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DOES THE EXOGENEITY OF OIL PRICES MATTER IN THE OIL PRICE-MACRO-ECONOMY RELATIONSHIP FOR GHANA?

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Abstract

Using annual data from 1971 to 2014 we consider whether the relationship between crude oil prices and the macro-economy in the relatively small economy of Ghana is affected by the treatment of crude oil prices as exogenous or endogenous. We use vector autoregressions, vector error-correction models, scenario-based dynamic forecasting, and autoregressive distributive lag specifications. There is little evidence that international crude oil prices have a significant negative effect on Ghana's output in either the short-run and long-run, regardless of whether crude oil prices are treated as exogenous or endogenous. This implies that increases in crude oil prices do not put a binding constraint on the monetary authorities to loosen monetary policy to offset its adverse effect on output. If inflation is a priority, policy makers could focus on inflation stabilization by tightening monetary policy when oil prices rise.

Keywords: Ghana, oil prices, exogeneity, macro-economy.
JEL codes: C32, F31, F41;

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1. Introduction

The aim of this paper is to empirically investigate the macroeconomic effects of oil price shocks in Ghana. The effects of oil price movements on the economy have received great attention since the seminal work of Hamilton (1982). However, there is very little literature that consider the treatment of international oil prices as exogenous, especially for small countries. The only papers that appear to treat crude oil prices as exogenous are Ahmed and Wadud (2011) and Park et al (2011) for Malaysia and Korea, respectively. However, these papers employ a structural vector autoregression approach (SVAR), where the effects of all macroeconomic variables on oil prices are restricted under some stringent assumptions. The models used by all other papers considering small countries include the oil price as endogenous (for example, Chang and Wong, 2003, Jumah and Pastuszyn, 2007, Adam and Tweneboah, 2008, Rafiq et al, 2009, Dawson, 2007, Masih et al, 2011, and Al-Fayoumi 2009). For a small developing country such as Ghana[1], domestic economic conditions will unlikely have a significant impact on world oil prices. However, world oil prices are expected to affect economic activities in Ghana since the country has been a traditional oil importer for several years. Hence, the inclusion of the international crude oil price as an endogenous variable when modelling the crude oil price effect for such a country seems unjustifiable and represents model misspecification.

We address this issue by considering the treatment of international crude oil prices as exogenous employing different methodologies than used by Ahmed and Wadud (2011) and Park et al (2011). We employ ARDL specifications and dynamic forecast

[1] According to Trading Economics, Ghana's GDP of 47.33 billion US dollars constitutes only about 0.08% of total world GDP.

scenarios using vector autoregressions (VARs) with the crude oil price included as an exogenous variable. To the best of our knowledge, such an approach to examine exogenous oil price effects has not been previously considered for any country. There have also been few papers that consider oil price effects on the macroeconomy. Hence, our approach to examining the exogenous oil price effect on Ghana's economy represents the contribution of this paper. Following the previous literature and for comparative purposes, we also consider models that treat crude oil prices as endogenous.

The rest of the paper is organised as follows. Section 2 discusses Ghana's economy, section 3 reviews the literature whilst section 4 discusses the research methodology. Section 5 presents and analyses the results, and section 6 concludes the paper.

2. Significance of oil in the Ghanaian economy

Energy consumption plays an important role to economic growth in Ghana (Akinlo, 2008). Figure 1 shows that Ghana's oil dependence has increased from 28% to 52% between 2000 and 2014, while oil consumption rose from 37 thousand to 83 thousand barrels per day (Indexmudi.com).[2] Figure 2 illustrates Ghana's sectoral fuel consumption in 2015 while Table 1 illustrates Ghana's fuel mix at sectoral level for four selected periods.[3]

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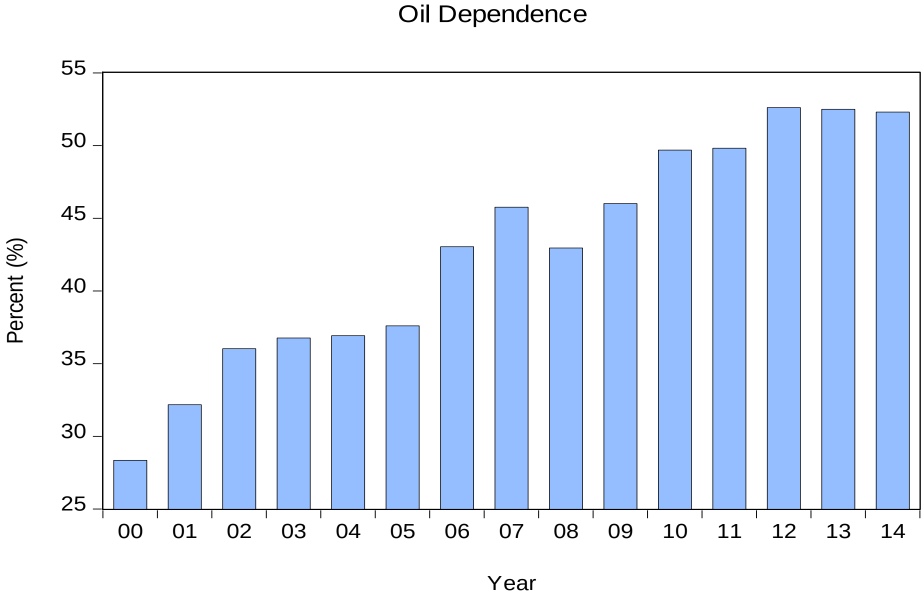
[2] Oil dependence is the ratio of oil consumption to total energy consumption. It is a useful indicator in determining Ghana's ability to switch from oil to other fuels when oil prices are high or during an oil market crisis (ESMAP, 2005).

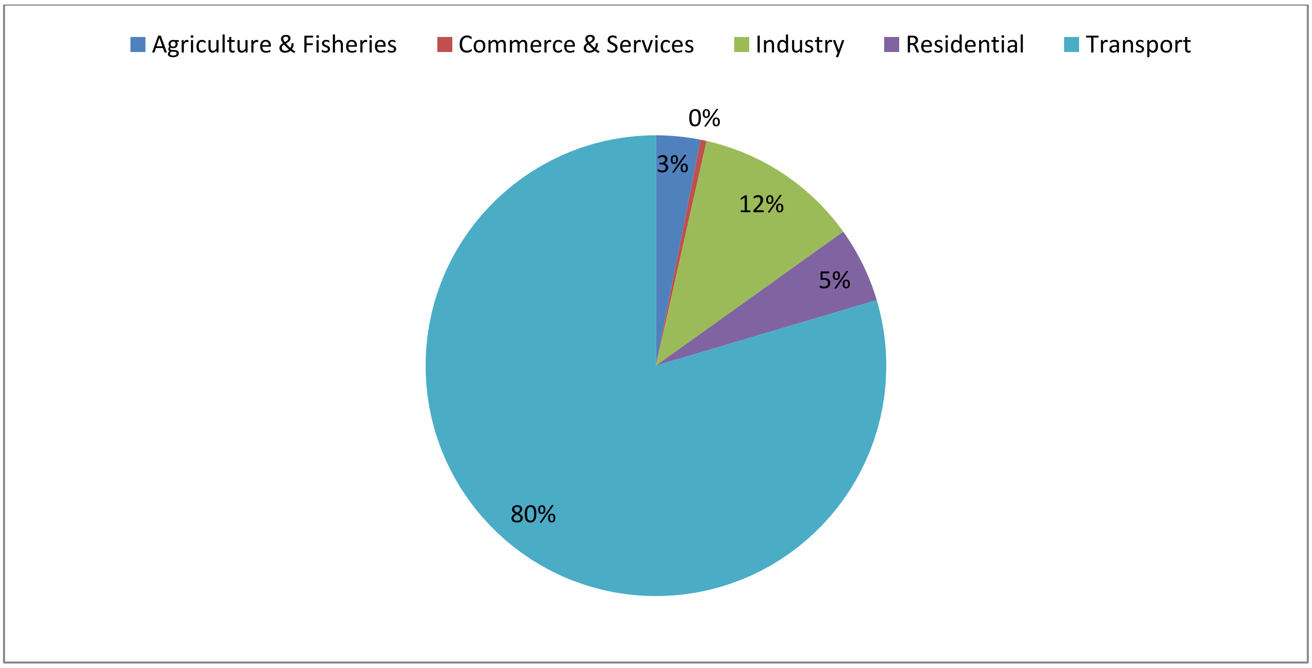
[3] Fuel mix is the ratio of consumption (or production) of different fuels to the total energy consumed either at primary energy or final energy level. It indicates the level of diversification of a country's fuel supply and

Figure 1: Oil consumption as a share of total energy consumption in Ghana



Source: Ghana Energy Commission report 2015 and authors' calculations

Figure 2: Ghanaian petroleum product consumption by sector for 2015



Source: Energy Commission of Ghana

energy security. The more diversified the fuel mix, the less vulnerable the country is to fuel supply shocks (Bhattacharyya, 2010)

Table 1: Ghana's Fuel Mix for 1999, 2006, 2012, and 2016

Sector	Year	Coal	Oil products	Natural gas	Hydro	Combustible renewals	Electricity	Total
Industry	1999	0.00	0.23	0.00	0.00	0.38	0.39	1.00
	2006	0.00	0.33	0.00	0.00	0.38	0.29	1.00
	2012	0.00	0.25	0.00	0.00	0.55	0.20	1.00
	2016	0.00	0.45	0.00	0.00	0.25	0.30	1.00
Transport	1999	0.00	1.00	0.00	0.00	0.00	0.00	1.00
	2006	0.00	1.00	0.00	0.00	0.00	0.00	1.00
	2012	0.00	1.00	0.00	0.00	0.00	0.00	1.00
	2016	0.00	1.00	0.00	0.00	0.00	0.00	1.00
Residential	1999	0.00	0.04	0.00	0.00	0.92	0.04	1.00
	2006	0.00	0.04	0.00	0.00	0.92	0.04	1.00
	2012	0.00	0.05	0.00	0.00	0.83	0.12	1.00
	2016	0.00	0.06	0.00	0.00	0.78	0.16	1.00
Commerce and services	1999	0.00	0.50	0.00	0.00	0.00	0.50	1.00
	2006	0.00	0.25	0.00	0.00	0.00	0.75	1.00
	2012	0.00	0.09	0.00	0.00	0.44	0.47	1.00
	2016	0.00	0.04	0.00	0.00	0.34	0.62	1.00
Agriculture/forestry	1999	0.00	1.00	0.00	0.00	0.00	0.00	1.00
	2006	0.00	1.00	0.00	0.00	0.00	0.00	1.00
	2012	0.00	1.00	0.00	0.00	0.00	0.00	1.00
	2016	0.00	1.00	0.00	0.00	0.00	0.00	1.00

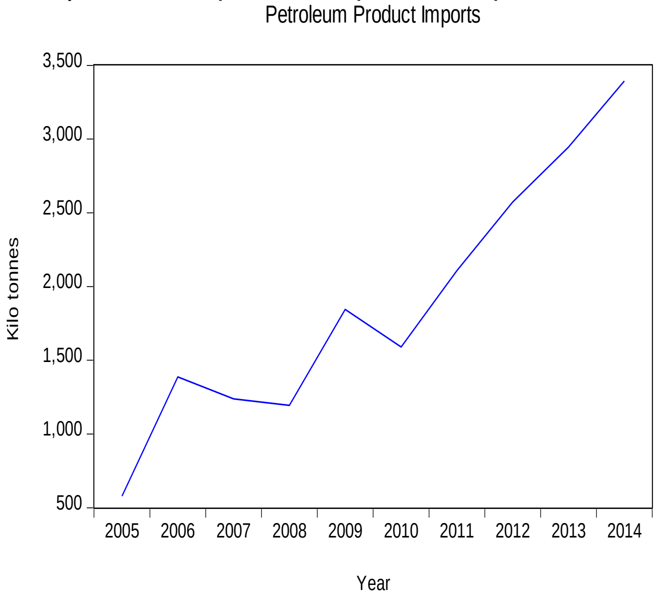
Source: Energy Commission of Ghana

Table 1 reveals that Ghana has been highly dependent on oil, with the transport and agricultural sectors depending almost entirely on oil products which suggests that these are the least diversified sectors in terms of oil usage. Figure 2 indicates that the transport sector is responsible for about 80% of Ghana's petroleum consumption in 2015. The second highest oil consumer was the industrial sector which accounted for about 12%. Although the agricultural sector depends entirely on oil products (see Table 1), it is only responsible for about 3% of Ghana's total petroleum consumption (Figure 2). This is because agriculture in Ghana is still largely peasant based with very little mechanised farming. Although a few commercial farmers employ modern farming practices that use machines and fuel, the majority of Ghana's farming is labour intensive. Hence, oil usage in the sector arises mainly from the transportation of farm produce to consuming centres.

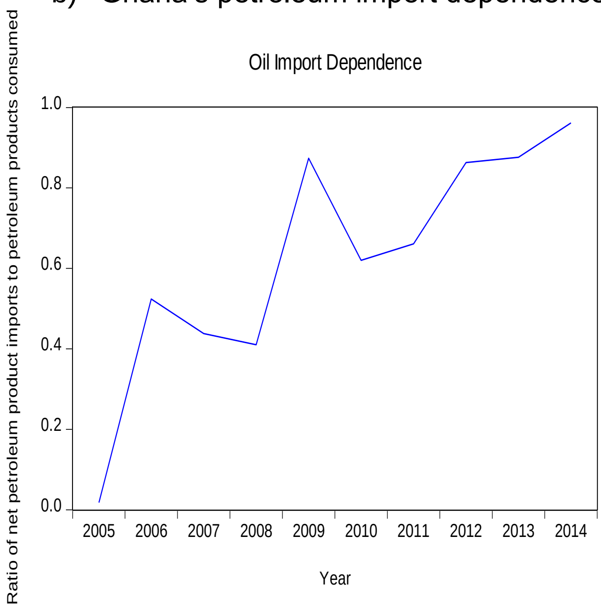
The data above shows that petroleum products form an important part of Ghana's energy and are very important to the Ghanaian economy. The country's petroleum product imports increased from 578.3.7 kilo tonnes of oil equivalent (KTOE) in 2005 to 3,393.8 KTOE in 2014 (see Figure 3a).

Figure 3: Ghana's Petroleum Product Imports and Oil Import Dependence

a) Ghana's petroleum product import



b) Ghana's petroleum import dependence



Source: Energy Commission of Ghana

Another indicator of a country's exposure to oil supply shocks is petroleum import dependence (Bhattacharyya 2010). This is the difference between oil consumption and oil production (net oil imports) divided by oil production. Ghana's petroleum import dependence has generally trended upwards between 2005 and 2014 (see Figure 3b). Both graphs in Figure 3 suggest that Ghana could be vulnerable to oil supply shocks despite becoming an oil producer.

Ghana's continued dependence on imported petroleum products can be attributed to two main factors. First, the only refinery in Ghana, the Tema Oil Refinery (TOR), has been unable to increase production capacity, mainly due to management problems. However, with rapid economic growth the country's need for refined petroleum continues to increase. Hence, Ghana imports significant amounts of refined petroleum oil to meet the growing domestic demand for petroleum products. Second, the crude oil Ghana produces cannot currently be refined in Ghana due to technical problems. As a result, the majority of crude oil produced in Ghana is exported. For example, in 2014 Ghana produced exported 104 thousand barrels of oil per day of the 104 thousand barrels produced (see Figure 4b and 4c). Oil refinery in Ghana remained constant at 45 thousand barrels per day since 1999 (see Figure 4d), whilst oil consumption continues to increase – reaching 83 thousand barrels per day in 2014 (see Figure 4a).

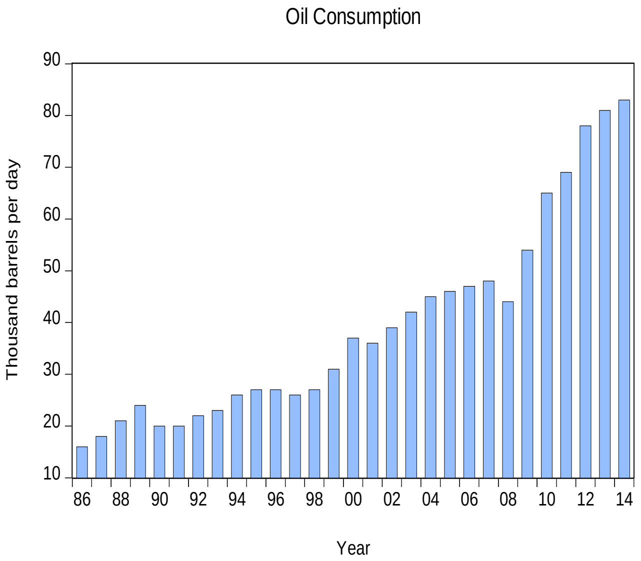
The importance of oil imports makes it interesting to empirically investigate the relation between oil prices, economic growth and the macro-economy in Ghana, which is the main focus of this paper.

3. Literature Review

Hamilton (1983) was the first to provide evidence of a relationship between world oil prices and the macro-economy and noted that seven out of eight post World War 2 recessions in the United States were preceded by dramatic oil price shocks. There has since been a substantial body of research in the oil price-macro-economy relationship for several countries.

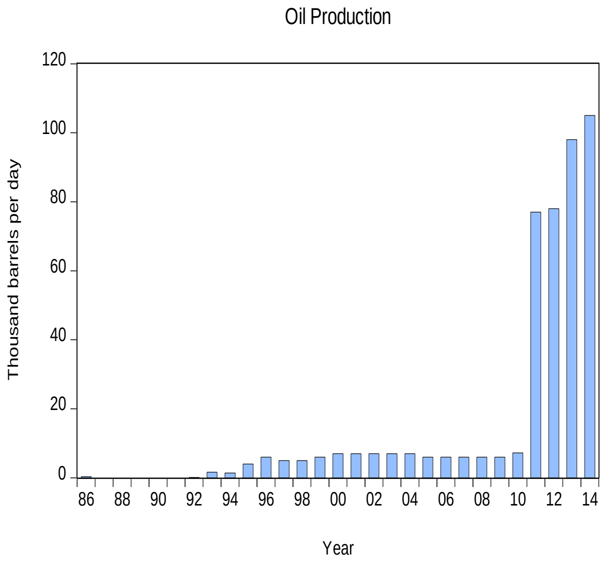
Figure 4: Crude Oil Production, Consumption, Exports, and Refinery in Ghana

(a) Ghana' Crude Oil Consumption (thousand barrels per day



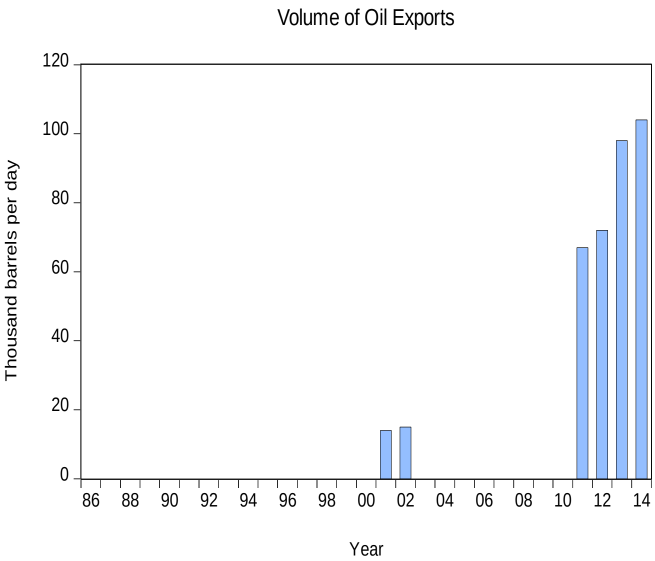
source: indexmundi.com

(b) Ghana's Crude Oil Production (thousand barrels per day)



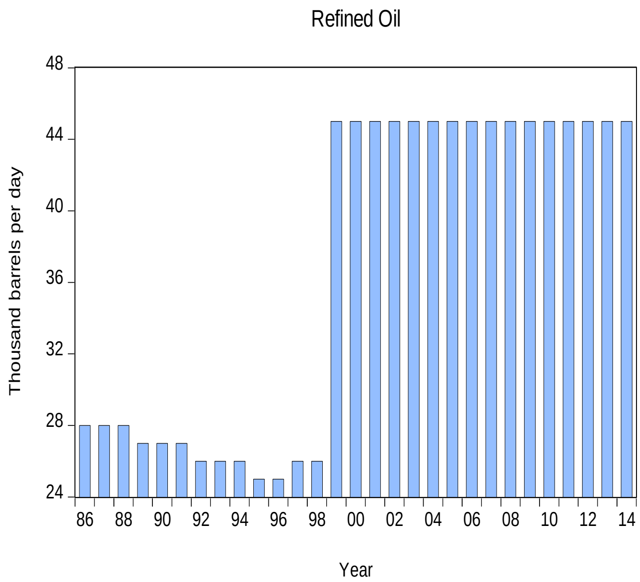
source: indexmundi.com

(c) Crude oil Exports in Ghana (thousand barrels per day)



source: indexmundi.com

(d) Annual Crude Oil Refinery in Ghana by TOR



source: opendataforafrica.org

Hamilton (1996), applying impulse response functions and Granger causality tests to quarterly US data from 1948 to 1994, found a highly significant negative effect of net oil prices on GDP growth. Bernanke et al (1997) used a VAR system of US macroeconomic indicators and world oil prices with monthly data from January 1965 to December 1995 to simulate the effects of three oil shocks: 1972-76, 1979-83 and 1988-92. They conclude, in contrast to Hamilton (1996), that the economic cost of oil price shocks comes from the resulting tightening of monetary policy (arising from the central bank's concern about rising inflation) rather than the oil price changes themselves. However, Leduc and Sill (2004) showed that the real effects of oil price shocks reducing output greatly exceed the monetary policy effects. Nevertheless, they also note that since 1979, the Federal Reserve's monetary policy accounts for about 40 percent of the fall in output following a rise in oil prices, suggesting a non-negligible impact of monetary policy.

Hooker (1997) and Segal (2011) demonstrated that oil price effects on the US economy substantially reduced after the 1990s. Segal (2011) noted that oil price rises stopped affecting the US macro-economy sometime in the 1980s, because oil price shocks stopped passing through to core inflation. Hooker (1997) argued that the relationship between oil prices and US real GDP broke down in the 1980s due to oil price misspecification rather a weakened relationship. According to Hooker (1997), the original specification of oil prices in log levels or differences produced no causal relationship between oil prices and output growth from the 1980s whilst oil respecifications that account for the dramatic fall in oil prices and increase in oil price volatility around this period produced significant results. Using Granger causality tests, Zhang (2008) found that oil price increases have a significant negative effect on Japan's economic growth, which is consistent with the findings of Hamilton (1983, 1996, and 2003).

Kilian (2009) and Hamilton (2009a, 2009b) suggest that the effect of oil price shocks depends on the cause of the oil price shock. Kilian (2009) shows that oil price shocks caused by oil supply disruptions cause a temporary decline in real US GDP, whilst a positive aggregate oil demand shock will initially trigger a positive effect on the economy. Kilian (2009) argues that the direct positive effect of aggregate demand shocks dominates the indirect negative effect of higher oil prices in the short term. However, the adverse indirect effect dominates in the long term, yielding an eventual negative macroeconomic effect of the aggregate oil demand shock. Hamilton (2009a, 2009b) reports similar findings for the US.

Fofana et al (2009) found that a sustained world oil price increase above $55 a barrel negatively affects the South African economy, with GDP growth declining and the current account worsening. Evidence that oil prices have a negative and statistically significant effect on output and the trade balance for Malaysia, South Africa, India, Thailand, South Korea, and Turkey is reported by Rafiq et al (2009), Ozlale and Pekkurnaz (2010), Ahmed and Wadud (2011), Park et al (2011), and Guivarch et al (2009).

Jumah and Pastuszyn (2007) used annual data from 1965 to 2004 to investigate the relationship between world oil prices and aggregate demand in Ghana through the interest rate channel. Using cointegration and impulse response methods they found that oil prices negatively impact output through their effect on Ghana's general price level. They also noted that the central bank initially eases monetary policy in response to oil price rises to reduce any effect on output, if at the expense of inflation. Similar results for Ghana were reported by Tweneboah and Adam (2008) and Cantah and Asmah (2015). However, all of these papers treat crude oil prices as endogenous and not exogenous (which we do).

The literature above provides mixed evidence regarding the effects of international oil price shocks on economic growth, although such shocks generally have a negative impact on growth in developing countries. These mixed findings seem mainly due to differences in methodologies, sample periods, types of data, countries considered, and national and regional characteristics considered by this literature.

Despite the large body of empirical literature investigating the link between oil prices and macroeconomic fundamentals, few studies consider treating oil prices as exogenous. With the possible exception of Ahmed and Wadud (2011) and Park et al (2011), who used structural identification restrictions to treat crude oil prices as exogenous in a SVAR, all other studies on the topic treat crude oil prices as endogenous, even for small countries like Ghana. However, the treatment of international crude oil prices may be important for countries with relatively small economies. This study builds on the existing literature by examining the relationship between international crude oil prices and economic growth in Ghana by treating the international crude oil price as exogenous in some models and endogenous in other models. This is to determine whether the crude oil price-macro-economy relationship in Ghana is related to the treatment of the crude oil prices. Comparison of the different treatment of oil prices regarding oil price effects on the macro-economy has not yet been considered in the literature. Further, as far as we are aware, this will be the first investigation of exogenous oil price effects for Ghana.

4. Econometric Methodology

We apply the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to determine each variable's order of integration. For both tests, the unit root ($I(1)$) null hypothesis is rejected in favour of the stationary ($I(0)$) alternative if the test statistic is more negative than the critical value.

Perron (1989) argues that the ADF and PP tests are biased towards non-rejection of the null hypothesis in the presence of structural breaks because the persistence of shocks in many macroeconomic series arise from large and infrequent shocks, rather than a unit root. Hence, fluctuations are stationary around a deterministic trend function which may have breaks. We therefore also apply the Lee and Strazicich (2003) unit root test that allows for possible structural breaks. The Lee and Stracizich unit root test addresses the limitations of other similar procedures (Perron, 1989; Zivot and Andrews, 1992; and Lumsdaine and Papell, 1997) by, for example, endogenously determining any structural breaks and allowing for more than one structural break. The Lee and Strazicich Lagrange multiplier (LM) method tests the null hypothesis that a series contains a unit root with two structural breaks, while the alternative hypothesis is that the series is stationarity around a trend with structural breaks. The break dates are endogenously determined where the test statistic is minimized. Critical values are provided in Lee and Stazicich (2003).

If all variables are integrated of order one, $I(1)$, we can use the Johansen procedure to determine whether a cointegration relationship between them exists, that is, whether the variables form a stationary linear combination. The Johansen method is based on the following level VAR model:

$$y_t = \delta + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_k y_{t-k} + u_t \qquad (1)$$

where, y_t is a column vector containing n $I(1)$ variables, and the subscript t denotes the time period. δ is an $n \times 1$ vector of intercepts, β_1 to β_k are $n \times n$ coefficient matrices where k is the maximum lag of the VAR, and u_t is an $n \times 1$ vector of error terms. The Johansen procedure transforms the VAR into a vector error-correction model (VECM) to test for up to r cointegrating equations, thus:

$$\Delta y_t = \delta + \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \ldots + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t \qquad (2)$$

where, $\Pi = (\sum_{i=1}^{k} \beta_i) - I_n$ represents the long-run coefficient matrix, $\Gamma_i = (\sum_{j=1}^{i} \beta_j) - I_n$ the short-run coefficient matrices and Δ denotes the first difference operator. When there are r cointegrating vectors Π can be decomposed into two parts; α and β'. α is an $n \times r$ coefficient matrix that gives the speeds of adjustment to the r cointegrating equations, whilst β' is an $r \times n$ matrix of long-run coefficients.

The Johansen procedure utilises the trace ($LR_{tr}(r_{H_0}) = -T \sum_{i=r_{Ho}+1}^{K} ln(1 - \hat{\lambda}_i)$) and maximum eigenvalue ($LR_{max}(r_{H_0}) = -Tln(1 - \hat{\lambda}_{r_{H_0}+1})$) likelihood ratio statistics. r_{H_0} denotes the number of cointegrating equations under the null, T is the sample size and $\hat{\lambda}_i$ is the estimated i[th] eigenvalue of the Π matrix, where the eigenvalues are arranged in *descending* order: $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_n$. These statistics test the sequence of null hypotheses that $r = r_{H_0}$ against the alternatives that $r \geq r_{H_0} + 1$ (trace) and $r = r_{H_0} + 1$ (maximum eigenvalue).

If the $r = 0$ null is not rejected there are no cointegrating vectors and the hypothesis testing sequence is completed. However, if the no cointegration null is rejected, the $r = 1$ null is the next test in the sequence and so on. Thus, the number of cointegrating vectors tested is sequentially increased until the null cannot be rejected.

If the null that $r = 0$ is not rejected equation (2) becomes the following difference VAR (DVAR) that contains only the differences of I(1) variables (with no long-run component):

$$\Delta y_t = \delta + \sum_{i=1}^{p} \Gamma_i \Delta y_{t-i} + u_t, \qquad \text{where, } p = k - 1 \qquad (3)$$

The above specifications are based on standard reduced form VARs where all variables are endogenous and are therefore suitable for our models where the international crude oil price is treated as endogenous. However, for the models where the crude oil price is treated as exogenous we employ two other methods. First, we use scenario-based dynamic forecasts from a reduced form DVAR in which the (first difference of the) oil price, denoted by Δx_t, is included as exogenous. This DVAR is:

$$\Delta y_t = \delta + \sum_{i=1}^{p} \Gamma_i \Delta y_{t-i} + \gamma \Delta x_t + u_t \qquad (4)$$

The use of scenario forecasting as is common place in, for example, simulating the consequences of exogenous policy interventions.

Under the assumption that all differenced variables are stationary, the estimated DVAR model allows us to decompose the historical fluctuations of oil prices into orthogonal components which correspond to oil supply and oil demand shocks (Baumeister and Kilian 2012). Following Baumeister and Kilian (2012), we let:

$$y_t = \sum_{i=0}^{\infty} \Theta_i w_{t-i} \approx \sum_{i=0}^{n-1} \Theta_i w_{t-i} \qquad (5)$$

where, Θ_i represents the matrix of impulse responses at lag $i = 0,1,2, \ldots$ and w_t is the vector of uncorrelated structural shocks. Baumeister and Kilian (2012) noted that the reduced-form forecast corresponds to the expected change in oil prices conditional on the expectation that all future shocks are zero. Any departures from this benchmark can be corrected by putting pre-identified sequences of future structural shocks (called forecast scenarios) into the structural moving average representation of the DVAR, and the dependent variable can then be projected into the future.

By analogy to equation (5), a structural moving average representation of the DVAR can be written as:

$$y_{t+h} = \sum_{i=0}^{\infty} \Theta_i \, w_{t+h-i} = \sum_{i=0}^{h-1} \Theta_i \, w_{t+h-i} + \underbrace{\sum_{i=h}^{\infty} \Theta_i \, w_{t-i}}_{y_t} \quad (6)$$

where, y_{t+h} is the dependent variable projected h periods into the future. To remove the dependence of the forecast scenario on y_t, it is expedient to normalize all conditional forecasts relative to the baseline forecast by setting all future structural shocks in equation (6) to zero. The plot of this normalized conditional forecast denotes the downward or upward adjustments of the baseline forecast that would be necessary if a given hypothetical scenario were to occur. That is, for a given sequence of future structural shocks $\{w_{t+1}^{scenario}, \dots, w_{t+h}^{scenario}\}$, the revision required in the baseline forecast of $y_{t+h}, h = 1,2, \dots$, if the scenario were to come true would be:

$$y_{t+h}^{revision} = \sum_{i=0}^{h-1} \Theta_i \, w_{t+h-1}^{scenario} - \sum_{i=0}^{h-1} \Theta_i \, w_{t+h-1}^{baseline} = \sum_{i=0}^{h-1} \Theta_i \, w_{t+h-1}^{scenario} \quad (7)$$

Formally, this approach is analogous to the construction of standard impulse response functions. The main difference between the two is that impulse responses involve a one-time structural shock $w_t^{scenario} \neq 0$ followed by $w_{t+i}^{scenario} = 0 \; \forall \; i > 0$, whilst forecast scenarios tend to comprise sequences of nonzero structural shocks that extend over several periods.

The second approach that we employ to treating oil prices as exogenous is the autoregressive distributive lag (ARDL) cointegration bounds testing approach proposed by Pesaran et al (2001). This approach identifies both short-run and long-run effects and is appropriate when there is uncertainty over whether the series in the model are I(0) or I(1). This is relevant for our data given there is some ambiguity over whether some of our variables are I(1) or I(0), as discussed below. The ARDL model applied to the five variables we consider is:

$$\Delta LRGDP_t = a_0 + \sum_{j=0}^{n} \alpha_j \, \Delta LRGDP_{t-j} + \sum_{j=0}^{n} \mu_j \, \Delta LCOP_{t-j} + \sum_{j=0}^{n} \lambda_j \, \Delta LCPI_{t-j} \quad (8)$$

$$+ \sum_{j=0}^{n} \Theta_j \, \Delta LIR_{t-j} + \sum_{j=0}^{n} \Psi_j \, \Delta LEXR_{t-j}$$

$$+ \delta_1 LRGDP_{t-1} + \delta_2 LCOP_{t-1} + \delta_3 LCPI_{t-1} + \delta_4 LIR_{t-1} + \delta_5 LEXR_{t-1} + \varepsilon_t$$

where, ε_t is the white noise error term. We test the (restricted intercept) null hypothesis of no cointegration, being $a_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$, by comparing the conventional F-statistic to the small sample upper and lower bound critical values reported in Narayan (2005). If the F-statistic is below the lower bound the no cointegration null hypothesis cannot be rejected, whereas an F-statistic exceeding the upper bound indicates rejection of the null and evident cointegration. If the F-statistic falls between the bounds the test is inconclusive.

5. Results and analysis

The data are annual time series from 1971 to 2014 (43 observations). The variables are expressed in logarithmic form, which is indicated by an L prefix in variable names. LCPI is the log of Ghana's consumer price index (CPI), which is differenced to obtain the inflation rate (denoted INF), and LRGDP is the log of Ghana's real GDP (RGDP), where RGDP is obtained by diving nominal GDP by CPI (after dividing by 100). LCOP is the log of world crude oil prices (COP), LEXR is the log of the Ghana cedi exchange rate with the US dollar (EXR) and LIR is the log of the Bank of Ghana's nominal interest rate (IR). Data definitions and sources are given in Table 2.

Table 2: Variable definitions and sources

Variable	**Description**	**Source**
GDP	Ghana's gross domestic product	World Bank Development Indicators
EXR	Ghana's cedi exchange rate	IMF International Financial Statistics
COP	International Crude Oil Price (UK Brent)	British Petroleum (2014)
CPI	Ghana's consumer price index	World Bank Development Indicators
IR	Bank of Ghana nominal interest rate	Data Stream

These variables have been used in previous papers examining the oil price-macroeconomic relationship. These include: Hamilton (1996), Hamilton (2003), Hooker (1996), Chang and Wong (2003), Jumah and Pastuszyn (2007), Rafiq et al (2009), Park et al (2011), Bernanke, Gertler and Watson (1997), Leduc and Sill (2004), Oladosu (2009), Tweneboah and Adam (2008) and Ahmed and Wadud (2011).

We employ two specifications to model the oil price-macroeconomic relationship for Ghana. The first is based on the following variables as previously used by Tweneboah and Adam (2008):

$$VAR1 = f(LRGDP, LCOP, LCPI, LIR, LEXR) \tag{9}$$

The second specification includes only two variables in the model, being the real GDP growth rate and crude oil prices, following Hamilton (2003) and Oladosu (2009), thus:

$$VAR2 = f(LRGDP, LCOP) \tag{10}$$

This second model is a robustness check that allows us to assess whether the exclusion of other macroeconomic variables affects the oil price and GDP relationship. Most papers in the literature included other macroeconomic variables such as interest rates, inflation, exchange rates, etc. in their models.

Figures A1 to A6 in Appendix A show that all five series specified in (10) exhibit a visual trend suggesting all data are likely to be non-stationary and will need differencing to induce stationarity. We now assess this using unit root tests.

5.1 Unit Root Tests

ADF and PP tests are reported in panel (a) and panel (b), respectively, of Table 3. We use MacKinnon's (1996) critical values for both tests and the optimal lag length for the ADF test is chosen using the modified Schwarz criterion proposed by Ng and Perron (2001).

Table 3: ADF and PP unit root tests

Panel (a): ADF test

	Intercept only				Intercept and trend			
	Levels data		First differences		Levels data		First differences	
	t-statistic	Lag	t-statistic	Lag	t-statistic	Lag	t-statistic	Lag
LRGDP	1.98	0	-4.48***	0	-0.94	0	-5.58***	0
LCOP	-2.23	0	-6.23***	0	-2.50	0	-6.27***	0
LIR	-1.81	0	-7.77***	0	-1.47	0	-7.97***	0
LCPI	-3.68**	0	-2.41	1	0.01	0	-5.29***	0
LEXR	-1.35	0	-23.52***	0	-11.02***	0	-6.12***	9

Panel (b): PP test

	Intercept only		Intercept and trend	
	Levels data	First differences	Levels data	First differences
	t-statistic	t-statistic	t-statistic	t-statistic
LRGDP	1.68	-4.42***	-0.94	-5.52***
LCOP	-2.23	-6.23***	-2.49	-6.27***
LIR	-1.74	-7.75***	-1.31	-8.02***
LCPI	-3.10**	-3.97***	-0.23	-5.25***
LEXR	-1.56	-24.90***	-7.72***	-26.19***

Note: * indicates significance at 10% level, ** indicates significance at 5% level and *** indicates significance at 1% level

According to both ADF and PP tests the unit root null hypothesis cannot be rejected at the 5% level for all variables in levels (except LCPI with only an intercept and LEXR with both intercept and trend). The unit root null is rejected for all series in first differences by both tests (except LCPI with only an intercept using the ADF test).[4] The results broadly suggest that all the series can be regarded as $I(1)$.

To account for potential structural breaks, we report the Lee-Strazicich (2003) LM unit root test with two structural breaks in both level and trend (model C) in Table 4.

[4] We consider the results suggesting LCPI is $I(0)$ implausible because it implies Ghana's prices do not rise while the one result indicating LCPI is $I(2)$ could be due to the ADF test's low power. Since LEXR only rejects the unit root null when both intercept and trend are included the data cannot be regarded as stationary since LEXR requires detrending to achieve this. Hence, both series are considered nonstationary with a maximum order of integration of one.

Table 4: Lee-Stracizich LM unit root tests with two structural breaks

	Intercept only			Intercept and trend		
Series	Lag	$\hat{T}_B$	t-statistic	Lag	$\hat{T}_B$	t-statistic
LRGDP	2	1981 2010	-3.15	2	1981 1992	-4.47
LCOP	5	1986 2008	-2.78	0	1980 1997	-4.08
LCPI	5	1981 1984	-2.72	4	1990 1995	-4.86
LIR	5	1981 1990	-2.28	0	1997 2007	-5.93**
LEXR	5	1980 1999	-3.33	5	1981 1994	-6.52**

Note: critical values are drawn from Lee and Stracizich (2003) critical values, *** denotes significance at 1% level, ** denotes significance at 5% level and * denotes significance at 10% level

Table 4 unambiguously indicates that the null hypothesis of a unit root cannot be rejected for LRGDP, LCOP, and LCPI for both the intercept only and intercept and trend models. While the levels of LIR and LEXR contain a unit root for the intercept only model they are stationary around a structural break for the intercept and trend case. While these results are broadly consistent with our conclusion that all series are $I(1)$ there are a few anomalies, as there were with the ADF and PP tests results. Thus, we proceed assuming all series are $I(1)$ although we will account for the possibility that some may be $I(0)$ by using the ARDL specification.

Next, we consider the results of our estimated models. Models that treat crude oil prices as exogenous are referred to as ‘exogenous crude oil price models’ whilst models that treat crude oil prices as endogenous are referred to as endogenous crude oil price models.

5.2 Exogenous crude oil price models

5.2.1 Dynamic forecasting using scenarios

In this section, we employ five-variable and two-variable DVARs (with crude oil prices included as exogenous) to conduct scenario forecasting. Since all variables are assumed to be $I(1)$, all the data is used in first differences, which is indicated by a “D” prefix in a variable’s name. The ordering of the endogenous variables follows the Cholesky decomposition with the variables placed in decreasing order of exogeneity. Hence, real GDP growth is placed first, followed by the growth rates of CPI, the interest rate, and the exchange rate.

We report lag selection criteria for DVARs with 0 to 4 lags in Appendix B1. The Akaike information criteria (AIC) indicates 1 lag while the Schwarz information criteria (SIC) suggest 0 lags. Since 0 lags implies all slope coefficients are insignificant, we include 1 lag in the five-variable DVAR. Misspecification tests reported in appendices B2 and B3 indicate that the model is free from evident autocorrelation and heteroscedasticity. However, Appendix B4 suggests the residuals of the DLRGDP and DLEXR equations exhibit significant non-normality (primarily due to an outlier in 2006 for the former and 1983 for the latter). We are therefore careful in interpreting the results of t-tests (especially when inference is “borderline”) because critical values based on the normal distribution will not be appropriate. However, we note that the coefficient estimator remains BLU in the face of departures from normality. The results of the estimated five-variable DVAR model is presented in Table 5.

Table 5: Estimated Five-Variable DVAR

	DLRGDP	DLCPI	DLIR	DLEXR
DLRGDP(-1)	0.152	-0.390	0.373	-0.492
	(0.682)	(-1.352)	(0.948)	(-0.785)
DLCPI(-1)	-0.163	0.391	0.282	0.136
	(-0.920)	(1.701)	(0.897)	(0.273)
DLIR(-1)	-0.075	-0.184	-0.362	-1.016
	(-0.738)	(-1.408)	(-2.028)	(-3.569)
DLEXR(-1)	0.044	-0.019	0.114	0.275
	(0.721)	(-0.240)	(1.049)	(1.593)
C	0.073	0.188	-0.084	0.208
	(1.420)	(2.808)	(-0.916)	(1.432)
DLCOP	-0.014	-0.032	-0.107	-0.296
	(-0.217)	(-0.378)	(-0.937)	(-1.620)
$\bar{R}^2$	0.035	0.211	0.040	0.199
s	0.128	0.166	0.226	0.360
$F(R^2)$	1.301	3.192	1.339	3.037

Note: Each equation's dependent variable is specified in the top row. The suffix (-1) indicates the first lag of that variable (specified in the first column) while figures in parentheses below coefficients are estimated t-ratios. $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom, s is the regression standard error and $F(R^2)$ is the F-statistic for deleting all slope coefficients from each equation.

All variables in the GDP growth (given in the column headed DLRDGP) have a statistically insignificant effect on Ghana's real GDP growth according to the t-statistics. Although the coefficient of crude oil prices has the expected negative sign it is highly insignificant.[5] In fact, the crude oil price variable is insignificant in all four equations (even at the 10% level).

However, considering t-ratios in VAR models can be misleading because of inefficiency due to the inclusion of numerous redundant variables. We therefore also explore the dynamic response of GDP growth to the change in oil price growth

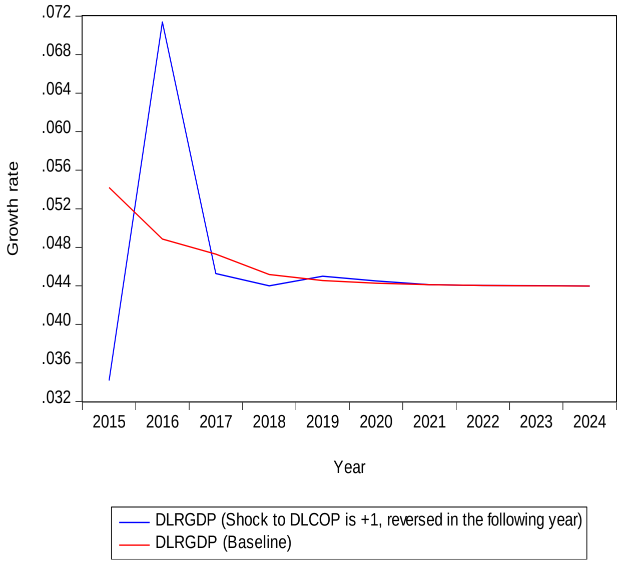
[5] Because the t-statistic for the oil price variable in the DLRGDP equation is very small in magnitude, it is very unlikely that the appropriate critical values from the non-normal distribution would be so small as to cause the null hypothesis to be rejected. Hence, we are confident that DLCOP's coefficient is not significantly different from zero. While the Central Limit Theorem suggests that the coefficients in large samples tend towards the normal distribution even when the residuals are not normal our samples size may not be large enough to invoke this result.

(DLCOP). Because DLCOP is exogenous, it is not appropriate to employ standard impulse response function analysis and use appropriate scenario-based forecasting instead. The DVAR is solved for two scenarios over the forecast period 2015 – 2024: a baseline scenario and oil price shock (high oil price) scenario. The baseline scenario specifies no growth in oil prices (DLCOP=0), that is, a zero rate of change each period. The high oil price scenario specifies DLCOP=1 in 2015 (which is a 100%, or doubling, of the oil price in 2015) and zero in the following years. Hence, the shock is temporary. The results of these forecast scenarios are presented in figures 5a and 5b.

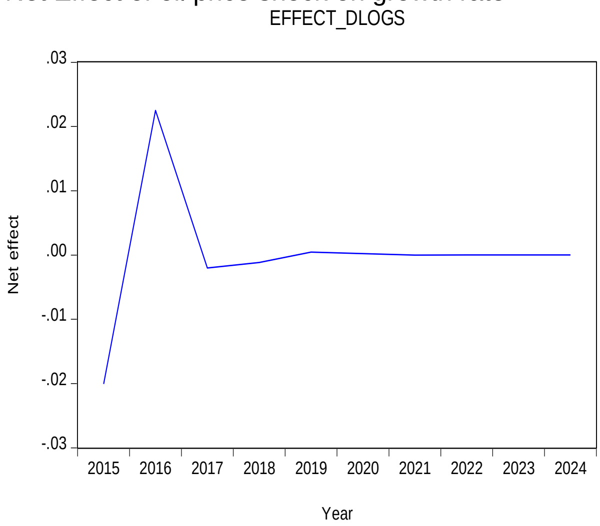
Figure 5a compares the predicted GDP growth rates for the two scenarios (comparative forecast) and Figure 5b shows the implied net effect of the oil price shock. The initial predicted effect of a temporary doubling of oil prices in 2015 is to reduce growth by about 2% relative to the baseline scenario, which is economically substantive. However, the effect immediately reverses, with the oil shock scenario rising above the baseline by around 2% in 2016 before the net effect declines to almost zero after two years.

Figure 5: Forecast scenario impact of higher oil price on GDP growth, 2015 – 2024

(a)
Comparative forecast of oil price shock on growth rate



(b)
Net Effect of oil price shock on growth rate



Asymmetric effects

Many previous studies that consider asymmetric effects of oil price shocks on the macro economy find that positive and negative shocks have a different size of response (e.g. see Hooker 1997, 2002, Hamilton 2003, 2011, and Rahman and Serletis 2011). We explore such potential asymmetry by separating the exogenous oil price variable ($DLCOP$) into its positive ($DLCOPP$) and negative ($DLCOPN$) components, thus:

$$DLCOPP = DLCOP \quad \text{when } DLCOP > 1, \quad \text{otherwise } DLCOPP = 0 \qquad (11)$$

$$DLCOPN = DLCOP \quad \text{when } DLCOP < 1, \quad \text{otherwise } DLCOPN = 0 \qquad (12)$$

The results of the estimated DVAR with $DLCOPP$ and $DLCOPN$ replacing $DLCOP$ are presented in Table 6. DLCOPN has the expected negative sign in the DLRGDP equation if the coefficient on DLCOPP does not have the expected sign. However, the coefficient of both DLCOPN and DLCOPP are highly insignificant which suggests no significant (asymmetric) oil price effect on real GDP growth. This is not consistent with Hooker (1997, 2002), Hamilton (2003), and Rahman and Serletis (2011) who find that negative oil price shocks boost economic growth while positive shocks have no significant impact for oil importing countries.

Table 6: Estimated Asymmetric Five-Variable DVAR

	DLRGDP	DLCPI	DLIR	DLEXR
DLRGDP(-1)	0.161	-0.398	0.348	-0.490
	(0.715)	(-1.361)	(0.879)	(-0.767)
DLCPI(-1)	-0.139	0.370	0.218	0.141
	(-0.759)	(1.549)	(0.674)	(0.271)
DLIR(-1)	-0.081	-0.178	-0.344	-1.017
	(-0.792)	(-1.338)	(-1.909)	(-3.501)
DLEXR(-1)	0.040	-0.016	0.123	0.274
	(0.652)	(-0.196)	(1.129)	(1.559)
C	0.057	0.202	-0.039	0.205
	(0.954)	(2.616)	(-0.377)	(1.215)
DLCOPP	0.020	-0.062	-0.198	-0.289
	(0.222)	(-0.538)	(-1.276)	(-1.157)
DLCOPN	-0.098	0.043	0.119	-0.313
	(-0.608)	(0.205)	(0.418)	(-0.683)
$\bar{R}^2$	0.017	0.192	0.033	0.176
s	0.129	0.168	0.227	0.365
$F(R^2)$	1.118	2.622	1.234	2.461

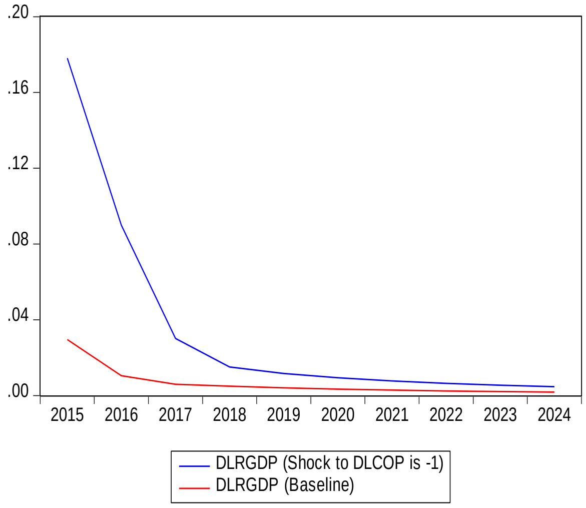
See notes to Table 5.

We employ a similar scenario-based forecasting exercise to that used previously. Since the coefficient of DLCOPP does not have the expected sign we apply the scenario forecast only to negative oil price shocks ($DLCOPN$). That is, the negative oil price scenario specifies DLCOPN=-1 in 2015 (which is a 100% reduction of the oil price in 2015) and zero in the following years. The baseline scenario is as specified previously. Figures 6a and 6b graph the two forecast scenarios and the net effect of a negative oil price shock to real GDP growth, respectively.

Figure 6: Impact of a negative oil price shock on real GDP growth

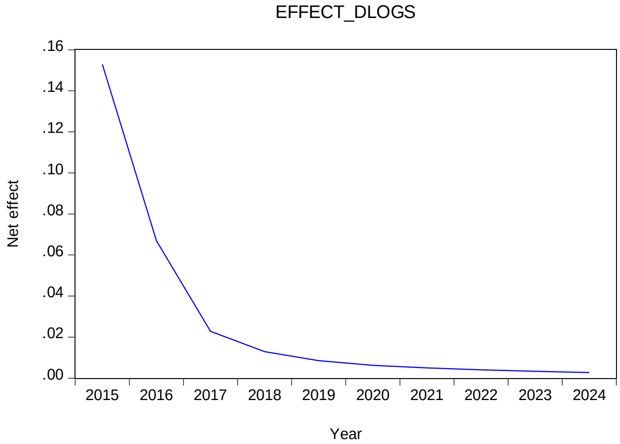
Comparative forecast of a negative oil price shock on growth rate

(a)



Net effect of a negative oil price shock on growth

(b)



Figures 6a and 6b indicate that GDP growth rises following a temporary negative shock to the oil price compared to the baseline scenario. This increase is substantial in the first year, being 15 percentage points higher in the negative oil shock scenario, however, the increased growth is predicted to slowly evaporate and be close to zero by 2024. This contrasts with the symmetric DVAR's forecast scenario analysis because the shock is much larger in magnitude, always positive and sustained over several periods, if it ultimately dissipates. This suggests evidence in favour of an economically substantial asymmetric effect, which contrasts with the lack of significance of the oil prices variables in the DLRGDP equations of the DVARs.

We also consider bivariate model (with and without asymmetries) including only crude oil prices and DLRGDP variables following Hamilton (2003) and Oladosu (2009). This will help determine whether the exclusion of the other macroeconomic variables affects the relationship between DLCOP and DLRGDP. Because we treat crude oil prices as exogenous this model is a single equation with two variables. The results of the two-variable models without and with asymmetric effects are presented in Appendix B9. The findings are consistent with those obtained from the five-variable DVAR models because the crude oil price variables are all insignificant with the coefficients of DLCOP and DLCOPN being negative and the coefficient of DLCOPP being positive. The results of the forecast scenarios for the two-variable models (see appendices B10 and B11) are also qualitatively similar to those from the five-variable DVARs. That is, the oil price shock on GDP growth is negative in 2015, positive in 2016 and dissipates to zero thereafter in the model with DLCOP. In the asymmetric model, a negative-shocks substantially stimulates growth for a few periods before declining to near zero. This suggests that the crude oil price effect on Ghana's GDP growth does not depend on the inclusion of other macroeconomic variables in the model: the other macroeconomic variables have no influence on the oil price and macro economy relationship.

5.2.2 The ARDL model

All estimated DVARs above only consider short-run effects. To avoid the omission of potential long-run relationships we now apply the ARDL bounds cointegration test that incorporates both short-run and long-run effects. Starting with a maximum of (n=) 4 lags, we choose the optimal lag structure using the AIC as the ARDL (1, 1, 1, 0, 0) specification. Tests reported in Appendix B12 indicate that the model is free from evident autocorrelation and heteroscedasticity and is therefore presented as adequate. Since the (restricted intercept and no trend) F-statistic (being 10.640) lies above the upper bound critical value at all conventional levels of significance (the 1% and 5% upper bound critical values are 4.37 and 3.49, respectively) the no cointegration null hypothesis is rejected.[6] This indicates the existence of a long-run relationship, which is reported in equation (13) below, with t-ratios given in parentheses.

$$\underset{}{\widehat{LRGDP}} = \underset{(1.308)}{0.414LCOP} - \underset{(-1.252)}{0.381LCPI} - \underset{(-2.728)}{0.866LIR} + \underset{(2.320)}{0.554LEXR} + \underset{(19.948)}{27.490} \quad (13)$$

The t-ratios in (13) suggest that LIR and LEXR both have a significant effect on LRGDP in the long-run whereas LCPI and LCOP are insignificant suggesting they have no long-run effect on LRGDP. Hence, crude oil prices have no long-run effect on the GDP.[7]

The conditional error-correction model derived from the estimated ARDL specification is given as equation (14). The insignificance of $\Delta LCOP_t$ indicates no significant short-run effect of oil price growth on real GDP.

$$\Delta\widehat{LRGDP}_t = \underset{(3.652)}{4.132} + \underset{(0.476)}{0.026\Delta LCOP_t} - \underset{(-3.408)}{0.376\Delta LCPI_t} - \underset{(-3.461)}{0.150LRGDP_{t-1}} \quad (14)$$

$$+\underset{(1.199)}{0.062LCOP_{t-1}} - \underset{(-1.148)}{0.057LCPI_{t-1}} - \underset{(-2.430)}{0.130LIR_{t-1}} + \underset{(1.943)}{0.083LEXR_{t-1}}$$

5.3 Endogenous crude oil price models

[6] The restricted intercept specification is reported because the F-statistic lies between the bounds with the unrestricted intercept case indicating uncertainty over whether there is cointegration.
[7] This is consistent with unreported results (available from the authors on request) based upon Engle and Granger cointegration results.

For the endogenous crude oil price models all variables including crude oil prices are endogenous. Following the approach used for the exogenous crude oil price models we separately estimate five-variable and two-variable models using the variables given by equations (9) and (10).

Table 7: Five-Variable Model Johansen's Cointegration Tests

r_{H_0}	$LR_{tr}(r_{H_0})$	5% critical Value	Probability-value
0*	96.98349	69.81889	0.0001
1*	55.05516	47.85613	0.0091
2*	30.66568	29.79707	0.0396
3	7.780397	15.49471	0.4892
4	0.935461	3.841466	0.3334
r_{H_0}	$LR_{max}(r_{H_0})$	**5% critical Value**	**Probability-value**
0*	41.92834	33.87687	0.0044
1	24.38947	27.58434	0.1217
2*	22.88529	21.13162	0.0280
3	6.844937	14.26460	0.5076
4	0.935461	3.841466	0.3334

Note: "r_{H_0}" denotes the null hypothesis that there are at most r cointegration equations, $LR_{tr}(r_{H_0})$ and $LR_{max}(r_{H_0})$ represent the Trace and Maximum Eigenvalue statistics, respectively, while * denotes rejection of the null hypothesis at the 5% level.

Both AIC and SIC indicate one lag level for the five-variable and two-variable VARs (see appendices C1 and C5, respectively). Since one lag level implies no short-run dynamics we employ VECMs with one lagged difference for all variables. Both specifications are free from evident autocorrelation and heteroscedasticity although there is some evidence of non-normality distributed residuals in the real GDP equation. The diagnostic tests are presented in appendices C2, C3, and C4 for the five-variable model and in appendices C6, C7, and C8 for the two-variable model. As for the DVAR models we are therefore careful in interpreting the results of hypothesis tests in the DLRGDP equation. The results of the Johansen cointegration test, with one lagged dependent variable and unrestricted intercept, for the five-variable and two-variable models are reported in Table 7 and 8, respectively.

Table 8: Two-Variable Model Johansen's Cointegration Tests

r_{H_0}	$LR_{tr}(r_{H_0})$	5% critical Value	Probability-value
0*	16.167	15.495	0.040
1	1.359	3.841	0.244
r_{H_0}	$LR_{max}(r_{H_0})$	**5% critical Value**	**Probability-value**
0*	14.808	14.265	0.041
1	1.3592	3.841	0.244

See notes to Table 9.

For the five-variable model, the trace test indicates two cointegrating equations whilst the maximum eigenvalue test indicates one cointegrating equation. For the two-variable model, both tests indicate one cointegrating equation. We impose our theoretical prior belief of one cointerating equation for both models because this is generally supported by the Johansen test results.[8] The estimated cointegrating equations normalised on LRGDP for both models are presented in (15) and (16), where $ECT5$ and $ECT2$ are the error-correction terms of both models. T-ratios are in parentheses. The coefficient on crude oil prices is positive and statistically significant in both cointegrating equations, which is not consistent with theoretical expectations.[9]

$$\underset{}{LRGDP} = \underset{(7.767)}{5.153}LCOP - \underset{(-7.687)}{5.112}LCPI + \underset{(-4.924)}{2.852}LIR + \underset{(7.826)}{3.992}LEXR + 15.832 + ECT5 \qquad (15)$$

$$LRGDP = \underset{(4.867)}{1.412}LCOP + 18.736 + ECT2 \qquad (16)$$

The corresponding restricted VECMs (VECs) are reported in Table 9 and 10, respectively.

[8] Hanck (2006) suggests that the Johansen procedure severely over-rejects the null of "less cointegration" versus the alternative of "more cointegration" in small samples when r>0, which further suggests favouring an inference of one rather than two cointegrating equations.

[9] The other variables in (15) are statistically significant, and while the negative sign of LCPI's coefficient is consistent with theoretical expectations the positive signs of the coefficients on LIR and LEXR are not. This raises doubts over the plausibility of (15) as a long-run equation for LRGDP.

Table 9: Five-Variable Model VEC results

	D(LRGDP)	D(LCOP)	D(LCPI)	D(LIR)	D(LEXR)
ECT5(-1)	0.021	0.135	-0.022	-0.053	0.111
	(1.064)	(2.936)	(-0.849)	(-1.542)	(2.141)
D(LRGDP(-1))	0.122	0.129	-0.372	0.403	-0.704
	(0.551)	(0.247)	(-1.279)	(1.038)	(-1.194)
D(LCOP(-1))	0.029	0.350	-0.053	-0.046	-0.053
	(0.348)	(1.790)	(-0.488)	(-0.317)	(-0.242)
D(LCPI(-1))	-0.242	-0.225	0.463	0.439	-0.324
	(-1.271)	(-0.502)	(1.856)	(1.317)	(-0.641)
D(LIR(-1))	0.026	0.394	-0.280	-0.580	-0.439
	(0.193)	(1.228)	(-1.566)	(-2.429)	(-1.210)
D(LEXR(-1))	0.060	0.042	-0.035	0.0871	0.351
	(0.944)	(0.281)	(-0.421)	(0.784)	(2.081)
C	0.086	0.093	0.175	-0.122	0.290
	(1.635)	(0.753)	(2.544)	(-1.322)	(2.077)
$\bar{R}^2$	0.042	0.100	0.202	0.071	0.295
s	0.127	0.299	0.167	0.223	0.338
$F(R^2)$	1.303	1.763	2.726	1.521	3.860

See notes to Table 5.

For LRGDP to be forced towards its long-run value the error-correction term must be negative and statistically significant in the DLRGDP equation of the VEC. However, this is not the case in both the five-variable and two-variable VECs, which implies LRGDP is not being forced towards its long-run value. This provides further evidence that contradicts the expectation that crude oil prices have a negative long-run effect on GDP. In this sense, the results from the VECs are consistent with those from the ARDL model and our general conclusion is that crude oil prices do not have a negative and significant long-run effect on GDP. The coefficient on DLCOP in the DLRGDP equation is statistically insignificant in both the five-variable and two-variable VECs which suggests that oil price shocks have no significant impact on output in the short term. This is broadly consistent with our results from the DVARs.

Table 10: Two-Variable Model VEC results

	D(LRGDP)	D(LCOP)
ECT2(-1)	-0.021	0.182
	(-0.973)	(3.815)
D(LRGDP(-1))	0.327	0.174
	(2.169)	(0.522)
D(LCOP(-1))	-0.025	0.003
	(-0.393)	(0.024)
C	0.032	0.080
	(1.524)	(1.692)
$\bar{R}^2$	0.067	0.223
s	0.126	0.2780
$F(R^2)$	1.976	4.916

See notes to Table 5.

Our results contrast with those of Adam and Tweneboah (2009) who, using the same five-variable VECM framework as us, found significant negative effects of oil price shocks on Ghana's output in both the short-run and the long-run. Our results also differ from those of Jumah and Pastuszyn (2007) who found that oil prices are significantly negatively correlated with Ghana's economic growth. One difference between these papers and ours that may explain our contrasting findings is that we use data covering a more recent period.[10] Our results are also inconsistent with those of Fofana et al (2009), Rafiq et al (2009), and Park et al (2011) who examined the crude oil price-macro economy relationship for other developing countries in a less recent period to us. Given our results are broadly robust to the treatment of oil prices as exogenous or endogenous they provide an interesting insight into the oil price-macro economy relationship during the post 2007 period when world oil prices have dramatically fallen.

[10] Also, Adam and Tweneboah (2009) interpolated their GDP data from annual to quarterly. Whilst using higher frequency data is preferable the interpolation method introduces variation into the data that may not be accurate. There are also some doubts over the plausibility of the Johansen cointegrating equation that they report because the interest rate has an unexpected significant positive impact on GDP

Our general finding that international crude oil price movements have an insignificant effect on Ghana's GDP may be explained by the nature of Ghana's economy. Like most West African countries, primary production dominates Ghana's economic activity. The agricultural sector was the largest in Ghana from the 1960s to 2005 with its average contribution to GDP being over 50% in this period. Since mechanized farming in Ghana remains at an infant stage, the agricultural sector relies predominantly on labour rather than machines and therefore has a relatively low fuel dependence from oil. Further, the services sector, which became the largest sector in Ghana from 2006, is dominated by communication, finance, and general administration services. As for agriculture, these services have a relatively low use of oil, and are relatively insensitive to oil price shocks. The industrial sector is Ghana's smallest sector with the manufacturing subsector contributing a relatively small amount to total industrial output. Ghana's industrial sector relies mostly on electricity for energy rather than oil. This relatively low reliance on oil could explain the insignificant effects of international crude oil prices on output in Ghana, especially given the fall in oil prices since 2007.

The insignificant impact of oil prices on Ghana's GDP could also be due to the subsidies the government provided on petroleum products for several years before full deregulation in 2015. That the full cost of petroleum products was not always passed on to consumers could also have shielded the economy from the adverse effects of oil price shocks, however, this has not been formally tested.

6. Conclusion

This paper investigates the macroeconomic impact of international oil price shocks in Ghana using exogenous and endogenous crude oil price models. The exogenous oil price models employed were short-run DVARs (involving scenario-based forecasting) and ARDL models that considered both short-run and long-run relationships among variables. For the endogenous oil price models, we used VECs based on the standard Johansen procedure.

Overall, our results suggest that international crude oil price shocks have no significant negative effect on GDP in the short-run or the long-run. Nevertheless, the forecast scenario results suggest that a one-time crude oil price shock causes an initial two percentage point reduction in GDP growth followed a year later by an offsetting two percentage point increase. However, the effect of the shock is transitory, becoming almost zero after about two years. Further, the asymmetric forecast scenario results suggest that a negative crude oil price shock initially raises growth by 15 percentage points, although this effect slowly evaporates through time. The ARDL specifications indicate no significant oil price effect on GDP in either the short-run or long-run. A significant long-run positive impact of oil prices on GDP is indicated by the Johansen cointegrating equations, however, there are serious doubts over whether these estimated cointegrating equations represent plausible long-run models of GDP and therefore inference from them is treated with serious caution. The VEC models suggest no significant short-run effect of oil prices on GDP. Hence, we interpret our results as oil prices having no plausible significant effect on Ghana's GDP. The general insignificance of the crude oil price effect could be due to the low level of industrialization and mechanized farming in Ghana, the overall structure of the Ghanaian economy, and the subsidization of petroleum products up to 2015.

One policy implication of our results is that if crude oil prices have no significant (negative) effect on GDP policy makers have discretion in deciding the path of output under most circumstances. For example, an oil price spike does not constrain monetary authorities to loosen monetary policy to offset its adverse effect on output. If inflation is a priority, policy makers could focus on inflation stabilization by tightening monetary policy during oil price rises.

Avenues for future research include the following. First, as more data becomes available, future research could examine the oil price macro economy relationship after the government removed all subsidies on petroleum products in 2015, because the results may be different from the era with subsidies. Second, because agriculture historically accounted for a large percentage of Ghana’s GDP, future research can consider how oil price shocks affect the individual agricultural, services, and industrial sectors.

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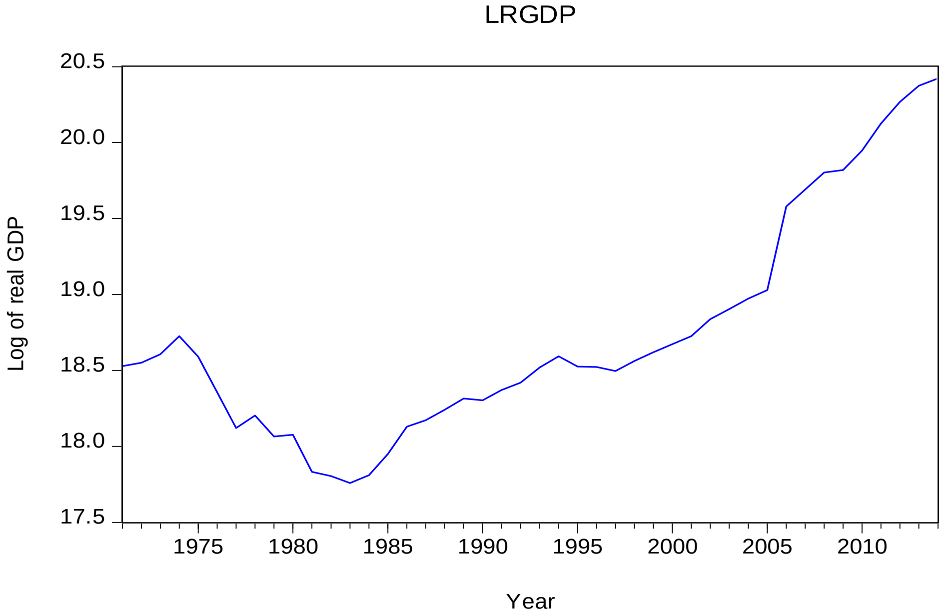
Appendices

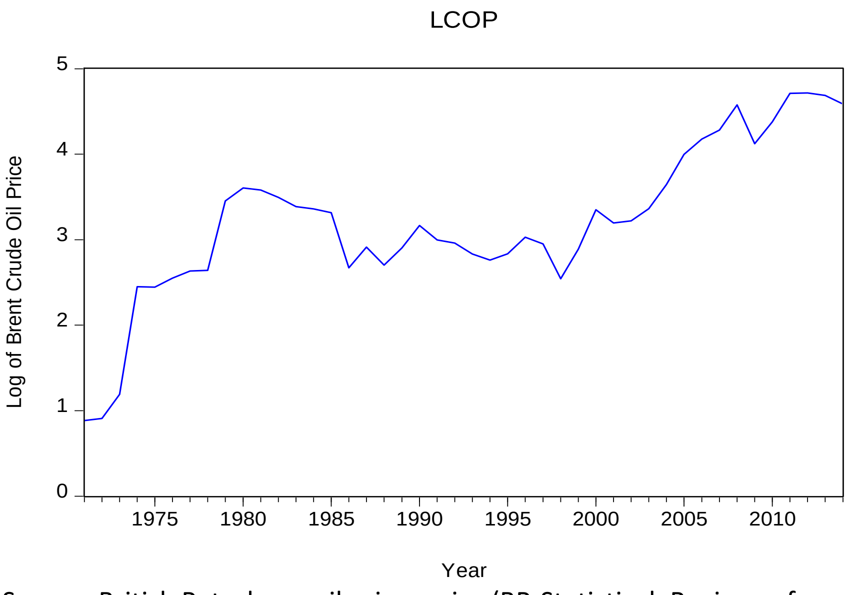
Appendix A: Variable graphs

Figure A1: LRGDP



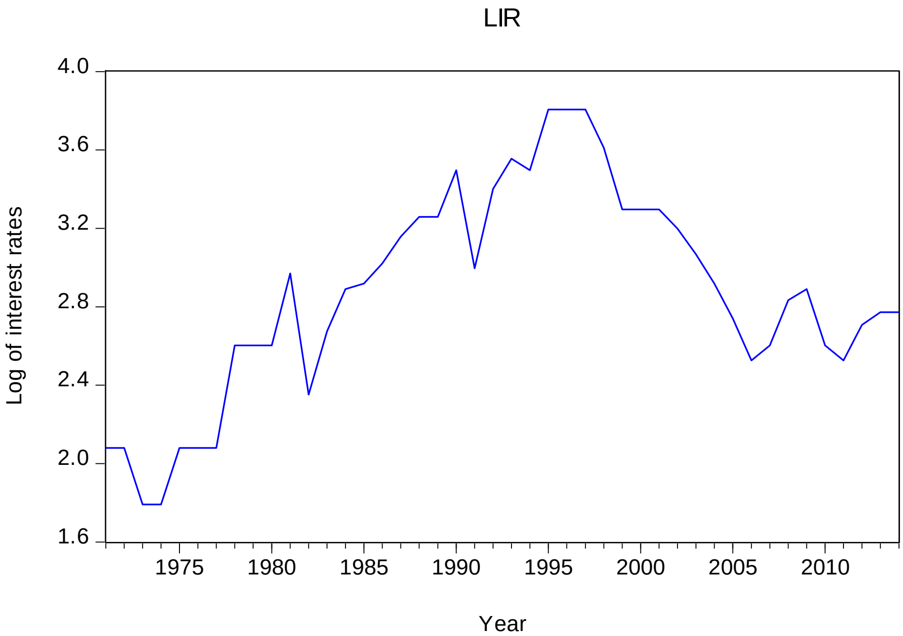
Source: Author's calculations using World Bank series for Nominal GDP (current LCU) (World Bank 2014, Series Code: "NY.GDP.MKTP.CN") and Consumer price index (2010=100) (World Bank 2014, Series Code: "FP.CPI.TOTL")

Figure A2: LCOP



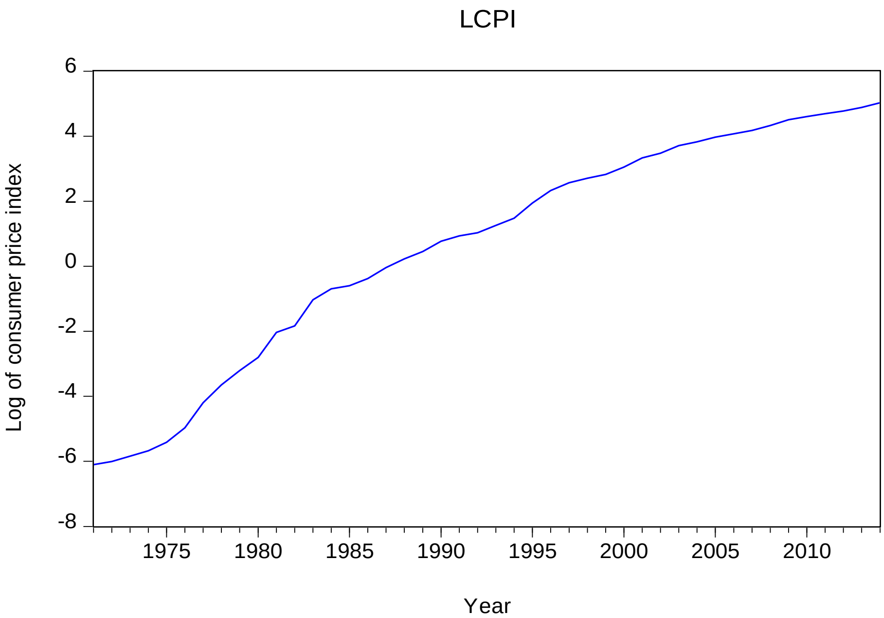
Source: British Petroleum oil price series (BP-Statistical_Review_of_world_energy_2014_workbook)

Figure A3: LIR



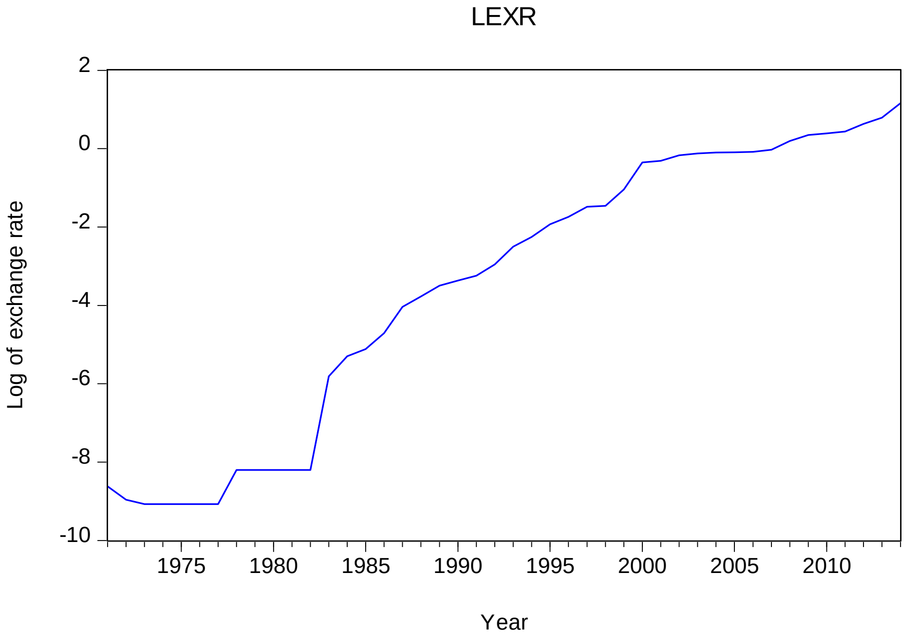
Source: Data stream (GSS 2014, Series Code: GHY60…)

Figure A4: LCPI



Source: World Bank series for Consumer Price Index (2010=100) (World Bank 2014, Series Code: "FP.CPI.TOTL")

Figure A5: LEXR



Source: IMF International Financial Statistics series for GH₵/US$ (IMF 2017, Series Code: “AE---ZF---)

Appendix B: Exogenous crude oil price models

Appendix B1: Five-Variable DVAR Lag Selection Criteria

Lag	AIC	SIC
0	-1.697831	-1.356587*
1	-1.844501*	-0.820771
2	-1.584099	0.122118
3	-1.014639	1.374065
4	-1.338437	1.732754

Notes: AIC denotes the Akaike information criterion, SIC is the Schwarz information criterion and * indicates lag order selected by the criterion.

Appendix B2: Five-Variable DVAR Autocorrelation LM test

Null hypothesis: No serial correlation at lag h		
Lag (h)	LM-stat	Prob.
1	16.84505	0.3957
2	15.40529	0.4952
3	11.03825	0.8071
4	21.50884	0.1598

Appendix B3: Five-Variable DVAR Heteroscedasticity test (without cross terms)

Chi-sq	df	Prob.
116.1116	100	0.1293

Appendix B4: Normality test For the Five-Variable DVAR

Component	Skewness	Chi-sq	df	Prob.
1	1.019602	7.277124	1	0.0070
2	0.299682	0.628665	1	0.4278
3	0.589639	2.433722	1	0.1188
4	0.706476	3.493756	1	0.0616
Joint		13.83327	4	0.0078
Component	Kurtosis	Chi-sq	df	Prob.
1	7.927008	42.48197	1	0.0000
2	3.284889	0.142033	1	0.7063
3	3.598759	0.627396	1	0.4283
4	6.006710	15.82053	1	0.0001
Joint		59.07193	4	0.0000
Component	Jarque-Bera	df	Prob.	
1	49.75909	2	0.0000	
2	0.770698	2	0.6802	
3	3.061118	2	0.2164	
4	19.31429	2	0.0001	
Joint	72.90520	8	0.0000	

Appendix B5: Two-Variable DVAR Lag Selection Criteria

Lag	AIC	SIC
0	-1.152672	-1.067361
1	-1.248821	-1.120854*
2	-1.246433	-1.075812
3	-1.227501	-1.014224
4	-1.280896*	-1.024963

Appendix B6: Two-Variable DVAR Autocorrelation LM test

Null hypothesis: No serial correlation at lag h		
Lag (h)	LM-stat	Prob.
1	0.383684	0.5356
2	0.046842	0.8287
3	2.138319	0.1437
4	1.196845	0.2740

Appendix B3: Two-Variable DVAR Heteroscedasticity test (without cross terms)

Chi-sq	df	Prob.
0.260	3	0.8469

Appendix B8: Normality test For the Basic Two-Variable DVAR model

Component	Skewness	Chi-sq	df	Prob.
1	1.216841	10.11813	1	0.0015
Joint		10.11813	1	0.0015
Component	Kurtosis	Chi-sq	df	Prob.
1	8.659313	54.71420	1	0.0000
Joint		54.71420	1	0.0000
Component	Jarque-Bera	df	Prob.	
1	64.83233	2	0.0000	
Joint	64.83233	2	0.0000	

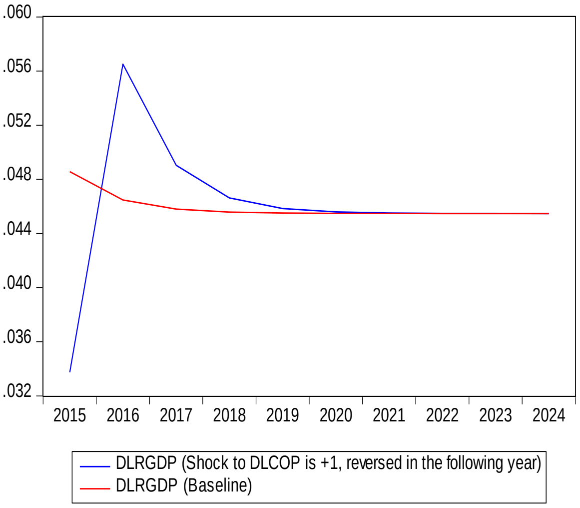
Appendix B9: Two-variable DVAR results

	DLRGDP	DLRGDP
DLRGDP(-1)	0.261832	0.247661
	(1.62627)	(1.51903)
DLRGDP(-2)	0.214089	0.217831
	(1.32849)	(1.34316)
C	0.024188	0.010879
	(1.10535)	(0.38549)
DLCOP	-0.007205	
	(-0.11433)	
DLCOPP		0.036916
		(0.42778)
DLCOPN		-0.112253
		(-0.73294)
$\bar{R}^2$	0.082397	0.071550
s	0.126169	0.126913
$F(R^2)$	2.197285	1.770636

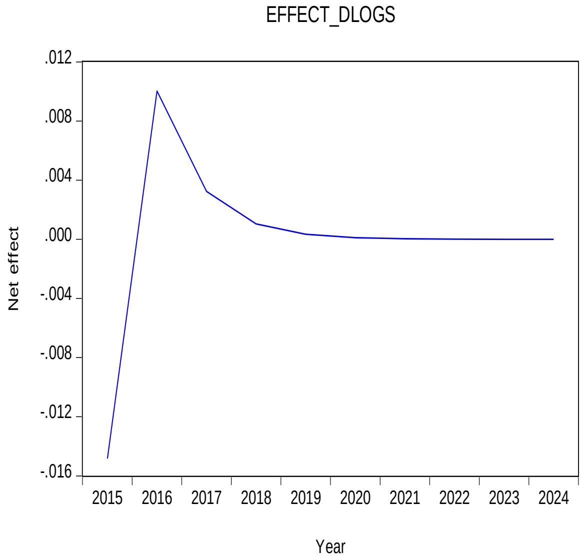
See notes to Table 5.

Appendix B10: Impact of oil price shock on GDP growth rate, 2015 to 2024

(a)
Comparative forecast of oil price shock on growth rate

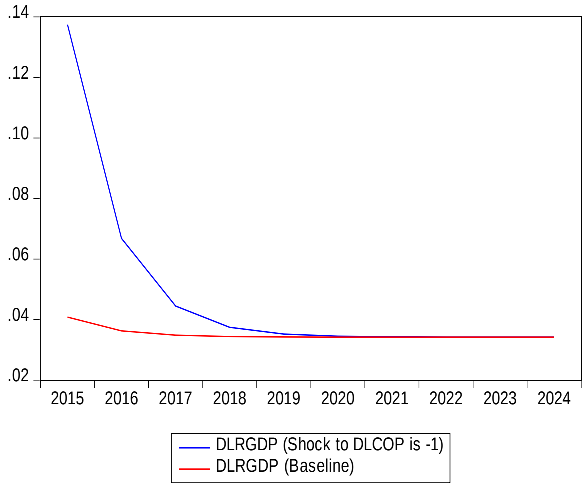


(b)
Net Effect of oil price shock on growth rate

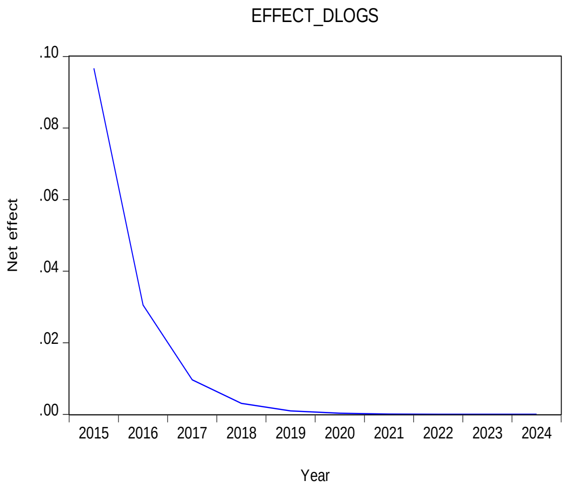


Appendix B11: Impact of negative shock to oil price growth rate

(a)
Comparative forecast of a negative oil price shock on growth rate



(b)
Net effect of a negative oil price shock on growth



Appendix B12: ARDL misspecification tests

FA2	0.869 [0.429]
FMH	1.517 [0.194]

FA2 denotes the F-version of the Breusch-Godfrey test for second-order autocorrelation, while FH represents the F-version of White’s test (excluding cross-terms) for heteroscedasticty. Probability values are given in squared parentheses.

Appendix C: Endogenous crude oil price models

Appendix C1: Lag Selection Criteria for the Five-Variable Levels VAR

Lag	AIC	SIC
0	8.357790	8.568900
1	-3.022895*	-1.756236*
2	-2.874244	-0.552034
3	-2.697333	0.680426
4	-2.624196	1.809112

Appendix C2: Five-Variable VEC Autocorrelation LM test

Null hypothesis: No autocorrelation at lag h		
Lag (h)	LM-stat	Prob.
1	27.93878	0.3107
2	21.96996	0.6375
3	25.66972	0.4254
4	22.31216	0.6177

Appendix C3: Five-Variable VEC Heteroscedasticity test (no cross-terms)

Chi-sq	df	Prob.
200.9079	180	0.1364

Appendix C4: Five-Variable VEC Normality test

Component	Skewness	Chi-sq	df	Prob.
1	1.287654	11.60637	1	0.0007
2	0.254922	0.454896	1	0.5000
3	0.245532	0.422003	1	0.5159
4	0.693955	3.371013	1	0.0664
5	0.110698	0.085778	1	0.7696
Joint		15.94006	5	0.0070
Component	Kurtosis	Chi-sq	df	Prob.
1	8.339739	49.89743	1	0.0000
2	4.834657	5.890442	1	0.0152
3	3.301712	0.159303	1	0.6898
4	4.140260	2.275338	1	0.1314
5	3.568319	0.565227	1	0.4522
Joint		58.78774	5	0.0000
Component	Jarque-Bera	df	Prob.	
1	61.50379	2	0.0000	
2	6.345338	2	0.0419	
3	0.581306	2	0.7478	
4	5.646350	2	0.0594	
5	0.651005	2	0.7222	
Joint	74.72779	10	0.0000	

Appendix C5: Two-Variable Level VAR Lag Selection Criteria

Lag	AIC	SIC
0	3.466010	3.550454
1	-1.141351*	-0.888019*
2	-1.012092	-0.589872
3	-0.957913	-0.366805
4	-1.056495	-0.296500

Appendix C6: Two-Variable VEC Autocorrelation LM test

Null hypothesis: No serial correlation at lag h		
Lag (h)	LM-stat	Prob.
1	6.251664	0.1811
2	2.094737	0.7183
3	4.818339	0.3064
4	3.285732	0.5112

Appendix C7: Two-Variable VEC Heteroscedasticity test (no cross-terms)

Chi-sq	df	Prob.
19.45367	18	0.3644

Appendix C8: Two-Variable VEC Normality test

Component	Skewness	Chi-sq	df	Prob.
1	1.006130	7.086081	1	0.0078
2	0.177474	0.220478	1	0.6387
Joint		7.306559	2	0.0259
Component	Kurtosis	Chi-sq	df	Prob.
1	8.503216	52.99942	1	0.0000
2	3.498069	0.434127	1	0.5100
Joint		53.43355	2	0.0000
Component	Jarque-Bera	df	Prob.	
1	60.08550	2	0.0000	
2	0.654605	2	0.7209	
Joint	60.74011	4	0.0000	