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Disaggregated Inflation and Asymmetric Oil Price Pass-through in Nigeria

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ABSTRACT

The oil price – inflation relationship has continued to significantly feature in the macroeconomic debate, a situation that is guaranteed by nineteen oil market disruptions experienced by the world over the last 40 years (Verleger, 2019). The debate on the dynamic behavior between oil price and domestic inflation is an ongoing process and recent literature indicated that the relationship shows non-linearities, which could have some implication for monetary policymaking. We estimate NARDL models of the link between oil price and inflation decomposed into consumer price index sub-indices of food, core, other energy and transport and find support for long-run asymmetry in relation to oil price shocks as well as incomplete pass-through of oil price to inflation. Our results suggest that it takes within 4-8 quarters for the disaggregated inflation to converge to its long-run equilibrium after a negative or positive unitary oil price shock. Hence, we conclude that there is the need to boost domestic oil refining capacity and fostering of competition in the domestic market as well as unlocking investment in other bio-fuels and other low-cost energy products to reduce energy imports in Nigeria.

Keywords: Oil Price Shocks, Inflation, NARDL Model, Asymmetric Pass Through, Cointegration
JEL Classifications: C12, C22, C32, E31, Q43

1. INTRODUCTION

Oil is generally recognized as "life blood" of the transportation sector and also a vital input to the manufacturing sector. This is one pretext why oil price shocks are commonly related to the real economy: domestic output (Mensah et al., 2019; Zhao et al., 2016) and prices (Abu-Bakar and Masih, 2018; Afees, 2017; Narayan et al.,[1] 2019; Kilian and Xiaoqing, 2019). Yet, confusion remains about the oil price - output nexus and the relationship between oil price and inflation. The transmission of oil price shock movements through the economy is arguably influenced by the nature of the shock, for instance, the effects from endogenous (demand driven) oil price shock are not similar to the exogenous shock (Syed, 2018). While Syed and Syed Zwick (2016) and Abu-Bakar and Masih (2018) argued that inadequate model choice can be accountable for the mixed results, Coibion and Gorodnichenko (2015) found that inflationary expectations drive the inconclusive debate about the link between oil price and consumer prices in the literature.

On the basic question about improving the empirical results on the oil price - inflation nexus in particular, some researchers (e.g., Syed, 2018) argued that looking more at the nature of price shocks can produce a better conclusive result. Incidentally, the use of disaggregated data has been explored in the literature to help reveal important and relevant information about the debate. While Kilian (2009) decomposed oil price data into global crude oil supply shock, global industrial commodities demand shock, and crude oil related global demand shock to examine

1 The views expressed in this paper are solely those of the authors and does not necessarily represent those of the Central Bank of Nigeria.

the changes in oil prices effect on macroeconomic aggregates, other studies have decomposed the macroeconomic variables to analyze the oil price – inflation interaction. For example, Syed (2018); Sek (2017); Khan and Malik (2017); Bala and Chin (2017); Ibrahim and Chancharoenchai (2014); Ibrahim and Said (2012); Bachmeier and Cha (2011) amongst others considered the disaggregated inflation data using the different sub-groups of consumer price index (CPI) inflation such as food and others to determine the direct impact, the transmission mechanism and the second round effects of oil price change on inflation. This study adopts the perspective in the literature that there is need to validate disaggregation while estimating the oil price – inflation link for improved understanding of the spillovers for optimal monetary policy (Bouakez et al., 2008); as the policy objective of managing the oil price pass-through to domestic households can only be attained with a good knowledge of the oil price - inflation nexus.

Therefore, this paper revisits the debate about oil price shock pass-through to inflation by using disaggregated data for Nigeria. In this context the major contribution of this study is to decompose CPI inflation into four different leading sub-groups: food, core, other energy and transport using updated data series from 1996Q2 to 2019Q1. Nigeria is under a monetary targeting regime whose efficacy depends largely on stable money-inflation relationship, and hence the significance to properly understand the likely price stability effects from oil price shocks. Another reason for choosing Nigeria is that beyond having a relatively concentrated petroleum industry (the distribution of market shares among competing firms), the country is one of the largest producers of sweet oil in the Organization of the Petroleum Exporting Countries (OPEC) and has high consumption of petroleum products (Nweze and Edame, 2016; Akinlo, 2012). This makes the economy to remain susceptible to oil price fluctuations. Therefore, to allow for segregation of the effect of increase and decrease in oil prices, the study deployed the Non-linear ARDL (NARDL) approach of Shin et al. (2014) to test whether disaggregated domestic inflation respond asymmetrically to oil prices changes.

The econometric results can be summarized as follows. The long-run asymmetry behavior of oil price and CPI sub-indices holds in Nigeria. And that after a negative or positive unitary oil price shock, the disaggregated inflation adjusts to its long-run equilibrium within 4-8 quarters. In terms of contribution to existing literature, the paper is among the first to look at the dynamic link between oil price and CPI sub-indices in Nigeria, that is, by testing how changes in oil price impacts on disaggregated components of inflation basket using updated series from 1996Q2 to 2019Q1. It also considered Bonny Light crude oil price in the NARDL models in question, unlike the use of international reference oil price in literature.

This article proceeds as follows. Section 2 presents the literature review, while Section 3 the data and describes the methodology. In Section 4 we discuss the main empirical results and check for the robustness of our analysis, while section 5 concludes.

2. LITERATURE REVIEW

2.1. Theoretical Literature

In other to include oil price and the augmented lag values of the explanatory variables, this study is situated on the Çatik and Önder (2011) augmented backward looking short-run Phillip curve equation, which is specified as:

$$i = \alpha(L)i_{t-1} + \mu(L)y_t + \delta(L)\Delta oil_t + \varepsilon_t^s \quad (1)$$

Where i is inflation; y is the output gap; oil is oil price and ε^s is the aggregate supply curve. Also, $\alpha(L)$, $\mu(L)$ $\delta(L)$ are the polynomials in the lag operator (L) of inflation rate, output gap and oil price inflation, respectively (Salisu et al., 2017) The estimated coefficients of all parameters; α, μ, and δ are expected to be positive (Çatik and Önder, 2011), even as the magnitude of the coefficient of δ depends on the structure of the economy and lies between 0 and 1 (Marquez and Pauly, 1984). This implies that the closer the coefficient to 1, the higher the degree of oil price pass-through and vice versa. Further, is the argument that oil pass-through could be asymmetric due to an oligopoly structure (Meyer and Cramon-Taubadel, 2004), policy environment or regulation (Ibrahim, 2015), and cost structures or market power (Karantininis et al., 2011).

2.2. Empirical Review on Oil Price and Consumer Prices

The relationship between oil price and inflation has caught the attention of many researchers who have employed different approaches to examining the linkages between the two variables.

Anwar, Khan, and Khan (2017) studied the impact of oil price increase on persistent increase in price level in Pakistan from a period of 2002:1 to 2011:12. The study employed ordinary least square method and the result shows that there exist a positive and significant impact of oil price on inflation while exchange rate also shows a significant impact; however, it has a negative relationship with inflation. Also, Malik (2016) investigated how oil price affect inflation in Pakistan with data from 1979:1 to 2014:12. The study employed Augmented Phillips curve framework and the study revealed that, continuous increase in oil price have a strong relationship with inflation.

Using different methods, Živkov et al. (2018) investigated the impact of oil price changes on inflation in Central and Eastern European countries with a monthly time–series data from January 1996 to June 2018. The study applied wavelet-based Markov switching approach, and found that exchange rate does not significantly affect inflation in the process of transmission mechanism between oil price and exchange rate unless there is depreciation in the exchange rate. Similarly, Al-Eitana and Al-Zeaudb (2017) investigated the relationship between crude oil prices volatility as well as its impact on inflation in Jordan with data from 2000:1 to 2013:12. The study used Analysis of Variance and the result revealed that crude oil prices account for little impact on inflation in Jordanian economy.

Using granger causality test, Rangasamy (2017) investigated how the movements in the petrol price affects inflation in South

Africa using yearly data from January 1976 to December 2015. The result of the Granger causality test and the Auto-Regressive Distributed Lag Approach (ARDL) revealed that petrol price has significant impact on the level of inflation, and this is not only so, as oil price also granger causes other prices in South Africa. Also, Subhani et al. (2012) investigate the connection among crude oil price and inflation in Pakistan using annual time series-data from 1980 to 2010. The result reveals that, crude oil price granger causes inflation and inflation does not granger causes crude oil price in Pakistan for the period of study.

In the same vein, from a cross country analysis, Castro et al. (2017) examined the oil price pass-through to inflation, with evidence from disaggregated European data which consist of (France, Germany, Italy and Spain) using monthly time-series data from January 1996 to December 2014. Employing Granger causality test, the result shows that inflation responded in different patterns and magnitude with respect to various economies. López-Villavicencio and Pourroy (2019) evaluated the pass-through of oil price changes to consumer prices for a large sample of countries; comparing countries with and without inflation targeting (IT) from 1970 to 2017. They employed State-space models and the results suggest that countries with IT policies have a higher oil price – inflation pass-through than countries without IT policies.

Applying vector error correction model (VECM) and vector auto-regression (VAR), ALsaedi (2015) examined the association between oil prices, inflation, exchange rate and economic activities in Gulf Cooperation Council countries using monthly data from 2010 to 2014. The study employed the VECM and the result shows that oil prices and devaluation have strongly significant positive effect on economic activity. Inflation also has positive effect on economic activity. Also, Sibanda et al. (2015) investigated how crude oil prices as well as exchange rate dictates inflation expectations in South Africa with data 2002:2 to 2013:3. The study employed VECM and the result shows that crude oil prices and exchange rate have significant impact on inflation expectations in South Africa with high rate of adjustment back to equilibrium in the case of any disequilibrium. Conflitti and Luciani (2019) examined oil price pass-through to core inflation in the U.S. and Euro area using yearly time-series data from 1984 to 2016. VAR model was employed and the result shows that the oil price passes through core inflation only via its effect on the whole economy. Bhattacharya and Bhattacharyya (2001) examined how increase in oil prices affect inflation and output in India for the period of 1994:4 to 2000:12. The Granger causality result seems to be bi-directional, while inflation responded positively to 1% shocks in oil prices after the period of 7 months as shown from the impulse response result.

In other sets of cross countries analysis, Bala and Chin (2018) investigated the linear relationship between and impact of oil price on changes in inflation in Algeria, Angola, Libya, and Nigeria for the period 1995 to 2014. They employed the ARDL dynamic panel and the result shows that there is positive and significant relationship between money supply, exchange rate, Gross Domestic Product (GDP) and inflation; while food production shows a negative and significant impact on inflation. Salisu et al. (2017) investigated the impact of non-linear relationship between oil price and inflation in oil exporting and importing countries with quarterly data for the period of 2000 to 2014. The study employed dynamic heterogenous panel data models and the result shows that there is a significant relationship between the variables in the long run, while the short run result produces a mixed result. However, it is shown that, oil price brings to bear a larger impact on inflation of net oil importing countries than their oil exporting equivalents.

Similarly, Choi et al. (2018) analyzed how instabilities in the international oil prices affect national inflation by employing an unbalanced panel data covering 72 developed and emerging economies for the period from 1970 to 2015. The result shows that there is a positive and significant impact of international oil prices on national inflation for these countries. This impact lingers for 2 years and vanishes afterwards. The impact was similar for both developed and emerging economies. However, this relationship and impact was non-linear with positive impact having a larger effect than the negative impact. Also, Binder (2018) examined the dynamics of consumers' gas price and inflation expectations using data from the Michigan Survey of Consumers (MSC). Employing Panel Analysis, the findings revealed that, consumers on average view gas price and inflation as negatively correlated and they do expect gas price inflation to feed into future core inflation, but this quickly decreases with forecast horizon.

Asghar and Naveed (2015) investigated the long-run pass through of world oil prices to domestic inflation in Pakistan from January 2000 to December 2014 using ARDL bounds testing approach and Granger causality. They found that in the long-run international oil prices and exchange rate significantly affect the inflation rate in Pakistan. Furthermore, oil price (LOILP) has positive relationship with inflation and Nominal Exchange Rate has negative relationship with inflation rate in Pakistan. The findings of the Granger causality test reveal that there is uni-directional causality running from world oil prices to inflation rate, from inflation to exchange rate, and from world oil prices to exchange rate in Pakistan. Also, Husaini et al. (2019) investigated the empirical evidence concerning the relationship between the international oil price and energy subsidy, and price behavior. Using time series data covering the period 1981-2015, the study employed the ARDL approach which revealed that oil price and energy subsidy are significant in influencing the pattern of price behavior. The producer price index (PPI) was more sensitive to changes in the oil price than the CPI. The PPI was found to be affected more while the CPI was less affected.

Hammoudeh and Reboredo (2018) examined the link between oil prices and market-based inflation expectations in the United States. Using linear ARDL model, the study found that the impact of oil price changes on inflation expectations is more intense when oil prices are above a threshold of 67 USD per barrel. Shaari et al. (2018) investigated the effects of retail selling prices of petrol and diesel on inflation in Malaysia using monthly data from 2010 to 2015. The ARDL result shows that there are significant effects of retail selling prices of petrol and diesel on inflation in the long run.

Likewise, using linear and NARDL, Sek (2017) examined the linear and non-linear pass-through impact of oil price variations on four national price directories in Malaysia using Annual data for the years 1980 to 2015. The study employed ARDL and NARDL models and the result shows evidence of linear and non-linear pass-through impact of oil price variations on national prices athwart sectors. Oil price variations have positive effect on the growth in output, which in turn influence increase in commodity prices, while oil price variations have a partial direct impact on consumer prices in the long run. Also, Lacheheb and Sirag (2019) captured the asymmetric association between oil price and inflation in Algeria for the period of 1970–2014 using NARDL. The findings show that there is an asymmetric relationship between oil price and inflation as well as a significant impact.

Bec and De Gaye (2015) empirically investigated the implication of oil price forecast errors on inflation forecast errors for the United States, France and United Kingdom for the period of 2005q1–2013q. The study employed threshold nonlinear model and found that, oil price forecast contributes positively and significantly to the behavior of inflation forecast errors in all the countries. Specifically, the oil price forecast errors have a double impact on the inflation expectation forecast error. Abu-Bakar and Masih (2018) investigated the oil price pass-through to domestic inflation, whether symmetric or asymmetric in India using monthly data from 1994 to 2018. The ARDL and NARDL results revealed that an increase in oil price have a significant impact on the increase in inflation, while decrease in oil price does not have significant impact on inflation within the period of study. However, the ARDL result produced a contradicting result of no long run relationship between oil price and inflation as compared to NARDL result.

Jiranyakul (2018) examined the effect of oil price shocks on the local inflation rate in Thailand using monthly data from January1993 to December 2016. The study employed symmetric and asymmetric cointegration tests with structural breaks and the result depicts that, industrial output and oil price have significant and positive impact on inflation in the country both in the short and long run. Lacheheb and Sirag (2019) examined the association between oil price and inflation in Algeria using annual data from 1970 to 2014. Using NARDL model, the result shows the presence of a non-linear relationship between oil price and inflation in both the long run and the short run. However, the long run impact seems to be greater than the short run impact.

Likewise, Nasir et al. (2018) examined the consequences of oil price blows on the BRICS economies for the period of 1987QII – 2017QII. Employing a Time-Varying Structural Vector Auto-Regressive (TV-SVA) framework, the study reveals that each country responded differently in terms of direction and magnitude to the shocks in crude oil prices, while such relationship is also non-linear in nature between countries exporting and those importing oil.

The above review offers in-depth understanding of the knowledge instituted from on-going debate on how oil price shocks impact inflation. Previous studies have applied diverse choice of modelling approaches but the results have been unsettled. In addition, studies investigating the asymmetric impacts of oil price changes on disaggregated inflation in Nigeria have used panel analysis i.e., Nigeria and other countries with the analysis based on data series for the period ending 2014. Therefore, this study expects to fill the gap in the literature by considering a single country case study on Nigeria.

3. DATA AND METHODOLOGY

3.1. Data

This study applied time series data comprising the Bonny Light oil price, the food CPI, the other energy CPI, the transport CPI, the Core inflation CPI, the output gap and the exchange rate. Unlike previous studies that considered global crude oil prices, such as OPEC reference oil price, Brent oil price, WTI oil price, and Dubai oil price amongst others, as a proxy for the oil price, this study used Nigeria's Bonny Light crude oil price. This study employed quarterly data from the period 1996Q2–2019Q1. The data were chosen based on their availability. The data on oil price is sourced from the Central Bank of Nigeria (CBN) Statistical database while GDP and the disaggregated CPIs are collected from National Bureau of Statistics.

3.2. Research Methodology

The derived theoretical framework for the oil price and the disaggregated inflation nexus is written in Equation (1) as:

$$dsg\_cpi = \mathrm{f}\,(y, op) \tag{1}$$

Where *dsp_cpi* is the disaggregated CPI including food, core, other energy, and transport inflation; y is the output gap[2], and op is the spot price of Bonny Light oil. In addition, this study considered er in the inflation, oil price pass-through model because Nigeria is a small open economy operating under a flexible exchange rate regime, as such, exchange rate dynamics has a significant influence on the macroeconomic variables (see Udeaja and Isah, 2019; Ha, Stocker and Yilmazkuday, 2019; Adelajda, 2019; Marodin and Portugal, 2019). Consequently, Equation (1) is extended to Equation (2) as follows:

$$dsg\_cpi = \mathrm{f}\,(y, op, er) \tag{2}$$

As previously stated, this study applied the NARDL approach of Shin et al. (2014) to model the relationship. The merit of NARDL approach as offered by Van Hoang et al. (2016) applies in this study. And for the purpose of distinct pathway analysis, the study considers five regressions for each of the disaggregated CPIs separately.

The symmetric ARDL model specification follows the standard framework of Pesaran et al. (2001) as given below in Equation (3):

$$\Delta dsg\_cpi = \beta_0 + \beta_1 dsg\_cpi_{t-1} + \beta_2 y_{t-1} + \beta_3 op_{t-1} + \beta_4 er_{t-1} + \sum_{i-1}^{N1} \delta_i \Delta dsg\_cpi_{t-i} + \sum_{j=0}^{N2} \alpha_j \Delta y_{t-j} + \sum_{h=0}^{N3} \lambda_h op_{t-h} + \sum_{k=0}^{N4} \varphi_k er_{t-k} + \varepsilon_t \tag{3}$$

Where β_0, β_1, β_2, β_3, and β_4 are the long run parameters for the intercept and slope coefficients to be estimated in Equation (3). In

2 The output Gap is calculated using the HP filter which penalises variation and trend. $Min^*_t \sum_{t=0}^{\infty}(y_t - y^*_t) + \lambda \sum_{t=2}^{\infty}(y^*_{t+1} - y^*_t) - \sum_{t=0}^{\infty}(y^*_t - y^*_{t-1})^2$.

the long run, it is assumed that $\Delta dsg\_CPI_{t-I}=\Delta y_{t-j}=\Delta op_{t-h}=\Delta er_{t-k}=0$. In the short run, however, estimates are computed as δ_i, α_j, λ_h and Φ_k for disaggregated inflation, output gap, oil price and real effective exchange rate, respectively.

The preferred ARDL model, based on optimal lag is selection using Akaike Information Criterion, Hannan-Quinn Information Criterion or Schwartz Information Criterion, is used to test for the long run cointegration in the model. The null hypothesis of no cointegration is expressed as H_o: $\beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$ while the alternative of cointegration is denoted as H_I: $\beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$. Further, the Equation (3) is re-specified to introduce an error correction term as follows in Equation (4):

$$\Delta dsg\_cpi = \eta v_{t-1} + \sum_{i-1}^{N1} \delta_i \Delta dsg\_cpi_{t-i} + \sum_{j=0}^{N2} \alpha_j \Delta y_{t-j} + \sum_{h=0}^{N3} \lambda_h op_{t-h} + \sum_{k=0}^{N4} \varphi_k er_{t-k} + \varepsilon_t \quad (4)$$

Where v_{t-1} is the linear error correction term and the parameter η is the speed of adjustment. Equation (3) and (4) represents the scenario under the assumption of symmetric behaviour of oil price on disaggregated CPI, hence, no decompositions of oil price into positive and negative shocks in the model.

For the case of asymmetric behaviour of oil price on disaggregated inflation, the NARDL is given as in Equation (5):

$$\begin{aligned} \Delta dsg\_cpi &= \beta_0 + \beta_1 dsg\_cpi_{t-1} + \beta_2 y_{t-1} + \\ &\beta_3 op^+_{t-1} + \beta_4 op^-_{t-1} + \beta_5 er_{t-1} + \\ &\sum_{i-1}^{N1} \delta_i \Delta dsg\_cpi_{t-i} + \sum_{j=0}^{N2} \alpha_j \Delta y_{t-j} \\ &+ \sum_{h=0}^{N3} \left(\lambda^+_h op^+_{t-h} + \lambda^-_h op^-_{t-h}\right) + \sum_{k=0}^{N4} \varphi_k er_{t-k} + \varepsilon_t \end{aligned} \quad (5)$$

The oil price variable (opt) is decomposed into p^+_{t-1} and p^-_{t-1}in Equation (5), indicating positive and negative changes in oil price, respectively. This can also be viewed hypothetically as in Equation (6) and (7):

$$op^+_{t-1} = \sum_{h=1}^{t} \Delta op^+_h = \sum_{h=1}^{t} \max\left(\Delta op_h, 0\right) \quad (6)$$

$$op^-_{t-1} = \sum_{h-1}^{t} \Delta op^-_h = \sum_{h=1}^{t} \min\left(\Delta op_h, 0\right) \quad (7)$$

Consequently, Equation (5) is re-specified to contain the error correction term as in Equation (8):

$$\begin{aligned} \Delta dsg\_cpi &= \psi \chi_{t-1} + \sum_{i-1}^{N1} \delta_i \Delta dsg\_cpi_{t-i} + \sum_{j=0}^{N2} \alpha_j \Delta y_{t-j} \\ &+ \sum_{h=0}^{N3} \left(\lambda^+_h op^+_{t-h} + \lambda^-_h op^-_{t-h}\right) + \sum_{k=0}^{N4} \varphi_k er_{t-k} + \varepsilon_t \end{aligned} \quad (8)$$

Table 1: Unit root test

Phillips-Perron (1988) test			
Variable	**Levels**	**First DIFF**	**Order**
Headline Inflation	2.9077	−8.0172^A	I (1)
Exchange Rate	−1.6517	−5.4718^A	I (1)
Output Gap	−2.7959	−4.8519^A	I (1)
Oil	−2.3115	−9.6962^A	I (1)
Food CPI	4.1420	−8.1978^A	I (1)
Core CPI	1.4314	−8.0085^A	I (1)
Other Energy CPI	−0.1748	−6.5726^A	I (1)
Transport CPI	1.1037	−9.9095^A	I (1)

Note: A, B and C represent significance at 1%, 5% and 10% respectively. The constant and time trend is included in the levels but trend is excluded from the first difference equations. The optimal lag order is selected based on Schwarz information Criterion

Table 2: Bounds test for non-linear cointegration

Critical values			Lower bound		Upper bound
1%			2.3		3.09
5%			2.68		3.69
10%			3.6		4.78
Model	**Headline inflation**	**Food CPI**	**Core CPI**	**Other energy CPI**	**Transport CPI**
F Statistics	18.42	15.8	10.07	8.66	18.67
Critical values from Narayan (2005)					

Source: Extract from Results

Table 3: Non-Linear ARDL model

Variable	Nonlinear ARDL model				
	With headline inflation	**With food CPI**	**With core CPI**	**With other energy CPI**	**With transport CPI**
Oil-POS	0.3252^A (0.1138)	0.1042^A (0.0353)	0.7571^B (0.3432)	0.5108^A (0.1589)	0.2367 (0.3449)
OIL-NEG	−0.1565 (0.1487)	−1.2344 (1.2794)	−0.4115 (0.4079)	−0.1711 (0.2187)	−0.2669 (0.5237)
Output GAP	2.2198 (1.5869)	6.4199 (9.3654)	5.4378 (4.4040)	2.1842 (2.6356)	1.5160 (5.1461)
Exchange rate	0.9960^A (0.1948)	0.3853^A (0.1002)	1.0492^B (0.4606)	0.5725^A (0.0921)	0.6117^A (0.3282)
C	−57.5212^A (14.4070)	−218.9191 (201.6382)	−48.9219 (30.9342)	−31.4755^A (9.4161)	−10.2089 (26.3642)
ECM(-1)	−0.0690^A (0.0063)	−0.0208^A (0.0020)	−0.0370^A (0.0046)	−0.0957^A (0.0128)	−0.0354^A (0.0032)
Serial correlation	0.3018	0.0849	0.3417	0.3643	0.3925
Functional form	0.1332	0.4444	0.212	0.7955	0.5054
Hetroske dasticity	0.1706	0.3370	0.2059	0.4084	0.1447
CUSUM	Stable	Stable	Stable	Stable	Stable
CUSUMSQ	Stable	Unstable	Stable	Stable	Unstable

Note: () are standard errors and A, B, C represent statistical significance at 1%, 5% and 10% respectively. serial correlation test is carried out using Lagarange Multiplier test for serial correlation of variables, to test for functional form Misspecification, Ramsey rest test is used, Normality is tested using Jaque&bera (1981) test., hetroskedasticity is tested using breusch-pagan test and finally stability of the model is tested using Brown et al. (1975) model for cumulative sum of squares (CUSUM) and cumulative sum of squares square (CUSUMSQ)

The error correction term (χ_{t-1}) in Equation (8) captures the long run equilibrium in the NARDL model, while its related parameter (ψ) conveys the speed of adjustment i.e., how long it takes the system under a shock to adjust to its long run. Similar to the linear ARDL, the pre-testing for cointegration is carried out in the NARDL using the F-distributed Bound test. Also, to establish whether or not the asymmetries are significant in both the short run and long run, the study used the Wald test.

3. RESULTS AND DISCUSSION

At the onset, a preliminary analysis of the data was conducted using a unit root test to check for stationarity. The Phillips and Perron (PP) test was employed, and is appropriate as it makes a non-parametric correction to the test statistic. It is robust to unspecified hetroskedasticty and autocorrelation in the disturbance process of the test equation. The null hypothesis of this test is that there is unit root. In order to proceed to the full NARDL model the null Hypothesis must be rejected and presence of second difference variables must not be established I (2). The Table 1 above shows the results of the test. From the unit root test there is no presence of I(2) variables. Hence, the next stage is to proceed to the cointegration testing amongst the variables.

Table 2 presents the results for the bounds test for cointegration on the disaggregated inflation variables. From the results obtained, it can be established that there exists a long-run relationship amongst the variables in question as the null hypothesis of no-long run

Figure 1: CUSUM control graphs

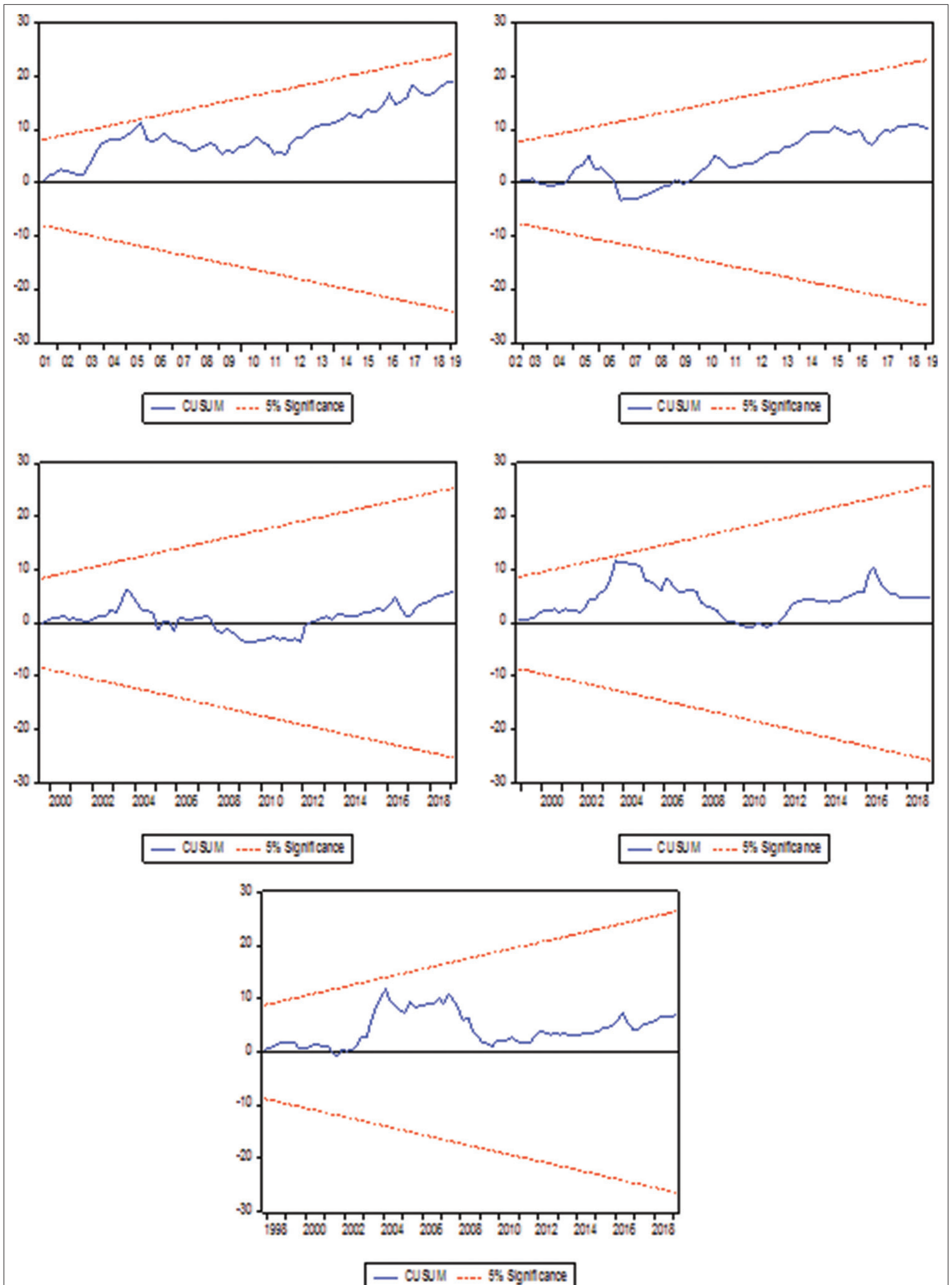
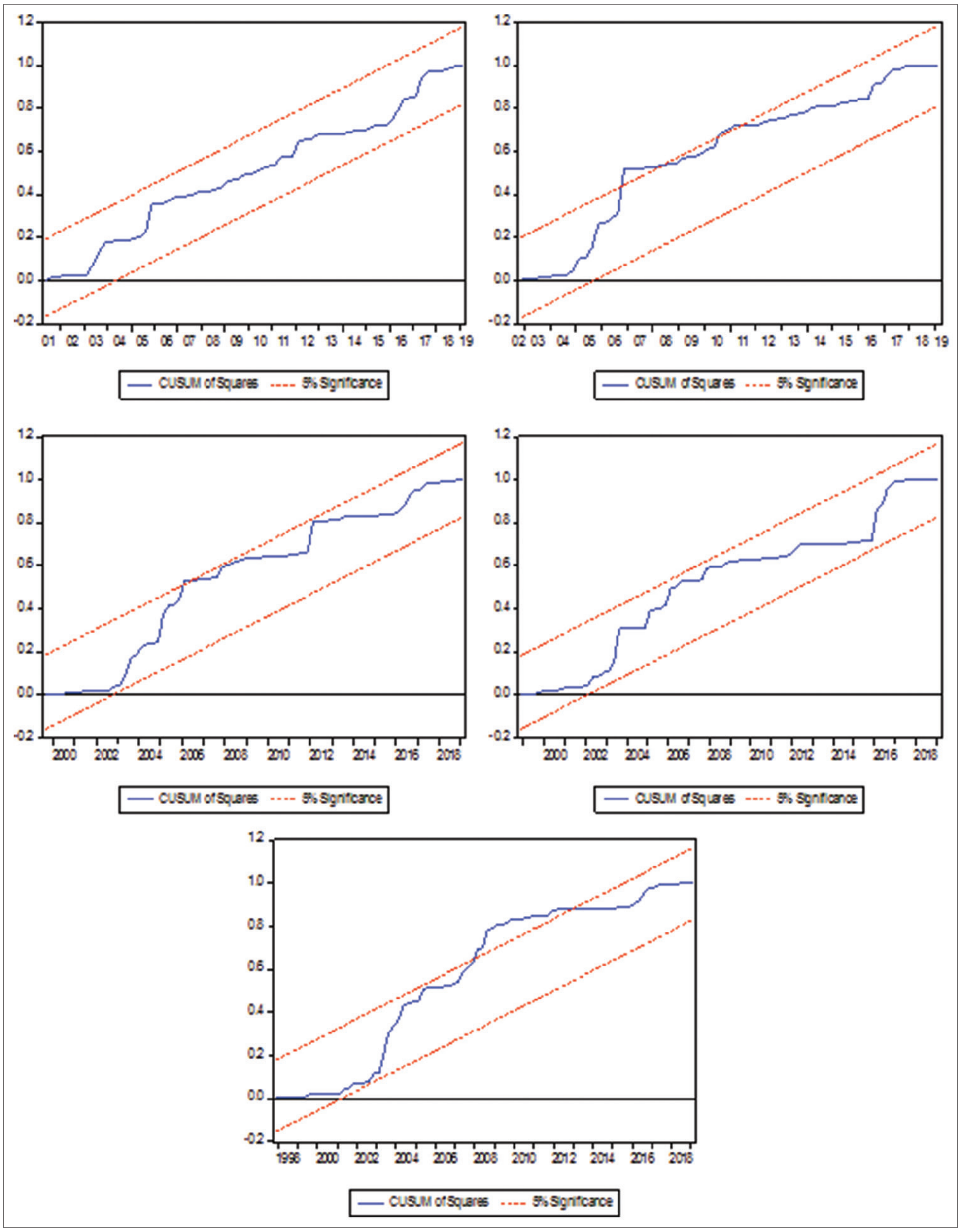


Figure 2: CUSUMSQ control graphs



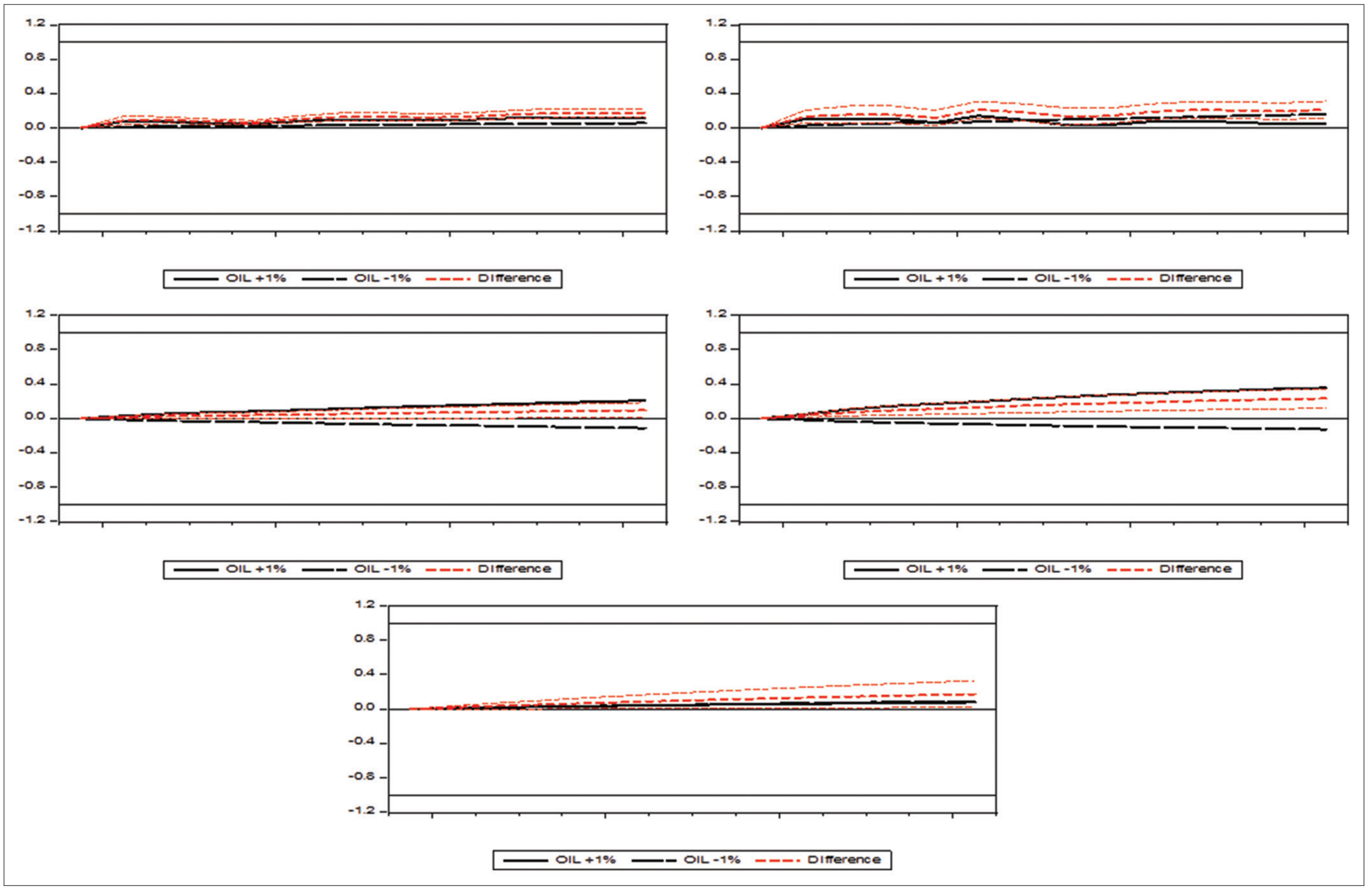
relationship can be rejected for all models at 1% level. Therefore, there exists a long-run relationship between the variables.

The five NARDL models are estimated and the results are shown in Table 3 for the different disaggregated CPIs. The estimated models present the response of inflation dynamics to both positive and negative changes in the price of oil. From the results, oil price is found to have an asymmetric impact on headline, food, core, other energy and transport CPI. A positive oil price change positively affects the disaggregated CPI and is statistically significant for all the CPI sub-indices observed with the exception of transport. A positive oil price shock explains about 76, 51, and 24% changes in core, other energy and transport CPI, respectively. The negative changes in oil price was found to be negative, however, statistically insignificant in the models examined. The results obtained shows that the pass-through of oil price to inflation is incomplete, which is in agreement with the findings of Ibrahim (2015), Cunadoand de Gracia (2005) and Lacheheb and Sirag (2019), and Bala and Chin (2017, 2018). The findings point toward oil price stickiness'[3] in the domestic retail market for PMS (Premium Motor Spirit), AGO (Automotive Gas Oil) and DPK (Dual Purpose Kerosene), driven by marker power and the difficulty of making supply adjustment (Karantininis et al., 2011, Borenstein and Shepard, 2002).

Further, it was found that exchange rate had a positive and statistically significant impact on inflation on all index observed, however, the output gap was positive and statistically insignificant for all the NARDL models in question. The error correction term for the models under discussion is significant at 1%. The error correction mechanisms for the models estimated ranged from 2.1 to 9.6%. The coefficient of the error correction term captures the

3 Market power by Firms (suppliers) does not allow competition and they hold up prices of their products.

Figure 3: Dynamic multipliers graphs



speed of adjustment or disequilibrium correction of the models to a long run steady state equilibrium shock (Dhungel, 2014).

Diagnostics tests were carried out on the NARDL models. The presence of serial correlation was rejected using the Breusch-Godfrey Serial Correlation LM test. The models are also well specified using the Ramsey RESET test, and failed to reject for the presence of homoscedasticity in the data using the Breusch-Pagan-Godfrey Test. In addition, stability checks were carried out using Brown et al. (1975) approach. The cumulative sum (CUSUM) and cumulative sum of square (CUSUMSQ) statistical control, which is based on recursive residuals, are presented in Figures 1 and 2, respectively. From the results of the CUSUM and CUSUMSQ, the coefficients of all models are stable over time within the 5% critical bounds. For the test of asymmetric adjustments post-positive or negative oil price shock, ensuing from the work of Shin et al. (2014), the asymmetric cumulative dynamic multipliers were derived under the five NARDL models in question. The results are presented in Figure 3. From the graphs, it can be inferred that it takes 4-8 quarters to converge to the long-run multipliers (i.e., from an initial long-run equilibrium to a new long-run equilibrium after a negative or positive unitary shock).

4. CONCLUSION

Our empirical analysis on oil price and disaggregated inflation relationship was motivated by the fact that Nigeria is an oil exporting/importing nation in practice whose oil imports as ratio of total import stood at about 27% and the proportion of oil exports to total export was about 93% in 2018 (CBN, 2019). Thus, understanding the empirical interaction between oil – inflation nexus remains critical. Besides, Nigeria is currently under a monetary targeting regime whose efficacy depends largely on stable money-inflation relationship, as such, it is worthwhile to properly know the likely price stability effects from exogenous shocks like oil price changes. This study, therefore, applied a non-linear cointegration approach (NARDL) using quarterly data from 1996Q2 to 2019Q1 to test for asymmetric cointegration relationship among the variables under discussion.

The estimated results confirm the existence of long-run asymmetry behavior of oil price-CPI sub-indices in Nigeria. The results show that an increase in the oil price increases the disaggregated inflation rates in question. A positive oil price shock explains about 76, 51, and 24% fluctuations in core, other energy and transport CPI, respectively. However, negative oil price shock does not seem to significantly feed into the level of inflation. This suggests that the pass-through of oil price to inflation is incomplete, which affirms the findings of Ibrahim (2015), Cunado and de Gracia (2005) and Lacheheb and Sirag (2019), and Bala and Chin (2017, 2018).

Another important finding is that it takes a long time for inflation adjustment after a negative or positive unitary shock, as traversing to long-run equilibrium is achieved within 4-8 quarters. This asymmetry of oil price adjustments conveys valuable information about the propensity of firms (suppliers) to adapt their business strategies, depending on the specific factors affecting the international oil market. Our characterization of the relationship between oil – disaggregated inflation nexus in Nigeria, does not seem to fully tell the whole story. Thus, the development of a robust model, at least with respect to the specification of market power and the difficulty of making supply adjustment, and its estimation, seem the natural next steps to check the conclusions reached above.

In terms of policy, the findings assert the need for all agencies of government to expedite action in ensuring that appropriate policies and institutions are put in place and implemented to boost domestic oil refining capacity and functioning of competition in the domestic market. In addition, mobilize private capital, international and domestic, to unlock investment in other bio-fuels and other low-cost energy products in order to reduce energy imports in Nigeria.

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