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Research Article

The Asymmetric Effects of Oil Price Shocks on Aggregate Demand for Goods and Services in Ghana

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Procyclicality has been discovered in crude oil price shocks on aggregate demand. Most studies have used linear estimation techniques, resulting in the loss of asymmetric correlations. We disaggregate the impact of changes in oil prices into positive and negative shocks on aggregate demand and its components from 1970 to 2015 using the nonlinear ARDL framework. The results show that oil price shocks in Ghana have a long-term beneficial asymmetric impact on aggregate demand and its components. Specifically, a positive change in oil price (0.230) has a greater positive effect on the aggregate demand than a negative effect (-0.009) emanating from a negative change in the oil price shock. Further, the same result was obtained for the components of the aggregate demand with the impact on investment expenditures (0.662) being the greatest. Policymakers should diversify energy demand according to our recommendations. Instead of exporting crude oil, officials should encourage its refinement and consumption. Lastly, we suggest that policymakers hedge and use price-smoothing strategies to reduce oil price volatility.

1. Introduction

Oil price shocks have supply-side, demand-side and terms-of-trade effects on aggregate demand [1, 2]. For oil-importing countries, price increases are expected to drive adverse effects on their economies. The terms of trade effect of oil price shock are transmitted through the transfer of wealth from oil-importing to oil-exporting countries [2–4].

Since Hamilton's [5] influential paper, there has been a mixed of findings on the asymmetric impacts of oil prices on the macroeconomy. The main characteristics of these analyses are mostly applicable to industrialized oil-importing countries. Mork [6], Hamilton [7], and Moshiri [8], among others, have derived positive and negative oil price disturbances independently.

In this study, we focus on Ghana, one of the few developing oil-exporting economies in sub-Saharan Africa that has not been extensively studied in terms of the impact of oil price shocks on its economy in the nonlinear framework (see [9]). Historically, Ghana has been overdependent on crude and refined oil to generate electricity and fuel to support residential, industrial, transportation, and other important sectors of the economy. Ghana's oil find is modest by global standards and, as such, unlikely to deliver an economic transformation of the nonoil sectors in the long term. Oil is still expected to have a big impact on the economy's growth and development, as long as politicians do not act like rent-seekers and waste oil revenue [10, 11].

Ghana has been classified as a net exporter of crude oil since it began producing it, with all anticipated windfalls in foreign exchange reserves from oil revenues and corporate taxes on upstream to downstream companies. Oil revenues were expected to spur infrastructure development, crowd-in private sector investment, create jobs, and boost aggregate output overall [12]. However, these expectations are based on the continuation of global oil price increases. The movement in crude oil prices has implications for Ghana's fiscal resources as it is both an importer and exporter of oil. Oil prices rose from an average of US $80 in 2010 to US $110 in 2013, propelling the Ghanaian economy to grow at a rate ranging from 7.3% to 15%. However, with an average oil price of $99 per barrel in 2014, the economy grew by only 4.2 percent [13]. The average price of the commodity in 2019 and 2020 was US$56.99 and US$39.68, respectively, with the Ghanaian economy adjusting at a real growth rate of 6.5 percent and 0.88 percent. Oil price rises in the 2021 COVID-19 era have also slowed the expected recovery in growth. Ghana, like many small oil-dependent economies, has experienced high uncertainties in economic growth rates and fiscal consolidation. Thus, oil price declines and their effects on Ghana's fiscal management and macroeconomic stability serve as illustrative examples of the economic disruptions that oil price shocks could cause. So, it is very important to look into the common occurrence of oil price changes and how they affect Ghana's aggregate demand.

A rise in oil prices affects Ghana's aggregate demand through aggregate production of goods and services by reducing the amount of energy needed as an input in the production. This is known as the "real effect" of oil price shocks. In addition, as oil prices rise, it causes a transfer of wealth from Ghana to exporting countries. The reduction in wealth or income causes consumers to hold back on their consumption expenditure, which will depress aggregate demand and output. However, the net effect will depend on the magnitude of goods and services imported by the oil-exporting countries from Ghana. Finally, the effect of an oil price increase or decrease on the aggregate demand of Ghana emanates from the policies taken to respond to the oil price increase or decrease. Specifically, to reduce the effect of oil price increases in recent times so as to pursue macroeconomic stability, the Bank of Ghana pursues contractionary monetary policy, which has the potential to reduce real activity.

Based on the above background, the overall objective of the study is to investigate the asymmetric impact of oil price shocks on aggregate demand. Specifically, we estimate the long-and short-run nonlinear asymmetric impact of oil price disturbances on aggregate demand and examine the cumulative dynamic long-run adjustment path of aggregate demand to exogenous oil price disturbances for the Ghanaian economy. The aggregate demand variable is further disaggregated, and the long-and short-run nonlinear asymmetric impacts of oil price shocks are estimated. A nonlinear asymmetric relationship permits the investigation of the effects of shocks in oil prices on aggregate demand variables without recourse to whether the data generating process is linear or not. According to Dramani and Frimpong [14], there is a high probability of an asymmetric relationship between oil price shocks and macroeconomic variables for the following reasons: First, since Ghana exports and imports crude oil, both favorable and unfavorable shocks can lead to variant effects on aggregate demand. Second, an increase in external oil prices usually has a meaningful pass-through effect on domestic prices compared with a decrease in crude oil prices. Finally, disaggregated demand responds to oil price shocks in different ways since they reflect the behavior of different economic agents.

Based on the potential presence of an asymmetric relationship between oil price shocks and macroeconomic aggregates in Ghana, we contribute to the existing body of knowledge in a number of ways. To begin, we categorize oil price shocks as positive or negative (asymmetric) shocks in order to determine which price shocks have a greater impact on the macroeconomy. The findings suggest a potential policy space for Ghana's economy to model an insulator against specific price shocks. Second, there are virtually no studies on the asymmetric effects of oil price changes on total demand in Ghana. Four related studies [15–18] assumed that oil price shocks had linear and symmetric effects on Ghana's economy. According to Hamilton [5], this assumption is dubious. To our knowledge, this is the first study in Ghana to study the relationship between oil price shocks and aggregate demand using the nonlinear ARDL framework. Though Nchor et al. [16] examined oil price shocks on the economy, it used a vector error correction model (VECM) approach, which is a linear form model. In this study, both the positive and negative shocks are evaluated in a unified nonlinear framework. Additionally, Jumah and Pastuszyn [15] did their study before Ghana became a crude oil exporter. Other studies have focused on macroeconomic stability and oil price shocks in Ghana (see [14]). Third, we decompose aggregate demand into four expenditure components (household final consumption, private investment, government spending, and imports) in order to assess the impact of oil price shocks on each. This is not the case in Nchor et al. [16]. Fourth, despite the extensive literature on the impact of oil price volatility on economic aggregates, most of it focuses on developed countries, leaving developing countries like Ghana out.

The rest of the study is organized as follows. Section 2 reviews the related literature. Section 3 presents the methodology and describes the data used for the study. Section 4 presents and discusses the results, while Section 5 gives the conclusion and policy recommendations.

2. Related Literature

The majority of studies, including Kilian [19], Chuk [20], Morana [21], Kilian and Murphy [22], and Lorusso and Pieroni [23, 24], identified three mechanisms through which increases in oil prices affect macroeconomic aggregates. These are the aggregate demand and supply channels, as well as the interest rate channel. Oil prices, like the prices of any other commodity, are influenced by demand and supply shocks. As a result, the macroeconomic consequences of oil price volatility vary according to the underlying source of the price disturbance and the country's status as a net importer or exporter. For example, price increases caused by oil supply shocks will result in a decline in output, whereas price increases caused by a boom in global economic activity will result in an increase in output.

2.1. Supply-Side Shocks. Oil supply shocks are determined by the physical quantity of oil available for sale and the unpredictability of future supply and production capacity. Constraints on crude oil production in the face of rising demand exacerbate crude oil prices [25–27]. The supply of oil is determined by macroeconomic conditions. Changes in oil supply can occur as a result of production disruptions caused by geopolitical upheavals or as a result of production rigidity caused by Organization of Petroleum Exporting Countries- (OPEC-) imposed production quotas on member countries since 1973. In 2008, OPEC controlled roughly 45 percent of global oil supply, giving it greater influence over global oil supply and prices [28]. Additionally, the authors noted that government energy policy, tax policy, and technological factors all have a significant impact on oil supply. In March 2020, supply-side shocks to crude oil prices resulted from Saudi Arabia's and Russia's supply-side price wars. As a result, there was an oversupply of crude, resulting in an unprecedented collapse in crude oil future prices.

2.2. Demand-Side Shocks. Demand for oil shocks is triggered by global economic instabilities and the unpredictability associated with unanticipated changes in crude oil demand. Global economic expansion drives up energy demand, which is hampered by stagnant supply. Crude oil is a critical raw material in the manufacturing process. Thus, changes in the business cycle, which are linked to global economic expansion and contraction, result in changes in oil prices [29, 30]. Global economic expansion increases energy demand and, consequently, oil prices, whereas economic contraction reduces oil demand and drives oil prices lower. Barky and Kilian [31] identified oil demand as a significant driver of the real price of oil to this end. In the year 2020, crude oil prices plummeted to negative levels due to low demand during the COVID-19 pandemic, as governments closed borders and businesses closed.

2.3. Interest Rate Shock. According to Segal [32], oil price shocks cause distortions. Monetary policy can only affect nominal GDP growth because it does not directly control all economic aggregates. Effective monetary policy can influence either nominal GDP growth or inflation, but not both. Thus, inflation-targeting central banks may want to tighten monetary policy (increase interest rates) to contain the inflationary effects of oil price shocks. This may cause a decline in real GDP or a lag in potential GDP growth.

Some recent research has examined the asymmetric effects of oil price shocks on aggregate and disaggregated demand. Among the recent examples are Iwayemi and Fowowe [4] and Gómez-Loscos et al. [33]. The various points of view expressed by authors in existing studies are primarily attributed to the inadequacy of the linear framework used. Mork [6] contends that examining the effect of crude oil price shocks on total demand necessitates distinguishing between increases and decreases in oil price shocks. More recently, some studies have revealed an asymmetric relationship between oil prices and output in OECD countries [34, 35]. Cunado [36] and Rafiq et al. [37] investigated the effects of oil price volatility on important macroeconomic aggregates and discovered that the relationship between oil prices and major macroeconomic variables is a short-run phenomenon. The assumption of a linear or symmetrical relationship between oil price shocks and aggregate demand is very restrictive because; in many cases, the relationship between oil price volatility and aggregate demand variables is potentially more asymmetric than symmetric.

Kilian and Park [38] used nonlinear and linear VAR to assess the impact of oil price changes on the exchange rate and real GDP. Positive oil price shocks outperformed negative shocks in terms of statistical significance. This shows that the effect of the oil price is asymmetrical and that a decrease in the oil price had no significant effect on output. According to Mehrara [39], Ahmed and Wadul [40], and Rafiq and Bloch [41], oil price fluctuations have varying impacts on major macroeconomic variables like GDP. The rate at which rising oil prices affect macroeconomic variables differs from falling crude oil prices. Most of the research finds that oil price fluctuations have no significant impact on all sectors of the economy equally and that economic aggregates' responsiveness is asymmetric. Because rising oil prices harm oil-importing countries while benefiting oil-exporting countries, we expect sensitive economic variables to respond differently in these oil-dependent countries. For Lee et al. [42] and Jimenez-Rodriquez and Sánchez [43], we must consider the magnitude, sign, and business cycle of the correlation between oil price instability and economic aggregates. The unexpected drop in crude oil prices from mid-2014 to mid-2015 was linked to monetary policy. On this basis, Kose and Bainmaganbetov [44] show that stabilizing monetary policies respond to oil price shocks with expansionary monetary policies (reducing interest rates and increasing exports). However, monetary authorities do not directly control all aggregate demand components, which may lead to output stabilization.

Nchor et al. [16] employed the VECM estimator to examine the dynamic connection between positive and negative oil price unpredictability and macroeconomic variables. The authors concluded that the oil price dynamics has both symmetric and asymmetric effects on macroeconomic variables, such as government expenditure, inflation, real imports, and the exchange rate in Ghana, and that the effect of an increase in the oil price has a stronger magnitude than the negative effect. This current study focuses on aggregate demand and its expenditure components in a nonlinear autoregressive distributed lagged (NARDL) framework, which is superior to the VECM approach.

3. Methodology

3.1. Modeling Asymmetries. Numerous econometric strategies have been used to model the relationship between oil price shocks and aggregate demand. Markov switching, generalized autoregressive conditional heteroscedasticity (GARCH), structural vector autoregression (SVAR), and cointegration are just a few of the techniques available.

In this study, we consider the asymmetric NARDL model recently developed by Shin et al. [45], which excels at modeling nonlinearities and asymmetries simultaneously

Table 1: Dynamic asymmetric estimation of disaggregated aggregate demand and oil price shocks (final specifications).

	Model 1 (GDP)	Model 2 (CON)	Model 3 (PINV)	Model 4 (GOV)	Model 5 (IMP)
Y_{t-1}	-0.319**	-0.989*	-0.219	-0.185	-0.891***
	(0.102)	(0.359)	(0.154)	(0.110)	(0.230)
OPS^{+}_{t-1}	0.0733**	0.163*	0.145	0.0965	0.288**
	(0.0239)	(0.0731)	(0.0949)	(0.0588)	(0.101)
OPS^{-}_{t-1}	0.00292	-0.0963*	-0.0188	0.00532	0.106
	(0.0159)	(0.0446)	(0.0761)	(0.0449)	(0.0949)
ΔY_t	0.151	0.219	-0.294	0.0519	0.307
	(0.172)	(0.244)	(0.186)	(0.182)	(0.168)
$\Delta \text{OPS}^{+}_{t}$	-0.0191	0.200	0.261	-0.000468	0.518*
	(0.0414)	(0.129)	(0.253)	(0.140)	(0.238)
$\Delta \text{OPS}^{+}_{t-1}$	-0.0800**	0.0164	0.125	0.0430	0.157
	(0.0248)	(0.0776)	(0.156)	(0.0894)	(0.134)
$\Delta \text{OPS}^{-}_{t-2}$	-0.0719	0.0280	-0.265	-0.301*	-0.390*
	(0.0385)	(0.0892)	(0.251)	(0.136)	(0.185)
$\Delta \text{OPS}^{-}_{t-3}$	-0.0353	0.166	-0.678*	-0.0127	0.0926
	(0.0397)	(0.0852)	(0.255)	(0.144)	(0.194)
LRM2	0.119**	0.185*			0.571*
	(0.0414)	(0.0790)			(0.214)
FB					-0.0252*
					(0.0120)
Constant	4.636**	17.97*	4.088	3.542	6.464*
	(1.628)	(6.719)	(3.012)	(2.192)	(2.886)
R -sq.	0.739	0.577	0.595	0.444	0.654
Adj. R -sq.	0.582	0.323	0.376	0.145	0.424
AIC	-159.0	-90.72	-8.225	-52.06	-31.26
BIC	-131.6	-63.30	17.48	-26.36	-2.132
F	4.714	2.274	2.724	1.485	2.839
Obs.	41	41	41	41	41

Standard errors in parentheses, $^{*}p < 0.05$ and $^{***}p < 0.001$. Y_t represents the dependent variable in each case.

for both short- and long-run cointegrating systems. The NARDL model is regarded as an extension of the widely used linear ARDL model [46, 47]. Additional justifications for using the NARDL framework include the following: First, its flexibility and simplicity make it possible to model the complex and common phenomenon of shifts in asymmetry direction between short-run and long-run. Second, unlike other error correction models, which can distinguish between only short-run and long-run asymmetry, the NARDL model can observe the path of asymmetric adjustments to long-run equilibrium. Third, it allows the model specification to include a mix of variables integrated of order 0 (I(0)) and order 1 (I(1)). Fourth, with the choice of appropriate lag orders and correct specification, the NARDL purges itself from residual serial correlations and perfectly deals with weak endogeneity of all independent variables. This is because it possesses the desirable characteristics of the ARDL-based dynamic corrections. The data structure used in this study is best supported by the intuitive flexibility of the NARDL.

3.2. Empirical NARDL Model of Oil Price Shocks on Aggregate Demand. In this study, we model the impact of oil price shocks on aggregate demand and its components in Ghana using Shin et al.'s [45] NARDL described in the Appendix. We include other control variables to capture the transmission channels of oil price shocks. Following the specifications provided by Shin et al. [45] in equation (A.1) in the Appendix, we posit the following empirical asymmetric cointegrating (long-run) relationships in

$$Y_t = \beta^{+}\text{OPS}^{+}_{t} + \beta^{-}\text{OPS}^{-}_{t} + +\tau'\text{MPV}_t + u_t, \quad (1)$$

where Y_t is a measure of aggregate demand in real terms. We use real GDP and its disaggregated components (household final consumption expenditure (CONS), investment expenditure (PINV), government expenditure (GOV), and imports (IMP)) to measure aggregate demand. OPS is the measure of exogenous oil price shocks decomposed into

Table 2: Asymmetric statistics for disaggregated components of aggregate demand and oil price.

Statistics	Model 1 (GDP)	Model 2 (CONS)	Model 3 (PINV)	Model 4 (GOV)	Model 5 (IMP)
L^{+}_{OPS}	0.230***	0.165***	0.662*	0.521**	0.323***
f -stat	(37.94)	(33.35)	(3.456)	(4.953)	(20.57)
L^{-}_{OPS}	-0.009	0.097	0.086	-0.029	-0.119
f -stat	(0.0344)	(6.687)**	(0.062)	(0.014)	(1.64)
W_{LR}	21.15*** (0.000)	57.95*** (0.000)	11.12*** (0.003)	13.42*** (0.001)	3.902* (0.060)
W_{SR}	0.2456 (0.624)	0.0517 (0.822)	0.8006 (0.379)	0.9207 (0.346)	2.623 (0.118)
F_{PSS}	3.5523*	2.8230	2.3837	2.4181	5.5922**
CHSQ-SC	18.9 (0.3983)	16.4 (0.5644)	22.13 (0.2261)	18.48 (0.4242)	18.19 (0.4434)
CHSQ-HET	1.324 (0.2498)	0.271 (0.6026)	0.03575 (0.8500)	2.6 (0.1069)	4.824 (0.0281)
CHISQ-FF	1.421 (0.2633)	0.2755 (0.8424)	2.726 (0.0675)	1.179 (0.3395)	3.917 (0.0229)
CHSQ-NOR	0.9189 (0.6316)	(0.03676 (0.9818)	0.753 (0.6863)	0.3033 (0.8593)	0.1477 (0.9288)

NOTES: L^{+}_{OPS} and L^{-}_{OPS} represent the long-run coefficients associated with positive and negative price shocks, respectively. W_{LR} and W_{SR} represent the Wald test for long-run symmetry and short-run symmetry, respectively. Pesaran et al. [41] 5% critical values for F_{PSS} are -3.23 and 4.35 for $k = 3$ and $k = 2$, respectively.

negative and positive partial sums of price falls and rises, which is $\mathrm{OPS}_t = \mathrm{OPS}_0 + \mathrm{OPS}^{+}_t + \mathrm{OPS}^{-}_t$ with OPS_0 is initial value. MPV is a vector of selected exogenous macroeconomic control variables, such as official exchange rates (NEXR), real broad monetary supply (M2), and fiscal balance (FB). All variables are log-transformed, except fiscal balance, which contains negative values. Official exchange rates are also not log-transformed. All parameters and notations are already defined in equation (A.1) in the Appendix.

From equation (1), we develop the following nonlinear asymmetric ARDL model following equation (A.2) in the Appendix:

$$\begin{aligned}\Delta y_t &= \alpha_0 + \alpha_1 y_{t-1} + \phi^{+}\mathrm{OPS}^{+}_{t-1} + \phi^{-}\mathrm{OPS}^{-}_{t-1} + \phi_{w,i}\mathrm{MPV}_{t-i} \\ &\quad + \sum_{i=1}^{p-1}\psi_i \Delta y_{t-i} + \sum_{i=0}^{q-1}\left(\theta^{+}_i \Delta\mathrm{OPS}^{+}_{t-i} + \theta^{-}_i \Delta\mathrm{OPS}^{-}_{t-i} + \theta_{w,i}\mathrm{MPV}_{t-i}\right) + \varepsilon_t,\end{aligned} \tag{2}$$

where in equation (1), $\beta^{+} = -\phi^{+}/\alpha_1$ and $\beta^{-} = -\phi^{-}/\alpha_1$ and all notations are defined in the Appendix under equation (a2).

Following the four steps outlined by Shin et al. [45] (see Appendix), we first estimate equation (2) by the standard OLS (see results in Table 1). Second, we tested the null hypothesis $(\alpha_1 = \phi^{+} = \phi^{-})$ of no long-run relationship between the levels of Y_t, $\mathrm{OPS}_t{}^{+}$, and OPS^{-}_t through the use of the bounds testing F_{PSS} statistics. Third, using the standard Wald statistics, we tested for long-run reaction symmetry, where $(\beta^{+} = \beta^{-})$, and short-run adjustment symmetry in which $(\theta^{+}_i = \theta^{-}_i)$ for all cases where $i = 1, 2, 3, \cdots, q-1$ (see Table 2). We finally derive the asymmetric cumulative dynamic multiplier effects of a unit shock to both $\mathrm{OPS}_t{}^{+}$ and OPS^{-}_t on Y_t. See nomenclature below for the description of the variables.

The results are presented in Tables 1 and 2. The analysis is repeated by replacing the real GDP variable with the selected disaggregated components as dependent variables.

3.3. Data Presentation and Analysis. Aggregate demand refers to the total demand for goods and services in Ghana. Available time series statistics from the World Bank's World Development Indicators, OPEC statistical database, IMF International Financial Statistics (IFS), and the United Nations national income statistics for the period 1970 to 2015 are used for the analysis. The annual data used include the average crude oil price of the Organization of Petroleum Exporting Countries (OPEC), the official exchange rate, the real broad money supply (M2), and the real GDP and the components of the disaggregated expenditure of the national accounts. The time period and the variables included were constrained by the available disaggregated data for the expenditure components. The summary statistics of the variables are provided in Table 3.

4. Results and Discussions

4.1. Time Series Properties of the Data. We employ the augmented Dickey-Fuller (ADF) unit root test to check the time series properties of the data to ascertain the order of integration of the variables. This is important because NARDL is only applicable if the series are a mixture of I(0) and I(1) but not I(2). We also used the time-series plots to provide a qualitative view of our time series data. The time series plots (Figures 1 and 2) of the level variables and first difference variables show that they are mean-reverting after the first differencing, except for the official exchange rate. From Table 4, the variables are a mix of I(0) and I(1). Therefore, it is appropriate to use the NARDL framework by Shin et al.

Table 3: Descriptive statistics.

Variable	Mean	St.dev	Skewness	Kurtosis	Min	Max
LGDP	23.1331	0.5185	0.6900	2.2429	22.5215	24.2341
LCONS	22.9116	0.4675	0.4742	1.8007	22.2958	23.7608
LGOV	21.1530	0.5566	0.7754	3.1062	20.3081	22.4176
LPINV	21.4903	0.7114	0.8079	2.6643	20.4946	23.0556
LIMP	22.1518	0.7554	0.5839	2.4284	20.9467	23.7015
LROP	3.5646	0.6648	0.5889	3.0420	1.8058	4.5357
LRM2	21.0756	0.7606	0.3898	2.0428	19.7841	22.6018
FB	-6.0461	3.0606	0.1888	2.8799	-11.5000	1.7000
NEXR	0.5149	0.8192	2.0783	7.4477	0.0001	3.7115

Variables nomenclature: *LGDP* denotes log *GDP*, *LCONS* means log consumption expenditure, *LGOV* denotes log of government expenditure, *LPINV* denotes log investment expenditure, *LIMP* denotes the log of imports expenditure, *LROP* is log of real oil price, *LRM2* means log real broad money supply, *FB* means fiscal balance, and *NEXR* is the official exchange rate.

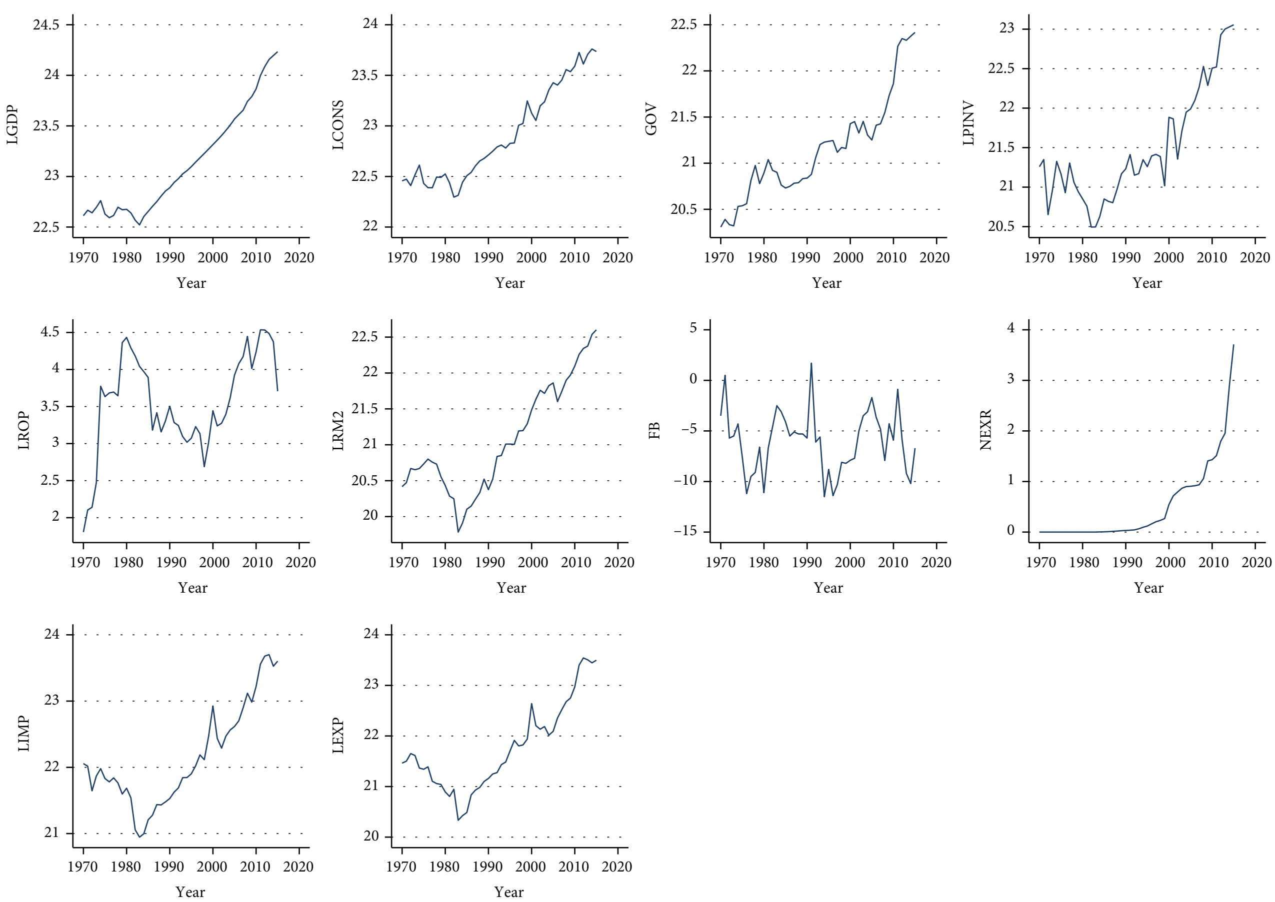

Figure 1: Behavior of time series plots of the variables when they are at same levels.

[45] to examine the long-run and short-run asymmetric relationships among the variables of interest.

Aggregate demand is proxied by real GDP, and real oil price changes are decomposed into positive and negative changes. We include the real money supply, fiscal balance, and official exchange rate as exogenous controls to capture monetary policy as well as fiscal and international price pass-through effects.

4.2. Asymmetry Impact of Oil Price Shock on Aggregate Demand and Expenditure Components. We estimated the NARDL model to assess the asymmetric effects of oil price shocks on aggregate demand and selected expenditure components. The estimations were done using a general-to-specific approach with the help of the minimized Bayesian Information Criteria (BIC) and to select the best-fit NARDL models for further analysis. The results presented in Table 1

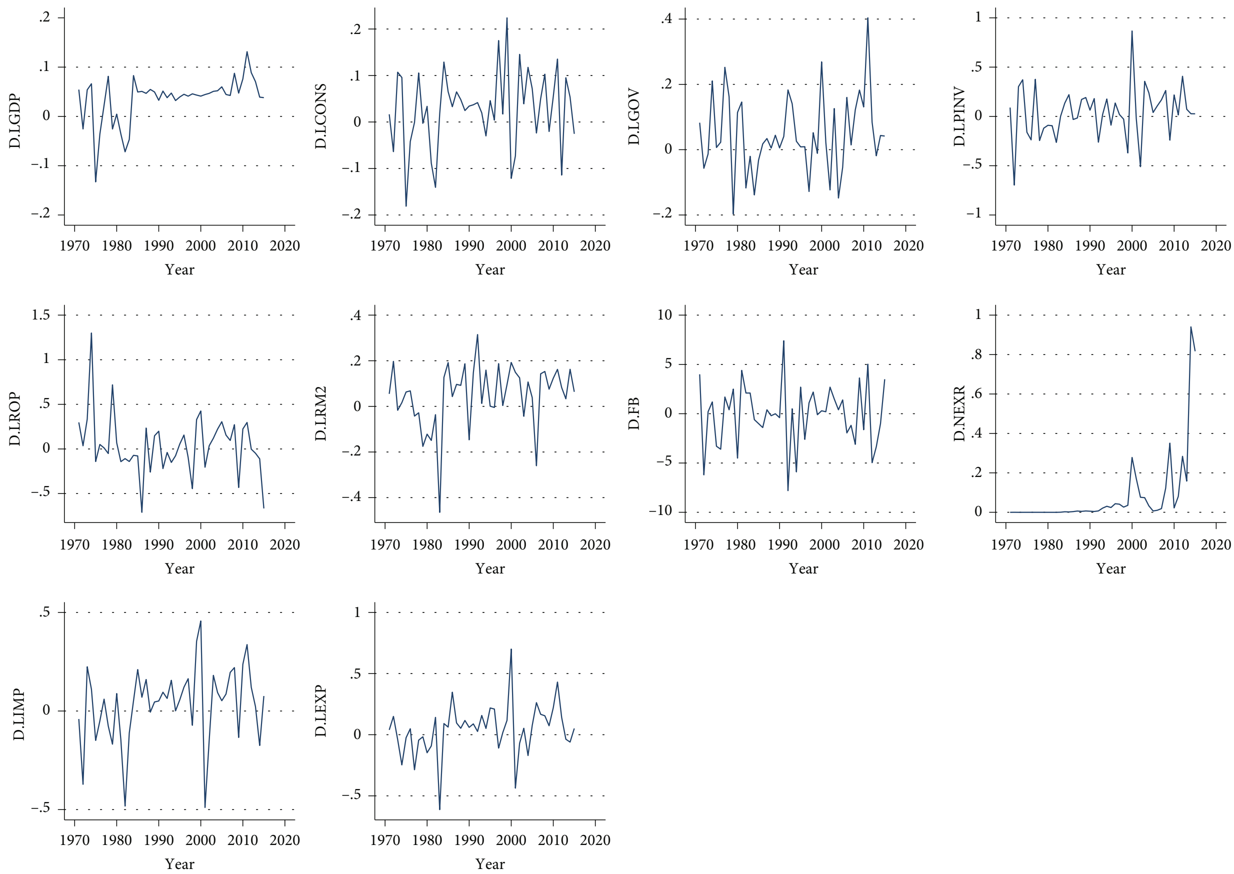

Figure 2: Behavior of time series plots of the variables after first differencing.

Table 4: Unit root test results.

Variables	Level: Intercept	Level: Trend	First difference: Intercept	First difference: Trend
LROP	0.347	-2.534	-6.074***	-6.166***
LGDP	5.376	-0.926	-3.251***	-5.687 ***
LCONS	2.300	-2.445	-6.508***	-7.444***
LGOV	2.644	-1.307	-5.501***	-6.227***
LPINV	1.008	-2.524	-8.245***	-8.847***
LIMP	1.207	-2.012	-5.788***	-6.284***
LRM2	2.388	-1.163	-5.323***	-6.135***
FB	-1.431	-3.856**	-9.759***	-9.587***
NEXR	8.747***	5.257***	-0.832	-2.307

***Significant at 1% and **significant at 5%. Critical values at 5%: Level: -3.520; First difference: -3.524; Trend: -2.628.

consist of the selected NARDL models and Table 2 shows the relevant model diagnostic and asymmetric statistics. Generally, the models are well fitted, as indicated by the standard diagnostic statistics. The coefficients of the estimates in Table 1 are not directly interpretable, so we focus on Table 2 for the asymmetry analysis.

4.3. Diagnostic and Asymmetric Statistics. From Table 2, the Wald test is used to test the null hypothesis of the presence of a symmetric relationship against the alternative hypothesis of an asymmetric impact of crude oil price on aggregate demand and its expenditure components. The W_{LR} test firmly rejects symmetric relationships across all the estimated models (1–5) in the long-run. This is an indication that, in the long-run, aggregate demand and the expenditure components differently responds to positive shocks from negative shocks to the price of crude oil in Ghana. Based on the results on Table 4, there is a statistically significant positive long-run asymmetric impact of the oil price shock on the aggregate demand. Specifically, a positive change in oil price (0.230)

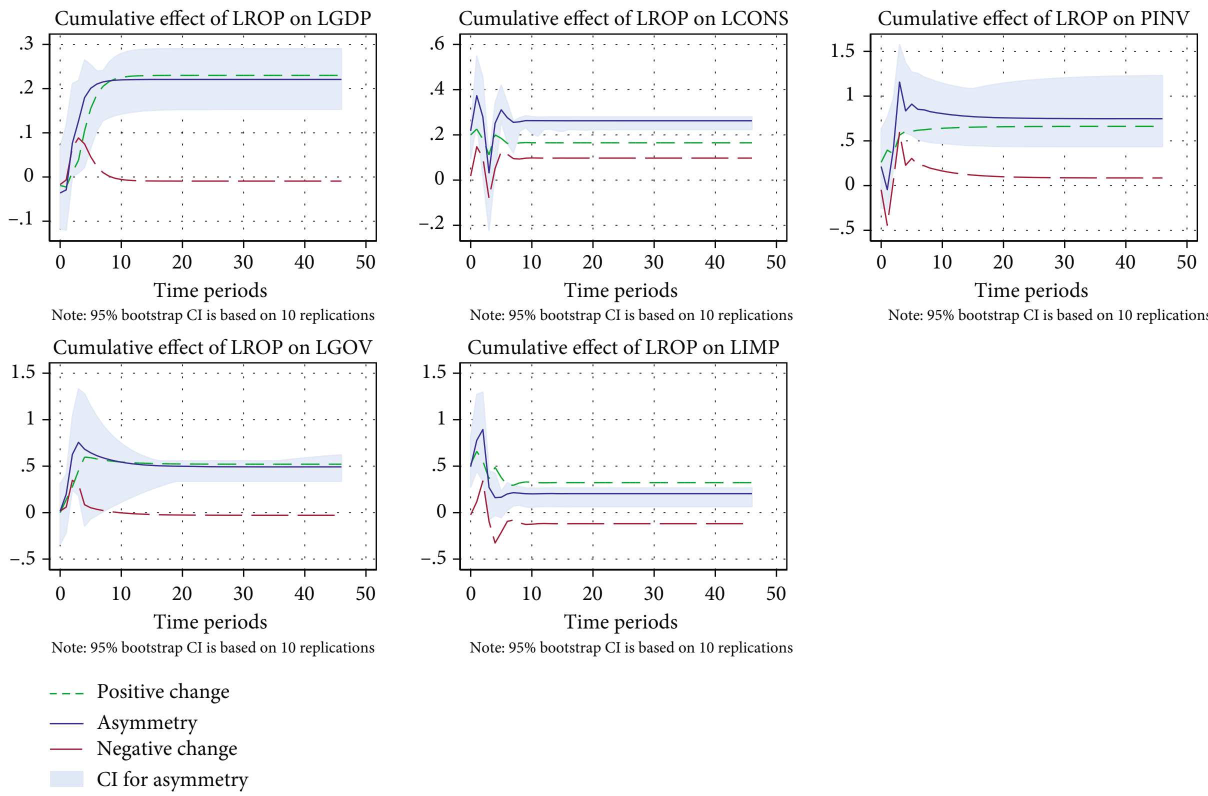

Figure 3: Dynamic multiplier adjustments of aggregate demand components to a unit change of crude oil price.

has a greater positive effect on the aggregate demand than a negative effect (-0.009) emanating from a negative change in the oil price shock. However, the latter coefficient is not statistically significant. More explicitly, a 1% shock to oil prices will induce about 0.23% increases in aggregate demand. The implication of this result is that economic agents adjust their expenditures to absorb such price shocks leading to increases in aggregate demand (see model 1).

Furthermore, from Table 2, the long-run coefficients for L^{+}_{OPS} are statistically significant and positive for the aggregate demand components collaborating the results in model 1 with the impact on investment expenditures (0.662) being the greatest followed by government expenditure (0.521). However, the least effect of positive oil price shock is on consumption expenditure (0.165). Therefore, following a 1% shock to oil prices, government expenditure (GOV), private investment (PINV), and imports expenditures (IMP) will respond positively by about 0.66%, 0.52%, and 0.32%, respectively, in the long-run. We conclude therefore that a positive oil price shocks cause the aggregate demand and the expenditure components to increase.

The coefficients for negative oil price shocks, L^{-}_{OPS}, are all insignificant except Model 2 (CONS). The household consumption expenditure (CON) model has both positive and negative significant long-run effects. Specifically, with a 1% increase in oil prices, household consumption expenditure is expected to increase by about 0.17%, and with a 1% decrease, consumption expenditures still increase by 0.097% in the long-run. This could be deduced from household dependence on the consumption of oil-related products.

From the results, we also find that there is no short-run asymmetric effect, as the Wald test could not reject (weak-form) summative symmetric adjustment at the 5% significance level. This implies that, in Ghana, the response of aggregate demand and the expenditure components to increases and decreases in crude oil prices is not statistically different in the short-run. The asymmetry statistics and model diagnostic tests provided in Table 2 indicate that serial correlation (CHSQ-SC) and heteroscedasticity (CHSQ-HET) are no problems. The normality (CHSQ-NOR) test results generally show that the models are correctly specified.

4.4. Dynamic Multiplier Adjustments. The asymmetric adjustment paths depicted in Figure 3 also indicate that the effects of positive oil price shocks remain dominant for aggregate demand and the expenditure components. For aggregate demand, the asymmetry line is closer to the positive changes in oil prices than to the negative changes. After the initial quick adjustments, the slope of the positive change is relatively steeper than the negative change. This means that aggregate demand responds stronger and faster to positive crude oil price shocks and slowly adjusts to the long-run equilibrium. Thus, positive crude oil price shocks dominate the effect on aggregate demand in Ghana. With respect to household consumption expenditure and private investment, the dominance of the positive price shocks is pronounced, as the asymmetry line lies above the positive change line. In all cases, there is a very quick return of the effect to the long-run adjustment path after about 3 to 5 months of the price shocks. The disaggregated results back up the findings that oil price shocks have an asymmetric long-term effect on Ghana's aggregate demand.

The outcomes could be deduced from Ghana's overdependence on crude oil as the main source of producing energy. In general, the results establish that in the long-run, aggregate demand responds faster to positive (increase) crude oil price shocks than it adjusts very slowly to negative (decrease) oil price shocks in Ghana. The study establishes that the asymmetric effect of oil price shocks on aggregate demand is a long-run rather than a short-run phenomenon in Ghana.

5. Conclusion

Due to Ghana's dual status as an oil importer and exporter, this study conducted an empirical investigation to determine the asymmetric effect of crude oil price shocks (increases and decreases) on aggregate demand in Ghana for the sampled period of 1970-2015. We employed the NARDL estimator, which is capable of estimating both long-run and short-run asymmetry simultaneously. The effects of crude oil price shocks were classified into positive and negative shocks to reflect the observation [48] that asymmetric effects are frequently observed in the relationship between macroeconomic variables and crude oil prices. The study finds that in Ghana, oil price shocks have a positive asymmetric long-run impact on aggregate demand and expenditure components. Aggregate demand returns to its long-run path within a short period after a price shock. Overall, aggregate demand responds faster to positive changes or increases in oil price shocks. Despite being a net-oil exporter, Ghana is dependent on imported crude oil for industrial and energy needs. Thus, Ghana's demand for imported crude is inelastic. In the absence of rapid structural changes in the economy, the country will remain vulnerable to changes in international oil prices.

The results have important policy implications. Positive oil price shocks should be dealt with more aggressively by policymakers. First, developing strategic oil reserves is a good idea to deal with supply-side shocks, given the country's reliance on crude oil imports. This will reduce supply risk and stabilize the economy's response to global oil price shocks. Second, the country must continue to promote the adoption of more renewable energy-dependent and efficient technologies. This will reduce the country's need for crude oil by reducing household and industrial consumption and lowering import bills. As a last resort, the country should consider increasing its participation in the oil futures and derivatives markets. Historically, there have been some successes.

The result of the study can be generalized across the majority of net oil-importing sub-Saharan African (SSA) countries that are dependent on crude oil imports as a primary source of energy. Evidence shows that most developing countries have become vulnerable to oil price shocks as their external debt to GDP ratio is highly dependent on oil import bills. The recent crude oil price hikes due to the Russia-Ukraine war have exerted devastating impacts on most of SSA since oil price volatilities have been indicated to have a weighty impact on the terms of trade in SSA [49]. Therefore, the methods or principles applied in this study can be applied to other African countries having the same status as Ghana.

Appendix

The Asymmetric Nonlinear ARDL (NARDL) Framework

Following the specifications provided by Shin et al. [45], the asymmetric cointegrating relationship is written as

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \tau' w_t + u_t, \tag{A.1}$$

where y_t and x_t are scalar variables and β^+ and β^- are the asymmetric long-run parameters. w_t is a $g \times 1$ vector of other regressors entering the model symmetrically with τ', a parameter. u_t is the error term which is independently identically distributed with mean zero and finite variance. However, x_t is decomposed as $x_t = x_0 + x_t^+ + x_t^-$. It is a $k \times 1$ vector of regressors that asymmetrically enter the model. x_0 represents the initial value while x_t^+ and x_t^- are partial sum processes of positive and negative changes in x_t around the threshold of 0, respectively. It thus shows the difference between positive and negative changes in the rate of growth of x_t. To this end, x_t is defined as $x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \sum_{j=1}^{t} \max(\Delta x_j, 0)$ for positive partial sums while $x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \sum_{j=1}^{t} \min(\Delta x_j, 0)$ for negative partial sums. Δ represents first difference of the variables and $j = 1, 2, \cdots, t$ while Σ is the summation sign. Thus, NARDL employs this decomposition of the variables for decreases and increases in the model (for more exposition on NARDL, see Shin et al. [45]).

By extending the Pesaran et al.'s [41] ARDL framework, the long-run and short-run asymmetric error correction model (that is, the asymmetric and nonlinear ARDL) is specified as follows:

$$\begin{aligned}\Delta y_t = {} & \alpha_0 + \alpha_1 y_{t-1} + \phi^+ x_{t-1}^+ + \phi^- x_{t-1}^- + \phi_{w,i} w_{t-i} \\ & + \sum_{i=1}^{p-1} \psi_i \Delta y_{t-i} + \sum_{i=0}^{q-1} \left(\theta_i^+ \Delta x_{t-i}^+ + \theta_i^- \Delta x_{t-i}^- + \theta_{w,i} w_{t-i} \right) + \varepsilon_t,\end{aligned} \tag{A.2}$$

where α_0 is the constant, α_1 is the parameter of $y_{t-1} \cdot y_{t-1}$, x_{t-1}^+, x_{t-1}^-, and w_{t-i} are lags of y_t, x_t^+, x_t^-, and w_t, respectively. ψ_i is the autoregressive parameter and ϕ^+ and ϕ^- are asymmetric distributed-lag parameters. However, in equation (A.1), $\beta^+ = -\phi^+/\alpha_1$ and $\beta^- = -\phi^-/\alpha_1$ are long-run asymmetric parameters. ε_t is the error term. θ_s are short-run parameters. For $i = 1, 2, \cdots, q-1$ and $i = 1, 2, \cdots, p-1$ for distributed-lag part and autoregressive parts, respectively.

There are four steps proposed by Shin et al. [45] in the application of NARDL. First, equation (2) is estimated using OLS and then apply bounds testing F_{PSS} statistic provided by Shin et al. [45]. Second, we look for long-run relationships between the variables, y_t, x_t^+, and x_t^- at their levels by testing the null hypothesis $(H_n : \alpha_1 = \phi^+ = \phi^- = 0)$. Third, we check for the existence of a short-run asymmetry, using the null hypothesis that $H_n : \theta_i^+ = \theta_i^-$. For any short-run asymmetry to be established in equation (A.2), the null hypothesis can also be expressed as $\sum_{i=0}^{q-1} \theta i^+ = \sum_{i=0}^{q-1} \theta i^-$ for all $i = 0, 1, 2, 3, \cdots, q-1$. Finally, we use the nonlinear ARDL model in equation (A.2) to derive two dynamic multipliers, m_h^+ and m_h^-. These measure the cumulative dynamic adjustment effect of a unit change in x_t^+ and x_t^- on y_t. Both are defined as follows:

$$m_h^+ = \sum_{i=0}^{h} \frac{\partial y_{t+1}}{\partial x_t^+}, m_h^- = \sum_{i=0}^{h} \frac{\partial y_{t+1}}{\partial x_t^-}, \tag{A.3}$$

with $h = 0, 1, 2, \cdots, \infty$.

From the model, as $h \longrightarrow \infty$ then $m_h^+ \longrightarrow \beta^+$ and $m_h^- \longrightarrow \beta^-$, respectively.

Nomenclature

Y_t: Aggregate demand (real GDP)
CONS: Household final consumption expenditure
PINV: Investment expenditure
GOV: Government expenditure
IMP: Imports
OPS: Oil price shocks
OPS_t^+: Positive oil price shock
OPS_t^-: Negative oil price shock
OPS_0: Initial value of oil price shock
β^+ and β^-: Asymmetric long-run parameters
w_t: $g \times 1$ vector of other regressors
τ': Parameter
MPV: Vector of selected macroeconomic variables
α_0: Constant
α_1: Parameter of y_{t-1}
ψ_t: Autoregressive parameter
ϕ^+ and ϕ^-: Asymmetric distributed-lag parameters
ε_t: Error term
θ_s: Short run parameters.

Data Availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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