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Oil Price and Exchange Rate Nexus in Selected African OPEC Countries: Emphasis on Nigeria, Gabon and Algeria (1986-2023)

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Abstract

This study examined the relationship between oil price and exchange rate in three African OPEC countries namely Nigeria, Algeria and Gabon from 1986 to 2023. Time series secondary data on Brent and WTI crude oil prices were sourced from statista.com while data on Exchange Rate and External Reserves were sourced from the World Bank. The Toda-Yamamoto model which is an augmented Vector Autoregressive model, was employed to analyse the data. Impulse Response Functions was used to analyse the response of variables to shocks. The findings revealed a unidirectional causality running from oil price to exchange rate in Nigeria and no causality between oil price and exchange rate in both Algeria and Gabon. Findings also revealed an insignificant impact of oil prices on exchange rate in Algeria and Gabon but a significant impact was found in Nigeria. Exchange rate on other hand was found to be insignificant on world oil price for the three countries. The study also compared the impact of the two different oil prices i.e. Brent and WTI on exchange rate and found the same result in the three countries. The study therefore recommends that all the three countries should continue their efforts to diversify their economy away from heavy dependence on oil. Promoting sectors such as agriculture, manufacturing, services, and tourism can help reduce vulnerability to oil price fluctuations.

Keywords: Brent Crude Oil Price, Exchange Rate, Toda-Yamamoto, Volatility, West Texas Intermediate Crude Oil Price.

JEL classification code: O24, P28, Q47

1. Introduction

The impact of oil price to the development of any nation cannot be overemphasized. An increase in the international price of crude oil means an increase in the economic progress of a nation. A nation's wealth can be affected by severe movement in oil price through changes in exchange rate (Sanusi, 2020). To put it differently, when the price of oil increases, countries that export oil may observe their currency's value going up, whereas countries that import oil may see their currency's value going down, and the opposite holds true as well (Sanya & Oloruntuyi, 2017; Krugman, 1983 cited in Ogundipe et al., 2014; Bangura et al., 2021). In addition, exchange rate fluctuations can also cause the price of crude oil to change. For instance, the depreciation of US dollars can benefit foreigners by lowering prices in the global oil market (Bloomberg and Harris, 1995).

The depreciation of exchange rates in oil-exporting countries has been a serious issue due to the continuous volatility in global crude oil prices. Among these countries, developing oil exporters are the most vulnerable (Aleksandrova, 2016). Nigeria, Gabon, and Algeria are examples of African nations that have been affected by fluctuations in crude oil prices. Before the 1970s oil boom, Nigerian economy relied on agriculture, which contributed to 70% of its GDP and 90% of its foreign exchange (Adedipe, 2004 cited in Ogundipe et al., 2014). However, after the discovery of oil, it became the primary source of income, accounting for 95% of export earnings and 83% of the budget (Ogundipe et al., 2014). Being heavily dependent on oil exports, Nigeria remains susceptible to changes in international crude oil prices (Englama et al., 2010).

Algeria and Gabon have also experienced exchange rate depreciation in recent decades. Algeria, as the largest country and a significant energy exporter, relies heavily on oil production, which accounts for over two-thirds of its wealth and more than 95% of its total exports. The revenue from oil constitutes over 75% of tax revenues and approximately 60% of the state budget (Khettab, 2016). While the Algerian economy has been impacted by crude oil price volatility, the effect on the Algerian dinar has not been as severe as in Nigeria and Gabon, as illustrated in Figure 1.

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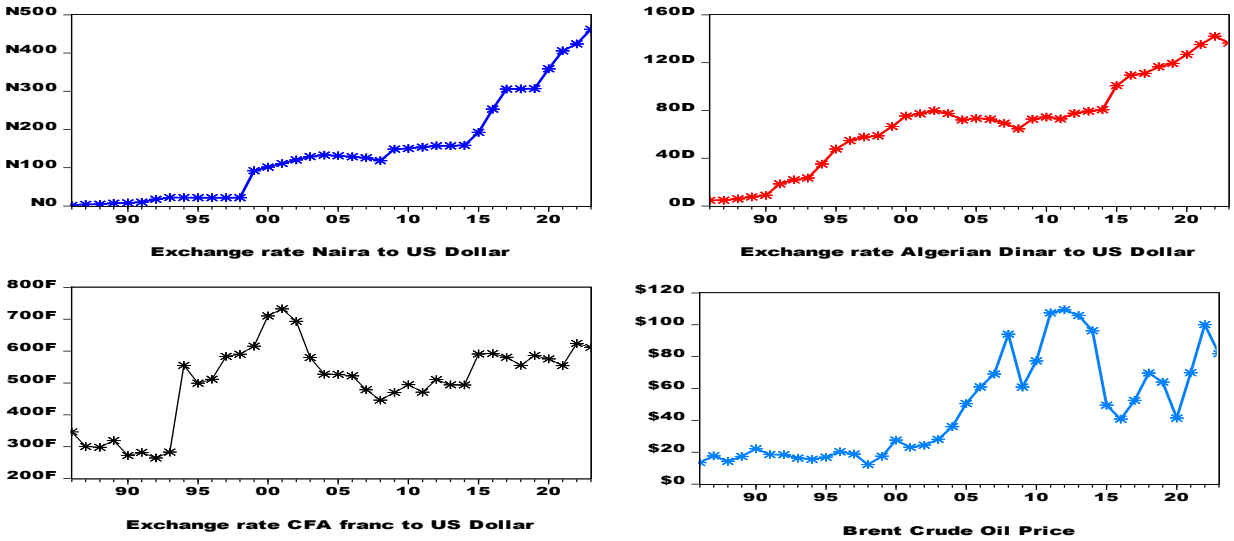

Figure 1: Trend of Brent Crude Oil Price, Exchange Rate Naira to US Dollar, Exchange Rate Algerian Dinar to US Dollar and Exchange Rate CFA Franc to US Dollar from 1986 To 2023.

Source: Author's Compilation, 2023

During the period from 2001 to 2008, when Brent crude oil prices rose from US$28 to US$94 per barrel, the exchange rate between the Nigerian naira and the US dollar remained relatively stable, fluctuating between 111 and 119 naira. In contrast, the Gabonese CFA franc and the Algerian dinar appreciated against the US dollar, with the exchange rate for the former increasing from 732XAF to 446XAF, and the latter from 77DZD to 65DZD. However, from 2012 to 2016, when global oil prices fell from US$109 to US$41 per barrel, the exchange rate of the Nigerian naira to the US dollar depreciated from 158 to 253.492 naira. Similarly, during this period, the Gabonese CFA franc and the Algerian dinar also experienced depreciation, with the former falling from 511XAF to 593XAF and the latter from 78DZD to 109.44DZD. Since then, the exchange rates in these three countries have continued to depreciate due to fluctuations in global oil prices. As of May 2023, the exchange rate for the Nigerian naira to the US dollar was 462 naira, while the Algerian dinar stood at 136DZD, and the Gabonese CFA franc at 612XAF.

Fluctuations in oil price make oil dependent countries vulnerable to exchange rate fluctuation which has the tendency to further result to economic instability, fiscal imbalances, inflationary pressures, and reduced competitiveness in the international market. These vulnerabilities pose threats to overall economic growth, development, and welfare in these countries.

While some studies such as Djebbouri (2018), Ahlem and Abderahmane (2022), Benhabib et al. (2014), Musa et al. (2020), Ogundipe et al. (2014), Wiafe et al. (2017) among others confirmed the

negative significant impact of fluctuations in global crude oil prices on exchange rates, other studies such as Henry (2019), Englama et al. (2010), Igbinovia and Ogiemudia (2021), Avielele (2020) found a mixed results. Therefore, there is lack of concensus as to the relationship between oil price and exchange rate among literatures which is the motivation for this study.

Also, while previous studies have examined the relationship between oil price volatility and exchange rates, further research is needed, especially to include a wider range of countries beyond Nigeria. Additionally, the lack of clarity regarding the specific type of crude oil price used in previous studies presents a challenge for policymakers, given the various variants of crude oil prices available. Therefore, this study aims to investigate the nexus between oil prices and exchange rates in three OPEC African countries: Nigeria, Algeria, and Gabon. The study will use the Brent crude oil price and compare its relationship with exchange rate to that of West Texas Intermediate (WTI) crude oil price.

2. Literature Review

2.1 Empirical Literature Review

In a bid to investigate the nexus between oil price and exchange rate, several studies have been conducted by researchers. Some focused on one country while others cut across two or more countries. Most of the country-specific stduies were done in Nigeria. Some of them saw a significant negative impact of oil price on exchange rate e.g. Musa et al. (2020) using the Autoregressive distributed lag model found a significant short-run and long-run negative impact of oil price on exchange rate in Nigeria from 1983 to 2017. Similarly, using the ARDL model, Henry (2019) found a significant long-run negative impact of oil price volatility on exchange rates in Nigeria. His findings however, showed an insignificant negative relationship in the short run. Another similar study conducted by Ogundipe et al. (2014) using the vector error correction Model (VECM) on annual time series data spanning from 1970 to 2011 found a significant negative impact of world oil price on exchange rate volatility in Nigeria. Similar to Ogundipe et al. (2014), Englama et al. (2010) employing the VECM on monthly time series data from 1999 to 2009 revealed that a permanent increase of 1.0% in oil prices in the international market will lead to a long-run increase in exchange rate volatility by 0.54% and a short-run increase by 0.02%.

Some Nigerian studies also examined the causality between exchange rate and oil prices in Nigeria e.g. Adejola et al. (2022) used the descriptive statistics and VAR granger causality test to examine the oil price-exchange rate nexus in Nigeria with monthly data from 1980 to 2020 within the framework of the wavelet analysis. The findings revealed that in the short run there is a one way causality running from oil prices to exchange rates. However, in the long run, a two-way causation exist between oil prices and exchange rates. Adi et al. (2022) used the VAR-AGARCH model to

examine the shocks and volatility transmission between oil price and exchange rate markets in Nigeria using daily data from 2009 to 2020. Their findings revealed that both the WTI oil price and Brent oil prices have a bidirectional shock and volatility with naira exchange rate.

Other Nigerian studies found a positive relationship between oil price and exchange rate though the impact was not significant e.g. Using the VECM, a study conducted by Igbinovia and Ogiemudia (2021) from 1983 to 2019 revealed that oil price has a long-run positive non-significant influence on exchange rate volatility. However the impact is negative but insignificant in the short-run. Laslty, similar study conducted by Ojebiyi and Wilson (2011) using the ordinary least square regression and correlation analysis on monthly data from 1999-2009, found a weak and negative relationship between exchange rate and oil price in Nigeria.

The few studies conducted in Algeria saw a significant negative impact of oil price volatility on exchange rate. For instance, Ahlem and Abderahmane (2022) used the ordinary least squares (OLS) regression method to examine the impact of oil price changes on the Algerian dinar from 2004 to 2018. Their findings revealed a significant negative impact of oil price on exchange rate of Algerian dinar to US Dollars. Also, using the vector autoregressive model (VAR) on monthly time series data from 2003 to 2013. Benhabib et al. (2014) found a significant negative impact of oil price on the exchange rate of Algerian dinar. Similarly, Djebourri (2018) used the VECM on annual time series data from 1980 to 2017 and found a significant negative impact of oil price shocks on exchange rate in Algeria.

Few other studies were done in countries like Ghana, South Africa and Pakistan. For instance, In Ghana, Najimu and Mahama (2022) used the correlation matrix, cointegration tests and regression analysis to examine the impact of exchange rate volatility on crude oil prices in the downstream petroleum industry. Their findings revealed a positive impact of exchange rate on downstream prices of petroleum. They also found a long-term relationship between exchange rate and oil prices in the downstream petroleum industry in Ghana. In the same context, using the fully modified ordinary least squares (FMOLS) and the ARDL model, Wiafe et al. (2017) saw a significant negative impact of crude oil prices on exchange rate of Ghana cedi.

In South Africa, Hlongwane et al. (2022) used the TGARCH model on monthly time series data from January 1960 to November 2021 in examining the nexus between volatility in oil prices and exchange rate volatility. Their findings revealed a significant negative impact of oil prices on exchange rates in South Africa. In the context of the pakistanian economy, Ahmed and Qaiser (2016) found a positive impact of oil price on exchange rate volatility using the vector error correction model (VECM) and the EGARCH model in examining the influence of oil price volatility on exchange rate fluctuations from the first quarter of 1983 to the second quarter of 2014.

Several cross-country studies were done on the relationship between oil price volatility and exchange rate. For instance, Edewusi and Duru (2022) used the non-linear ARDL model to explore the impact of oil price volatility on the foreign exchange of major oil producing countries, Nigeria and Angola from 1999 to 2020. Their findings revealed an adverse effect of oil price volatility on the foreign exchange of the two countries. Also, in an effort to investigate the correlation between oil price fluctuations and currency volatility in Nigeria and South Africa from 2009 to 2019, Avielele (2020) conducted a study using the ordinary least squares (OLS) and the ARDL model. The results yielded a mixed outcome. Specifically, there was a significant negative relationship observed between changes in oil price and the Nigerian naira. On the other hand, the findings indicated a positive relationship between South African rand and crude oil prices. Sanya and Oloruntuyi (2017) used the structural vector autoregressive model (SVAR), EGARCH to examine the relationship between oil price volatility and macroeconomic performance in Angola and Nigeria. Findings from the impulse response function and variance decomposition analysis revealed that the most substantial impact on the exchange rate was observed when it experienced shocks resulting from fluctuations in oil prices.

Nouira et al. (2022) employed the asymmetric non-causality, impulse response functions, and causality-in-variance to analyze the effects of oil price fluctuations on exchange rates in selected MENA countries (Egypt, Jordan, Morocco, Qatar, Saudi Arabia, Tunisia, and UAE) between the period of 2001 to 2017. The findings revealed a casual relationship between rising oil prices and exchange rate in the case of Tunisia and Saudi Arabia. Donkor et al. (2022) employed the VAR model to examine the relationship between oil price volatility and bilateral exchange rate volatility in oil-dependent countries, both before and after the global financial recession of 2008-2009. The findings revealed the presence of both unidirectional and bidirectional causality between oil price volatility and exchange rate volatility in the selected countries.

A study conducted in the Sub-Saharan African countries by Ehikioya et al. (2020) from 2004 to 2017 using the VECM, found a significant long-run relationship between oil price and exchange rate in Nigeria, Angola, The Republic of Congo, Guinea and Gabon. Lastly, using the non-linear ARDL model on data from 1995 to 2018, Sanusi (2020) found an asymmetric relationship between oil price and exchange rate in both the short-run and long-run within the oil-exporting developing countries.

2.2 Theoretical framework

Purchasing Power Parity

The Purchasing power parity (PPP) theory was propounded by Gustav Cassel in 1916. The PPP is a widely recognized economic concept that suggests that exchange rates should adjust to ensure that the purchasing power of different currencies are equal. The underlying principle of PPP theory is the law of one price which states that identical goods should have the same price in different markets when expressed in a common currency. According to PPP, changes in relative prices levels

between countries should be reflected in the exchange rate between their currencies. The ratio of the general price level of goods determines the exchange rate between two countries (Cassel, 1916).

$S=P_1/P_2$

Where:

S represents the exchange rates between two currencies

P_1 is the price level of a basket of goods and services in one country (the base country).

P_2 is the price level of the same basket of goods and services in another country (the target country).

In simpler terms, the equation states that the exchange rate between two currencies should be such that the cost of a given basket of goods and services is the same in both countries when assessed in their individual currencies.

The principle notes that if each currency pair is set at equal, then the exchange rate difference will represent deviations resulting from the relative currency's purchasing power compared to the base exchange rate (Ibenta, 2012). In the context of oil price volatility and exchange rates, PPP theory implies that fluctuations in oil prices should influence the exchange rates to maintain parity in the prices of internationally traded goods. This theory has been used in studies like Najimu and Mahama (2022) and Avielele (2020). The relevance of PPP theory to the study of oil price volatility and exchange rates lies in understanding how fluctuations in oil price can impact the relative price levels of countries and consequently exchange rate. Oil is a globally traded commodity, and changes in its prices can have widespread effects on economies and international trade.

3. Methodology

3.1 Data Source and Description

This study employed time series data which span the period of 1988 to 2023. Data on oil price was derived from Statista.com while the data on exchange rate and external reserves in Nigeria, Gabon and Algeria were sourced from World Bank.

Description of Variables

Oil price: This is the price at which crude oil is sold in the international market. It is measured in US dollars. The Brent crude oil prices will be used for the analysis and the result will be confirmed with the WTI crude oil prices for robustness check.

Exchange rate: Exchange rate is the price of a country's currency in terms of one unit of another

country's currency. For Nigeria, exchange rate is measured as the value of Naira to one US Dollar. For Algeria, it is measured as the value of Algerian Dinar to US Dollar. For Gabon, it is a measure of the value of Central African Franc to one US Dollar.

External Reserves: This is the amount of revenue saved by a country from trading with other nations and it is measured in millions US dollars.

3.2 Model Specification

The model for this study was adapted from the study done by Ogundipe et al. (2004) where exchange rate volatility was a function of oil price, external reserves and interest rate.

Vol EXR= *f* (OILP, ER, INT)

In order to achieve the objective of this study, the general functional form of the model will be stated as follows:

EXR= *f* (OILP, ER)

Where EXR = Exchange Rate, OILP= World Crude Oil Price, ER = External Reserves

3.2.1 Toda-Yamamoto Model

This study employed the Toda-Yamamoto model to examine the nexus between oil price and exchange rate in three African oil exporting countries, Nigeria, Algeria and Gabon. Toda-Yamamoto is a multivariate model that is considered if series are of different orders of integration say I(0) and I(1) Salisu (2015). The Toda-Yamamoto causality method utilizes a modified Wald test to examine restrictions on individual parameters within the Vector Autoregressive (VAR) model with lag length k. The overall order of the system is expanded by incorporating the maximum integration order (d_{max}). The approach involves estimating the VAR model with lag length ($k+d_{max}$), while disregarding the coefficients associated with the last lagged variables (d_{max}) (Toda and Yamamoto, 1995).

The general form of the Toda-Yamamoto Model where all the variables are endogenous for the three countries is stated as follow:

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$$LEXR_t = \lambda_0 + \sum_{i=1}^{K} \alpha_{1i} LEXR_{t-1} + \sum_{j=K+1}^{K+dmax} \alpha_{1j} LEXR_{t-j} + \sum_{i=1}^{K} \beta_{1i} LOILP_{t-1} + \sum_{j=k+1}^{K+dmax} \beta_{1j} OILP_{t-j} + \sum_{i=1}^{K} \delta_{1i} LER_{t-1} + \sum_{j=k+1}^{k+dmax} \delta_{1j} LER_{t-j} + \varepsilon_{1i} \quad ----------1$$

$$LOILP_t = \lambda_0 + \sum_{i=1}^{K} \alpha_{2i} LEXR_{t-1} + \sum_{j=K+1}^{K+dmax} \alpha_{2j} LEXR_{t-j} + \sum_{i=1}^{K} \beta_{2i} LOILP_{t-1} + \sum_{j=k+1}^{K+dmax} \beta_{2j} LOILP_{t-j} + \sum_{i=1}^{K} \delta_{2i} LER_{t-1} + \sum_{j=k+1}^{k+dmax} \delta_{2j} LER_{t-j} + \varepsilon_{2i} \quad ----------2$$

$$LER_t = \lambda_0 + \sum_{i=1}^{K} \alpha_{3i} LEXR_{t-1} + \sum_{j=K+1}^{K+dmax} \alpha_{3j} LEXR_{t-j} + \sum_{i=1}^{K} \beta_{3i} LOILP_{t-1} + \sum_{j=k+1}^{K+dmax} \beta_{3j} LOILP_{t-j} + \sum_{i=1}^{K} \delta_{3i} LER_{t-1} + \sum_{j=k+1}^{k+dmax} \delta_{3j} LER_{t-j} + \varepsilon_{3i} \quad ----------3$$

Where d_{max} = maximum order of integration, K= the optimal lag length as given by various information criteria. λ_1 --- λ_3 represent the intercepts, α, β, δ represent the coefficients of the explanatory variables in the three equations, ε_{1i} --- ε_{3i} represent the stochastic error term or white noise components. All the variables are represented in logarithmic form to avoid the issue of changing variances in oder to make the data more suitable for analysis (Ozturk, Cinar and Emek, 2020).

Note for the sake of simplicity, the variable EXR and ER will be replaced by NEXR and NER in the case of Nigeria, ALGEXR and ALGER in the case of Algeria and GABEXR and GER in the case of Gabon because the data are not uniform while OILP remains the same for the three countries. Where NEXR= Exchange rate Naira to US Dollar, GABEXR= Exchange rate of Central African Franc to US Dollar, ALGEXR= Exchange rate of Algerian Dinar to US Dollar, OILP= International Oil price, NER= Nigerian External Reserves, GER= Gabonese External Reserves, ALGER= Algerian External Reserves.

4.0 Analysis and Discussions

4.1. Correlation Matrix

The correlation matrix can be used to check for the existence of multi-collinearity, a violation of one of the assumptions of the Ordinary Least squares. There is multi-collinearity in a model if variables show a very strong correlation among each other.

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Table 1: Correlation matrix

	NIGERIA			ALGERIA			GABON		
	EXR	OILP	ER	EXR	OILP	ER	EXR	LOILP	LGER
EXR	1	0.59	0.68	1	0.65	0.60	1	0.36	0.32
OILP	0.59	1	0.50	0.65	1	0.60	0.36	1	0.67
NER	0.68	0.50	1	0.60	0.60	1	0.32	0.67	1

Source: Author's Compilation, 2023

From the correlation matrix above, all the variables combinations show a positive relationship between each other but the correlation coefficients though above 0.5 in most cases are not strong for there to be multi-collinearity. We can conclude on this premise that the model is free from multi-collinearity.

4.2 Pre-Estimation Test

4.2.1 Unit Root Test

It is necessary to regularly examine the time-series characteristics of macroeconomic variables in order to prevent obtaining a spurious result. In this study, the Augmented Dickey-Fuller unit root test was employed to assess the presence of unit roots in the model and the result was confirmed using the Philips-Perron statistic.

Table 2: Unit root test results

	ADF			Philips- Perron		
Variables	Levels	1st Difference	I(d)	Levels	1st Difference	I(d)
Nigeria						
LNEXR	-3.9662a*	-	I(0)	-3.2144a**	-	I(0)
LOILP	-2.1974	-5.9881b*	I(1)	-2.1974	-5.8205b*	I(1)
LNER	-1.9359	-5.7294b*	I(1)	-1.7920	-9.0670b*	I(1)
Algeria						
LALGEXR	-3.958b*	-	I(0)	-3.7114a*	-	(I(0)
LOILP	-2.1974	-5.9881b*	I(1)	-2.1974	-5.8205b*	I(1)
LALGER	-1.1752	-4.5271b*	I(1)	-1.1715	-5.2673b*	I(1)
Gabon						
LGABEXR	-4.868b*	-	I(0)	-1.9545	-6.1921b*	I(1)
LOILP	-2.1974	-5.9881b*	I(1)	-2.1974	-5.8205b*	I(1)
LGER	-4.168b**	-	I(0)	-4.206b**	-	I(0)

*Where a represents model with intercept, b represents model with trend and intercept, * represents significance at 1%, ** represents significance at 5%.*

Source: Author's Compilation, 2023

The results indicate that the first two models exhibit a combination of stationary I(0) and non-stationary I(1) variables, confirming a mixed order of integration. However, the results for the third model are contradictory. Despite this inconsistency, all models exhibit a mixed order of integration for the variables. Based on these findings, we can proceed to examine the long-run relationship among the variables using the ARDL Bound test, as proposed by Pesaran et al. (2001).

4.2.2 ARDL Bound Cointegration Test

When the unit root test shows a mixed order of integration of variables. The Engle-Granger and Johansen cointegration test cannot be used. The appropriate method to adopt is the ARDL bound test as developed by Pesaran et al. (2001). The decision criterion involves rejecting the null hypothesis of no levels relationship if the computed F-statistic exceeds the upper bound value. Conversely, if the calculated F-statistic is lower than the lower bound value, the null hypothesis is accepted. However, when the computed F-statistic falls between the lower and upper bound, the test result is inconclusive.

The ARDL bound test result is stated as follows

Table 3: ARDL Bound test results

	Nigeria			Algeria			Gabon					
Dependent Variable	LNEXR	LOILP	LNER	LALGEXR	LALGER	LOILP	LGABEXR	LOIL	LGER	Signif.	Lower I(0)	Upper I(1)
										10%	3.17	4.14
F-statistic	4.94	4.30	3.82	18.4	1.10	2.17	1.29	3.88	13.6	**5%**	**3.79**	**4.85**
K	2			2			2			2.50%	4.41	5.52
Sample	37			34			37			1%	5.15	6.36

Source: Author's Compilation, 2023

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From the ARDL bound test above, it can be seen that in the case of the Nigerian Model, when LNEXR is a dependent variable, there is a long-run relationship since the computed F-value of 4.94 is greater than the I(1) bound of 4.85 at 5%. However, the test is inconclusive when LOILP and LNER are dependent variables since their computed F-values of 4.30 and 3.82 both lie between the 5% I(0) and I(1) bounds. From the Algerian Model, there is a long-run relationship when LALGEXR is a dependent variable because the computed F-value of 18.4 is greater than the 5% I(1) of 4.85. However, there is no long-run relationship when LALGEX and LOILP are dependent variables since the computed F-values of 1.10 and 2.17 are way below the 5% lower bound I(0) of 3.79. Lastly, for the Gabonese Model, a long-run relationship only occurs when LGER is a dependent variable since the computed F-value of 13.6 is far above the 5% I(1) bound of 4.85. However, there is no long-run relationship when LGABEXR is a dependent variable because the computed F-value of 1.29 is below the 5% lower bound of 3.79. Also the test is inconclusive when LGER is used as dependent variable since the computed F-value of 3.88 lies between the 5% I(0) and I(1) critical values.

4.3 Toda -Yamamoto Model Estimation

Before estimating the Toda-Yamamoto model, it is important to know the maximum order of integration (d_{max}) of the variables. It was clear from the unit root test that, the d_{max} is 1. Also we need to determine the optimal lag length for each of the models in order to get the value of k for each of the models. This is determined below.

Table 4: Optimal Lag Length Selection

Lag	LR	FPE	AIC	SC	HQ
Nigeria(Endogenous Variables are LNEXR, LOILP, LNER)					
0	NA	0.060357	5.706097	5.840776	5.752027
1	153.6749*	0.000613	1.113012	1.651727*	1.296729*
2	15.67142	0.000591*	1.062001*	2.004753	1.383506
3	11.33791	0.000648	1.118999	2.465788	1.578293
4	8.035071	0.000805	1.265789	3.016614	1.86287
Algeria (Endogenous Variables are LALGEXR, LOILP, LALGER)					
0	NA	0.046245	5.439782	5.574461	5.485711
1	194.9977	0.000118	-0.530728	.007987*	-0.347011

2	21.19477	9.31E-05	-0.786308	0.156444	-0.464802*
3	8.498707	0.000115	-0.611009	0.73578	-0.151715
4	17.01435*	9.30e-05*	-0.891804*	0.859021	-0.294723
Gabon (Endogenous Variables are LGABEXR, LOILP, LGER)					
0	NA	0.024058	4.786273	4.920952	4.832202
1	105.7992*	0.001205*	1.789046*	2.327761*	1.972763*
2	4.688285	0.001745	2.144817	3.087569	2.466323
3	11.49129	0.001903	2.195425	3.542214	2.654719
4	9.184402	0.002235	2.287484	4.03831	2.884566

*Where * indicates lag order selected by the criterion, LR = sequential modified LR test statistic (each test at 5% level), FPE = Final prediction error, AIC = Akaike information criterion, SC = Schwarz information criterion and HQ = Hannan-Quinn information criterion*

Source: Author's Compilation, 2023

From the table above, 3 out of 5 of the information criteria i.e. LR, SC and HQ suggest 1 lag for the Nigerian model. Also, 3 out of 5 of the criteria i.e. LR, FPE, AIC suggest 4 lags in the Algerian model while in the Gabonese model, all the 5 criteria suggest 1 lag. These will be used for the study. Hence, supplementing the optimal lags with the maximum order of integration (d_{max}) in each of the three models, the estimated coefficients of the VAR ($k+d_{max}$) is given as follows:

4.3.1 Toda-Yamamoto Estimates

The estimates below represent the Toda-Yamamoto estimates for the three countries of focus:

Table 5: Toda-Yamamoto Estimates

	Nigeria			Algeria			Gabon		
	LEXR	LOILP	LER	LEXR	LOILP	LER	LEXR	LOILP	LER
LEXR(-1)	0.634 (0.001)	0.215 (0.296)	0.284 (0.354)	0.262 (0.186)	0.461 (0.481)	0.822 (0.101)	0.982 (0.00)	-0.128 (0.757)	-0.660 (0.65)
LEXR(-2)	0.176 (0.203)	-0.134 (0.477)	0.016 (0.954)	-0.068 (0.724	-1.015 (0.231)	-1.005 (0.042)	-0.129 (0.488)	0.402 (0.290)	0.809 (0.58)

LOIL P(-1)	-0.477 (0.001)	0.743 (0.000)	0.335 (0.241)	-0.060 (0.314)	0.928 (0.001)	0.582 (0.000)	0.100 (0.286)	0.856 (0.00)	1.664 (0.03)
LOIL P(-2)	0.016 (0.920)	-0.111 (0.598)	-0.131 (0.674)	0.049 (0.535)	-0.610 (0.093)	-0.431 (0.03)	0.010 (0.923)	-0.026 (0.911)	0.434 (0.60)
LER(-1)	0.004 (0.100)	0.087 (0.503)	0.803 (0.000)	-0.124 (0.020)	-0.109 (0.646)	0.477 (0.00)	-0.067 (0.012)	0.019 (0.745)	0.061 (0.76)
LER(- 2)	0.347 (0.477)	0.023 (0.875)	-0.266 (0.220)	-0.055 (0.473)	0.240 (0.491)	0.380 (0.053)	0.018 (0.504)	0.003 (0.959)	-0.106 (0.62)

Source: Author's Compilation, 2023

From the result above, one period lag of oil price has a significant negative impact on exchange rate in Nigeria. A 1% increase in oil price will bring about 0.477% fall in the exchange rate of naira to dollar. Conversely, oil price has a negative insignificant impact on exchange rate in Algeria. For instance, a 1% increase in oil price will bring about a 0.060% fall in the exchange rate of Algerian dinar to dollar. In addition, a positive insignificant relationship was found between oil price and exchange rate in Gabon. For instance, a 1% increase in one and two period lags of oil price will bring about a 0.1 and 0.01% increase in exchange rate.

Also, changes in exchange rate does not have any significant impact on oil prices in all three countries. In addition, oil price has a significant positive impact on external reserves only in Algeria and Gabon. The impact on the other hand is insignificant in Nigeria. Also, external reserves of Algeria and Nigeria have no significant impact on world oil price but Gabonese external reserve has a significant positive impact on oil price.

4.4 Toda-Yamamoto Granger Causality Test

The ARDL bound test result only shows if there is a long-run relationship among the variables in a model but does not show the direction of causality. This necessitates the use of Toda-Yamamoto granger causality test to check for the direction of causality. The Toda-Yamamoto causality approach utilizes a modified Wald test to examine constraints on individual parameters in the Vector Autoregressive VAR (k), where k represents the lag length. The Wald Statistic employs a Chi-Square distribution, where the degrees of freedom are determined by the number of lagged variables eliminated, in order to assess the significance of a function (Stephen, 2020).

Table 6: Toda-Yamamoto Modified (Wald Test) Results

Null Hypothesis	Chi -Sq.	Df	Prob.	Direction of Causality
Nigeria				
LOILP does not granger cause LNEXR	11.58993	1	0.0007	Unidirectional LOILP →LNEXR
LNEXR does not granger cause LOILP	1.105151	1	0.2931	
LNER does not granger cause LNEXR	1.69E-05	1	0.9967	No causality
LNEXR does not granger cause LNER	0.869909	1	0.3510	
Algeria				
LOILP does not granger cause LALGEXR	6.731838	4	0.1508	No Causality
LALGEXR does not granger cause LOILP	3.097982	4	0.5416	
LALGER does not granger cause LALGEXR	28.45846	4	0.0000	Bi-directional
LALGEXR does not granger cause LALGER	41.55670	4	0.0000	
Gabon				
LOILP does not granger cause LGABEXR	1.150637	1	0.2834	No causality
LGABEXR does not granger cause LOILP	0.096065	1	0.7566	
LGER does not granger cause LGABEXR	6.513951	1	0.0107	Unidirectional LGER → LGABEXR
LGABEXR does not granger cause LGER	0.206185	1	0.6498	

Source: Author's Compilation, 2023

From the Toda-Yamamoto causality, a unidirectional causality runs from oil price to exchange rate in Nigeria since oil price granger causes exchange rate but exchange rate does not granger cause oil price. The result also shows no causality between exchange rate and external reserves. In the case of the Algerian economy, causality does not run between exchange rate and oil price. The result however shows a bi-directional causality between exchange rate and external reserves in Algeria. Lastly, result from the Gabonese model is slightly close to that of the Algerian model. For instance, the result shows no causality between oil price and exchange rate. Findings also revealed a unidirectional causality flowing from external reserves to exchange rate in Gabon.

4.5 Impulse Response Function

The impulse response function is used to check the response of each endogenous variables to shocks within themselves as well as shocks from other variables. The response of the Variables to shocks are depicted with the Cholesky impulse response functions below.

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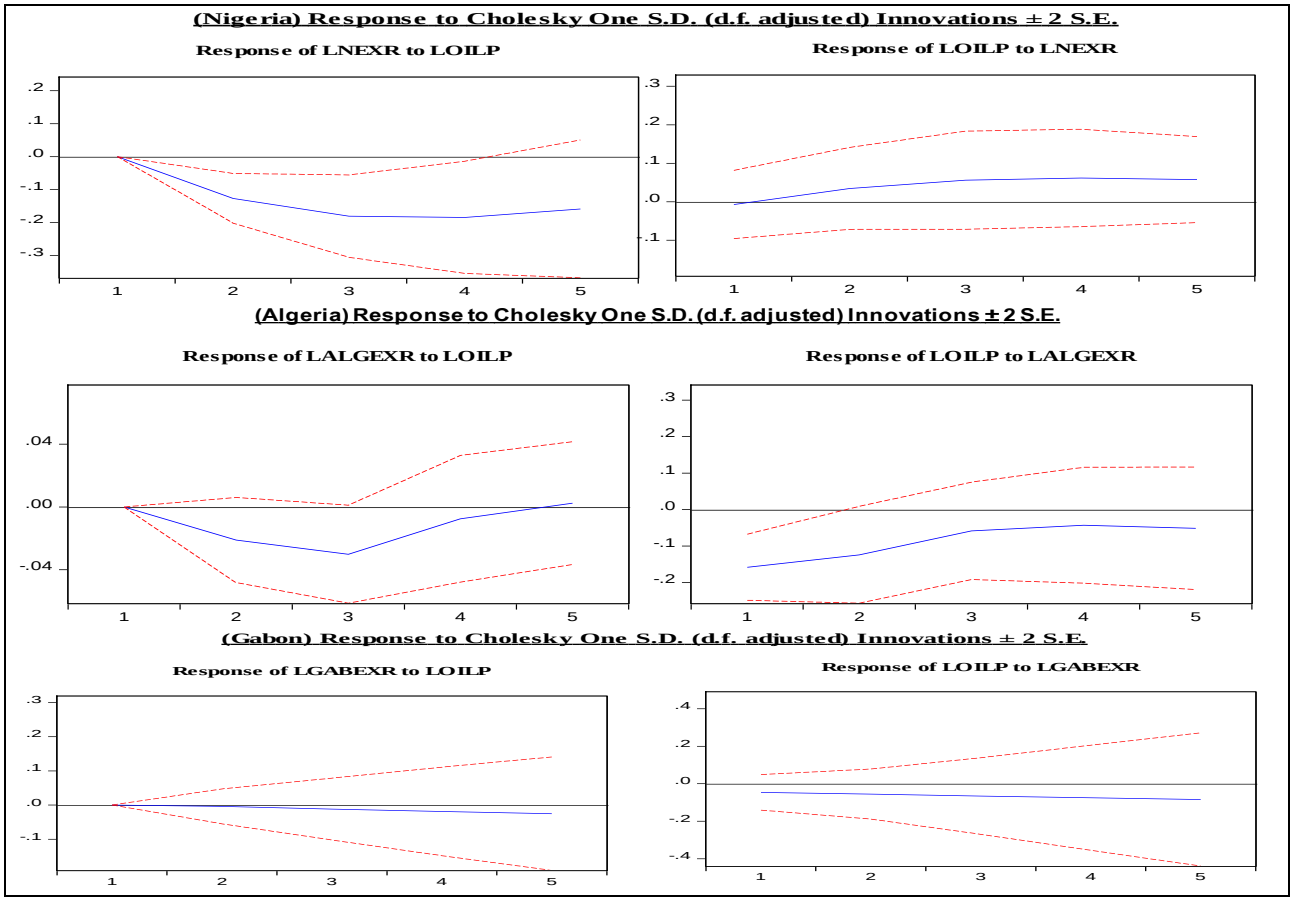

Source: Author's Compilation, 2023

Figure 2: Graph of Cholesky Impulse Response function for Nigeria, Algeria and Gabon.

From figure 2, in the case of Nigeria, the cholesky impulse response function shows that a one SD shock in oil price causes exchange rate to decline gradually from period 1 until it hits the steady state in period 3 and then rises gradually from period 4 and above. Conversely, a one SD shock in exchange rate causes oil prices to increase in period 1 up till period 3 and then hits the steady state up till period 5. In the Algerian case, a one SD shock in oil price causes exchange rate to decrease from period 1 and then rises again till period 5. On the other hand, a one SD shock in exchange rate causes oil price to rise from period 1 up till period 3 and then remains in a steady state till period 5. Lastly, in the case of Gabon, initially, there was no noticeable response of exchange rate to one SD shocks in oil prices up till period 2 when the response decline gradually and then maintain a steady state up till period 5. Oil price on the other hand maintain a steady state from period 1 up till period 5 despite a one unit SD shocks in Exchange rate.

4.7 Model Diagnostic Test

Before a model can be appropriate for policy formulation, it is important to verify that the estimates of the chosen model are reliable. The most relevant post-estimation test for multivariate models is the LM serial correlation test (Ogunjimi & Adebayo, 2019; Salisu, 2015). We are to accept the null hypothesis of no serial correlation if the probability value is greater than 5% otherwise, we reject the null hypothesis.

Table 7: VAR Residual LM Serial Correlation test result

Null Hypothesis: No Serial Correlation of Lag order h						
	Nigeria		Algeria		Gabon	
Lag	LM-stat.	Prob.	LM-stat.	Prob.	LM-Stat.	Prob.
1	8.381183	0.4974	12.40761	0.1954	12.93318	0.1667
2	11.4563	0.247	12.34714	0.1986	10.15448	0.3394
3	6.935246	0.6448	16.2861	0.0635	9.67348	0.3788
4	3.55453	0.9384	8.274643	0.511	12.9115	0.1677
5	7.225007	0.6147	5.788185	0.7635	5.162769	0.8205

Source: Author's Compilation, 2023

From the LM serial correlation result above, we are accepting the null hypothesis for all the three models that there is no serial correlation since the p-value of the LM-stat. is greater than 5% for all the three models. We can therefore conclude that the estimates of the model and its results are reliable for policy prescription.

4.8 Robustness Check

The variable used to capture oil price in the analysis done above was the world Brent crude oil prices. In order to check if our result is robust, we can replace the Brent crude oil price with West Texas Intermediate (WTI) oil price and then check if we would have similar findings for the three countries.

The summary of the Toda-Yamamoto causality for the three countries using WTI crude oil price as an alternative for Brent crude oil price.

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Table 8: Toda-Yamamoto Modified (Wald Test) Results based on WTI crude oil prices.

Null Hypothesis	Chi - Sq.	Df.	Prob.	Direction of Causality
Nigeria				
LWTIP does not granger cause LNEXR	9.7704	1	0.0018	Unidirectional LOILP →LNEXR
LNEXR does not granger cause LWTIP	1.4231	1	0.9698	
LNER does not granger cause LWTIP	0.5465	1	0.9698	No causality
LWTIP does not granger cause LNER	1.3656	1	0.4598	
Algeria				
LWTIP does not granger cause LALGEXR	4.6195	4	0.3286	No Causality
LALGEXR does not granger cause LWTIP	4.0077	4	0.7159	
LALGER does not granger cause LWTIP	2.1080	4	0.7159	Unidirectional LOILP → LALGER
LWTIP does not granger cause LALGER	29.9024	4	0.0000	
Gabon				
LWTIP does not granger cause LGABEXR	0.9602	1	0.3271	No causality
LGABEXR does not granger cause LWTIP	0.6436	1	0.4224	
LGER does not granger cause LWTIP	0.4163	1	0.5188	Unidirectional LOILP→ LGER
LWTIP does not granger cause LGER	4.8924	1	0.0270	

Source: Author's Compilation, 2023

From the result above, It was revealed that causality runs from WTI crude oil price to exchange rate in Nigeria. The exchange rate on the other hand does not granger cause WTI oil price. Also, there is no causality between external reserves and WTI oil prices in Nigeria. The result further shows no causality between WTI oil prices and exchange rate in both Algeria and Gabon. It however, shows a unidirectional causality running from WTI oil prices to external reserves in both countries. The findings above about WIT crude oil price is the same as the result we got when Brent crude oil price was used as as proxy for oil price. It is a sign of robustness of our models. It is a sign that whichever price is being selected, the effect will be the same in the three countries.

4.9 Discussion of Findings and Policy Implications

The findings from the analysis yield several significant policy implications for Nigeria, Algeria, and Gabon. Firstly, in Nigeria, there is a significant negative impact of a one-period lag in oil prices on the exchange rate, indicating that the Nigerian economy is vulnerable to fluctuations in oil

prices. This underscores the need for diversification away from oil dependency and possibly more prudent management of oil proceeds. In response, Nigerian policymakers should prioritize economic diversification efforts, invest in non-oil sectors, and establish effective mechanisms for saving and managing oil revenues. Additionally, they should consider implementing policies that can mitigate the adverse effects of oil price volatility on the exchange rate. This result is similar to the findings of Musa et al. (2020), Henry (2019), Ogundipe et al. (2014) and Englama et al. (2010).

Conversely, in Algeria, while a 1% increase in oil prices results in a negligible decline in the exchange rate of the Algerian dinar, previous research findings such as Djebourri (2018), Ahlem and Abderahmane (2022), and Benhabib et al. (2014) suggest a significant negative impact. This disparity may be attributed to government efforts to diversify the economy away from oil and central bank interventions in the foreign exchange market, highlighting the importance of these policy measures. Algerian policymakers should continue to support diversification initiatives and maintain a proactive stance in managing exchange rate stability.

In Gabon, a positive but insignificant relationship exists between oil prices and exchange rates, this may be possibly due to the efforts of the central bank to stabilize the regional currency, Central African CFA franc. These findings emphasize the role of monetary policies in managing exchange rate fluctuations. Therefore, Gabonese authorities should continue their efforts to maintain currency stability and explore measures to enhance the impact of monetary policies on exchange rates.

Additionally, the analysis revealed that changes in exchange rates do not significantly impact oil prices in any of the three countries. This lack of influence can be attributed to their limited global presence in the oil market compared to other countries like Saudi Arabia, Iraq and Kuwait that account for a significant portion of global oil production. This emphasizes the importance of international engagement and diplomatic efforts to increase their influence and leverage in global oil markets. In addition, oil price has a significant positive impact on external reserves only in Algeria and Gabon. The impact on the other hand is insignificant in Nigeria. This could be due to the fact that Nigeria spends most of the proceeds from oil in servicing debt. It could also be as a result of mismanagement of proceeds from oil. This suggests that Nigerian policymakers should focus on improving fiscal discipline, debt management, and establishing effective sovereign wealth funds to secure and manage oil revenues efficiently. In addition, external reserves of Algeria and Nigeria have no significant impact on world oil price but Gabonese external reserve has a significant positive impact on oil price.

From the Toda-Yamamoto causality, a unidirectional causality runs from oil price to exchange rate in Nigeria. which may necessitate policy measures to mitigate the impact of oil price fluctuations

on the exchange rate. Nigerian authorities should consider implementing policies that enhance exchange rate stability and reduce the economy's susceptibility to oil price shocks. This might include developing hedging mechanisms or building up foreign exchange reserves to cushion against adverse oil price movements.

The result also shows no causality between exchange rate and external reserves. However, this does not conform to economic theory, because when naira depreciates against dollar, Nigerian external reserves is expected to fall and vice versa and when there is an increase in external reserves, the exchange rate is expected to appreciate. In the case of the Algerian economy, causality does not run between exchange rate and oil price. This is however not in line with economic theory because an increase in international oil price is expected to increase the value of Algerian dinar because of the increase in foreign exchange earnings associated with the price increase. The result however shows a bi-directional causality between exchange rate and external reserves in Algeria. Lastly, result from the Gabonese model is slightly close to that of the Algerian model. For instance, the result shows no causality between oil price and exchange rate. This as explained above does not conform to economic apriori. Findings also revealed a unidirectional causality flowing from external reserves to exchange rate in Gabon.

5. Conclusion and Policy Recommendation

Oil price volatility is detrimental to a country whose economy rely heavily on oil. This study examined the nexus between oil price and exchange rate in three African OPEC countries namely Nigeria, Algeria and Gabon. Toda-Yamamoto was used to determine the causality among three variables i.e. Exchange rate, oil prices and external reserves. A unidirectional causality only runs from oil price to exchange rate in Nigeria. No causality between oil price and exchange rate exist in Algeria and Gabon. Impulse response functions was employed to examine the impact of shocks on the variables. Exchange rate was found to be insignificant on world oil price for the three countries. Also world oil price does not have any significant impact on exchange rate in Algeria and Gabon but Nigeria on the other hand is vulnerable to fluctuations in world oil price. Based on the findings, the study recommends that all the three countries should continue their efforts to diversify their economy away from heavy dependence on oil. Promoting sectors such as agriculture, manufacturing, services, and tourism can help reduce vulnerability to oil price fluctuations. The monetary authorities should monitor and intervene in the foreign exchange market when necessary to maintain exchange rate stability. The government should be transparent and enhance accountability in the management of oil revenues.

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