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Does Oil Consumption Respond Asymmetrically to Oil Price, Exchange Rate and Income Differentials?

(Adakah Penggunaan Minyak Respon Secara Asimetrik terhadap Harga Minyak, Kadar Pertukaran dan Perbezaan Pendapatan?)

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ABSTRACT

This study empirically evaluates the dynamic effects oil price, income and exchange rate on oil consumption in Algeria, Angola, Nigeria, South Africa, and Tunisia. Specifically, it tries to reveal the differential effects of rising and falling oil prices, economic prosperities and adversaries, as well as, exchange rate appreciations and depreciation on oil consumption in the selected countries. The current study relied on monthly data sourced from OPEC and IMF-IFS data banks and analyzed within the Nonlinear ARDL framework. The NARDL model traces asymmetry in macroeconomic relationships by isolating the effects of positive changes from negative changes. The empirical findings reveal that the effects of oil price deviations on oil consumption is asymmetric in the short-run in Angola and Tunisia, and in the long-run in Nigeria. Furthermore, income and exchange rate deviations affect oil consumption asymmetrically in Algeria, Nigeria, South Africa and Tunisia. However, exchange rate deviation does not have an asymmetric effect on oil consumption in Algeria. The overall implication of such asymmetric effects is that positive deviations could not offset negative deviations and vice-versa. Therefore, to guide against general welfare losses, policymakers should take cognizance of such nonlinear and asymmetric effects in their policy moderations.

Keywords: Energy demand; oil prices; exchange rate; income differentials; nonlinear ARDL; asymmetry.
JEL: Q4, Q41, Q42, Q43, Q410, Q420

ABSTRAK

Kajian ini secara empirik menilai kesan dinamik harga minyak, pendapatan dan kadar pertukaran terhadap penggunaan minyak di Algeria, Angola, Nigeria, Afrika Selatan, dan Tunisia. Secara khusus, ia cuba untuk mendedahkan perbezaan kesan kenaikan dan kejatuhan harga minyak, kemakmuran dan permusuhan ekonomi, serta, kenaikan dan penyusutan kadar pertukaran ke atas penggunaan minyak di negara-negara terpilih. Kajian semasa bergantung kepada data bulanan yang diperoleh dari bank data OPEC dan IMF-IFS dan dianalisis dalam kerangka ARDL Tidak Linear. Model NARDL mengesan asimetri dalam hubungan makroekonomi dengan mengasingkan kesan perubahan positif dari perubahan negatif. Penemuan empirikal menunjukkan bahawa kesan penyimpangan harga minyak terhadap penggunaan minyak adalah tidak simetri dalam jangka pendek di Angola dan Tunisia, dan dalam jangka panjang di Nigeria. Tambahan pula, penyimpangan pendapatan dan kadar pertukaran mempengaruhi penggunaan minyak secara asimetri di Algeria, Nigeria, Afrika Selatan dan Tunisia. Walau bagaimanapun, penyimpangan kadar pertukaran tidak mempunyai kesan asimetri terhadap penggunaan minyak di Algeria. Implikasi keseluruhan kesan tidak simetri ini adalah bahawa penyimpangan yang positif tidak dapat mengimbangi penyimpangan negatif dan sebaliknya. Oleh itu, bagi menelakkan kerugian kesejahteraan awam, penggubal dasar harus menyedari kesan tidak linear dan asimetri dalam polisi mereka.

Kata kunci: Permintaan tenaga; harga minyak; kadar pertukaran; perbezaan pendapatan; ARDL tidak linear; asimetri

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INTRODUCTION

One of the major issues that had preoccupied the minds of macroeconomic/energy researchers and policymakers across the globe, is the provision of appropriate and reliable explanations of the relevant factors that determine the level of oil consumptions. Several countries had witnessed an upsurge in oil consumption since the 1970s due to advancement in technology and the quest for rapid development. Oil price, on its part, continue oscillating from one price today and to another price tomorrow. On this ground, projections of future prices become a herculean task. Related to this, is the relative effects of exchange rate appreciation and depreciation and its subsequent pass-through to the macroeconomy. Notably, most economies depend on imports for the provision of oil for local consumptions. To that effect, the relative value of her local currency vis-a-vis her trading partners will invariably determine her oil consumptions capacities.

There is a large volume of studies investigating the relative effects of income and oil price on domestic oil consumption. This includes, Gately and Huntington (2002), Adeyemi et al. (2010), Adeyemi and Hunt (2014), Chang et al. (2019), Liddle and Huntington (2020) and Liddle and Sadorsky (2020). Despite this large number of studies, researchers are yet to have a common understanding on how oil consumption responds to the deviations in the aforementioned variables. While the probe on the possible asymmetric impacts of oil prices and income on oil consumption had attracted the attention of many scholars, however, it is equally notable that only very few studies considered the possibility of asymmetric pass-through from the exchange rate to oil consumption. Few among these include De Schryder and Peersman (2013), Shahbaz et al. (2018), Ghoddusi et al. (2019). A notable limitation in this array of studies is that African countries were not considered in any of them.

Unarguably, the price of crude oil and exchange rate dynamics are expected to influence the relative volume of oil consumed. Around the globe, some countries are net exporters while some are net importers of oil, while some fall in-between the two divides (Uche 2019). On this ground, the relative changes and oscillations in oil prices at the global level, and the exchange rate of the domestic currency, vis-à-vis the US dollar, could exert sufficient impact on the country's oil consumption levels. Based on the above premise, the core objective of this current study is to provide empirical and evident-based explanations of the effects of changing oil prices, national income and exchange rate movements on oil consumption in the selected African countries, consisting of Algeria, Angola, Nigeria, South Africa and Tunisia.

Furthermore, most previous studies, including, Godwin et al. (2004); Havraneck et al. (2012); Havraneck and Kokes (2015); Niyimbanira, (2015); Levin et al. (2017); Kanjilal and Ghosh (2018); Ghoddusi et al. (2019) were implemented within linear and symmetric specifications. That is, the authors assume that the effects of positive and negative changes in the explanatory variable(s) on the explained variable are always equal. However, studies (Hamilton, 2003; Adeyemi et al. 2010) have shown that such assumption has the potentiality to bias the elasticity estimates and invariably leads to erroneous conclusions. This view is equally corroborated by the studies of Arac and Hasnov (2014), Salisu and Ayinde (2016) and Liddle et al. (2020). Within the context of the present study, such assumption portends that the effects of a percentage rise (fall) in oil prices, income or exchange rate on oil consumption will be equal always. Additionally, Liddle et al. (2020) pointed out clearly that the assumption of equal impact of the exogenous variable(s) on the dependent variable does not reflect realities in modern-day economic dynamics. Expectedly, a perturbation on any of the regressors, could push some countries into devising more efficient ways of energy utilizations, maybe, through improvements in technology or retrofitting (Kanjilal & Ghosh, 2018). Whenever there is a drop in the price of crude oil, change in exchange rate, or changes in income, the advances previously achieved, would not be jettisoned. By so doing, the expected symmetric or equal effects will not subsist. The above narratives justify our non-alignment to linearity and symmetric assumptions in the ensuing relationship. However, it provided the necessary platform for the application of a non-linear and asymmetric model that has the capacity to trace the asymmetric differential effects of the changes in the exogenous factors on the endogenous variable.

To depart from previous studies and extend the frontier of knowledge in oil consumption literature, the current investigation applied the nonlinear ARDL model to probe the possibility of asymmetric effects of changing oil prices, income, and exchange rate dynamics on oil consumptions in the selected African economies. The Nonlinear ARDL, proposed by Shin, Yu and Greenwood-Nimmo (2014) is an enhanced version of the traditional ARDL introduced by Pesaran and Shin (1998) and its extension (bounds test technique) by Pesaran, Shin and Smith (2001). Among its uniqueness, the NARDL captures the partial deviations of positive and negative changes and its effects on the dependent variable. Based on this, the NARDL model has received wide acceptance and has been widely applied by several authors in the study of diverse macroeconomic phenomena. Among such studies are, but not limited to, Hoang et al. (2016), Shin et al. (2017), oil price and Korea's demand for imported oil, Meo et al. (2018), asymmetric dynamics between oil price, exchange rate and inflation on tourism demand in Pakistan, Hussain et al. (2019), exchange rate and GDP in Pakistan, Zhu and Chen (2019), oil prices and exchange rate on China's industrial prices, Liddle et al. (2020), asymmetric effects of income energy prices on energy demand in OECD countries.

As stated earlier, most previous studies did not give enough considerations to African economies. This equally provided another incentive for the current exposition. The selected African economies, comprising of Algeria, Angola, Nigeria, South Africa and Tunisia are among the African Emerging Economies (AEE) selected on the basis of their rapid growth and energy demand, data availability and consistency. Additionally, the five selected countries are among the first ten African economies with rising energy consumption levels (www.brookings.edu/africa-in-focus). Furthermore, Nigeria, Angola and Algeria are oil net exporters while South Africa and Tunisia are oil net importers. Therefore, the study will be able to balance the argument about the effects of the aforementioned factors in the context of oil-exporting and oil-importing nations. Moreso, the foreign exchange markets of these nations remain highly vulnerable to international shocks. Such situation has the tendency to affect the international competitiveness of their local currencies, and by extension, oil consumption. Based on this background, the current study promises to provide a timely and appropriate explanation of the impacts of oil prices, exchange rate deviations and income differentials on oil consumption in these countries through the application of NARDL. Such information will guide policymakers to avert general welfare losses, and by so doing, foster greater economic prosperities.

That being the case, the current study extends the frontiers of literature in the following ways; firstly, the study augments that of Liddle et al. (2020) by incorporating the exchange rate in oil consumption function using the nonlinear ARDL model. Secondly, unlike most previous studies, it considered the African emerging economies by probing the possibility of asymmetric effects running from oil prices, income and exchange rate to oil consumption through the application of NARDL. To the best of the authors' knowledge, this study is among the very few to critically investigate the simultaneous asymmetric pass-through of international oil prices, income and exchange rate variations on oil consumptions, particularly in the context of the selected African countries.

The above narrative is the introduction of the study, followed by literature overview in section two. The methodology and data sources are discussed in section three, whereas empirical analysis and discussion are presented in section four. The study is summarized in section five with some policy recommendations.

LITERATURE REVIEW

In this section, we gave a critical overview of available studies considered most relevant to the current enquiry either in content, context or methodology. Studies that considered the effects of crude oil prices on oil demand/consumption are relatively large in number, however, very few considered the effects of exchange rate deviations, and this forms the basis of this study. Among these studies as pointed out, researchers differ in their findings and conclusions. Notably, these divergences are predominantly due to differences in the economic context, the choice of models, underlying assumptions, the relevant time-frame, choice of variables, the functional form of models and choice of econometric technique (Atalla et al. 2018; Ghoddusi et al. 2019). Considering the asymmetric effects of income and energy changes on energy demand, Liddle et al. (2020) used a panel data set of 91 OECD and non-OECD economies analyzed with a panel regression econometric technique. Their findings reveal evidence of asymmetric effects of oil prices and income (GDP) on energy demand in most of the economies. Shahbaz et al. (2018) used the ARDL econometric technique to investigate the sensitivities of energy demand/consumption to foreign capital inflows and currency devaluation in the context of Pakistan economy. They conclude that both foreign capital inflow and currency devaluation have feedback effects on energy consumption.

Ghoddusi et al. (2019) used the Arellano-Bond System GMM estimator to estimate the effects of exchange rate shocks on Iranian gasoline consumption both in the level and volatility using Iranian monthly regional data. They discovered that an inverse relationship exists between the two variables. That is, energy consumption declined due to positive (appreciation) exchange rate shocks. Using a panel data technique in studying the US Dollars exchange rate and oil demand of OECD countries, De Schryder et al. (2013) discovered that appreciation of the US Dollars significantly leads to decline in oil demand in 65 oil-importing countries. They conclude that the impact of the exchange rate movements is larger than the impact of oil price changes. Adeyemi et al. (2010) study the asymmetric price responses and the underlying energy demand trend using OECD aggregate energy demand to determine whether the Asymmetric Price Responses (APR) and the Underlying Energy Demand Trend (UEDT) are substitutes or complements in modelling energy demand. The findings from the annual data of 17 OECD countries between the periods 1960 to 2006 reveal that UEDT is preferred to APR; while in some, they are substitutes. They conclude that a non-linear UEDT and APR are preferred in modelling energy demand.

Labandeira et al. (2017) carried out a meta-analysis of price elasticity of energy demand with a quantitative summary of recent empirical investigations both in the long term and short term. Based on their discovery, they conclude that economic agents react to energy products price changes, but the reactions are greater in the long-run than in the short-run. Salisu and Ayinde (2016) extended the studies on energy demand through a holistic review of the emerging issues in energy demand modelling. They affirm that, comparatively, the issue of asymmetry and time-varying effects are predominant lately in energy demand modelling than symmetry and constant coefficients. This further buttress the choice of asymmetry and nonlinear model in the current study. Arac and Hasanov (2014) applied the smoot transition vector autoregressive model and Generalized Impulse Response Function (GIRF) in the examination of asymmetric dynamic interrelationships between output and energy consumption in Turkey. They affirm that positive output shocks, much unlike negative shocks, have greater effects on energy consumption. Furthermore, Niyimbanira (2015) used a monthly time series data covering the period – January 2001 to December 2013 to study the dynamic interrelationship between fuel prices and exchange rate in South Africa. The evidence from the Impulse Response analysis of the VAR model provides a causal relationship between fuel price and exchange rate of the Rand. They conclude that fuel price increases in South Africa is a direct response to changes in the value of the local currency against the US dollar. However, they did not consider non-linearity in the interrelationship that could emanate from the distinct effects of positive and negative changes in the Rand exchange rate. This invariably makes their analysis and findings relatively unreliable. Kanjilal and Ghosh (2017) examine the income and price elasticity of gasoline demand in India using monthly time series data from 1972 to 2013. The evidence from the ARDL framework reveals that gasoline demand is highly elastic in response to changes in income and prices in the long-run, while it is inelastic in the short-run. Their study equally suffers the subjective assumption of linearity and symmetric effects as it did not consider the differential effects of positive and negative changes of the regressors.

Shin et al. (2017) applied non-linear ARDL and quarterly data that span two decades to determine whether oil price changes affect Korea's energy demand symmetrically or asymmetrically. Their analysis reveals that oil price effects are asymmetric in the long-run, but such does not exist in the short-run. They conclude that Korea's demand for imported crude oil responds more to oil price positive shocks than negative shocks. Pal and Mitra (2015) on their part, used a multiple threshold non-linear ARDL to evaluate the asymmetric relationship between oil prices and petroleum prices in the US economy. They discovered the presence of nonlinearity and asymmetry in the relationship and conclude that such asymmetric effects are highly pronounced at the lower quantiles of crude oil prices than at the upper quantiles. Zhu and Chen (2019) applied the non-linear ARDL to simultaneously study the asymmetric effects of positive and negative partial sums of changing oil prices and exchange rate movements on China's industrial productions. The findings from the analysis of monthly time series data between January 2000 to June 2019 reveal that asymmetry runs from positive and negative changes of oil prices and exchange rates to industrial productions only in the short-run.

The outcome of this in-depth review supports our earlier observations that most previous studies are based on the assumption of linearity and symmetric relationship between oil consumptions and its determinants. Moreover, conclusions from most studies implemented within both the linear and nonlinear frameworks are still inconclusive. Additionally, most of these previous studies considered mainly developed economies, without much considerations given to the developing countries, and African countries in particular. The above overview and the need to continuously appraise the current development in oil-macroeconomic nexus, are the justifications for this study.

METHODOLOGY

DATA

The study made use of monthly frequency data on oil consumption, oil prices, exchange rate and national income extracted from the Organization of Petroleum Exporting Countries (OPEC) bulletin and the International Monetary Fund's International Financial Statistics (IMF-IFS) data bank. The study covered 228 observations consisting of data on oil consumption, oil prices, exchange rate and national income, starting from January 2000 to December 2018 (2000M1 to 2018M12). The data on oil prices (West Texas Intermediate) and oil consumption (1,000 b/d) were extracted from OPEC annual statistical bulletin, whereas, exchange rate (national currency per US dollar, period average) and national income (gross domestic product in current US$) data were sourced from the IMF-IFS. All the data are expressed in their natural logarithmic form. Furthermore, data on oil consumption were originally annual frequencies, however, they were subsequently converted to monthly frequencies by adopting the quadratic match-sum process. The quadratic match-sum process is a useful procedure that converts low-frequency data sets to high-frequency series and permits amendments for seasonal deviations through dropping end-to-end data dispersions (Shahbaz et al. 2018; Uche and Nwamiri 2020; Sharif et al. 2020). Following the study of Liddle et al. (2020), we applied the non-linear autoregressive distributed lag model (NARDL). The model accounts for asymmetries in a relationship by decomposing the exogenous variable into its positive and negative partial sums. Oil consumption is the dependent variable, whereas, oil price, exchange rate and national income are the independent variables. Furthermore, the summary of the descriptive statistics is presented in Table 1 in the next section.

TABLE 1. Descriptive statistics

Description	OC	OP	EXR	GDP	OC	OP	EXR	GDP
		Algeria				Angola		
Mean	5.709	4.011	4.633	16.13	4.427	4.011	4.369	15.31
Std. Dev.	0.267	0.510	0.070	0.532	0.371	0.510	0.703	1.490
Skewness	-0.32	-0.283	1.310	-0.430	-0.039	-0.283	-1.445	-1.130
Kurtosis	1.794	1.860	4.260	1.787	2.125	1.860	5.688	3.391
		Nigeria				South Africa		
Mean	5.684	4.011	4.709	17.46	6.320	4.011	4.476	14.67
Std. Dev.	0.248	0.510	0.449	0.909	0.157	0.510	0.123	0.510
Skewness	0.394	-0.283	1.353	-0.467	-0.478	-0.283	-0.131	-0.281
Kurtosis	1.545	1.860	3.699	1.960	1.704	1.860	1.692	1.819
		Tunisia						
Mean	4.487	4.011	4.641	10.93				
Std. Dev.	0.063	0.510	0.137	0.387				
Skewness	1.964	-0.283	0.074	-0.154				
Kurtosis	7.012	1.860	2.367	1.738				

Note: The table presents the descriptive statistics of the dependent and the independent variables – OD (oil demand), OP (oil price), EXR (exchange rate) and GDP (income) of the five selected African countries. The variables are as earlier described.

MODEL SPECIFICATION

To give an empirical analysis of the dynamic relationship between oil consumption, the changing dynamics of crude oil price, exchange rate, and national income we present our model below.

$$loc_{jt} = f\,(lop_{jt}, lexr_{jt}, lgdp_{jt}) \quad (1)$$

where *loc, lop, lexr* and *lgdp* refers to logarithmic values of oil consumptions, oil prices, exchange rate and national income respectively of country j at different quarters t. *f* is a functional notation. To reveal both the long-run and short-run dynamics, we re-specify equation 1 to an error correction model following Pesaran, Shin and Smith (2001) ARDL bounds testing technique.

$$loc_{jt} = b_0 + b_1 lop_{jt} + b_2 lexr_{jt} + b_3 lgdp_{jt} + \varepsilon_t \quad (2)$$

Other variables are as described earlier with the inclusion of their natural logarithm values, the is the stochastic factor that takes care of other factors not included in the model. Our choice of variables is to conform economic theory's specification that the quantity of a product demanded is a function of income, price, but based on international interdependencies, the exchange rate of the local currency against the US dollars regularly affects such factors as energy and many other consumables (De Schryder et al. 2013). The empirical details of the above relationship are based on the Autoregressive Distributed Lag (ARDL) technique advanced by Pesaran and Shin (1998) and Pesaran et al. (2001). The model is preferred based on its capacity to simultaneously produce long- and short-run estimations. The model can accommodate fractionally integrated variables, and it can equally be applied even when the explanatory variables are endogenous (Peseran et al. 2001; Pal et al. 2015, 2016). The dynamic error correction linear ARDL model is provided as follows:

$$ln\Delta\gamma_t = \beta_0 + ln\beta_1\gamma_{t-1} + ln\beta_2 x_{t-1} + \sum_{i=1}^{n}\varphi_i ln\Delta\gamma_{t-i} + \sum_{i=0}^{n}\pi_1 ln\Delta x_{t-i} + \varepsilon_t \quad (3)$$

where γ_t is the dependent variable, x_t is the independent variable, Δ is difference operator, *ln* is the natural logarithm notation, while ε_t is the stochastic term. $\sum_{i=1}^{n}\varphi_i ln\Delta\gamma_{t-i}$ represents the short-run dynamics, $\beta_1\gamma_{t-1}$ represents the long-run equilibrium relationship.

Equation 3 is the typical ARDL model which we modify with our variables to form equation 4 presented as follows:

$$\Delta loc_t = \beta_0 + \beta_1 lod_{t-1} + \beta_2 lop_{t-1} + \beta_3 lexr_{t-1} + \beta_4 lgdp_{t-1} + \sum_{i=1}^{n}\varphi_i \Delta lod_{t-i} + \sum_{i=0}^{n}\pi_1 \Delta lop_{t-i} + \sum_{i=0}^{n}\pi_2 \Delta lexr_{t-i} + \sum_{i=0}^{n}\pi_3 \Delta lgdp_{t-i} + \varepsilon_t \quad (4)$$

The ARDL model (equation 4) is a linear model subsumed with the assumption of linearity and symmetric relationships between the variables, but several recent studies have shown that most economic fundamentals display non-linear (asymmetric) dynamics, equally economic variables are being affected by structural breaks (Shahbaz et al. 2018; Golit et al. 2019). Thus, we present the non-linear version of the ARDL tagged NARDL that can accommodate our hypothesis of asymmetry, the model is as specified in equation (5) below:

To begin, we present the long-run specification of the NARDL model as follows:

$$loc_t = \beta_0 + \beta_1 lop_t^+ + \beta_2 lop_t^- + \beta_3 lexr_t^+ + \beta_4 lexr_t^- + \beta_5 lgdp_t^+ + \beta_6 lgdp_t^- + \varepsilon_t \quad (5)$$

Where loc_t^+, lop_t^-, $lexr_t^+$, $lexr_t^-$, $lgdp_t^+$ and $lgdp_t^-$ are respectively the positive and negative partial sums of oil prices, exchange rate and output which we intend to confirm their differential effects on oil consumptions in each of the selected economy. The process to generate the partial sums of positive and negative changes illustrated by Shin et al. (2014) and many researchers including Bahmani-Oskooee and Mohammadian (2018), Meo et al. (2018), Shin et al. (2018), Uche (2019), Uche and Nwamiri (2020) is replicated in equations 6a, 6b, 7a, and 7b below:

$$lop_t^+ = \sum_{i=1}^{t} \Delta lop_t^+ = \sum_{i=1}^{t} \max\left(\Delta lop_i, 0\right) \quad (6a)$$

and

$$lop_t^- = \sum_{i=1}^{t} \Delta lop_t^- = \sum_{i=1}^{t} \min\left(\Delta lop_i, 0\right) \quad (6b)$$

$$lexr_t^+ = \sum_{i=1}^{t} \Delta lexr_t^+ = \sum_{i=1}^{t} \max\left(\Delta lexr_i, 0\right) \quad (7a)$$

and

$$lexr_t^- = \sum_{i=1}^{t} \Delta lexr_t^- = \sum_{i=1}^{t} \min\left(\Delta lexr_i, 0\right) \quad (7b)$$

$$lgdp_t^+ = \sum_{i=1}^{t} \Delta lgdp_t^+ = \sum_{i=1}^{t} \max\left(\Delta lgdp_i, 0\right) \quad (8a)$$

and

$$lgdp_t^- = \sum_{i=1}^{t} \Delta lgdp_t^- = \sum_{i=1}^{t} \min\left(\Delta lgdp_i, 0\right) \quad (8b)$$

Where $lop_t = lop_0 + lop_t^+ + lop_t^-$, $lexr_t = lexr_0 + lexr_t^+ + lexr_t^-$ and $lgdp_t = lgdp_0 + lgdp_t^+ + lgdp_t^-$.

From the above specifications, the long run coefficients of positive and negative partial sums of oil prices, exchange rate and output changes are respectively given as β_1, β_2, β_3 β_4, β_5 and β_6, while, β_0 is the coefficient of the dependent variable. For empirical estimation, we form the long run and short-run equations (9) in an NARDL setting as in Shin et al. (2014). That is,

$$\begin{aligned}\Delta loc_t = {} & \beta_0 + \beta_1 loc_{t-1} + \beta_2 lop_{t-1}^+ + \beta_3 lop_{t-1}^- \\ & + \beta_4 lexr_{t-1}^+ + \beta_5 lexr_{t-1}^- + \beta_6 lgdp_{t-1}^+ \\ & + \beta_7 lgdp_{t-1}^- + \sum_{i=1}^{n} \varphi_i \Delta loc_{t-i} \\ & + \sum_{i=0}^{n} (\theta_i^+ \Delta lop_{t-i}^+ + \theta_i^- \Delta lop_{t-i}^- \\ & \quad + \theta_i^+ \Delta lexr_{t-i}^+ + \theta_i^- \Delta lexr_{t-i}^- \\ & \quad + \theta_{II}^+ \Delta lgdp_{t-i}^+ + \theta_{II}^- \Delta lgdp_{t-i}^-) \\ & + \varepsilon_t \end{aligned} \quad (9)$$

Where n is the number of lag determined by AIC in this case, lag length of 2 is chosen, β_1, β_2, β_3, β_4, β_5, β_6 and β_7 are long-run coefficients including the positive and negative partial sums of exchange rate and income previously identified, β_0 is the coefficient of the independent variable. From equation (9) above, we derive the long- and short-run differentials impacts of oil price, exchange rates and income on oil consumptions in our selected African countries. The result representing equation (9) is summarized in Table-3 accordingly.

RESULTS AND DISCUSSIONS

To provide robust empirical analysis, we began with the descriptive statistics of individual variables, subsequently, the data series were subjected to stationarity test to avoid working with data that is differenced more than once, I(2) before achieving stationarity. As earlier highlighted, the ARDL and its extended versions, including the NARDL, requires that no variable in differenced more than once before it becomes stationary. However, the variable could be integrated of order-zero, I(0), order-one, I(1), or they could be a mixture of the two. After this, the empirical analysis proceeds with the test of long-run cointegration (bounds) test with the Wald F-statistic test. Thereafter, the analysis of short-run and long-run asymmetric analysis based on the NARDL specification follows suit. To validate the robustness of the estimated results, we subject the analyzed results to post estimation tests comprising of serial correlation test of Breusch-Godfrey serial correlation LM test, Heteroskedasticity test of ARCH, specification test of Ramsey RESET and stability test with the CUSUM and CUSUMSQ tests. For brevity, the CUSUM and CUSUMSQ graphs were added as attachment in the supplementary file.

Beginning with the exchange rate, Nigeria's local currency (the Naira) is the weakest with a mean value of 4.709, while the Angolan Kwanza is the strongest with a mean value of 4.369. The South African economy has the highest oil consumption level with a mean value of 6.320 compared with the lowest mean value of 4.427 recorded in Angola. The Nigeria economy has the highest national income (GDP) with mean value of 17.469 while the lowest income was observed in the Tunisia economy with a mean value of 10.933. Standard deviation value of 0.703 shows that Angola Kwanza is the most volatile, while the Algerian Dinar is the least volatile with mean of 0.070. Considering the spread, we discovered the predominance of non-zero skewness in all the variables, and across all the selected countries. The Kurtosis are mainly platykurtic in almost all the economies with the exception of one instance in Algeria, Nigeria, Tunisia, and two instances in Angola. The observed variations provide more incentives to probe for asymmetries in the response of oil consumption to the dynamics of global oil prices, exchange rates and income (GDP).

TABLE 2. Unit Root Tests

Country	Series	ADF Unit Root Test Statistics	Prob.	I(d)	Zivot-Andrew Unit Root Test Statistics	Prob.	I(d)	Break Point
Algeria	OC	-4.288	0.000	I(1)	-6.059	0.013	I(1)	2008M02
	OP	-7.043	0.000	I(1)	-7.362	0.018	I(1)	2015M02
	EXR	-4.567	0.000	I(1)	-6.155	0.009	I(1)	2003M10
	GDP	-4.857	0.000	I(1)	-5.268	0.007	I(1)	2008M03
Angola	OC	-4.288	0.000	I(1)	-6.059	0.013	I(1)	2008M02
	OP	-5.057	0.000	I(1)	-5.728	0.002	I(1)	2012M02
	EXR	-2.138	0.031	I(1)	-6.130	0.000	I(1)	2003M02
	GDP	-4.935	0.000	I(0)	-5.598	0.000	I(0)	2004M02
Nigeria	OC	-4.828	0.000	I(1)	-7.016	0.000	I(1)	2009M02
	OP	-4.288	0.000	I(1)	-6.059	0.013	I(1)	2008M02
	EXR	-12.45	0.000	I(1)	-12.78	0.045	I(1)	2015M11
	GDP	-3.443	0.010	I(0)	-5.704	0.030	I(1)	2006M03
South Africa	OC	-6.687	0.000	I(1)	-7.195	0.020	I(1)	2007M10
	OP	-4.288	0.000	I(1)	-6.059	0.013	I(1)	2008M02
	EXR	-4.625	0.000	I(1)	-6.129	0.032	I(1)	2010M11
	GDP	-3.808	0.003	I(0)	-5.259	0.005	I(1)	2018M02
Tunisia	OC	-4.2101	0.000	I(1)	-6.928	0.000	I(1)	2016M01
	OP	-4.288	0.000	I(1)	-6.059	0.013	I(1)	2008M02
	EXR	-3.880	0.002	I(1)	-6.816	0.000	I(1)	2015M10
	GDP	-4.354	0.000	I(1)	-5.258	0.025	I(1)	2008M01

Note: The table below summarizes the stationarity test of all the variables from the selected countries. I(1) and I(0) denote integration of order-one and order-zero respectively. OC, OP, EXR and GDP denote oil consumption, oil price, exchange rate and national income for each of the economies under investigation.

TABLE 3. NARDL results

	Algeria				Angola			
	Variables	Coefficient	t-Stat.	Prob.	Variable	Coefficient	t-Stat.	Prob.
Long-run:	C	0.181	2.301	0.022**	C	0.102	2.308	0.021**
	Oc	-0.034	-2.300	0.022**	Oc	-0.027	-2.597	0.010**
	Op+	-0.003	-0.676	0.499	Op+	0.005	0.414	0.678
	Op-	0.001	0.422	0.673	Op-	0.002	0.254	0.799
	Exr+	0.033	0.916	0.360	Exr+	-0.004	-0.342	0.732
	Exr-	-0.018	-1.124	0.262	Exr-	0.040	0.836	0.404
	GDP+	0.013	1.213	0.226	GDP+	0.009	0.926	0.355
	GDP-	-0.008	-0.412	0.680	GDP-	0.010	0.285	0.775
Short-run:	Δod(-1)	0.227	3.306	0.001***	Δoc(-1)	0.237	3.515	0.000***
	Δexr+	0.313	2.324	0.021**	Δoc(-2)	0.191	2.806	0.005***
	Δod(-2)	0.193	2.781	0.005***	Δoc(-3)	0.164	2.418	0.016**
	Δgdp_	0.892	7.031	0.000***	Δop+	-0.229	-1.880	0.061*
	Δop-	-0.273	-6.728	0.000***	Δexr+	0.172	1.3625	0.174
	Δoc(-3)	0.162	2.354	0.019**	Δop-	0.043	0.795	0.427
	Δoc-(-3)	0.076	1.694	0.091*				
	Δgdp-(-3)	-0.234	-1.694	0.091*				
	Δgdp-(-1)	-0.287	-2.020	0.044**				
	Δop-(-2)	0.084	1.855	0.065*				
	Δgdp-(-2)	-0.254	-1.790	0.075*				
	Δop-(-1)	0.098	2.157	0.032**				

cont.

cont.

		Nigeria				South Africa		
Long-run:	C	0.063	2.255	0.025	C	0.324	3.088	0.002***
	Oc	-0.009	-1.991	0.047	Oc	-0.054	-3.132	0.002***
	Op+	0.006	1.626	0.105	Op+	-0.004	-0.933	0.351
	Op-	0.004	1.008	0.314	Op-	0.001	0.850	0.396
	Exr+	0.003	0.728	0.467	Exr+	0.002	0.298	0.765
	Exr-	-0.037	-2.333	0.020**	Exr-	0.040	2.550	0.011**
	GDP+	-0.021	-3.141	0.001***	GDP+	0.054	2.514	0.012**
	GDP-	0.068	0.517	0.605	GDP-	0.419	2.515	0.012**
Short-run:	Δop+	0.317	11.864	0.000***	Δoc(-1)	0.225	3.344	0.001***
	Δgdp-	1.200	5.8894	0.000***	Δgdp+	2.030	8.483	0.000***
	Δoc(-1)	0.300	4.713	0.000***	Δexr-	0.477	7.354	0.000***
	Δgdp+	-0.394	-5.318	0.000***	Δoc(-2)	0.191	2.809	0.005***
	Δexr+	-0.090	-7.199	0.000***	Δgdp+(-2)	-0.510	-1.997	0.047**
	Δexr-	0.150	4.776	0.000***	Δexr-(-2)	-0.142	-2.040	0.042**
	Δop+(-1)	-0.119	-3.640	0.000***	Δoc(-3)	0.176	2.588	0.010**
	Δoc(-2)	0.212	3.646	0.000***	Δop+	-0.045	-1.959	0.051*
	Δop+(-2)	-0.066	-2.319	0.021**	Δexr+	0.087	1.970	0.050*
	Δexr+(-1)	0.033	2.640	0.009***	Δgdp+(-3)	-0.478	-1.941	0.053*
	Δop-(-2)	-0.060	-2.415	0.016**	Δexr-(-3)	-0.128	-1.891	0.060*
	Δop-	0.034	1.573	0.117	Δexr-(-1)	-0.155	-2.202	0.028**
	Δgdp+(-1)	0.134	1.756	0.080*	Δgdp+(-1)	-0.627	-2.418	0.016**
		Tunisia						
Long-run:	C	0.020	0.452	0.651				
	Oc	-0.005	-0.543	0.587				
	Op+	-0.003	-1.738	0.083*				
	Op-	-0.010	-3.933	0.000***				
	Exr+	-0.196	-3.720	0.000***				
	Exr-	-0.048	-2.768	0.006***				
	GDP+	-0.011	-1.916	0.056*				
	GDP-	0.003	0.075	0.939				
Short-run:	Δoc(-1)	-2.189	-16.462	0.000***				
	Δexr+	-0.095	-9.038	0.000***				
	Δoc(-2)	0.792	7.507	0.000***				
	Δgdp-	-0.770	-6.983	0.000***				
	Δop-	-0.093	-6.712	0.000***				
	Δoc(-3)	0.224	3.116	0.002***				
	Δop-(-3)	0.521	2.724	0.007***				
	Δgdp-(-3)	0.025	2.151	0.032**				
	Δgdp+	-0.210	-1.879	0.061*				
	Δgdp-(-1)	0.235	1.912	0.057*				
	Δop-(-2)	0.180	2.472	0.014**				
	Δgdp-(-2)	0.436	2.274	0.024**				
	Δexr+(-2)	0.021	1.841	0.067*				
	Δgdp-(-1)	0.149	2.040	0.042**				
	Δexr+(-1)	0.372	1.963	0.051*				

We present both short-run and long-run asymmetric effects of the independent variables on the dependent variable of all the countries in this table *, **, *** represents significant levels of 10%, 5% and 1% respectively, *Δ* is difference operator for the short-run relationships, + and – respectively represents positive and negative partial sums of the independent variables. OC, OP, EXR and GDP denote oil consumption, oil price, exchange rate and national income for each of the economies under investigation

TABLE 4. Long-run Cointegration (Bounds) Tests

Country	F-Statistic	Prob.	Summary
Algeria	1.224	0.295	Not cointegrated
Angola	1.716	0.118	Not cointegrated
Nigeria	2.635	0.017	Cointegrated
South Africa	3.357	0.002	Cointegrated
Tunisia	3.530	0.002	Cointegrated

Note: The F-satistics values were calculated by the bounds testing approach described by Pesaran et al, (2001) through the use of the Wald test procedure. The joint null hypothesis of no cointegration is $p = 0^+ = 0^- = 0$, moderating to this model, it becomes: c(2)=c(3)=c(4)=c(5)=c(6)=c(7)=c(8)=0.

TABLE 5. Asymmetric tests and robustness tests

Country		Relationship		
Algeria	Tests	Oc/Op	Oc/Exr	Oc/NI
	W_{LR}	Na	Na	Na
	W_{SR}	Na	Na	5.626***
B-G Serial LM: 2.190 (0.1146); Hetero. (ARCH): 0.0003 (0.9862); R-RESET: 0.064 (0.8001); Cusum/Cusumsq: S/S				
Angola	Tests	Oc/Op	Oc/Exr	Oc/NI
	W_{LR}	Na	Na	Na
	W_{SR}	4.077**	Na	Na
B-G Serial LM: 2.261 (0.1067); Hetero. (ARCH): 0.083 (0.9196); R-RESET: 0.239 (0.6249); Cusum/Cusumsq: S/U				
Nigeria	Tests	Oc/Op	Oc/Exr	Oc/NI
	W_{LR}	Na	2.196**	4.976***
	W_{SR}	6.901***	6.803***	10.093***
B-G Serial LM: 0.986 (0.374); Hetero. (ARCH): 0.239 (0.625); R-RESET: 0.064 (0.800); Cusum/Cusumsq: S/S				
South Africa	Tests	Oc/Op	Oc/Exr	Oc/NI
	W_{LR}	Na	4.234**	5.355***
	W_{SR}	Na	4.589***	2.453**
B-G Serial LM: 2.308 (0.102); Hetero. (ARCH): 0.038 (0.844); R-RESET: 34.127 (0.000); Cusum/Cusumsq: S/U				
Tunisia	Tests	Oc/Op	Oc/Exr	Oc/NI
	W_{LR}	2.136**	3.316***	5.355***
	W_{SR}	Na	8.132***	4.160***
B-G Serial LM: 2.466 (0.087); Hetero. (ARCH): 0.087 (0.767); R-RESET: 0.513 (0.608); Cusum/Cusumsq: S/U				

Note: The joint null hypothesis of no asymmetry is $-\theta^+/p = -\theta^-/p$: *, **, *** represents significant levels of 10%, 5% and 1% respectively. Oc/Op, Oc/Exr and Oc/NI denote the relationships between the dependent variable (Od - Oil consumption) and the independent variables (Op - Oil prices, EXR - Exchange rates and NI - National income) respectively. NW_{LR} and W_{SR} represents Wald long-run and short-run asymmetric tests respectively. **na:** indicates no asymmetry; B-G is Breusch-Godfrey, R-RESET stands for Ramsey RESET, while Hetero. stands for Heteroskedasticity test. Cusum/Cusumsq S/U indicate stable and unstable cumulative and cumulative square graphs which indicates model stability.

The stationarity tests conducted on each of the variables as presented in Table 2 above, reveals that none of the variables is integrated of order two I(2), rather we have a mixture of I(0) and I(1) in most of the countries. In most of the countries, we discover that income (GDP) becomes stationary at levels I(0), while every other variable became stationary after differencing once I(1). The presence of fractionally integrated variables makes the application of the NARDL possible for the present study.

The summary of long-run (Bounds) tests, long-run and short-run asymmetric tests and diagnostic tests are presented in the Table 5.

Our analysis began with the selection of optimal lag level based on AIC to ensure appropriate lag utilization. According to Bahmani-Oskooee and Bohl (2000), Stock and Watson (2012) and Meo et al. (2018), long-run relationships are mainly sensitive to optimal lags selection, the utilization of fewer lags does not capture some of the important information, while the utilization of more than necessary lags leads to lag over-fitting. Therefore, we use optimal lag of 3 based on AIC to give detail analysis. We present the long- and short-run results in Table 3, cointegration (bounds) tests based on Wald F-Statistics were reported in Table five, while test of asymmetry and post-estimation diagnostic tests are reported in table 5 accordingly. A long-run relationship exists among the variables in Nigeria, South Africa and Tunisia. However, long-run relationship was not established in the case of Algeria and Angola. The long-run and short-run results as presented in Table 3 was arrived through step-wise general-to-specific approach to ensure parsimonious results devoid of noisy outcomes. Moreover, exchange rate is expressed in a way that positive shock (Exr^+) and negative shock (Exr^-) represents a drop (depreciation) of the local currency and a rise (appreciation) of the local currency respectively.

Based on evidence from the Nonlinear ARDL analysis (Table-3) We discovered that, in the long-run, oil price shocks (positive and negative) do not significantly affect oil consumptions both in Algeria, Angola, Nigeria and South Africa. However, for Tunisia, both positive and negative shocks have a negative and significant impact on oil consumption. However, oil consumption levels in these countries remain positive in spite of the direction of oil prices (positive or negative). This implies that oil consumption in these countries are price inelastic. That is, the volume of oil consumption in these nations remain insensitive to oil price changes. This further highlights their level of oil intensities. Comparatively, 1% rise in oil prices results to -0.03% decline in oil consumption, whereas, oil consumption reduces by about -0.1% in response to oil price negative shock. This implies that oil consumption in Tunisia is more sensitive to falling oil prices. The evidence in the context of Tunisia corroborates the findings of Shin, Baek and Heo (2017) for the Korean energy demand. Considering the short-run effects, the effects of oil price deviations on oil consumptions are generally inconsistent in all the countries, raging between positive and negative effects. An immediate negative shock in oil prices gave rise to a significant reduction in oil consumptions, but with some lags. That is, the continuous shrink in oil prices gave rise to significant increases in oil consumption in all the countries. However, a significant reduction in the volume of oil consumption was witnessed in the short-run when oil price was rising, while a negative shock in the price of oil does not have a significant impact on the level of oil demand. The same outcome as witnessed with respect to long-run effects of oil price changes in Algeria and Angola was equally replicated in the economies of Nigeria and South Africa.

Expectedly, oil price changes have long-run asymmetric effects on oil consumption in Tunisia. Furthermore, oil price deviations affected oil consumption asymmetrically on in the short-run in Angola and Nigeria. However, oil price changes have neither long- nor short-run asymmetric effects on oil consumptions both in Algeria and South Africa. The post estimation tests presented in Table-5 provides more information on the robustness of the analysis. Accordingly, the estimates are free of serial autocorrelation and heteroscedasticity. They are equally stable as depicted by the Ramsey RESET test, and CUSUM and CUSUMSQ graphs.

Considering the effects of exchange rate deviations on consumption in the long-run in the selected African countries, the analysis (Table-5) in reveals that oil consumption in Algeria and Angola remained unchanged and insensitive to exchange rate deviations (appreciation and depreciation). This equally imply that oil consumption levels in the two countries are exchange rate inelastic in the long-run. In the context of Nigeria and South Africa, exchange rate depreciation has a positive but insignificant effect on oil consumption. This demonstrates that oil consumption in these two countries are insensitive to exchange rate depreciation. However, exchange rate appreciation of Nigeria's local currency has a significant but negative impacts on oil consumption. This aligns with the position of Ghoddusi et al. (2019) for the Iranian economy. However, appreciation of South Africa's Rand against the US dollar affects oil consumption positively and significantly. Specifically, 1% appreciation of the Nigeria's Naira results to -0.04% reduction in oil consumption, whereas, 1% appreciation of the South Africa's Rand results to about 0.04% increases in oil consumption. This connotes asymmetric effects in the relationship between exchange rate deviations and oil consumption in the nations. Furthermore, it goes to show the level of oil intensities in these two countries. Moreso, the level of development and advancement in South Africa as compared with Nigeria. The above finding is corroborative evidence to the study of Niyimbanira (2015). In Tunisia, oil consumption levels decline significantly in response to both exchange rate appreciation and depreciation, however, oil consumption shrinks more in response to exchange rate depreciations. That is, 1% positive deviation (depreciation) results to approximately -0.2% decline in oil consumption, whereas, exchange rate negative shock (appreciation) of equally proportion results to approximately -0.05% in oil consumption. This outcome clearly demonstrates asymmetry in the relationship between exchange rate deviations and oil consumption in Tunisia. It further reveals that oil consumption in Tunisia is more sensitive and declines more when the local currency (the Dinar) depreciates against the US dollar.

In terms of short-run effect, the impacts of exchange rate deviations (appreciation and depreciation) on oil consumption are equally inconsistent in all the countries. In most cases, positive and significant effects were recorded, while in some cases, the opposite case is recorded, and vice-versa. The test of asymmetry as presented in Table 5 reveals the prevalence of long-run (W_{LR}) and short-run (W_{SR}) asymmetric pass-through of exchange rate changes to oil consumption in Nigeria, South Africa and Tunisia. The implication of such asymmetric effects imply that policy guideline for in response to exchange rate appreciation may not apply for the effects of exchange rate depreciation, and vice-versa. It implies that different policy guidelines are needed to moderate the effects of positive and negative deviations. On the contrary, the exchange rate has no asymmetric effects on oil consumption in Algeria and Angola both in long- and short-run. The post estimation tests presented in Table-5 provides more information on the robustness of the analysis. Accordingly, the estimates are free of serial autocorrelation and heteroscedasticity. They are equally stable as depicted by the Ramsey RESET test, and CUSUM and CUSUMSQ graphs.

Algeria and Angola economies are unique and similar in the long-run, and reactions to both positive and negative deviation in income levels. Neither economic prosperities nor economic adversaries gave rise to any significant changes in the levels of oil consumptions in the long-run. Equally, in the short-run, neither economic growth nor slump had any significant effect on oil consumption in Angola, whereas in Algeria, the effects of immediate short-run positive shock in income lead to a significant increase in the level of oil consumption, but with some time lags, the continuous growth leads to some significant reductions in oil consumptions. None of such was established in moments of economic prosperities. In South Africa, a 1% increase in national income gave rise to 0.05% significant increases in oil consumption as against the whopping 0.42% increases in oil consumption when national income declines. The increased oil consumption volume recorded when national income shrinks in South Africa imply that drastic efforts are made to push the economy on the part of recovery, leading to the demand of more volumes of oil. It further demonstrates the country's heavy dependence on oil for industrial and domestic uses. It equally points to the prevalence of asymmetry in the relationship between oil consumption and income in South Africa. The dynamics of oil consumption and income are similar in Nigeria and Tunisia. Specifically, 1% increase in national income in Nigeria and Tunisia gave rise to approximately 0.02% and 0.01% significant reductions in oil consumption levels respectively, whereas economic down-turn of equal proportions do not have any significant effects on oil consumption levels in the two countries. The above evidence corroborates the findings of Arac and Hasanov (2014) for the Korean economy. Considering the short-term effects of rising and falling national income on oil consumptions in Nigeria, immediate fall in national income leads to a significant increase in oil consumption as against the reduction in oil consumption levels occasioned by an immediate increase in income.

Considering the short-run effects, in South Africa, a contemporaneous increase in national income lead to a significant rise in oil consumptions, but such a rise was gradually reduced with the passage of some few months. Falling national income did not give rise to any significant change in the level of oil consumption in South Africa in the short-run. With respect to Tunisian economy, a percentage rise in GDP resulted to 0.21% decline in oil consumption, while a rise in GDP of equal magnitude gave rise to about 0.77% reduction in oil consumption levels. This equally suggests the existence of asymmetry.

To confirm if the effects of national income deviations on oil consumption are asymmetric in the selected African nations, we carried out asymmetric test using the Wald test procedure (Table-5). The evidence indicates that both long-run (W_{LR}) and short-run (W_{SR}) asymmetries exist in the relationship between national income (GDP) and oil consumption in Nigeria, South Africa and Tunisia. In the case of Algeria, only short-run (W_{SR}) asymmetry exists between economic growth and oil consumption. *This implies that the positive changes could not offset the effects of the negative changes, and vice-versa.* Whereas in Angola, income deviations have no asymmetric effects on oil consumptions. The post estimation tests presented in Table-5 provides more information on the robustness of the analysis. The estimates are free of serial autocorrelation and heteroscedasticity and stable.

CONCLUSIONS

The study took a holistic approach to examine, simultaneously, the possibility of non-linear and asymmetry effects of the dynamics of global oil prices, exchanges rates deviations and the national income on oil consumption in each of the selected African countries. The selected African counties are among the top ten African Emerging Economies. Among the five countries, Nigeria, Angola and Algeria are net oil exporters while South Africa and Tunisia are net importers. The empirical analysis was based on monthly time series data between January, 2000 to December, 2018 (2000M1 – 2018M12). This gives a total of 228 observations consisting of data on oil consumption, oil prices, exchange rate and national income. The empirical analysis was conducted with a nonlinear model. The trace of asymmetry was premised on the fact that if it exists, its negligence, may be, due to lack of information about it, might lead to overwhelming welfare losses. To guide against such, the study applied the NARDL model due to its capacity to trace asymmetry both in the long- and in the short-run, and the flexibility of its application much unlike most traditional nonlinear models.

The empirical analysis reveals that, with the exception of Angola, exchange rates and income affected oil consumption asymmetrically in the selected African countries. However, short-run asymmetric effects were equally recorded between oil prices and oil consumption in Angola. Furthermore, the study equally discovered a short-run asymmetric pass-through of oil price changes to oil consumption in Nigeria, and a long-run asymmetric effect of oil prices in South Africa. Equally, in Nigeria and Tunisia, oil consumptions declines significantly in moments of rising national income, whereas, in South Africa, oil consumption increased in both moments of economic prosperity and adversaries. This goes to show the level oil intensity in South Africa. Furthermore, appreciation of Nigeria's local currency leads to a significant decline in oil consumptions, while a similar effect (appreciation of local currency) in South Africa resulted in significant increases in oil consumption. Accordingly, exchange rates depreciation of equal proportions in both nations do not have any significant impact on oil consumptions. Both appreciation and depreciation of the Tunisia currency and increased income lead to significant reductions in oil consumptions with the greatest reduction emanating from appreciation of the Tunisian Dinar against the US dollars.

Conclusively, policy formulations with respect to oil consumption, oil prices, exchange rate and national income in Nigeria, South Africa and Tunisia should take into consideration the existence of asymmetries. This is to avoid general welfare losses that could follow such nonlinear effects. As regards Algeria and Angola, asymmetry was only visible in the short-run emanating from changes in national income and exchange rate dynamics respectively. It is equally necessary to ensure that such short-run asymmetric effects are not neglected. Overall, the discoveries made by this study are critical for robust policy formulations and to abate general welfare losses in these African economies. The findings herewith, will equally be useful in some other economies that have similar economic conditions and structures with the selected African nations.

However, we observed that the CUSUMSQ graphs in Angola, South Africa and Tunisia were unstable. On this ground, there is a need to account for the effects of structural breaks in the dynamic relationship between oil consumption and its determinants.

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