positively skewed (to the right). This insinuates that the datasets utilized in this study are asymptotically normally distributed as suggested by the normality curve in the respective figures.

5. Results and Discussion

A preliminary analysis which is the test of unit root conveys if the dataset in question has stationarity. Stationarity has three different stages which are: I(0), which is stationary at levels; I(1), stationary at the first difference; and I(2) stationary at the second difference, respectively. In all cases, dataset which is stationary at the second difference is to be disregarded because using it may cause spurious regression analysis. The Philips and Peron (PP) stationary check was employed as it modifies the non-parametric test equation. And it also modifies an unspecified heteroskedasticity and autocorrelation. The unit root result is presented in table 1, where the null hypothesis, H_0 states that the series has unit root against the alternative hypothesis that the series has no unit root. However, all the variables are stationary after the first difference test I(1), except for inflation which is also the regressand in the model is stationary at levels I(0). The NARDL model condition before employing it is that there must be no presence of second difference I(2) therefore, employing the NARDL model is warranted.

Table 1. PP unit root test

Variables	Levels	First difference	Order
Exchange rate	1.142231	-4.63371	I(1)
Oil price	-1.57992	-5.93626	I(1)
Inflation	-3.20423	--	I(0)

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Interest Rate	-2.27498	-7.4136	I(1)

Source: extracted from eviews10. Note: the unit root test is conducted using intercept only and at a 5% critical value. further, the optimal lag is based on the Akaike Information Criterion

Table 2. Bound test for Non-linear co-integration

Critical values	Upper bound	Lower bound	F-statistics
10%	3.23	2.12	6.261389
5%	3.61	2.45	
2.5%	3.99	2.75	

Source: extracted from eviews10. Note: the H_0 suggests no level relationship/cointegration. When the f-statistics is greater than the upper-bound at 5%, then reject the H_0 and conclude that there is a levels relationship/cointegration but, once the f-statistics is less than the lower-bound at 5%, then accept H_0 and conclude that there are no levels relationship/cointegration in the model.

Table 2 is for the result of the F-bound test of levels relationship or cointegration. From the result of the bound test, the f-statistics is larger than the upper-bound at 10, 5, and 2.5 per cent critical values which means that long-run relationship exist in the model in which the short-run model and the error correction mechanism can be estimated.

Table 3. Long-run model

Variable	**Coefficient**	**t-Statistic**	**Prob.**
LOIL_POS	-2.42	-3.9677	0.0005
LOIL_NEG	-2.1564	-4.1709	0.0003
LR_POS	0.84246	2.49387	0.0196
LR_NEG	0.85212	1.28046	0.2121
LEXR_POS	-0.2887	-1.5618	0.1309
LEXR_NEG	-16.656	-3.6396	0.0012

Source: extracted from eviews10

Table 3 is the long-run estimate and the result shows that positive and negative oil prices have negative effects on inflation in Nigeria over the period of the study. The result indicated that inflation slowdown by about 2.42 per cent for every rising oil shock, but upswing by about 2.16 per cent, for every falling oil shock in Nigeria. Although the coefficient of positive oil price (*LOIL_POS*) does not conform to the apriori expectation, however, it is theoretically underpinning. When oil price rises, the demand for oil falls only by a lesser amount. This is due to the inelastic nature of demand for oil. This means that revenue from oil is likely to increase with increase in oil prices. An increase in oil revenue is expected to increase government expenditure and aggregate demand. When aggregate demand rises at full employment (where aggregate supply cannot change significantly), there will be upward pressure on the general price level which eventually transmits to inflation in the economy.

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However, falling oil price upswings inflation by about 2.16 per cent. When price of oil falls, given inelastic demand for oil, the demand of oil will increase by sizeable amount. This means that being an oil-dependent country, falling oil price in Nigeria is likely to cut back revenue from oil. This reduces fiscal petro-dollar revenue to the government, and that will lead to the shrinking of influx cashflow to the foreign reserve account, which could lead to depreciation of foreign exchange, to high cost of importation, and acccelerates cost of production, and further exert an absolute pressure on prices of goods and services in the economy. Hence, falling oil price has the tendency to fume inflation. However, what could be inferred from the estimated coefficients of oil price is that the effect of rising oil prices (2.45%) on inflation is larger than the effect of falling oil prices (2.16%) on inflation in Nigeria over the study period. This finding agrees with Bala and Chin, (2018), Renou-Maissant, (2019), and Shitile and Usman, (2020) in their separate studies.

The result also shows that rising interest rate increases inflation by 0.84 per cent while falling interest rate decreases inflation by 0.85 per cent but insignificant. This implies that the effect of negative interest rate on inflation is higher than its positive effect on inflation, though, by a smaller amount of about 0.01 per cent. Both the effect of rising and falling interest rate on inflation does not conform to apriori expectation. This is because, one of the way the monetary authority in Nigeria reduces inflation is by increasing official policy rate or reducing it. Even though, an increase in policy rate leads to instantaneous increase in bank lending rate which then transmits to interest rate (the cost of borrowing for investment). With rising cost of borrowing, investors are discouraged from undertaking loans for investment. This reduces the amount of liquidity in the economy and brings downward pressure on inflation. But this findimg proves that increasing the interest rate during rising prices of goods and services by monetary authorities will fuel inflation. A classical example is the year 2022 where inflation rose on monthly basis throughout, while on the other hand, the monetary authority keep on raising interest rates. In first half of the year, inflation was around 18.2 per cent but after december inflation rose to 21.34 per cent. Meanwhlie, the Central bank raised the interest rate from 13 per cent in July, to 14.5 per cent September, to 16.5 per cent in December (NBS, 2022). This agrees with Alfa (2019) in his study on long-run impact of interest rate, exchange rate and inflation on private sector investment in Nigeria.

However, appreciation of exchange rates decreases inflation, while depreciation of exchange rate inreases inflation, though the effect of appreciation of exchange rate on inflation is insignificant. The result shows that inflation falls by about 0.29 per cent when exchange rate is appreciated by one per cent but rises by about 16.7 per cent when exchange rate is

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depreciated. This logically implies that depreciation of exchange rate has much and significant effect on inflation than the appreciation of exchange rate in Nigeria over the period of this study. This finding does not confrom to the theoretical postulate that when domestic currency is devalued, exports from the domestic economy becomes cheaper while imports become dearer. This equally implies that the demand for export will increase and revenue from exports will also increase. If the proceeds from exports are judiciously used to enhance the productive capacity of the economy, the multiplier effect on general price level is likely to create a downward pressure on inflation in the economy. However, the success of this exchange rate policy trust depend largely on the elasticity of demand for import and for export. Where import is highly elastic but export highly inelastic, as is the case in Nigeria, such exchange rate policy is likely to fail.

Table 4. Short-run model

Variable	Coefficient	t-Statistic	Prob.
C	1.921335	6.39735	0.0000
D(LOIL_NEG)	0.754755	1.580393	0.1266
D(LOIL_NEG(-1))	1.890035	3.296985	0.0029
D(LR_NEG)	-0.20793	-0.29773	0.7684
D(LR_NEG(-1))	-1.35223	-1.93794	0.064
D(LEXR_POS)	0.202268	0.88703	0.3835
D(LEXR_POS(-1))	-0.3235	-1.42617	0.1662
D(LEXR_POS(-2))	-0.49245	-2.07909	0.048
D(LEXR_NEG)	-7.93962	-1.93019	0.065
$ECM_t(-1)$*	-0.914223	-7.37217	0.000

Source: extracted from Evies10

Table 4 is the short run results of NARDL model. The results in table 4 shows that falling oil shock has a negative and significant effect on inflation, while falling interest rate has positive and significant effect on inflation. But for rising exchange rate, the effect on inflation is positive and significant; but falling exchange rate has a significant positive impact on inflation. The error correction mechanism (ECM_t) is statistically significant and negative which means that for every disequilibrium, in the long-run, there is going to be automatic convergence in the model (Dhungel 2014). The study went ahead to estimate the asymmetry relationship in which it found that in the long run, all the variables have a nonlinear relationship with inflation.

Table 5. Asymmetric relationship

Variables	F-statistics	Chi-square	Probability
Oil price	17.19611	17.19611	0.0002
Exchange rate	21.28678	21.28678	0.0001
Interest rate	5.007226	5.007226	0.0252
Serial Correlation	1.406757	10.29318	0.1128

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Heteroskedasticity Test	0.566009	0.586522	0.4438
Ramsey RESET	0.038101	-	0.8465

Source: extracted from Evies10. Note: the hypotheses of the Asymmetry test are that: H_0 states that there is no asymmetry relationship at a 5% critical value. While the diagnostic tests hypotheses are also tested at a 5% critical value.

Moreover, table 5 presents the asymmetric relationship together with the post estimation result. In the case of all the three variables (oil price, exchange rate, & interest rate) the null hypothesis of no-asymmetries is rejected. This implies that there is asymmetric or nonlinear relationship in the study. However, post estimation tests were conducted on the model, whereby the serial correlation with the null hypothesis of no-serial correlation is accepted using the Breauch-Godfrey LM test. The RAMSEY RESET cleared the model from having model misspecification error, while the null hypothesis of homoscedasticity was not rejected using the ARCH test which means, the residuals have equal variation.

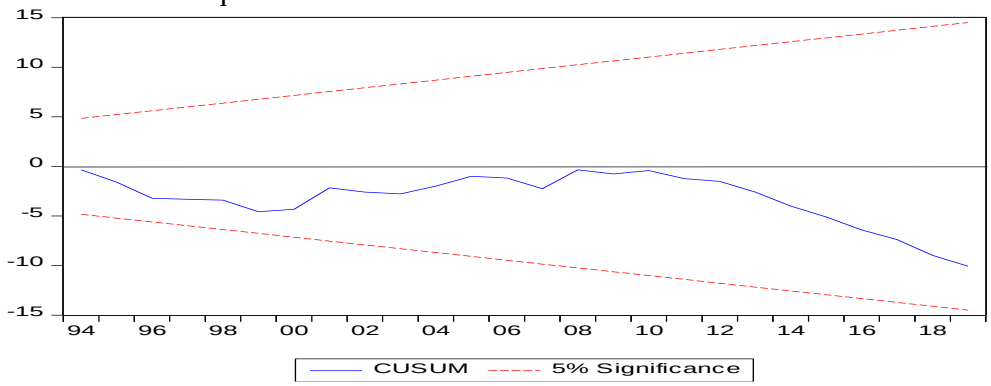

Figure 5. *CUSUM test*
Source: extracted from Evies10

Figure 5 is the CUSUM test (Cumulative Sum) for the structural stability test using Brown et. al, (1975) approach. The figures indicate that the model is stable at a 5% critical value (the two blue lines are critical bound within 5% and the red line is moving within the bound). The asymmetry dynamic multipliers are presented in the figure which shows the adjustment of inflation to long-run equilibrium after a positive or negative oil shock and rising or falling exchange rate. However, the magnitude at which rising oil prices affect inflation is greater than the magnitude at which falling oil prices affect inflation and it takes less than a year to adjust or converge to the long-run multipliers after a positive or negative unitary oil shock. Also, the impact of a depreciating exchange rate is greater than the impact of an appreciating exchange rate on inflation and it takes more than a year for inflation to adjust

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or converge to long-run multipliers after a falling or rising exchange rate regime.

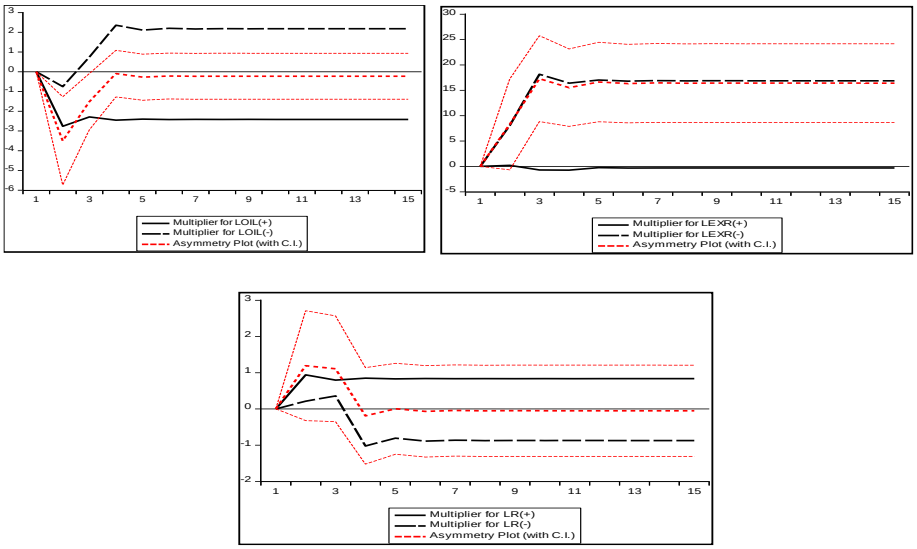

Figure 6. Dynamic Multipliers

Conclusion and policy implications

This study employs the linear autoregressive distributed lag(ARDL) model to examines the asymmetric pass-through effect of oil prices and exchange rate on inflation in Nigeria from 1970 to 2020. Shortrun and long-run asymmetries are introduced in the models via positive and negative partial sum decompositions of the price of oil. The study find positive long-run relationships, implying that positive changes in oil prices has greater effect on inflation than the negative changes in oil prices; and that also implies that, in the long-run, the effect is greater than in the short-run.

Overall, the results suggest that, in the long-run, positive oil price changes have a considerably larger impact on consumer prices and exchange

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rates than negative changes, and that the pass-through effect of oil price on domestic inflation is incomplete. Given our findings in this paper, we may conclude that excess fluctuations in the price of oil will lead to volatile exchange rates and consumer prices and volatile inflation, which may exert challenges on policymakers. In fact, inflation and exchange rates rates in the Nigeria have been volatile over the sample period as indicated in Figure 1

The implication of rising oil price is increase in oil revenue leading to increase in the number of barrels sold thereby translating to economic growth. For the interest rate, the reaction of exchange rates to rising and falling interest rate is indifferent, implying that exchange rates appreciate regardless of whether the interest rate rises or falls.

Also, the long-run result shows that depreciation of exchange rate has much and significant effect on inflation than the appreciation of exchange rate in Nigeria over the period of this study. The implication of this finding is that, in Nigeria where import is highly elastic but export highly inelastic, depreciation of her currency may not be an optimal exchange rate policy trust for the country.

Additional important policy implication of our findings is that Nigeria should take serious steps to reform the various subsidy programs that have been in place for decades now. Reforming subsidy programs can reduce price distortions, which can reduce inefficiencies and production costs.

Another important policy implication of our findings is related to economic diversification. Nigeria economy heavily depend on oil export revenues and therefore, lack economic diversification. Consequently, Nigeria depend heavily on the outside world for the supply of most of goods and services. As importer of refind products, this will transmit into rising domestic cost of production. Thus, when oil prices are rising, import prices will increase and, in order to keep domestic prices stable, nigerian government have been providing subsidy to avoide backlash from public and trade unions at the expense of providing infrasyructure and social services.

The current initiative by the government on total subsidy withdrawal, will reduce budget deficits, encourage investiments into oil industry and rove more revenue for infrastructure and social services.

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