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Oil Price Fluctuations and Exchange Rate in Selected Sub-Saharan Africa countries: A Vector Error Correction Model Approach

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ABSTRACT

This study employs the Johansen cointegration and the vector error correction model (VECM) to assess the dynamic relationship that exists between oil price fluctuations and the real exchange rate in selected Sub-Saharan Africa countries from January 2004 to December 2017. The result of the monthly data analysis provides evidence to support a cointegration between oil prices and the real exchange rate in sub-Saharan oil dependent nations. The results of the study established a long-run equilibrium connection between fluctuations in oil price and the real exchange rate. Importantly, the study demonstrates the significant power of oil prices to predict the movement of real exchange rates in Nigeria, Angola, the Republic of Congo, Equatorial Guinea and Gabon. This study has implications not only for investors and industry leaders but also for policymakers responsible for the growth and stability of the economy. The results of this study also attest to the need for urgent economic diversification to other sectors of the economy both to reduce the negative influence of oil price fluctuations and to boost economic growth.

Keywords: Oil Price, Exchange Rates, Sub-Sahara, Cointegration, Economy
JEL Classifications: C32, F31, F32, F41, Q43

1. INTRODUCTION

Crude oil is an increasingly valuable natural resource with large-scale influence in both advanced and emerging economies. The product has been at the centre stage in global economic growth and trade (Iwayemi and Fowowe, 2011; Raji et al., 2017). Several economies depend on crude oil for productivity. For oil exporting nations in the sub-Saharan African region, crude oil provides foreign revenue to support economic activities leading to economic performance. Interestingly, before the finding of oil in large quantities in the sub-Saharan Africa region, agriculture was the leading source of foreign revenue for the government. However, since the early 1970s, when the world experienced an oil boom, oil exporting countries in the region relegated the importance of agriculture and other parts of the economy to become a mono-cultured economy. Since then, these countries have been generating a higher percentage of their foreign earnings from crude oil transaction at the international oil markets (Ehikioya, 2019). At the global oil markets, the America dollar is the most tradable and acceptable legal tender for invoicing and settlement, which means any fluctuations in oil prices in addition to the America dollar, could manipulate the exchange rates of trading countries differently (Olomola and Adejumo, 2006; Salisu and Mobolaji, 2013). Like other emerging economies, sub-Saharan Africa nations have suffered as well as benefit from the effect of oil price fluctuations. These nations have also suffered from the influencing

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power of exchange rate volatility, high inflation and the instability of other macroeconomic variables, which continued to challenge policymakers entrusted with the responsibility of stabilising and growing the economy.

Over the last few years, however, there have been increasing concerns about the effect oil price fluctuations would have on the exchange rate and the economy (Kisswani, 2016; Mensah et al., 2017). The works of Golub (1983) and Krugman (1983b) advanced the theoretical and empirical evidence on the transmission mechanisms in which oil price volatility may impact the economic performance of a nation through economic variables like the exchange rates. According to their studies, "wealth effect" and "the terms of trade effect" are the two different channels oil price movements may be channelled to the economy through the exchange rates. The influence of the oil price shocks through these channels may differ from countries that export oil to countries that import oil (Chen et al., 2010). The study of Fratzscher et al. (2014) documented that the reaction of exchange rates to oil price volatility is due partly on whether the economic activity domiciled in nations that import oil or in countries that export oil. In the wealth effect mechanism, Krugman (1983b) and Golub (1983) argued that where there is a rise (fall) in oil prices, while the exchange rate of oil exporting nations may appreciate (depreciates), oil importing nations are likely to experience depreciation (appreciation) in exchange rates. In this instance, oil importing countries seen as transferring income to oil exporting countries (Chen and Chen, 2007; Lizardo and Mollick, 2010; Hasanov, 2010).

Furthermore, the implication of the oil price movements suggests the propensity for the oil prices to either appreciate or depreciate the country's currencies relative to the US dollar. For countries in sub-Saharan Africa that depend mainly on crude oil exporting to earn foreign revenue, a drop in oil prices could cause the depreciation of exchange rates. And this could result in a high level of uncertainty for investment, higher inflation, higher interest rates, lower values for stocks and economic recession. In terms of trade, which is another essential transmission mechanism of shocks in the oil price to the economy through the exchange rates, changes in oil price may impact oil exporting nations and oil importing nations differently. Crude oil exporting countries according to the views of terms of trade will experience a favourable trade balance and a surge in the value of the national legal tender when there is a drop in the movement of oil prices. Conversely, an upward trend in oil prices will result in a decrease in value of the local currency and trade imbalance of oil importing countries (Chen et al., 2003; Fratzscher et al., 2014).

Since the 1970s economic recessions in the Western world, the connection between oil prices and macroeconomic variables has remained an issue of concern for the stakeholders of the economy, especially the policymakers and investors. Moreover, since the post-Bretton Woods period, studies mostly in advanced economies have documented the effect of crude oil price fluctuations on the economy (Golub, 1983 and Kisswani, 2016). However, the results of the studies on the impact of oil price fluctuations on exchange rates from different backgrounds and using a range of models, samples for analysis and control variables vary considerably. For example, research work by Benhmad (2012) indicated that there is a cointegrated connection between the two variables and that oil price shocks were responsible for the persistent US dollar volatility. In a similar study, Camarero and Tamarit (2002) used a panel cointegration technique to evaluate the connection between oil price movements and real exchange rates in Span. They documented the influence of oil price as a critical factor responsible for the long-term shift in the exchange rate. While Akram (2004); Cavalcanti and Jalles (2013) documented evidence of a positive connection between the oil price and the America dollar, Wu et al. (2012); Turhan et al. (2013) reported an adverse connection between the two variables. Similarly, Huang and Guo (2007) and Basher et al. (2012) assessed the influence of oil prices on exchange rates and reported the existence of a weak correlation between the variables. Moreover, few related studies such as Iwayemi and Fowowe (2011), Salisu and Mobolaji (2013) and Raji et al. (2017) studied the connection between oil prices and exchange rate in Nigeria and their study found related results.

Furthermore, despite the theoretical and empirical appeal on the link between oil price fluctuations and exchange rates, how oil price fluctuations impact on exchange rates and its volatility is still much open for debate, especially in emerging economies in the sub-Saharan Africa region. Recent economic activities, high level of uncertainties for investors, depreciation of the currencies in the region, low performance of the stock market, high consumer price index, high cost of borrowing and inconsistencies in government policies, suggest the influence crude oil price fluctuations at the global markets could have on the different economies in the region. Crude oil price fluctuations can occur at any time, and its impact on the exchange rates as well as the economy requires constant investigation. The implication of the relationship between oil price fluctuations and exchange rates in developing nations is particularly significant not only for the government but also for investors, researchers and other stakeholders of the economy desirous for economic growth. According to the World Bank statistics, emerging markets will represent about 50% of the global economic growth rate by 2050, which means a good understanding of the relationship between oil price fluctuations and exchange rates is imperative for the stakeholders of the economy. Moreover, the absence of consistent evidence on the connection between oil price fluctuations and exchange rates, especially in emerging markets indicates that more work is required to extend the research and analysis on this issue. The need to investigate this issue is particularly important and urgent, given the fact that exchange rates remain a significant channel oil price fluctuation passes through to the real economy.

Thus, the study objective is to assess the dynamic relationship between oil price fluctuations and exchange rates in selected sub-Saharan Africa nations, namely Nigeria, Angola, Equatorial Guinea, the Republic of Congo and Gabon. The study employed the vector error correction model (VECM) to analyse the monthly data of real oil prices and the real effective exchange rate from 2004 to 2017. The motivation to use VECM in this study is due to its ability to explore long-term and short-term relations among variables, especially when there is the presence of cointegration. Apart from potential misspecification bias, the inability to examine long-term relations is one of the shortcomings associated with the use of VAR. The current study hypothesises that movements in oil price have a relationship with the exchange rates of the US and the currencies of countries in the sub-Saharan Africa region. The assessment of the dynamic connection between oil price fluctuation and exchange rate and their influence on economic performance is essential for the decision-makers, investors and other agents of the sub-Saharan Africa economy. The finding of this study suggests that a decrease in oil prices would cause the exchange rate to decline. Conversely, an upward movement in oil prices would result in an exchange rate to appreciate. The implication of this result for the stakeholders of the economy is that upward oil price volatility and exchange rate stability are essential factors along with other macroeconomic fundamentals for oil exporting nations in the region to achieve the desired economic growth and development. The result is also significant for the investors and policymakers who daily attempt to carefully watch the movement of these two variables for decision making.

Several sources of shocks have been identified in various piece of literature to affect economic activities, and oil price fluctuations are reported to be the principal factor amongst others impacting changes in real exchange rates (Chen and Chen, 2007). Studies such as Blanchard and Gali (2007) and Basher et al. (2012) underscored how oil price movements might affect macroeconomic fundamentals like the interest rates, unemployment rates, inflation and GDP growth rates. Observing the different macroeconomic variables that affect the economy, the exchange rate has been identified as the critical path oil price shocks can pass on to the economy. Using the monthly data of G7 nations from 1972:1 to 2005:10, Chen and Chen (2007) carried out a panel analysis to examine the long-run connection between real oil prices and real exchange rates. They tested for the presence of cointegration among exchange rates and real oil prices and found that there is a connection between the two variables. Similarly, Zhang (2013) employed the monthly data with structural breaks to assess the existence of a long-run equilibrium connection between real oil price and the real effective exchange rate and reported a cointegration between real oil and real effective exchange rate. Using cointegration tests and error correction model, Hasanov (2010) investigate whether real oil price would explain the variations in the real exchange rate in Azerbaijan. In that study, Hasanoy reported that real oil price has an impact on the real exchange rate in the long run.

In a related study, Chaudhuri and Daniel (1998) showed that shocks in oil price was the fundamental element responsible for the America real exchange rate fluctuations. Tiwari et al. (2013) used the wavelet transform network model and Granger causality to analyse monthly data from February 1986 to March 2009 in Romania and documented that changes in oil prices impose an influence on the real exchange rate both in the short run and long run. Also, Benhabib et al. (2014) in Algeria used cointegration and VAR model on monthly data from 2003-2013 to evaluate the association between oil prices and real exchange rate fluctuations. They reported that movement in oil prices was key to changes in the real exchange rate. However, in a similar study carried out in Thailand, Jiranyakul (2015) argued that oil prices do not cointegrate with real exchange rate except where there is some level of volatility in the oil price, which may result to fluctuations real exchange rate. Similarly, Cifarelli and Paladino (2010) used the generalised autoregressive conditional heteroskedasticity-in-mean (GARCH-M) technique to evaluate this issue and documented evidence of an adverse influence of oil price changes on exchange rate fluctuations. Furthermore, empirical studies such as Akram (2004) for Norway, Lizardo and Mollick (2010) for Canada, Mexico, Norway and Russia as oil exporting nations, Basher et al. (2012) for China, India and Brazil and Benhmad (2012) for the US highlighted considerable evidence that shift in oil price affects exchange rate movements.

However, several other studies have shown that there is no connection between oil price movements and exchange rates. For example Mohammadi and Jahan- Parvar (2010) used threshold and momentum-threshold autoregressive (TAR and M-TAR) models on data from thirteen oil exporting nations to investigate the causal relationship and dynamic interaction between oil price movements and exchange rate. The study reported that there was no evidence of a short-run causality in either direction between real oil price movements and real exchange rates. In another study, Huang and Gou (2007) constructed a four-dimensional structural VAR model to explore the level to which the movement in oil prices impact the real exchange rate fluctuations in China from 1990 to 2005. The findings of that study revealed a slight rise in the long-term real exchange rate due to shocks in the real oil price. In addition, studies such as Wu et al. (2012) for US and Jahan-Parvar and Mohammadi (2008) for Mexico, Bahrain, Algeria and Kuwait also documented evidence of a connection between the prices of oil and exchange rates. And thus, cannot support to offer evidence about the future prediction of the variables.

The last two decades have seen surprising oil price fluctuations in the global oil markets. During this period and especially in 2008, the global economic growth rate experienced a slowdown partly due to global financial crises resulting from the volatility of macroeconomic indicators. For the oil-producing nations in sub-Saharan Africa economies known to be heavily dependent on oil export, this makes them more vulnerable to movements in oil prices at the global markets and the influence of other macroeconomic factors like the exchange rate. The study of Osuma et al. (2019) corroborates with the above assertion owing to the contagion effects of the 2016 global drop in oil prices that adversely affected the Nigerian deposit money banks exposed to the oil and gas sector. Also, they documented that the decline in oil prices steered the negative GDP experienced in two consecutive quarters that made Nigeria be in a recessionary state in 2016. However, during the economic recession in 2016, the exchange rate served as a countercyclical policy tool to stabilise the economy. Since the recent oil price movements, the global economic output has been prolonged due to oil dependency by most emerging economies to earn revenue. Therefore, it is significant to assess the influence of oil price fluctuations on the exchange rate and the economy.

The results of this study are appealing and help to explain the relationships between oil price fluctuations and the exchange rates in sub-Saharan Africa. This paper contributes to the growing literature in several ways. Firstly, by adopting the Johansen Co-integration and VECM to analyse the monthly data from January 2004 to December 2017, the study offers a more appropriate framework and understanding of the behaviour of the two variables in selected oil-exporting nations in emerging economies. Secondly, the study is one of the recent few to explore the connection between oil price fluctuations and the exchange rate in sub-Saharan Africa, especially since the 2016 economic recession in Nigeria. Thirdly, the study throws light on the exchange rate and economic growth response to oil price fluctuations. Fourthly, the study will help policymakers to understand better the behaviour of oil prices and exchange rates, and formulate appropriate policies and programs to stimulate economic growth. Finally, the study will benefit investors, professionals, researchers and other stakeholders of the economy interested in knowing how to estimate risks and enhance investment decisions.

The remaining part of the paper is organised as follows: In Section 2, we described the data set and the model used in the study. Section 3 discussed the empirical findings and policy implications of oil price fluctuations on the exchange rate. In section 5, the study concludes with recommendations.

2. METHODOLOGY

2.1. Source of Data

This paper employed the monthly data for real oil prices and real exchange rates for the US dollar to the currencies of the selected sub-Saharan Africa nations from January 2004 to December 2017. For the set of countries in the study, we considered membership of the Organization of the Petroleum Exporting Countries (OPEC) since the body regulates their activities. Besides, the study took into consideration data availability for the sampled countries. The study employed data obtained from the International Financial Statistics (IFS), published by the International Monetary Fund (IMF) and the West Texas Intermediate (WTI) crude oil prices as published by the US Energy Information Administration. Several studies on oil prices and exchange rates have used these data sources and proved to be reliable (Mensah et al., 2017 and Kisswani, 2016; Olomola and Adejumo, 2006; Raji et al., 2017; Chimezie et al., 2020). These data sources are more readily obtainable than the country-specific data sources for a study of this nature. For this study, the exchange rate is the amount of a country's currency per US dollar, and it suggests that as the exchange rate moves upward, the nation's currency depreciates and the dollar appreciates. We computed the real exchange rates from the nominal exchange rates using consumer price indexes. Data on the exchange rates to the dollar were taken from each country's Central Bank. To account for the real oil price, we obtained the US price at the global oil markets and converted using the US dollar exchange rate to domestic prices. After that, we adjusted the figure using the consumer price index for each of the countries in the study.

We refer to the exchange rate data as that of the countries in sub-Saharan Africa (SSA) in the study. The selected exchange rates from sub-Saharan Africa nations which were calculated as units of each country's currency per US dollar are the Nigerian Naira (NGN), Angolan Kwanza (AOA), Congolese Franc (CDF), Equatoguinean CFA Franc (XAF) and Gabonese CFA Franc (XAF). For this study, we will tag the Equatoguinean CFA Franc as EGXAF to differentiate it from the Gabonese CFA Franc. We choose these countries since they rely on crude oil export to generate revenue to finance economic activities. In budgetary allocation, these countries usually benchmark the global oil market prices to set the national budget. However, the recent oil price fluctuations revealed the efforts of these countries to adjust for market volatility to deal with the consequences of price volatility on the economy. In sub-Saharan African region, Nigeria top the list of oil-producing countries followed by Angola.

The summary statistics of the variables are presented in Table 1. At a glance, the variables appear negatively skewed with excess kurtosis, which is typical for financial time-series data influenced by economic activities. The average monthly price of crude oil for the sample period is $67.8210 per barrel with a standard deviation of $1.81 per barrel. The result shows that oil price skewed positively, which suggests the extent of variation from a normal distribution. Except for Gabon with a negative monthly average value, all other countries' currencies in the study reveals a positive monthly average value. Moreover, while the exchange rates of Gabon and the Congo DRC are positively skewed, other countries appeared to be negatively skewed. The currencies of the countries in the sample period showed kurtosis ranging from 2.4099 to 6.3071. The Jarque–Bera statistic shows that the sample data in the series are normally distributed. The Ljung-Box Q-statistics suggests that there is no problem of serial correlation for most exchange rate returns during the period of study.

2.2. Data Properties

This study aimed to assess the dynamic connection between oil price fluctuations and exchange rates of certain sub-Saharan Africa countries. The study used time-series data, which are known to behave in a non-stationary manner. The study proceeds by investigating if there is a connection between oil price variations and exchange rates using the Johansen cointegration test. Before then, we transformed

Table 1: Descriptive statistics of the variables

Panel	ΔROP	ΔNGN	ΔAOA	ΔCDF	ΔEGXAF	ΔXAF
Mean	67.8210	3.7591	3.0384	1.0517	0.0652	–0.0229
Std. Dev.	1.8111	2.0712	1.3509	3.0552	3.0096	2.0046
Max	2.1503	13.0367	8.0243	5.001	4.1002	4.0339
Min	–0.1777	–1.0538	–2.0258	–6.0270	–4.3722	–5.1171
Skewness	0.4620	–1.7424	–0.6904	–1.1403	–1.7073	0.9140
Kurtosis	2.8411	4.1508	6.3071	3.0667	4.6670	2.4099
Jarque–Bera	42.1192	40.9620	29.6711	162.3541	323.7902	323.7932
Prob.	0.0000	0.0000	0.0000	0.0000	0.0030	0.0012
Obs.	168	168	168	168	168	168

ROP: Real oil prices (WTI), NGN: Nigerian naira, AOA: Angolan Kwanza, CDF: Congolese Franc, EGXAF: Equatoguinean, CFA Franc and XAF: Gabonese CFA Franc the data into the natural logarithms to eliminate or correct for possible skewness in the residuals. After that, we investigate the properties of the variables using the Augmented Dickey-Fuller (ADF) test as well as the Philips Peron (PP) test to establish the presence of a unit root. (Dickey and Fuller, 1981; Phillips and Perron, 1988). We defined the ADF unit root tests in intercept and intercept with trend as:

$$\Delta\lambda_t = \alpha_0 + \alpha_1 Z_{t-1} + \sum_{t=1}^{\infty} \mu_t \Delta X_{t-1} + \varepsilon_t \quad (1)$$

$$\Delta\lambda_t = \alpha_0 + \alpha_1 Z_{t-1} + \sum_{t=1}^{\infty} \mu_t \Delta X_{t-1} + \alpha_1 t + \varepsilon_t \quad (2)$$

The unit root test using PP is expressed in equations 3 and 4 for intercept and intercept with trend, respectively.

$$\Delta\lambda_t = \pi_o + \beta Z_{t-1} + \varepsilon_t \quad (3)$$

$$\Delta\lambda_t = \partial_0 + \partial_1 t + \beta Z_{t-1} + \varepsilon_t \quad (4)$$

Where Z_t the variables and ε_t is the Gaussian white noise residual vector. The null hypothesis tested is defined as $\partial > 0$, which implies that the time series data are non-stationary. The Akaike Information Criteria (AIC) is used to determined lag length.

2.3. Test of Cointegration

To study the connection between the oil price fluctuations and exchange rate in sub-Saharan African economies, we employed the Johansen cointegration test as established by Johansen and Juselius (1990) to analyse the non-stationary data. Unlike the Engle and Granger (1987) that is concerned on the cointegration test using a single equation and the vector autoregressive (VAR) model, the use of Johansen cointegration analysis is more suitable for this work because of the ability of the model to explore the co-movements between the variables. The Johansen and Juselius (1991) test for cointegration uses a system of equations to define the long-run equilibrium connotation between variables. The a priori expectation of this study is that there is the existence of a cointegration among two variables, which means that there exists a long-run symmetry connection between oil price fluctuations and exchange rates of the economies investigated in the study. The regression equation is specified as:

$$Z_{it} = \beta_o + \beta_1 P_t + \varepsilon_t \quad (5)$$

Where Z_{it} denote the real exchange rate, β_0 is a constant vector, P_t represents the real oil price and ε_t is the Gaussian white noise residual vector. The study expressed the vector error correction model developed by Johansen and Juselius (1991) as:

$$\Delta Z_t = \Psi + \sum_{j=1}^{k-1} \mu_j \Delta Z_{t-j} + \Pi Z_{t-k} + \varepsilon_t \quad (6)$$

Where Δ indicates the first difference notation, Z_t is the px1 which is the vector of the n variables, ψ is the px1, which is the constant vector demonstrating a direct movement in a system and k = Lag structure. The Gaussian white noise residual vector is represented by the ε_t. While μ_j is a p x $(k - 1)$ matrix that shows short-term changes between variables across p equations at the j[th] lag, Π is a (p x p) coefficient matrix, which is the cointegrating vectors. To assess the reduced rank of the matrix Π, the vector error correction model of Johansen and Juselius (1991) employs the $\lambda_{Trace} = -T \sum_{i=r+1}^{P} In(1-\lambda'_t)$, which is the trace statistics and $\lambda_{\max} = -TIn(1-\lambda'_{r+t})$, which represents the Maximum Eigenvalue method. Where T represents the number of observations in the sample study, r is the number of individual series and λ is the Eigenvalues. To assess the short-run interrelationship between the variables, we used the Vector Error-Correction Model (VECM), which is a controlled form of VAR with the inbuilt specification. We specify the VECM for the short-run relationship as follows:

$$\Delta \ln RER_t = \beta + \sum_{k=1}^{p} \mu_{2k} \Delta \ln ROP_{t-k} + \sum_{k=1}^{p} \delta_{2k} \Delta \ln RER_{t-k} + \lambda_2 \alpha_{t-1} + \varepsilon_t \quad (7)$$

$$\Delta \ln ROP_t = \beta + \sum_{k=1}^{p} \mu_{1k} \Delta \ln ROP_{t-k} + \sum_{k=1}^{p} \delta_{1k} \Delta \ln RER_{t-k} + \lambda_1 \alpha_{t-1} + \varepsilon_t \quad (8)$$

Where λ_1 and λ_2 are the coefficients for the error correction that signifies the promptness of change to restore the long-run equilibrium connection between the variables and α_{t-1} represent the error correction term from the cointegration model. The short-run dynamics of the variables is captured using ΔIn ROP_{t-k} and ΔIn RER_{t-k}.s

3. EMPIRICAL RESULTS

3.1. Unit Root Analysis

The behaviour of the data is analysed using the Augmented Dickey-Fuller and Philips-Perron tests to establish if the data have a unit root or not. The appropriate lag length is selected employing the Akaike Information Criterion (AIC). In Table 2, the findings of the ADF and PP tests in level and first difference for the variables are presented. The result of the analysis indicates that the variables are non-stationary at the levels. This result implies that the unit root test do not in any form reject the assumption of a unit root of the variables in all the countries. However, when we took the first difference of the variables, the findings indicate that the variables are stationary and integrated of order one, 1(1). This result suggests that we can reject the null hypothesis at the first difference of the variables in the study.

With this result indicating that the properties of the variables are integrated of order 1(1), we are convinced to proceed with the analysis of cointegration tests to establish if a long-term connection is present between variables of study in the sub-Sahara Africa region. The existence of cointegration among the variables suggests that fluctuation in oil prices can adequately account for exchange rate movements in the economies of study. In Figure 1, we demonstrate oil price and exchange rate dynamics for the different currencies in the study. The report from the figure indicates that oil prices co-move with the exchange rates for each country over the sample period. This finding supports the studies by Huang and Guo (2007), Lizardo and Mollick (2010) who reported that oil price fluctuations affect exchange rates.

Given the order of integration of the variables, the study proceeds to test if there is a cointegration between oil price movements and the different countries' exchange rate assessed. The result of the cointegration test is reported in Table 3. The result of the analysis using the Johansen cointegration test shows sign of a long-term symmetry connection between oil prices and exchange rates of Nigeria, Equatorial Guinea and Gabon. This result suggests the need to accept the alternative hypothesis that a cointegration exists between the two variables. In order words, since the λ_{Trace} value is higher than the 5% critical value, the λ_{Trace} test statistic rejects the null hypothesis of r = 0 and accept the alternative hypothesis of r > 0. However, for the λ_{max} test statistic, the study dismisses the null hypothesis of r = 0 to accept r = 1. This result implies that oil price sufficiently captures the movements of real exchange rates of Nigeria, Angola, DRC, Equatorial Guinea, and Gabon. This result specifies that as an oil-exporting nation, in the long-run, any increase or decrease in real oil prices will cause the real exchange rates of the US to currencies of the economies in the sub-Sahara Africa region to appreciate or depreciate. In addition, the cointegration between oil price and the exchange rates of nations in consideration explains the over reliance of these economies on earnings from crude oil to finance economic activities. The result of this study confirms the long-run connection between oil price fluctuations and the real exchange rate as established in Akram (2004), Benhmad (2012), Wu et al. (2012), Tiwari et al. (2013) and Mensah et al. (2017). Moreover, Huang and Guo (2007) reported similar results for China between 1990 and 2005. They documented that real oil prices cause the long-run real exchange rate to appreciate.

Table 2: Results of the unit root test

Variable	ADF				PP			
	Level		1st difference		Level		1st difference	
	C	C & T	C	C & T	C	C & T	C	C & T
ΔROP	–2.266	–1.750	–12.744***	–12.826	–2.008*	–1.089*	–10.826*	–10.815*
ΔNGN	–2.287	–1.933	–12.435	–12.209	–1.997*	–1.081*	–10.757*	–10.675*
ΔAOA	–2.577	–1.008	–11.610	–12.665***	–3.948*	–2.782*	–10.819*	–10.838*
ΔCDF	–4.024	–1.984	–10.614	–12.665***	–5.433*	–1.719*	–16.631*	–14.633*
ΔEGXAF	–3.697*	–1.248	–13.699*	–13.323	–3.225*	–2.084*	–10.061*	–13.025*
ΔXAF	–2.307	–1.364	–12.744***	–12.826	–4.431	–2.472	–12.110*	–10.815*

*, ** and *** imply significance at 1%, 5% and 10% respectively. C: Constant and T: Trend

Figure 1: Crude oil prices (WTI) and exchange rates from Jan. 2004 to Jan. 2018

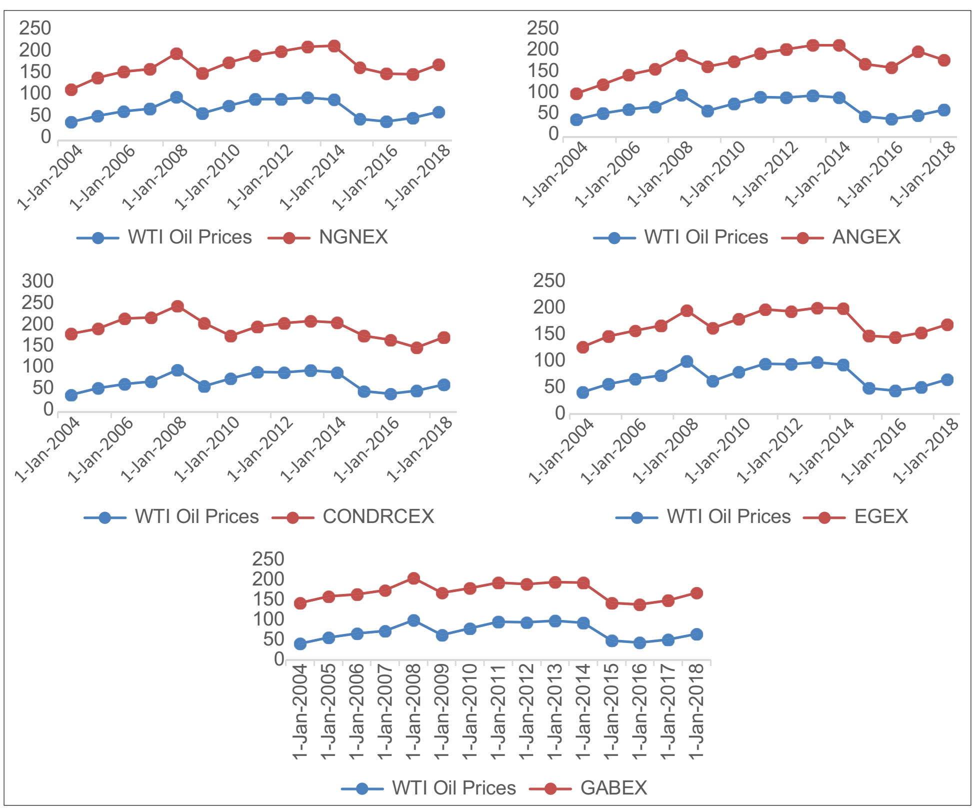

Table 3: Results of cointegration test results

Variable	λ_{Trace}		Prob.**	λ_{max}		Prob.**
	Test statistic	0.05 Critical value		Test statistic	0.05 Critical value	
	r≤1 (0)	r≤1		r≤1 (0)	r≤1	
ΔNNG	14.017	15.495	0.003	13.192	15.495	0.001
ΔAOA	7.350	3.841	0.126	7.002	3.841	0.026
ΔCDF	4.111	14.265	0.463**	3.172	14.265	0.000
ΔEGXAF	7.153	3.841	0.041	5.900	3.841	0.041
ΔXAF	5.004	11.027	0.008	3.248	11.027	0.000

*Denotes rejection of the hypothesis at the 0.05 level and **MacKinnon-Haug-Michelis (1999)

Table 4: Results of the vector error correction model

Variable	ΔlnRER			ΔlnROP		
	Coefficient	Std error	t-stat	Coefficient	Std error	t-stat
ECT-1	–0.17681	0.13176	–1.34187	–1.20059*	0.38114	–3.15001
ΔlnRER				0.13413	0.08643	1.55184
ΔlnROP	0.20847**	0.15806	1.31897			
C	3.02718	0.66973	4.51999	5.08092	1.27453	3.98651
R^2	0.56063			0.62331		

*, ** and *** implies 1%, 5% and 10% level of significance respectively

According to Granger (1988), to establish a relationship between two or more variables, there should be evidence to support at least a one-way connection between the cointegrated variables. To this end, the study took a step further to evaluate the short-run dynamic relations between the oil prices and real exchange rates of the selected sub-Sahara Africa economies using the vector error correction model (VECM). As presented in Table 4, the result reveals a negative and statistically significant value of the error correction term (ECt-1) at the 1% level. The implication of the negative causality in the short-run between the variables demonstrates the tendency for the variables which currently deviate from the mean position to converge in the long-run to the point of equilibrium, ceteris paribus. This finding is in agreement with Reboredo and Rivera-Castro (2013), and Adiguzel, et al., (2013). Although there is no short-run connection running from the exchange rate to oil prices, the study, however, reveals a sign of unidirectional relationship from oil price fluctuations to exchange rates in the selected sub-Saharan Africa countries.

4. CONCLUSION

The paper assesses the long-run equilibrium connection that exists between oil price fluctuations and real exchange rates in selected sub-Saharan Africa nations. This study employs the Johansen and Juselius (1991) vector error correction model (VECM), which provides an appropriate technique to test whether there is cointegration between the two variables of interest. Unlike the vector autoregression (VAR) technique, the VECM is essential to avoid any possible misspecification bias and to deal with the challenge of exploring the long-term connection of variables. Also, the VECM exhibits superior forecasting ability to other modelling techniques like the vector autoregressive model.

Following the analysis of this study, there is empirical evidence that a cointegrating connection exists between oil price fluctuations and real exchange rates of countries selected in sub-Saharan Africa region. The finding of this study suggests that oil prices impact exchange rates movement through which the economies of the selected African nations may be affected. This finding is consistent with the hypothesised symmetry relationship between the two variables and the findings of existing studies such as Olomola and Adejumo (2006) Mensah et al. (2017). The results of this study have salient implication for the policymakers responsible for the economy, analyst and investors for risk management and decision making, among other compelling issues in business. Furthermore, given the empirical indication that oil price co-moves with the exchange rate, it is imperative for the government to deploy the monetary policy aimed at controlling the inflationary effects based on the magnitude of oil price movements. Moreover, emerging markets are projected to make a significant positive impact on the global economy growth rate by 2050s. Thus, understanding the cointegrating relations between oil price movements and exchange rates is important for the stakeholders of the economy. Finally, given the significant role exchange rate and oil prices may have on the economy, the study suggests that this area of research be further considered, especially in other emerging economies and taking into consideration other variables and modelling techniques.

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