How Distortionary are Oil price shocks to Consumer prices? Empirical evidence from Nigeria using dynamic co-integration Models

ABSTRACT

This paper examines the response of consumer prices to the oil price shocks in Nigeria. The current oil price slump and its slowness to rise for giving hope to economic recovery poses a threat to many oil-backed economies, particularly Nigeria. As such, oil price and consumer price index are modelled, based on dynamic error-correction models, with aim to capture asymmetric response of consumer prices to a change in oil price. Quarterly time series data spanned from 2001Q1 to 2016Q4 were obtained and analyzed using dynamic co-integration method which allows for asymmetric adjustments. Our results revealed that three disaggregated consumer prices exhibit some degree of persistence to the long-rung values, however, their responses are faster to a rise than to a fall in oil price. Correspondingly, aggregate price is found to be rigid downward, suggesting high prices of consumer commodities in Nigeria. This serves as a confirmation that low oil price is likely attributed to the high costs of basic consumer commodities in Nigeria, perhaps due to subsidy removal. We thus recommend that a credible price stabilization policies should be designed to curbing price-increased effect that oil price downturn may have on consumer commodities, such target should specifically more on food and beverages, clothing, and energy prices.

Keywords: consumer prices; oil price; stabilization policies; economic recovery

1. INTRODUCTION

The slump in oil price in the past few years and the slowness of this price to rise in giving hope to economic recovery still pose a threat to many oil-dependent developing countries' economies. The price of crude oil slumps to as low as US$20 per barrel in 2016 from about US$100 per barrel in 2014. This raises a serious economic threat to some Organization of Petroleum Exporting Countries (OPEC) oil-reliant developing countries. This has consequently called for a series of summits held by OPEC on how to obtaining an appreciable oil price. More recently, the International Monetary Fund (IMF) report [1] highlighted that the price of crude oil in the international market likely drop to US$15. This may result from the effect of the discord in OPEC summits to cut supply and the intention of some members, Saudi Arabia and Iran in particular, to increase production. As the dwindling oil price is perceived to have little effect on the growth of these countries as their gross domestic product (GDP) is projected to rise despite the general unfavourable oil market condition. This may not be the same for Nigeria, whose annual budget often benchmarked on the oil price.

For Nigeria, the consequence of drastic fall in oil price may add more to the pressure of the nation for the need to borrow for financing its deficit. However, the extent the recent low oil price may affect the consumer prices in Nigeria is an important concern that needs to investigate. This is because a fall in oil price often has a large impact on the Nigerian economy since the country solely relies on oil export for foreign earnings. More so, adverse effect of oil price may much affect low income earners who often comprises majority, as the effect may reduce purchasing power, increase unemployment and exacerbate poverty incidence.

The effect of oil price on micro and macroeconomic variables is widely spread in the literature but many of the studies mostly conducted during oil price soaring periods. Few studies that recently conducted opined that the cushion effects, especially borrowing, would counteract the negative influence of falling oil price. However, such an expectation may not be realistic, because, first, the shortage value from expected oil revenue, resulting from a fall in oil price for oil-dependent economy, and amount to balance the shortage could be known but the lingering effect of the slum of oil price on economy cannot ascertain; second, the process of borrowing for cushion the effect of fall in oil price usually cumbersome and bureaucratic which may slow down the balancing; third, it is lenders that often dictate the condition of borrowing which usually renders the borrower less counteract the negative shock of oil price; and lastly, negative effect of oil price shock quickly reflects on economy than injection. These have yet taken into consideration in the literature despite that oil prices majorly determine aggregate and disaggregate input and output prices, especially consumer prices [2]. Thus, this study primarily intends to explore distortionary effects of oil prices on consumer prices. This gives rise to corresponding hypothesis that changes in oil price has a significant influence on consumer prices. The findings of this study would more relevant for policy design in dealing with unfavorable oil price cycle that may face oil backed-economies, especially developing economies.

Accordingly, apart from the impressive need to examine the issue for Nigeria, this paper extends the literature in four aspects. First, the present paper provides new empirical evidence in relation to the behavior of disaggregated consumer prices to oil price fluctuations which contains a limited number of studies in the literature. Second, we employ threshold method, a widely used method in recent studies to explore the nonlinear behavior of disaggregated consumer price index and oil price shocks. Though we recognize that vector auto regression (VAR) was used by Umar and Abdulhakeem [3] to examine the impact of oil price fluctuation on macroeconomic variables in Nigeria, however, this method has an important limitation. The VAR is a static model, and a static model may not appropriately capture dynamic relationship of which oil price and macroeconomic variables often exhibit as the absolute positive impact of oil price shock on macroeconomic variables may not the same as negative impact. However, this can be accommodated in a dynamic threshold model. Thus using a dynamic threshold specification is more appropriate and this method is used to empirically examine the nonlinear relationship between oil price and consumer prices in Nigeria for the first time in this paper. Third, this paper draws useful policy recommendations from its findings which may benefit oil-reliant developing economies when faced with low oil price. Specifically, the sample used in this study consists of quarterly data span from 2001Q1 through 2016Q4 to enable draw a robust conclusion. Finally, consumer price index is disaggregated in order to capture the in-depth impact of oil price shock on consumer prices.

The remaining part of the paper is divided into five sections, follow this introduction is section 2 which highlights the nature of Nigerian economy dependency on oil; section 3 presents literature review; section 4 describes the data and methodology; section 5 presents empirical results; finally, section 6 offers conclusion and policy recommendations.

2. Nigerian oil-economy and trend of oil price and consumer prices

The 1973 oil price shock was recognized as an economy spin-boost to many oil exporting countries and this increased the influence of OPEC, as a body of world major oil exporting countries, for advocating for greater resource control of the nonrenewable and using the oil revenues for socioeconomic development [4]. Shortly after this period, Nigerian economy gradually shifted from agro-based economy to oil-based economy, and by the end of 1980, through 1990, the economy heavily depends on oil foreign earnings. For instance, as noted by Adedeji et al. [5], oil revenue accrued to the Nigerian government during the boom in 1970 was about US$718 at which the price of oil was only about US$10.97 per barrel. Before the end of the year, the price per barrel speedily increased to about US$103.07 which led to an increase in the oil revenues. The price was at its peak in the 2000s during which, specifically in 2008, a barrel of oil was traded at about US$137 (see Figure below). As documented, the revenues from the export of crude oil in Nigeria account for more one-third of the country's gross domestic product (GDP), and the percentage of revenue to value of export in 2014 stood 91% [6]. The price slightly fluctuated down to about US$98.95 in 2014, however, recently the shocks of the fluctuation persists as the price deeply falls to about US$50, predictively it may further slump to as low as US$20 or even lower due to increase in oil production, new fields discovery and modern technology of exploration.

The distortionary effect of the unstable oil prices especially in slump period may have adverse impacts on consumer prices in oil-dependent economies, including Nigeria. This is because the cost of production of both import and locally produced consumer commodities depend on oil price which usually subsidized. When government removes subsidy that might follow falling oil prices, then the consequence is more likely resulting in high cost of commodities prices.

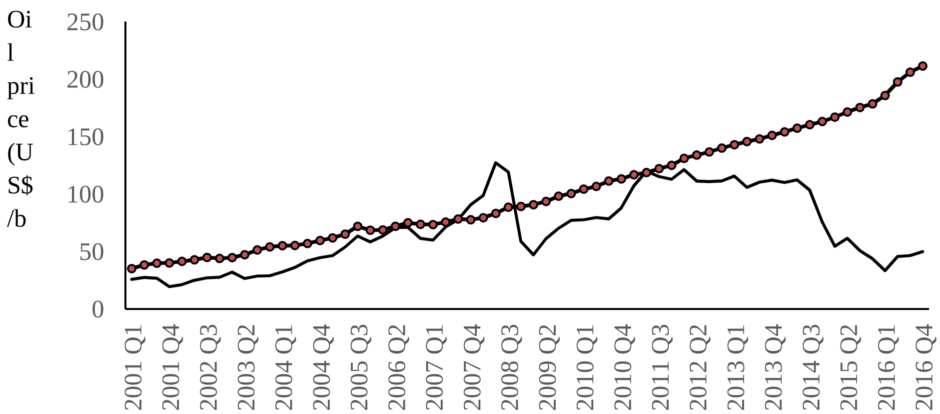

Figure 1. Aggregate consumer price and oil price
Data source: Central of Bank Nigeria (CBN)

The trend of consumer prices in Nigeria in the Figure above shows that the response of the market prices to changes in the oil price could not necessary be same, for instance, as a fall in the oil price may lead to an increase in commodity prices, and vice versa. An asymmetric relationship is expected to exist between the oil price and consumer prices in the case of Nigeria as the country's economy is heavily reliant on oil, whose price is unpredictable and the crowd out effect of such reliance may have more negative impact on non-oil sectors. Thus, the adjustment process of the disaggregated consumer prices may differ when oil price fluctuates which may not allow a symmetric relationship between the two variables. The speed of asymmetric adjustment of the consumer prices, if exists, can be more cleared by observing the response of the disaggregated consumer prices to changes in the oil price. However, this receives little attention in the literature for Nigeria in particular.

3. Literature Review

The precariousness of crude oil prices and its consequences on both macro and micro economic variables has widely been debated and analysed in the literature started from most two popular frameworks: input-output initiated by Eleish's [7] and Carruth, Hooker and Oswald's [8] efficiency-wage model. In particular, the attention of these frameworks most often focused on changes in the oil price and its effect on economic activities. For instance, many studies had the viewed that a change in oil price often has a strong influence in determining economy behaviour of many oil-economy countries in the world. Precisely, some studies explained that most production of outputs globally use primary inputs that are mainly determined by fuel energy. Thus, fluctuations in oil prices mostly has a great impact on economy of both oil importing and exporting countries. Though, infrastructural deficit and high export demands are also observed to lead to high cost of food [9], but these may be considered as piece of input when compare to the impact of oil price.

As it has also been observed, oil price shocks have different transmission mechanisms on economic variables, whether at supply side or demand side, of which in many cases the relationships are often found to be non-linear. According to which, a spike in oil price, when oil product is considered as a primary input of production, the effect would increase production costs. The effect is more likely to cause a sharp decline in production of output as the firms would not able to produce at full scale. As a consequence, economic growth and employment rate would decline [10]. As argued by Lardic and Mignon [11], increase in oil price may have an asymmetric effect on unemployment rate, a consequence of fall in demand, when consumer prices increase. As they illustrated, for example, if oil price sticks downward, production cost would increase, thus industrial sectors would tend to shift production from energy dependent productive activities to alternative energy source with relatively low price. Hence, a change in production setup would require the need for different labour which supply may fall short. Thus, to increase labour supply, wage rate likely needs to raise and add to production outlay which often borne by consumers.

In addition to the evidence of macroeconomic variables response to oil price shocks, investments and consumptions are found to be more sensitive to a change in oil price in an inverted direction. This analogy is explained by profit maximization motive of rational investors. Since investors often engage in business activities where entrepreneurial conditions are favourable, and any disturbance to the conditions will make them reallocate their resource, which also will affect consumption to change. For example, some studies, such as Chen, Lee and Goh [12], argued that when oil price stickily downward, it adversely affects economic performance and returns on investments decline. In response to the recession, if the cycle persists, investors will adjust their capital structure by withdrawing their capital from the markets, and invest in other economies that promise higher returns. This would correspondingly result to lack of capital for firms in the recessive economy and decline the economic activities. Interest rate will increase which may occur as a result of insufficient of capital in the markets. This will further increase costs of production. Firms will take measures, which may include production reduction, wage cut and lay off workers, to meet up with a high cost of production. In aggregate, such decision most likely slows economic growth and increases unemployment rate [13]. In an emphatic explanation, Dogrul and Soytas [14] claimed that oil prices shocks can increase the marginal cost of production which consequently can reduce output and productivity and thus declines aggregate employment rate.

From the previous empirical evidence, the response of aggregate output to oil price shocks often finds to be linear. This commonly tested using traditional linear econometric modeling as well as the standard unit roots and cointegration analysis. For example, Caporale and Gil-Alana [15] used fractional cointegration to examine the relationship between oil price shocks and economic output, and recently, Ahmad and Hernandez [16] and Godrul and Soytas [17] separately employed a linear method to test the effect of oil prices on economic output. Their findings suggest that oil prices have a direct influence on the variable. However, recently, it has been put forward that nonlinear asymmetric relationship may likely to exist between oil price and macroeconomic variables especially consumer prices. If such case exists, then linear relationship assumption and specification of linear model in such scenario would be incorrect [18]. For instance, Fayang-Yu et al. [19] found that Taiwan's macro-output reacts asymmetrically over changes in energy prices, as the shocks show a negative effect on the output. In a recent similar study, Aliyu and Tijjani [20] employed asymmetric cointegration method to investigate input price (exchange rate)-trade balance nexus in Nigeria. They provide evidence that non-linear relationship exists between macroeconomic variables examined.

As oil price shock has characterized been volatile, the economic variables of oil exporting countries and oil-economies are much affected. The same can be said for Nigeria, a world classed oil exporting country and whose economy is heavily depended on hydrocarbon. There still need to deeply understand how Nigeria's economy response to changes in energy prices, particularly oil price-consumer prices nexus has been overlooked. This attracts the attention of this study to test the pass-through effect of oil price shocks on consumer prices in Nigeria.

4. Data and models

The quarterly data used for the analysis were obtained from the Central Bank of Nigeria (CBN). The data spanned from 2001Q1 to 2016Q4. From the CBN database, aggregated consumer price index (ACPI) and seven subcomponents of price levels were retrieved to represent different price indexes. These subcomponents include the non-food and beverage price index (NFBI), the food and beverage price index (FBI), and Clothing and Footwear price index (CFI), with the assigned weights of 25.6%, 21.01%, and 3.2%, respectively. Also included are energy consumption price index (ECPI): a measure of prices of housing water, electricity, gas and fuel; transport and communication price index (TCI), furnishings and household equipment maintenance (FHI), and other goods and services price indexes (OGSI), with each assigned weights of 7.0%, 2.71%, 2.10%, and 0.69%, respectively. The oil price variable is the Bonny light crude oil price in the US dollars used as a measure of the world oil price. All variables are expressed in natural logarithm.

Before testing for co-integration, the oil price and disaggregated consumer prices are shown to be integrated of order one, using conventional Augmented Dickey-Fuller (ADF) and Philip-Perrons (PP) tests. The ADF and PP unit root tests are used to determine the stationary of the commodities prices and oil price variables. The assumption is that individual variable is stationary at level and that the null hypothesis of a unit root should be rejected. If this hypothesis cannot be rejected, then the first difference should be taken. If the hypothesis is rejected, then, as suggested by Engle and Granger [21], such variable is said to be integrated of order one, that is $I(1)$. Once the variables are integrated of the same order, the co-integration test is conducted in determining whether the variables share long-run relationship.

We employed two approaches: Engel-Granger (EG) approach, developed by Engel and Granger; and Enders-Siklos (ES) approach, developed by Enders and Siklos [22]; for long-run co-integration test. The EG and ES have wide application in testing co-integration especially in a bivariate equation. ES is an extension of the EG, both assume null hypothesis of no co-integration. However, EG tests symmetric co-integration while ES tests asymmetric co-integration between two variables. Following the EG two-step procedure: first, we estimate a static OLS regression to detect whether the variables share long-run relationship. The long-run equation is specified as:

$$x_t = \alpha_0 + \alpha_1 lnoilp + \varepsilon_t \qquad [1]$$

where x_t is dependent variable, represents the disaggregated consumer prices, $oilp_t$ is the independent variable, natural log of oil price, α_0 and α_1 are the intercept and slope, respectively, and ε_i is classical error term which represents any deviation from the long-run equilibrium between the dependent and independent variables.

Second, we obtain residuals from the long-run equation and test whether they are stationary using ADF test, with the critical values adjusted to account for the co-integrating coefficients that are estimated. The ADF test applied on the residuals for the stationarity is as follow:

$$\Delta\hat{\varepsilon}_t = \rho\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p}\theta_i\Delta\,\hat{\varepsilon}_{t-i} + \mu_t \qquad [2]$$

where μ_t is assumed to be normally distributed with zero mean and a constant variance. The null hypothesis is that $\rho = 0$, i.e. there is no co-integration. If this hypothesis is rejected, it implies that the residuals are stationary and confirms that oil price and consumer disaggregated prices share long-run relationship. However, this relationship can only be considered to exist if the adjustment process between the variables is symmetric. However, if the adjustment of the deviation from the long-run equilibrium exhibits asymmetric process, then threshold autoregressive (TAR) and momentum threshold autoregressive (M-TAR) specifications, an alternative ES approach, are applied. The main instrument in the ES specification is the inclusion of Heaviside indicator function to Equation 2 to partition the lagged sequence of the residual into two to indicate above threshold and below threshold. The application of these methods in the present study is appropriate as the portioning of the residual will show how the consumer prices respond to positive and negative disequilibrium changes in the oil price. To allow this dynamic adjustment in the residual, we use ES approach and specify the equation below:

$$\Delta\hat{\varepsilon}_t = (I_t)\rho_1\hat{\varepsilon}_{t-1} + (1 - I_t)\rho_2\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p-1}\theta_i\Delta\,\hat{\varepsilon}_{t-i} + \mu_t \qquad [3]$$

where ρ_1 and ρ_2 are the speed of adjustment in any deviation from the long-run value, and p *-1* is the optimal lag order to render the disturbance terms in Equation 1 serially uncorrelated, and *'I'* is the Heaviside indicator specified to depend either on the level or changes of the error terms. In level form, the *'I'* is denoted as:

$$I_t = \begin{cases} 1 & \text{if} \quad \hat{\varepsilon}_{t-1} \geq 1 \\ 0 & \text{if} \quad \hat{\varepsilon}_{t-1} < 0 \end{cases} \qquad [4]$$

or for changes form, the *'I'* is denoted as:

$$I_t = \begin{cases} 1 & \text{if} \quad \Delta\hat{\varepsilon}_{t-1} \geq 1 \\ 0 & \text{if} \quad \Delta\hat{\varepsilon}_{t-1} < 0 \end{cases} \qquad [5]$$

The Equation 3 with 4 formed the TAR model, while Equation 3 with 5 formed the M-TAR model. TAR model can use when the adjustment of the series (ε_t) from above or below disequilibrium is assumed to take a long period, and M-TAR model is often preferred when the adjustment is assumed to exhibit momentum in one direction than the other [23]. But, either TAR model or M-TAR can be used to estimate asymmetric error correct model in the presence of asymmetric co-integration as the models are consistent when ε_t are stationary [24]. Though this is achieved through a grid search and retention of the significant values of the lagged residuals in the model, and the procedure cleans the model and minimizes the sum of squares errors from the fitted threshold models [25]. However, the positive disequilibrium from long-run equilibrium is short lived in the M-TAR model than TAR model. This makes TAR model preferable for the analysis in this present study as we assumed that the response of consumer prices to a fall in the oil price may not as faster as when there is an increase due to production costs adjustment.

The ES test of asymmetric co-integration is conducted with the hypothesis that there is no co-integration, i.e. H_0: $\rho_1 = \rho_2 = 0$. This hypothesis can be rejected if one or both of the speed of adjustments (ρ_1 and ρ_2) coefficients are significantly less than 0, which implies that long-run relationship exists between consumer disaggregated prices and oil price. Observing the presence of co-integration, we can proceed to test symmetric adjustment with the formulation of null hypothesis that $\rho_1 = \rho_2$. Both the asymmetric and symmetric co-integration are supported when the hypotheses $\rho_1 = \rho_2 = 0$ and $\rho_1 = \rho_2$ are rejected which will allow for testing asymmetric error-correction to capture short-run and long-run dynamics. The error-correction model is specified as:

$$\Delta p_t = \alpha + \rho_1 Z_{t-1}^{+} + \rho_2 Z_{t-1}^{-} + \sum_{i=1}^{p} \gamma_i \Delta\, p_{t-i} + \sum_{i=1}^{p} \theta_i \Delta\, oilp_{t-i} + \mu_t \qquad [6]$$

where p_t represents the consumer prices and its subcomponents as already defined, Δ is the first difference operator, k is the optimal lag order, Z_{t-1}^{+} represents $I\hat{\varepsilon}_{t-1}$ and Z_{t-1}^{-} represents $(1 - I_t)\hat{\varepsilon}_{t-1}$, the error-correction terms (ECT) that represent the deviation of the consumer prices from positive and negative long-run values. The ECT allow adjustments of consumer prices to respond to positive and negative distortion from equilibrium respectively. μ_t is the disturbance term which is assumed to be normally distributed with mean and constant variance. ρ_1 and ρ_2 are the parameters to be estimated, representing the speeds at which the price levels are corrected when they are above or below their equilibrium the next period. As reflected in the Figure plotted in section 2, we expect the ρ_1 coefficients to be greater than ρ_2 coefficients and sticky downward in reflecting commodities prices rigidity to a fall in the oil price.

5. Empirical results

Table 1 presents the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test equations. The results are consistent, as the null hypothesis that the variables contain unit roots at levels are not rejected, meaning that the variables contain random work and not stationary. However, all the variables are stationary after first differencing which as the null hypotheses are rejected at least at 5% significance level. This indicating that all the variables are integrated of order 1, that is *I*(1). Accordingly, this allows us to proceed with co-integration test.

From the results generated shown in Table 2, all the long run coefficients are statistically significant at the 1% level, meaning that the null hypothesis of no co-integration by all co-integration tests can be rejected. This indicates that oil price has a strong relationship with all market prices, with .61 change for all the items CPI market basket. This suggests that on average, for Nigeria, a change in oil price by 10% tends to be related to the expected increase in the consumer prices by roughly 6.1%.

Table 1. *ADF and PP Unit Root Test*

	Level		First difference		
variables	ADF	PP	ADF	PP	Results
LNCFI	.439	1.919	-7.023***	-9.572***	*I*(1)
LNFBI	-1.549	-1.730	-4.635***	-15.228***	*I*(1)
LNFHI	.552	1.312	-7.694***	-8.374***	*I*(1)
LNACPI	-1.130	-1.908	-7.576***	-12.485***	*I*(1)
LNOILP	-1.878	-1.763	-6.301***	-6.153***	*I*(1)
LNFNBI	-1.082	-1.313	-8.945***	-15.867***	*I*(1)
LNECPI	-1.998	-.422	-5.867***	-7.441***	*I*(1)
LNTCI	-1.081	-1.077	-7.691***	-7.689***	*I*(1)
LNOGSI	-2.424	-2.540	-6.870***	-7.129***	*I*(1)

Notes: ADF and PP test equations include trend term. For ADF test, Schwarz Info Criteria (SIC) is used to select the optimal lag length, while Barlett Kernel test equation is used for the selection of lag length for the PP. The bandwidth is selected using the Newey-West method. The prefix ‘LN’ denotes natural logarithm. ∗∗∗ and ∗∗ denote significance at 1% and 5%, respectively.

Noticeably, the magnitude of the pass-through effect of the OILP-ACPI system much appears among the subcomponents of the disaggregated prices. As expected, in the disaggregated prices, ECPI (.72) shown to more respond to change in oil price, followed by OGSI (.62) and TCI (.58). While the CFI (.42) has the lowest oil price pass-through in the long-run.

Table 2. *Long-Run Estimation and EG Co-Integration Test*

	Long-run Coefficients	ADF Tests on Residuals
LNCFI	.417 (5.542)***	-3.966 [.003]***
LNFBI	.523 (6.657)***	-3.861 [.004]***
LNFHI	.489 (6.217)***	-3.471 [.012]**
LNACPI	.607 (6.723)***	-3.824 [.005]***
LNFNBI	.604 (6.480)***	-3.713 [.006]***
LNECPI	.717 (7.250)***	-3.917 [.004]***
LNTCI	.582 (8.108)***	-4.238 [.001]***
LNOGSI	.617 (7.128)***	-3.613 [.008]***

Note: The Schwarz Info Criteria (SIC) is used to select the optimal lag order (k) in the EG test. t-statistics are in brackets and *p*-values are in parentheses. ∗∗∗ and ∗∗ indicate significance at 1% and 5% significance level, respectively.

Furthermore, as shown in Table 2, the unit root tests of the residuals obtained from the co-integration, Eq. 1, using ADF with trend, are all significant at better 1% significance level, implying that the residuals are stationary. This shows that long-run relationship exists between oil price and disaggregated consumer prices. Accordingly, this permits to proceed and test asymmetric co-integration. The estimation of the TAR consistent and M-TAR consistent models are presented in Table 3.

From the results, Table 3, for the TAR consistent model, the point estimate values of ρ_2 exhibit convergence with negative signs, while ρ_1 show divergence with positive signs, which are alternate for M-TAR consistent model. This indicates that commodities prices in Nigeria tend to adjust upward faster when there is an increase in the oil price and rigid downward when there is a decrease in the oil price.

Table 3. *Asymmetric Co-Integration Test*

TAR-Consistent								
	LNCFI	LNFBI	LNFHI	LNACPI	LNFNBI	LNECPI	LNTCI	LNOGSI
ρ_1^a	.039 (.951)	.038 (1.056)	.035 (.972)	.039 (1.114)	.044 (1.190)	.028 (.696)	.028 (.571)	.014 (.309)
ρ_2^a	-.156 (-2.294)	-.251 (-3.392)	-.165 (-2.103)	-.277 (-3.645)	-.168 (-2.625)	-.324 (-4.041)	-.404 (-4.165)	-.291 (-3.424)
τ	-.228	-.239	-.296	-.304	-.253	-.301	-.281	-.367
Φ	3.169 [.080]	6.314 [.015]	2.859 [.096]	7.156 [.010]	4.274 [.043]	8.632 [.005]	8.879 [.004]	5.957 [.018]
$\rho_1=\rho_2$	6.237	12.362	5.718	14.121	8.475	16.269	16.282	10.126

	[.015]	[.001]	[.020]	[.000]	[.005]	[.000]	[.000]	[.002]
M-TAR-Consistent								
$\rho_1{}^a$	-.036 (-.837)	-.085 (-1.655)	-.023 (-.548)	-.060 (-1.304)	-.071 (-1.365)	-.059 (-1.183)	.030 (.380)	-.107 (-2.058)
$\rho_2{}^a$	.0454 (.681)	.038 (.046)	.046 (.793)	.050 (.926)	.034 (.791)	.005 (.078)	-.107 (-1.698)	.055 (.753)
τ	-.035	.065	-.034	.030	.073	-.013	.061	-.013
Φ	.603 [.440]	1.753 [.190]	.478 [.492]	1.337 [.252]	1.249 [.268]	.710 [.403]	1.558 [.217]	2.478 [.121]
$\rho_1=\rho_2$	1.113 [.296]	3.275 [.075]	.955 [.332]	2.515 [.118]	2.432 [.124]	.631 [.430]	1.921 [.171]	3.344 [.072]

Note: [a] Entries are estimated value of *pi with t*-statistics in parentheses. Φ represents the *F*-joint statistics that follows a non-standard distribution of the sample values for the null hypothesis $\rho_1 = \rho_2 = 0$. The $\rho_1 = \rho_2$ represents the *F*-equal statistics for the null hypothesis of symmetric adjustment. The *p*-values are in brackets. τ denotes the threshold values. The optimal lag order of the equations are based on the SIC criteria.

This result is in line with the Ali et al.'s [26] study that finds that commodity prices mostly converge to positive disequilibrium. Since one of the two adjustment coefficients (ρ_2) is significant, the null hypothesis of no asymmetric co-integration can be tested as Ibrahim & Chancharoenchai argued. Examining co-integration under TAR consistent model, the ρ-values entries in the row of the Φ are less than 5% for LNFBI, LNACPI, LNFNBI, LNECPI, LNTCI, and LNOGSI and the values for LNCFI (0.08) and LNFHI (0.09) are slightly less than 10%, thus, the null hypothesis of $\rho_1=\rho_2=0$, is rejected. This indicates that oil price and disaggregated consumer prices are co-integrated. This study equally rejects the null hypothesis of symmetric adjustment, $\rho_1=\rho_2$, as the ρ-values of the *F*-equal statistics are all less than 5% significance level. However, the null of symmetric co-integration, under M-TAR model cannot be rejected at all levels. Since asymmetric co-integration process is allowed under TAR consistent model; and that the threshold values (τ) are found to have a strong evidence of co-integration adjustment process; and that the adjustment is substantiated by the standard *F*-tests which are significant at better 5%, thus, we can establish that the oil price and disaggregated consumer prices are co-integrated, and that the adjustment mechanism is asymmetric. The distortionary impact of oil price on disaggregated consumer prices is therefore modeled using the TAR asymmetric error-correction model (Equation 6). TAR model is preferred as the estimates of the threshold in this model appear substantially fit the data better than the M-TAR model.

The positive finding of co-integration between the oil price and disaggregated consumer prices, with the TAR consistent (unknown τ), justifies the estimation of the dynamics error-correction models with the TAR threshold specification. This allows to capture the short-run and long-run dynamics. We apply the general-to-specific procedure to trim insignificant first-differenced explanatory variables, and equally check each model, using various diagnostic tests, to ascertain whether the $\hat{\varepsilon}_t$ series are reasonably distributed. The estimation results of these models are presented in Tables 4.

Based on results, the DW-stat values in all models suggest that there is absence of serial correlation in the residuals, and as such, this shows the evidence of predictive power. Generally, the *F*-statistics are statistically significant, at least at the 10% conventional level, indicating satisfactory performance of the models, except in two models, CFI and TCI. The adjusted R^2 of the models are not quite strong but the coefficients in FBI, FHI, FNBI and OGSI models are all above admissible 20% which is a reflection of a good model fit. In addition, in all models, only FBI model indicates the presence of a weak autocorrection, nonetheless, the models pass almost the diagnostic tests, at the better 5% significance level.

In the estimated adjustment equations, Table 4, we find that the oil price shocks appear to have a positive significant distortionary effect specifically on CFI, FBI, ECPI and ACPI itself; and a negative significant distortionary effect on FHI in Nigeria. Meanwhile, the disaggregate market prices of FNBI and TCI as well as OGSI exhibit some degree of persistence.

Table 4a. *Estimation Results of Dynamic Error-Correction Models*

(a) Clothing and footwear price (CFI) response

$$\Delta p_t = \underset{[0.00]}{0.035} + \underset{[0.002]}{0.027}\, Z^{+}_{t-1} + \underset{[0.802]}{0.005}\, Z^{-}_{t-1} - \underset{[0.000]}{0.372}\, \Delta p_{t-2} - \underset{[0.000]}{0.169}\, \Delta p_{t-3}$$
$$- \underset{[0.000]}{0.130}\, \Delta p_{t-4} - \underset{0.031}{0.077}\, \Delta p_{t-5} + \underset{[0.095]}{0.047}\, \Delta oilp_{t-4}$$

$Adj-R^2 = 0.06$ $Hetro.\ test = 2.087\,[0.062]$ LM test $(2) = 0.355\,[0.703]$

$DW-stat = 2.021$ RESET $(2) = 32.777\,[0.000]$ $F-stat = 1.533\,[0.178]$

(b) Food and beverages price (FBI) response

$$\Delta p_t = \underset{[0.00]}{0.036} + \underset{[0.000]}{0.026}\, Z^{+}_{t-1} - \underset{[0.380]}{0.011}\, Z^{-}_{t-1} - \underset{[0.001]}{0.258}\, \Delta p_{t-2} - \underset{[0.000]}{0.382}\, \Delta p_{t-3}$$
$$+ \underset{[0.000]}{0.214}\, \Delta p_{t-4} - \underset{[0.000]}{0.300}\, \Delta p_{t-5} + \underset{[0.000]}{0.016}\, \Delta oilp_{t-1} + \underset{[0.000]}{0.024}\, \Delta oilp_{t-3}$$
$$+ \underset{[0.001]}{0.009}\, \Delta oilp_{t-5}$$

$Adj-R^2 = 0.22$ $Hetro.\ test = 1.017\,[0.440]$ LM test $(2) = 2.828\,[0.070]$

$DW-stat = 2.48$ RESET $(2) = 3.367\,[0.043]$ $F-stat = 2.825\,[0.009]$

(c) Furnishing & Household equipment price (FHI) response

$$\Delta p_t = \underset{[0.000]}{0.030} - \underset{[0.010]}{0.356}\, Z^{+}_{t-1} - \underset{[0.274]}{0.018}\, Z^{-}_{t-1} - \underset{[0.030]}{0.206}\, \Delta p_{t-2} - \underset{[0.020]}{0.188}\, \Delta p_{t-3}$$
$$+ \underset{[0.004]}{0.304}\, \Delta p_{t-5} - \underset{[0.002]}{0.040}\, \Delta oilp_{t-2} - \underset{[0.038]}{0.0514}\, \Delta oilp_{t-3} - \underset{[0.000]}{0.044}\, \Delta oilp_{t-4}$$
$$- \underset{[0.000]}{0.040}\, \Delta oilp_{t-5}$$

$Adj-R^2 = 0.29$ $Hetro.\ test = 2.118\,[0.040]$ LM test $(2) = 0.727\,[0.490]$

$DW-stat = 2.24$ RESET $(2) = 4.715\,[0.014]$ $F-stat = 2.933\,[0.006]$

(d) Food & non-beverages price (FNBI) response

$$\Delta p_t = \underset{[0.000]}{0.036} - \underset{[0.021]}{0.009}\, Z^{+}_{t-1} - \underset{[0.022]}{0.022}\, Z^{-}_{t-1} - \underset{[0.000]}{0.147}\, \Delta p_{t-3} + \underset{[0.000]}{0.1194}\, \Delta p_{t-4}$$
$$- \underset{[0.000]}{0.357}\, \Delta p_{t-6} - \underset{[0.013]}{0.032}\, \Delta oilp_{t-2} - \underset{[0.000]}{0.038}\, \Delta oilp_{t-5} - \underset{[0.024]}{0.032}\, \Delta oilp_{t-7}$$

$Adj-R^2 = 0.20$ $Hetro.\ test = 0.475\,[0.868]$ LM test $(2) = 0.198\,[0.821]$

$DW-stat = 2.11$ RESET $(2) = 1.479\,[0.239]$ $F-stat = 2.708\,[0.006]$

Note: Numbers in brackets are *p*-values. Hetro. test is Breusch_Pagan-Godfrey heteroskedasticity test; LM test is test for serial correlation up to order *p*; DW-stat is Durbin-Watson statistic test for serial correlation, set up to a maximum of 2 lags; RESET is Ramsey's misspecification test with the fitted terms set to 2; and *F*-stat. is joint *F* statistics for the null hypothesis that the coefficients of the parameters are equal to 0.

Turning to error-correction coefficients, it is assumed that oil price is exogenously determined the consumer prices. This implies that if the consumer prices are above the threshold value (the long-run equilibrium) after a fall in the oil price, then the consumer prices will adjust by Z^{+}. Conversely, if the consumer prices are below the long-run equilibrium after a rise in the oil price, then they will adjust by Z^{-}. However, this assumption is supported if the asymmetric error correction terms are each statistically significant with negative sign. Based on our results, we find that the adjustment of three prices - FNBI; TCI; and OGSI (Table 4) exhibit some degree of persistence as they appear more likely to be faster in the upward direction when they are distorted below their long-run value. The error-correction coefficients of 2.2% (FNBI), 1.5% (TCI), and 1.1% (OGSI) are statistically significant at the

5% and 1% levels, suggesting that the negative distortions of these prices from the long-run values are corrected the next quarter.

Also, for positive deviation, the statistically significant of the error-correction coefficients of FNBI, TCI, and OGSI, 1.0% each, including FHI, 3.6%, suggest that these prices are quicker downward to return to the equilibrium when they are above the long-run value. However, their responses are faster to a rise than to a fall in the oil price in Nigeria.

Table 4b. *Estimation Results Continued*

(e) Energy consumption price (ECPI) response

$$\Delta p_t = \underset{[0.071]}{0.016} + \underset{[0.000]}{0.030} Z_{t-1}^{+} - \underset{[0.267]}{0.044} Z_{t-1}^{-} + \underset{[0.006]}{0.195} \Delta p_{t-1} - \underset{[0.005]}{0.205} \Delta p_{t-2} + \underset{[0.000]}{0.233} \Delta p_{t-5} + \underset{[0.002]}{0.025} \Delta oilp_{t-4}$$

$Adj - R^2 = 0.13$ $Hetro.\ test = 0.320\,[0.924]$ LM test $(2) = 0.893\,[0.416]$

$DW - stat = 1.98$ RESET $(2) = 0.119\,[0.878]$ $F - stat = 2.443\,[0.037]$

(f) Transportation and communication price (TCI) response

$$\Delta p_t = \underset{[0.888]}{0.001} - \underset{[0.090]}{0.003} Z_{t-1}^{+} - \underset{[0.001]}{0.151} Z_{t-1}^{-} + \underset{[0.000]}{0.160} \Delta p_{t-1} + \underset{[0.000]}{0.050} \Delta p_{t-2} + \underset{[0.000]}{0.237} \Delta p_{t-3} + \underset{[0.005]}{0.043} \Delta p_{t-4} + \underset{[0.036]}{0.024} \Delta p_{t-5} - \underset{[0.072]}{0.010} \Delta oilp_{t-1} - \underset{[0.040]}{0.039} \Delta oilp_{t-2} - \underset{[0.000]}{0.034} \Delta oilp_{t-3} - \underset{[0.005]}{0.047} \Delta oilp_{t-5}$$

$Adj - R^2 = 0.08$ $Hetro.\ test = 1.100\,[0.051]$ LM test $(2) = 0.300\,[0.743]$

$DW - stat = 2.02$ RESET $(2) = 1.791\,[0.188]$ $F - stat = 0.636\,[0.788]$

(g) Other goods and service price (OGSI) response

$$\Delta p_t = \underset{[0.000]}{0.009} - \underset{[0.000]}{0.013} Z_{t-1}^{+} - \underset{[0.000]}{0.107} Z_{t-1}^{-} + \underset{[0.000]}{0.257} \Delta p_{t-1} - \underset{[0.000]}{0.194} \Delta p_{t-2} + \underset{[0.000]}{0.185} \Delta p_{t-3} + \underset{[0.000]}{0.289} \Delta p_{t-4} - \underset{[0.000]}{0.100} \Delta p_{t-5} - \underset{[0.000]}{0.023} \Delta oilp_{t-2} - \underset{[0.000]}{0.020} \Delta oilp_{t-3} + \underset{[0.000]}{0.020} \Delta oilp_{t-4} - \underset{[0.000]}{0.101} \Delta oilp_{t-5}$$

$Adj - R^2 = 0.21$ $Hetro.\ test = 4.727\,[0.000]$ LM test $(2) = 0.447\,[0.643]$

$DW - stat = 2.07$ RESET $(1) = 4.671\,[0.036]$ $F - stat = 2.375\,[0.020]$

(h) All items of consumer prices (ACPI) response

$$\Delta p_t = \underset{[0.000]}{0.028} + \underset{[0.000]}{0.013} Z_{t-1}^{+} - \underset{[0.382]}{0.014} Z_{t-1}^{-} - \underset{[0.002]}{0.174} \Delta p_{t-2} - \underset{[0.005]}{0.219} \Delta p_{t-3} + \underset{[0.000]}{0.259} \Delta p_{t-4} - \underset{[0.005]}{0.018} \Delta oilp_{t-2} + \underset{[0.060]}{0.015} \Delta oilp_{t-3}$$

$Adj - R^2 = 0.11$ $Hetro.\ test = 0.892\,[0.520]$ LM test $(2) = 0.482\,[0.620]$

$DW - stat = 1.80$ RESET $(1) = 0.910\,[0.345]$ $F - stat = 2.000\,[0.074]$

Note: see note under Table 3 for definitions.

More interestingly, we find the error-correction coefficients of CFI (2.7%), FBI (2.6%), ECPI (0.3%) and ACPI (1.3) to be positive and each is significant at the 1% significance level. This shows that they are rigid downward, indicating their slow adjustment to a fall in oil price.

Among these prices, the CFI and FBI have the larger error-correction coefficients. This confirms the recent high costs of food items in Nigeria, among others, attributed to fall in the oil price and decline in the output of crude oil in the country as indicated by the National Bureau of Statistics (NBS) [27]. Based on these findings, design and implementation of effective economic policies in curbing high costs of commodities prices influenced by oil prices distortionary effects may be helpful in Nigeria. The target should be more on food and beverages, clothing and energy prices in particular, as the impact of fall in oil price is relatively large on these prices.

More importantly, oil price slump more often poses a threat to oil-dependent economies especially those with thin foreign reserve, like Nigeria, as such they usually experience recession in terms of high cost of living. Thus, there is need for the government to diversify its economy and boost other sources of generating income and reduce economic dependency on oil for economy sustainability.

Finally, the findings of this study contribute to the literature as the obtained evidence specifically exposes the implications of oil price downturn shocks on consumer prices in an economy that heavily depend on earnings from the exports of crude oil as the main source income. In general, this study finds that the estimated asymmetric error correction coefficient of all items consumer prices (Table 4b) adjusts slower in response to oil price slump. This cast some doubt on achieving substantial goal in economic recovery plan of vision 2020 in Nigeria as oil price is predicted to fall more below the current price, with the threat of reduction in crude oil demand, due to discovery and shifting from use of crude oil to alternative nonrenewable energy by major crude oil consumers.

6. **Conclusion**

This paper examines the consumer prices response to the recent fall in oil price in Nigeria in which dynamic co-integration method, which allows for asymmetric adjustments, is applied on new data of oil price and disaggregated consumer prices. We find evidence of persistence long-run relationship between oil price shocks and FNBI, TCI and OGSI prices. The findings further show that CFI, FBI, ECPI prices are downward rigid in response to a fall in the oil price. This serves as a confirmation that low oil price is likely attributed to the high costs of food, clothing and basic energy consumption prices in Nigeria. This partially supports the Dutch disease hypothesis under which it is argued that oil economy is more vulnerable to the precariousness of oil price among other factors.

The trend of consumer prices in Nigeria indicates that the effects of changes in the price of crude oil in foreign oil market on output prices is not necessary to the same. For instance, a fall in the oil price may lead to an increase in commodity prices, and vice versa. An asymmetric relationship is observed to exist between the oil price and consumer prices in Nigeria. This may resulting from the heavily reliant of the country's economy on crude oil, whose price is unpredictable. As such, oil-economy experiences different cycles when oil price fluctuates. Thus, the adjustment process of the disaggregated consumer prices may differ when oil price fluctuates which may not allow a symmetric relationship between the two variables. The speed of asymmetric adjustment of the consumer prices is more cleared as the disaggregated consumer prices respond quickly to changes in oil price for Nigeria.

The positive finding of co-integration between the oil price and disaggregated consumer prices, with the TAR consistent (unknown τ), justifies the estimation of the dynamics error-correction models with the TAR threshold specification. This allows to capture the short-run and long-run dynamics. These findings of the present study at hand form an interesting comparison to the Ibrahim and Chancharoenchai's study reported for Thailand. Similar to our results, the authors find that changes in oil prices for Thailand had significant immediate impacts on the commodities prices, and that oil price is inflationary to general price level. Likewise in Nigeria, the disaggregated consumer prices respond differently to the fluctuations of oil price but are much slower in the downward direction when they are above the long-run value. This implies that a fall in the oil price leads to a high cost of energy in production of consumer goods in Nigeria that probably influences high consumer prices.

Thus, we recommend that credible and effective policies should be designed in curbing distortionary impact that fall in oil price may have on consumer commodities prices. Such policies should more particularly target stability of food and beverages, clothing and energy prices as the distortionary impact of oil price slump appears to be relatively larger on these prices in Nigeria. This will reduce high costs of food, shelter and clothing that may emanate from oil price shocks.

This study used TAR consistent models for all the estimations as M-TAR models failed to find asymmetric co-integration between variables, but, as pointed out by Matemilola, Bany-Ariffin and Muhtar [28], M-TAR model exhibits more momentum than TAR consistent model. Nonetheless, the latter is suitable for the present analysis for being recognized to have good power to capture 'deep' cycle in threshold adjustment process.

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COMPETING INTERESTS

No competing interests.

AUTHORS' CONTRIBUTIONS

Abdulkabir Adedeji designed the study, performed the statistical analysis, managed the analyses of the study, wrote the protocol, and wrote the first draft of the manuscript. Jiddah Ajayi managed the literature searches. Musa Mohammed and Jibrin Talba read and approved the final manuscript.

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