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Economic Fundamentals and Real Exchange Rate in African Oil Producing Countries: Evidence from Asymmetric Cointegration

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ABSTRACT: The role of exchange rates is very important in the international market and the variability of exchange rates both in the case of appreciation or depreciation is directly connected with the economic performance of a country. Exchange rate variations in oil-producing countries in Africa have been too high resulting in volatilities due to domestic and foreign shocks. High volatility of exchange rate may translate into reduction of trade flows, foreign direct investment, and instability in both interest rates and inflation rates. Several studies on the relationship between economic fundamentals and exchange rates focused more on Africa or country-specific with limited focus on African oil-producing countries using asymmetric cointegration. Therefore, this study examines the relationship between some economic fundamentals and real exchange rates in oil-producing countries in Africa. The dynamics panel non-linear autoregressive distributed lag and linear autoregressive distributed lag were used to investigate the relationship between economic fundamentals and real exchange rate (RER). The NARDL result shows evidence that there exists both short and long-run asymmetric relationship between economic fundamentals and RER. The study recommended that policymakers in these countries pay more attention to their macroeconomic policies to reduce the production and transaction costs of foreign direct investment (FDI).

INTRODUCTION

The exchange rate is one of the important key policy variables for better macroeconomic management. Macroeconomic stability on the external front depends on the proper choice of exchange rate regime. Exchange rate volatility affects international trade and directly leads to growth and domestic price levels. Movements in exchange rates are a natural feature of countries' adjustment over the business cycle. The cyclical behavior of exchange rates reflects changes in monetary policy over the business cycle, and thus it provides one of the channels through which short-run stabilization policy operates. So a country's economic health depends considerably on the appropriate choice of exchange rate regime.

Exchange rate variations significantly affect different aspects of the economy and also concerned parties. The role of exchange rates is very important in the international market and the variability of exchange rates both in the case of appreciation or depreciation is directly connected with the economic performance of a country. Exchange rate movements have become excessive after the implementation of flexible exchange rate regimes and the volatility of developing economies' currencies depends on the pegging system and the implied burden of the currency that a particular nation pegs (Chong & Tan, 2007).

The relationship between exchange rate volatility and international trade is the central part of the discussion of alternative exchange rate regimes. Fixed exchange rate supporters claim that exchange rate fluctuation acts as a weak factor for attaining prospective international trade flows. It is based on the view that exchange rates are majorly determined by fundamentals, where the volatility of an exchange rate may be dependent on changes in parity. The flexible exchange rate is based on the view of facilitating the adjustments of the balance of payments from external sources. Exchange rate volatility has direct and indirect effects on trade flows through transmission mechanisms on the structure of employment, investment, and output. According to Hwang & Lee (2005), exchange rate volatility is an inborn risk factor and this depends on the assumption that the profitability of firms and variations in exchange rates have a fixed relationship with each other.

The relationship of exchange rate volatility with international trade has been comprehensively studied in the literature but there is no unanimity about this relationship. (Cheong et al. 2005). Theoretically, the negative and positive relationship between exchange rate volatility and international trade can be described in different ways. If the risk-averse traders face a higher transaction risk and higher cost due to exchange rate volatility, they will decrease the volume of trade, and on the other hand, if the anticipated

cost of import expenditure decreases or the anticipated utility of export revenue increases, this leads to an increase in exchange rate volatility which ultimately increases the trading volume.

Exchange rate fluctuations significantly affect different aspects of the economy and also the concerned parties. The importance of exchange rates is extremely significant in the international market and the variability of exchange rates both in the case of appreciation or depreciation is directly connected with the economic performance of a country. Exchange rate movements have become excessive after the implementation of flexible exchange rate regimes and the volatility of developing economies' currencies depends on the pegging system and the implied burden of the currency that a particular nation pegs (Chong et al; 2014).

Most African currencies have weakened against the US dollar, fanning inflationary pressures across the continent as import prices surge. This, together with a growth slowdown, leaves policymakers with difficult choices as they balance keeping inflation in check with a still-fragile recovery. The average depreciation for the region since January 2022 is about 8 percent. However, Ghana's cedi and Sierra Leone's depreciated by more than 45 percent. Foreign exchange earnings took a hit in many countries as demand for the region's exports dropped because of the economic slowdown in major economies. At the same time, high oil and food prices, partly due to Russia's war in Ukraine increase the importation costs in 2022. Large budget deficits have compounded the effects of these external shocks by increasing the demand for foreign exchange. About half of the countries in the region had deficits exceeding 5 percent of gross domestic product in 2022 which adds more pressure on exchange rates.

African oil-producing countries recorded substantial depreciation against other major currencies largely due to the global appreciation of the US dollar in the second quarter of 2015. Also, at the end of January 2022, another depreciation of oil-producing countries' currencies was recorded which raised a concern about the effect of the fast depreciation of the currencies on other macroeconomic variables and the economy at large. There is a gap in information as to whether or not the recorded exchange rate movements have resulted in exchange rate volatility and to what extent it has impacted macroeconomic variables such as growth, interest rate, inflation, foreign direct investment (FDI), net foreign asset, and trade flows. It is against this backdrop that this study examined the extent of exchange rate volatility in oil-producing countries and identified its subsequent impact on economic fundamentals. There are differences between oil-producing countries and non-oil-producing countries in Africa because the depreciation in the oil-producing countries is very high. After all, oil-producing countries depend majorly on oil exports and the depreciation level of the non-oil-producing countries is not as high as oil-producing countries.

However, the implication of the oil price volatility suggests that oil prices can either appreciate or depreciate the country's currencies relative to the US dollar. For countries producing oil in Africa for export which is 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, inflation and 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 prices may impact oil exporting nations and oil importing nations differently. According to the view of terms of trade, oil-producing countries will experience a favorable trade balance and a surge in the value of the national legal tender when there is a drop in the movement of oil prices. However, an upward trend in oil prices will result in a decrease in the value of the local currency and a trade imbalance of oil importing countries (Fratzscher et al., 2015). The objective of this study is to examine the effect of economic fundamentals on real exchange rates in African oil-producing countries.

REVIEW OF RELEVANT LITERATURE

Babangida et al; (2021) researched the relationship between the real exchange rate and consumption in Nigeria using a nonlinear approach. A smooth transition autoregressive (STAR) model was employed in this study. Findings from the study show that domestic consumption determines the shift in the real exchange rate, suggesting nonlinear linkage with clearly distinct regimes. The lagged exchange rate is shown to have a significant linear effect on the current exchange rate. However, current foreign consumption is positive but has no significant impact on the exchange rate in the linear part of the model. In the nonlinear part of the model, evidence of a significant negative relationship between the real exchange rate and domestic consumption is found, thus, supporting the proposition of the standard international business cycle model. In addition, the study finds evidence of bi-directional nonlinear Granger causality between real exchange rate and domestic consumption.

Ayele (2022) investigated the real exchange rate misalignment and economic growth in East African least developed countries. The study used a Pooled Mean Group (PMG), dynamic OLS estimators for the panel, and an ARDL-bound testing model. The panel results revealed that the REER was significantly misaligned. The REER appreciates for an improved term of trade and net foreign asset position, while it depreciates for increased trade openness and broad money supply in the long run. The panel results also confirmed that the GDP per capita has a positive relationship between real investment and human capital, while a negative relationship between trade openness, net foreign aid inflows, and REER misalignment in the long run.

Hadood & Saleh (2022) researched modeling the equilibrium real exchange rate in an oil-exporting country. The study employed the ARDL model. The empirical result shows that an increase in oil revenue would lead to an increase in the domestic supply of foreign currencies which reflects a decline in the RER. The results also show that the ratio of M2/GDP and political

instability positively drives the RER against the US dollar. Also, terms of trade have a negative effect on the RER of Libyan dinar against the US dollar both in the short and long runs indicating that positive shocks in terms of trade improve the Libyan dinar against the US dollar.

Balcilar et al; (2019), revisited the exchange rate pass-through to inflation in Nigeria and South Africa. The study employed the Maki cointegration test and a flexible estimation approach of the Autoregressive Distributed Lag (ARDL) model. The results show that output growth in Nigeria increases inflation in the long run while it is anti-inflationary in the short run and for South Africa, the effect of output growth is negatively insignificant. In addition, the long-run effect of oil price is negatively significant in Nigeria, while for South Africa the short-run effect of oil price is positively significant.

Dung & Okereke (2022) investigated the determinants of the exchange rate in Sub-Sahara African Countries and this study employed Panel Least Square (PLS) estimation methods. This reveals that the inflation rate has a negative relationship with the exchange rate but it does impact significantly on it at the 5 percent level, also interest rate has a negative and insignificant impact on the exchange rate at the 5 percent level. However, the current account balance has a negative significant relationship with the exchange rate and terms of trade have a negative significant relationship with the exchange rate.

Samuel et al; (2018) investigated the implication of naira devaluation in Nigeria's economic development using the Classical Linear Regression Model (CLRM). The empirical results indicate that exchange and the inflation rate were sustained to have a positive and significant affiliation with GDP while external debt and public investment were negative and non-significant.
Ngalawa & Kutu (2017) examined the modeling of exchange rate variations and global shocks in Brazil. The empirical results of the study show that Brazil's exchange rates are significantly influenced by global shocks (interest rate).

Hashchyshyn et al; (2020) investigated how the interest rate influences the exchange rate. The results of the study indicate that the short-term impact of interest rate changes on the exchange rate is positive and statistically significant, although the economic significance is weak, while the long-term relationship is found to be insignificant.

Longe et al; (2019) examined oil price, trade openness, current account balances, and official exchange rate in Nigeria using the non-linear autoregressive distributed lag (NARDL) model. The empirical findings show that trade openness negatively affects official exchange rates both in the short run and long run. Also, the consumer price index positively significantly influences exchange rate value in the short run and long run. Positive changes in oil prices have a negative impact on the official exchange rate in the short run and the long run. Negative changes in the oil price have a positive insignificant effect on the official exchange rate and a negative significant effect on the official exchange rate in both the short run and long run. The error correction result verified that the variables (trade openness, current account, oil price, and consumer price index) correct 91 percent deviations of the exchange rate from short-run equilibrium back to equilibrium in the long run.

Cuestas et al; (2022) investigated the relationship between the real exchange rate and its fundamentals changed over time. The results of the study show that although the current account is significant at the 10% level with the pooled estimations, it is not significant with the other two methods. Government consumption does not seem to affect the real exchange rate with the pooled estimations and pooled weighted ones, but it is positively significant in the group mean estimations. Openness and the terms of trade have a positive and significant effect on the real exchange rate, while real GDP only shows a significant and positive effect in the pooled weighted regressions.

Moayed (2023), examined the effects of trade openness and some macroeconomic variables on exchange rate volatility in Iran. The findings of the study show the positive effect of money supply, government expenditures, and the negative favorable effects of trade openness, economic growth, currency system, and oil prices on exchange rate volatility both in the short run and long run. Even though the impact of economic growth and government expenditures were insignificant increasing the money supply had the highest adverse effect on the foreign exchange market, and increasing trade openness and the fixed exchange rate system decreased the exchange rate volatility. The currency system and monetary discipline of the Central Bank, along with the trade openness policy can have significant effects on reducing exchange rate volatility and economic stability in Iran.

Umaru et al; (2018) investigated the effects of exchange rate volatility on the economic growth of West African English-speaking countries using the Pooled OLS model, Fixed Effect Model, and Random Effect Model for analyzing the study. The empirical results obtained showed that the independent variable (real exchange rate) is statistically significant and negatively related to the dependent variable (GDP) in West African English-speaking countries excluding time-invariant variables.

Alagidede & Ibrahim (2016) examined the cause and effect of exchange rate volatility on economic growth in Ghana which employed the GMM model. The results of the study show that in the short run, output has an effect on exchange rate fluctuations in Ghana while in the long run exchange rate volatility is significantly influenced by government expenditure growth, money supply, terms of trade shocks, FDI flows and domestic output movements. Decomposing the shocks indicates that almost three-quarters of exchange rate volatility is self-driven.

METHODOLOGY

The ex-post facto quantitative research design was employed in this study, as it would enable the exploration of a possible causal relationship between two or more variables. The ex-post facto research design further allows records to determine past associations to develop a predictive model for forecasting the future relationship between variables. This design helps to capture the impact of the economic fundamentals on real exchange rate proxies. This research design was also employed by Yuting, et al; (2022), Dick, et al; (2014), and Bertram, et al; (2022) in testing their stated hypothesis and they were able to obtain significant results.

This study adopts a nonlinear relationship to investigate the relationship between economic fundamentals and real exchange rates in African oil-producing countries. Adeleye (2020) states the main reason behind panel data is that it accommodates the group and not the individual units in the group, which means that very little information is lost by taking the panel's perspective. The panel data for this study contains information on the same cross-section units of ten (10) African oil-producing countries. These data are sourced majorly from World Bank indicators. The panel data set covered 36 years from 1986 to 2022.

Panel ARDL: The Linear Model

The linear panel ARDL representation is written as follows:

$$\Delta RER_{it} = \sigma_1 + \sum_{j=1}^{p1} \delta_{1ij} \Delta TOT_{i,t-j} + \sum_{j=1}^{p1} \delta_{2ij} \Delta NFA_{i,t-j} + \sum_{j=1}^{p1} \delta_{3ij} \Delta FD_{i,t-j} + \sum_{j=1}^{p1} \delta_{4ij} \Delta INF_{i,t-j} + \sum_{j=1}^{p1} \delta_{5ij} \Delta GDP_{i,t-j}$$

$$+ \sum_{j=1}^{p1} \delta_{6ij} \Delta INT_{i,t-j} + \sum_{j=1}^{p1} \delta_{7ij} \Delta MS_{i,t-j} + \sum_{j=1}^{p1} \delta_{8ij} \Delta FDI_{i,t-j} + \gamma_t ect_{i,t-1} + \varepsilon_{it} \text{ ----------(1)}$$

Where
RER is Real Exchange Rate
TOT is Terms of Trade
NFA is Net Foreign Assets
FD is Foreign Deficit
INF is Inflation
GDP is Gross Domestic Product
INT is Interest Rate
MS is Money Supply
FDI is Foreign Direct Investment

Panel ARDL: The nonlinear model

The nonlinear form of the panel ARDL estimates the asymmetric responses of the nominal exchange rate (NER) to economic fundamentals variables. In this study, the asymmetric approach as suggested by Shin et al (2014) is adopted this decompose the interaction variables that detect both the upward and downward changes of the variables.

$$\Delta RER_{it} = \eta_i + \gamma_{1i} \Delta TOT_{i,t-1} + \gamma_{2i} \Delta NFA_{i,t-1} + \gamma_{3i} \Delta FD_{i,t-1} + \gamma_{4i} \Delta INF_{i,t-1} + \gamma_{5i} \Delta GDP_{i,t-1} + \gamma_{6i} \Delta INT_{i,t-1}$$

$$+ \gamma_{7i} \Delta MS_{i,t-1} + \gamma_{8i} \Delta FDI_{i,t-1} + \sum_{j=1}^{p^1} (\delta_{1ij}^{+} \Delta TOT)_{i,t-j}^{+} + (\delta_{1ij}^{-} \Delta TOT)_{i,t-j}^{-} + \sum_{j=1}^{p^2} (\delta_{1ij}^{+} \Delta NFA)_{i,t-j}^{+} + (\delta_{1ij}^{-} \Delta NFA)_{i,t-j}^{-}$$

$$+ \sum_{j=1}^{p^3} (\delta_{1ij}^{+} \Delta FD)_{i,t-j}^{+} + (\delta_{1ij}^{-} \Delta FD)_{i,t-j}^{-} + \sum_{j=1}^{p^4} (\delta_{1ij}^{+} \Delta INF)_{i,t-j}^{+} + (\delta_{1ij}^{-} \Delta INF)_{i,t-j}^{-} \sum_{j=1}^{p^5} (\delta_{1ij}^{+} \Delta GDP)_{i,t-j}^{+} + (\delta_{1ij}^{-} \Delta GDP)_{i,t-j}^{-}$$

$$+ \sum_{j=1}^{p^6} (\delta_{1ij}^{+} \Delta INT)_{i,t-j}^{+} + (\delta_{1ij}^{-} \Delta INT)_{i,t-j}^{-} + \sum_{j=1}^{p^7} (\delta_{1ij}^{+} \Delta MS)_{i,t-j}^{+} + (\delta_{1ij}^{-} \Delta MS)_{i,t-j}^{-} + \sum_{j=1}^{p^8} (\delta_{1ij}^{+} \Delta FDI)_{i,t-j}^{+} + (\delta_{1ij}^{-} \Delta FDI)_{i,t-j}^{-} + \varepsilon_{it} \text{ ----------(2)}$$

RESULT AND DISCUSSION OF FINDINGS

Descriptive Statistics

The RER has a mean value of 126.79, depicting that on average, during the 37 years periods studied, the RER was 126.79, while the standard deviation of 32.88 displayed that the volatility in RER was still manageable, as it clustered around the average value, suggesting that the RER is less susceptible to change over time. Meanwhile, the RER skewness was 3.27, depicting that RER was positively skewed to the right, portraying a long-right tail. At the same time, its peakedness was leptokurtic (14.62 > 3), showing that the RER series concentrated towards the mean, with occasional extreme outliers that caused the concentration. The probability value (p-value) of the Jacque-Bera statistics was 0.000, showing that the series was not normally distributed during the study period at a 0.05 significant threshold.

Foreign deficit (FD). The FD has a mean value of 12897.5 and a standard deviation of 75531.3, pointing out that, on average, the FD value for these countries was 12897.5. In contrast, the dispersion in foreign deficit over the 37-year studies from the mean value was 75531.3, depicting the volatility level in foreign deficit clustered tightly around the mean value, suggesting that it is more susceptible to change over time. Meanwhile, the skewness for FD was 7.22, depicting that FD was positively skewed to

the right, portraying a long-right tail. At the same time, its peakedness was leptokurtic (60.22 > 3), showing that the FD extreme concentrated towards the mean, with occasional extreme outliers that caused the concentration. The probability value (*p*-value) of the Jacque-Bera statistics was 0.032, showing that the series was not normally distributed during the study period.

Foreign direct investment (FDI) has a mean value of 1.52 billion and a standard deviation of 2.5 billion, pointing out that, on average, the countries attracted an average of 1.52 billion worth of FDI during the study period. In contrast, the dispersion in the FDI over the 37 years of studies from the mean value was 2.5 billion, depicting the volatility level in FDI clustered tightly around the mean value. Meanwhile, the skewness for FDI was 0.99, representing that FDI was positively skewed to the right, portraying a long-right tail. At the same time, its peakedness was platykurtic (6.77 > 3), showing that FDI extreme values concentrated towards the mean, with occasional extreme outliers that caused the concentration. The probability value (*p*-value) of the Jacque-Bera statistics was 0.000, showing that the series was not normally distributed during the study period.

The gross domestic product (GDP) has a mean value of 8.39 billion and a standard deviation of 1.12 billion, pointing out that, on average, the country's total monetary value of all goods produced and services rendered among these countries was 8.39 billion during the study period. In contrast, the dispersion in the GDP over the 37 years of studies from the mean value was 1.12 billion, depicting the volatility level in GDP clustered tightly around the mean value, making it less vulnerable to volatility. Meanwhile, the skewness for GDP was 2.19, showing that GDP was positively skewed to the right, portraying a long-right tail. At the same time, its peakedness was platykurtic (7.45 > 3), showing that extreme GDP values concentrated towards the mean, with occasional extreme outliers that caused the concentration. The probability value (*p*-value) of the Jacque-Bera statistics was 0.000, showing that the series was not normally distributed during the study period.

Another variable was the inflation rate (INF). The INF has a mean value of 43.41% and a standard deviation of 327.82, pointing out that, on average, inflation values among these countries was 43.41%, above the minimum inflation value recorded (-17.4%) in Egypt in 1987. In contrast, the dispersion in inflation over the 37-year studies from the mean value was 327.82, depicting the volatility level in inflation clustered tightly around the mean value, suggesting that it is more susceptible to change over time. Meanwhile, the skewness for INF was 11.01, depicting that INF was positively skewed to the right, portraying a long-right tail. At the same time, its peakedness was leptokurtic (127.71 > 3), showing that the INF extreme concentrated towards the mean, with occasional extreme outliers that caused the concentration. The probability value (*p*-value) of the Jarque-Bera statistics was 0.032, showing that the series was not normally distributed during the study period.

The terms of trade have a mean value of 96.746 across the ten countries sampled with a standard deviation of 36.091, suggesting that on average, during the entire 37 years of the study, the terms of trade across these countries was 96.746. The standard deviation above the mean value depicts the volatile terms of trade across the countries studied. This suggests that the terms of trade deviated from the mean value of almost 36.091 during the study period and are more susceptible to change over time. The minimum value of 27.044 and the maximum value of 181.767 indicate that the terms of trade have different values, with a maximum weight of 181.767 over the sample periods, as the lowest value was 27.044.

Furthermore, through the skewness and kurtosis, it was shown that TOT was positively skewed to the right, depicting a long-right tail with a platykurtic (2.55 < 3) peakedness; this means that the distributions are stable and predictable, in the sense that there will be extreme outliers in terms of trade values. The probability value (*p*-value) of the Jacque-Bera statistics was 0.012, showing that the series is not normally distributed during the study period.

The net foreign assets (NFA) have a mean value of 21551.82 billion and a standard deviation of 38929.57, pointing out that, on average, the country's total monetary value of all goods produced and services rendered among these countries was 21551.82 billion during the study period. In contrast, the dispersion in the GDP over the 37 years of studies from the mean value was 38929.57, depicting the volatility level in NFA clustered tightly around the mean value, making it less vulnerable to volatility. Meanwhile, the skewness for NFA was 2.67, showing that NFA was positively skewed to the right, portraying a long-right tail. At the same time, its peakedness was leptokurtic (10.1 > 3), showing that extreme NFA values concentrated towards the mean, with occasional extreme outliers that caused the concentration. The probability value (*p*-value) of the Jacque-Bera statistics was 0.000, showing that the series was not normally distributed during the study period.

The interest rate (INT) has a mean value of 14.89, with a 14.78 standard deviation over the sample period, suggesting that the INT averaged 14.89 despite its volatility of 14.78, which was below the average mean. The mean value further depicted that despite the fluctuations experienced, the countries' real effective exchange rate could still be more than the fluctuations experienced during the study perimeter. The minimum value of 0.050 and the maximum value of 80.33. Furthermore, the skewness and kurtosis revealed that INT was positively skewed to the right, depicting a long-right tail, while its kurtosis was leptokurtic (7.06 > 3). The probability value (*p*-value) of the Jacque-Bera statistics was 0.000, showing that the series was not normally distributed during the study period.

Table 1: Descriptive Statistics

	FD	FDI	GDP	INF	INT	MS	NFA	RER	TOT
Mean	12897.50	1.5200	8.3900	43.40967	14.89484	2.9800	21551.82	126.7045	96.74638
Median	24.52057	8.9400	4.7100	5.362907	11.21542	5.2400	4752.626	106.5400	94.48092
Maximum	691376.8	1.1600	5.7400	4145.106	80.33333	3.8900	193621.1	519.8700	181.7674
Minimum	-53573.44	-7.4000	30.48584	-17.64042	0.050000	4671800.	-20372.08	32.88403	27.04389
Std. Dev.	75531.30	2.5600	1.1200	327.8185	14.78954	6.2000	38929.57	75.24929	36.09071
Skewness	7.220965	0.991059	2.189803	11.01035	1.963232	3.263516	2.671117	3.274172	0.429994
Kurtosis	60.21526	6.744392	7.449540	127.7145	7.068429	14.76276	10.14963	14.61548	2.557906
Jarque-Bera	32790.30	169.0222	367.0556	151030.3	301.0436	1704.084	750.1009	1674.286	8.804839
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.012248
Observations	226	226	226	226	226	226	226	226	226

Source: Author's computation from Eviews 12

Panel Unit Root Test

The result of the unit root test summarized in Table 4.2 showed that the variables used in this thesis exhibit both stationary and non-stationary characteristics. RER, FD, MS, and FDI are stationary at first difference I(1) while TOT, NFA, INF, GDP, and INTR are stationary at levels I(0) with Breitung unit root. RER, TOT, NFA, FD, INF, INTR, and MS are stationary at levels I(0) while GDP, INTR, and FDI are stationary at first difference I(1) with Levin, Lin Chu (LLC) unit root test. Under the Im-Pesaran Shin (IPS) unit root test, RER, FD, INF, INTR, and MS are stationary at levels I(0) while TOT, NFA, GDP, and FDI are stationary at the first difference I(1). The result of the Augmented Dickey-Fuller (ADF) unit root test shows that FD, INF, GDP, and MS are stationary at levels I(0) while RER, NFA, INTR, and FDI are stationary at first difference I(1).

Table 4.2: Panel Unit Root Test

	Breitung		**LLC**		**IPS**		**ADF**	
I(d)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
RER	0.7823	-2.942***	-4.445***	-8.633***	-4.915***	-9.939***	16.279***	14.400***
TOT	-1.946**	-4.783***	-2.397***	0.1142	0.072	-10.007***	-2.178	0.610
NFA	-2.161**	-7.889***	-5.599***	-1.1870	0.696	-7.591***	0.390	3.838***
FD	0.1410	-2.388**	-12.485***[a]	-19.1667	-5.096***	-10.724***	6.557***	18.425***
INF	-5.599***	-13.530***	-5.499***	-12.847***	-7.624***	-13.517***	3.834***	9.512***
GDP	-4.456***	-13.311***	-10.623***	-3.284***	-12.600***	-4.880***	1.719***	6.810***
INTR	-2.128**	-11.135***	-6.353***	-6.353***	-1.330*	-10.388***	0.221	4.338***
MS	-11.134***	-6.427***	-3.398***	-9.193***	-4.612***	-11.716***	4.244***	10.340***
FDI	-12.771***	-8.378***	-15.130***	-6.942***	-13.484***	-9.049***	11.409***	2.037***

Source: Author's computation from STATA 15

Note: ***, **, * indicate statistical signi**fi**cance at 1%, 5% and 10%, respectively.

Table 3: Models without Asymmetry

Short Run

Variables	**MG**	**PMG**
LTOT	-2.655 (-2.83)***	-0.163 (-1.60)
LNFA	0.071 (0.49)	-0.029 (-0.82)
LFD	-0.012(-0.32)	-0.044 (0.63)
LINF	0.208 (-2.07)***	0.253 (-1.67)
LGDP	-0.028 (2.70)**	-0.017 (2.97)*
LINTR	0.013 (0.31)	0.009 (0.19)
LMS	-0.083 (-2.30)**	-0.006 (-0.06)

LFDI	-0.083 (-0.65)	-0.014 (-0.75)
CONSTANT	0.512 (0.21)	0.829 (2.60)***

Long run

Variables	**MG**	**PMG**
LTOT	1.090 (1.02)	0.162 (2.28)**
LNFA	0.003 (0.01)	0.025 (1.71)*
LFD	-0.189 (-0.92)	0.119 (7.45)***
LINF	0.389 (1.37)	0.078 (4.62)***
LGDP	0.193 (0.50)	0.011 (0.45)
LINTR	-0.084 (-0.70)	-0.040 (-2.48)***
LMS	-0.180 (-0.40)	0.028 (1.30)
LFDI	0.030 (0.22)	-0.081 (-5.44)***
ECT	0.400 (-4.60)***	-0.239 (-2.64)***
Hausman Test (X_k^2)		6.93 (0.544)

Source: Author's Computation from STATA 15 output

Note: The values in parentheses are the z statistics. ***, ** & * imply significance at the 1%, 5% and 10% levels, respectively

The equation for result interpretation is stated as:

$\Delta RER_{it} = 0.829 + 0.162TOT_{it} + 0.025NFA_{it} + 0.119FD_{it} + 0.078INF_{it} + 0.011GDP_{it} - 0.040INT_{it} + 0.028MS_{it} – 0.081FDI_{it}$ ----------(4.1)

The estimated long-run coefficients for the model were reported in Table 4.3 and restated in Equation (4.1). There is evidence that terms of trade (TOT), net foreign asset (NFA), foreign deficit (FD), and inflation (INF) exert a significant positive impact on the real exchange rate (RER). This implies that in terms of trade, net foreign assets, foreign deficit, and inflation increase by 1 percent, and this leads to 0.162, 0.025, 0.119, and 0.078 percent increase in real exchange rate, *ceteris paribus*, establishing that increasing these variables individually would result into increase in RER. Meanwhile, as exposed in Table 4.3, interest rate (INTR) and money supply (MS) separately depicted a significant negative nexus on RER; as INTR and MS increased by one percent, it led to a 0.040 and 0.081 percent decrease in real exchange rate, *ceteris paribus*. This means that increasing these variables individually would result in a reduction of the real exchange rate.

The influence of terms of trade LTOT and net foreign asset LNFA on real exchange rate RER is statistically significant at 5% (percent) and 10% (percent) respectively while foreign deficit LFD, inflation rate LINF, interest rate LINT, and foreign direct investment LFDI have 1% significant effect on real exchange rate. Therefore, terms of trade, net foreign assets, foreign deficit, inflation rate, interest rate, and foreign direct investment are significant factors that impact the exchange rate in African oil-producing countries. The estimated coefficients agreed with the a priori expectation except for foreign direct investment as opposed to the negative sign. This could be due to the fact the rise in the real exchange rate (RER) represents appreciation of the domestic currency. The estimation result, in the long run, showed that the real exchange rate appreciation causes a decrease in foreign direct investment.

The positive and significant terms of trade only confirmed the higher dependence of these countries on the exportation of oil production. The positive and significant coefficient of net foreign assets affirms the impact of the exchange rate value of its currency over time in African oil-producing countries.

$\Delta RER_{it} = -0.239 -0.163TOT_{it} -0.029NFA_{it} - 0.044FD_{it} -0.017INF_{it} + 0.253GDP_{it} +0.008INT_{it} -0.006MS_{it} – 0.014FDI_{it}$ ----------(4.1)

The purpose of this section is two-fold. The first is to examine the existence and the speed of adjustment back to long-run equilibrium using the error correction term (ECT) and the second is to evaluate the statistical significance of short parameters as observed in the long run. The error correction term (ECT) measures the short-run adjustment process that shows an appropriate negative sign under the two estimators and is statistically significant at 1%. The coefficient of ECT (-0.239) is negative and statistically significant and elaborates how speedily variables converge to equilibrium, indicating that the explanatory variables quickly adjust back to equilibrium at about 23.9 percent annually.

Furthermore, in the short run gross domestic product (GDP) and interest rate (INTR) exhibited a positive relationship with RER and this establishes that a percentage increase in GDP and INTR increase RER by 0.253 and 0.008 respectively while in terms of trade (TOT), net foreign assets (NFA), foreign deficit (FD), money supply (MS) and foreign direct investment (FDI) exhibited a negative relationship with RER. This establishes that as terms of trade (TOT), net foreign assets (NFA), foreign deficit (FD), money supply (MS), and foreign direct investment (FDI) increases by one percent, real exchange rate decreases by 0.163, 0.029, 0.044, 0.017, 0.006 and 0.014 percent respectively.

Table 4.4: Models with Asymmetry

Short Run

Variables	MG	PMG
LTOT^{+}	0.022 (0.08)	-0.436 (-2.05)**
LTOT^{-}	0.067 (0.24)	-0.425 (-1.92)*
LNFA^{+}	0.001 (0.26)	-0.002 (-1.09)
LNFA^{-}	-0.001 (-0.33)	-0.003 (-1.50)
LFD^{+}	-1.164 (-1.34)	-0.350 (-0.78)
LFD^{-}	-0.660 (-0.90)	-0.337 (-0.75)
LINF^{+}	0.030 (0.60)	-0.036 (-2.02)**
LINF^{-}	-0.013 (-0.17)	-0.046 (-1.24)
LGDP+	-0.017 (-0.28)	0.007 (0.32)
LGDP-	0.005 (0.10)	0.014 (0.35)
LINT^{+}	0.273 (1.48)	0.153 (1.93)**
LINT^{-}	0.211 (1.13)	0.067 (1.00)
LMS^{+}	0.042 (0.78)	0.029 (1.04)
LMS^{-}	0.257 (1.97)	0.177* (1.95)
LFDI^{+}	0.013 (0.21)	0.026 (1.01)
LFDI^{-}	-0.002 (-0.02)	0.046 (1.13)
CONSTANT	9.988 (0.29)	14.909 (6.23)

Long run

Variables	MG	PMG
LTOT^{+}	6.667 (2.01)**	0.400 (2.16)**
LTOT^{-}	8.467 (1.52)	-0.032 (-0.14)
LNFA^{+}	-0.017 (-1.02)	-0.001 (-3.06)***
LNFA^{-}	-0.002 (-0.12)	0.001 (2.71)***
LFD^{+}	-0.214 (-0.36)	-0.000 (-2.09)**
LFD^{-}	1.489 (0.57)	0.000 (0.86)
LINF^{+}	0.280 (0.90)	0.258 (3.24)***
LINF^{-}	-0.281 (-0.74)	-0.229 (-2.27)**
LGDP+	0.562 (-0.69)	0.116 (1.91)*
LGDP-	-1.449 (-1.70)*	-0.270 (-3.37)***
LINT^{+}	1.957 (1.66)*	-0.028 (-0.23)
LINT^{-}	0.739 (0.53)	-0.097 (0.72)
LMS^{+}	0.154 (0.40)	0.071 (1.26)
LMS^{-}	0.154 (-0.82)	-0.202 (-1.37)
LFDI^{+}	-0.598 (-0.88)	-0.094 (-1.30)
LFDI^{-}	-0.563 (-1.36)	-0.095 (-1.08)
ECT	-0.207 (-1.50)**	-0.157 (-7.51)***
Hausman Test (X_k^2)		7.83 (0.3200)

Source: Author's Computation from STATA 15 output

Note: All variables are in their logarithmic transformation. The values in parentheses are the standard errors. ***, ** & * imply significance at the 1%, 5% and 10% levels, respectively

Long-run asymmetric Dynamic

$RER_{it} = \tau + 0.400TOT^{+}_{it} - 0.032TOT^{-}_{it} - 0.001NFA^{+}_{it} + 0.001NFA^{-}_{it} - 0.004FD^{+}_{it} + 0.001FD^{-}_{it} + 0.258INF^{+}_{it} - 0.2291INF^{-}_{it} + 0.116GDP^{+}_{it} - 0.270GDP^{-}_{it} - 0.028INT^{+}_{it} - 0.097\ INT^{-}it + 0.071MS^{+}_{it} - 0.202MS^{-}_{it} - 0.094FDI^{+}_{it} - 0.095FDI^{-}_{it}$ ----------(4.2)

In the long run, there is evidence that an increase in terms of trade (+) exhibits a positive sign and is significant meaning a positive effect while a decrease in terms of trade (-) exhibits a negative sign meaning a negative sign, and is significant indicating a negative effect on the real exchange rate of the African oil-producing countries. This implies that African oil-producing economies/countries seem to experience an appreciation of real exchange rates following the terms of trade volatilities (positive and negative) in the long run.

Also, there is evidence that an increase in net foreign assets has a negative sign and a decrease in net foreign assets has a positive sign and are both significant indicating a negative effect on real exchange of African oil-producing countries. the estimated elasticities of NFA positive shocks about RER was -0.0007, portraying that all things being equal, a 0.0007% increase in RER was a result of a 1% decrease in NFA. This implies that an appreciation of one's country's currency will decrease the value of the asset denominated in the foreign currency. Likewise, in the long run, foreign deficit (FD) positive shocks alone had a negative significant impact on the real exchange rate (RER), and a negative shock in foreign deficit has a positive insignificant on the real exchange rate (RER).

Evidence shows that gross domestic product (GDP) has both positive and negative impacts on real exchange rates in African oil-producing countries. It was a mixed reaction for GDP because it was positive for GDP increases and negative for GDP decreases. The 1% decrease in GDP negative shock gave a 0.2695% increase in RER. Statistically, the coefficients of GDP positive and negative shocks were statistically significant at either 1% or 10% significant levels. Also, there is evidence in the long run, that both positive and negative inflation (INF) tend to exert a significant impact on real exchange rates in African oil-producing countries. It was a mixed reaction for the variable, as it was positive for INF increases and negative for INF decreases. The estimated elasticities of INF positive shocks on RER was 0.2576, indicating that *Ceteris paribus*, a 0.2576% increase in RER resulted from a 1% increase in INF. In contrast, *ceteris paribus*, the 1% decrease in INF negative shock gave a 0.2291% increase in RER. Evidence showed that interest rate (INT) has a negative impact on RER both positive and negative. This means that a 1% decrease in INT negative shocks gave a 0.097 increase in RER Statistically, the coefficients INT are insignificant. Likewise, evidence showed that foreign direct investment (FDI) has a negative impact on RER both positive and negative. This means that a 1% decrease in FDI negative shocks gave a 0.095 increase in RER Statistically, the coefficients INT are insignificant

Evidence shows that money supply (MS) has both positive and negative impacts on real exchange rates in African oil-producing countries. It was a mixed reaction for MS because it was positive for MS increases and negative for MS decreases. The 1% decrease in MS negative shock gave a 0.202% increase in RER. Statistically, the coefficients of MS positive and negative shocks were statistically insignificant.

Short-run asymmetric Dynamic

$RER_{it} = 7.83 - 0.456TOT^{+}_{it} - 0.425TOT^{-}_{it} - 0.002NFA^{+}_{it} - 0.003NFA^{-}_{it} - 0.349FD^{+}_{it} - 0.337FD^{-}_{it} - 0.036INF^{+}_{it} - 0.046INF^{-}_{it} + 0.007GDP^{+}_{it} + 0.014GDP^{-}_{it} + 0.153INT^{+}_{it} + 0.067\ INT^{-}it + 0.029MS^{+}_{it} + 0.177MS^{-}_{it} + 0.026FDI^{+}_{it} + 0.046FDI^{-}_{it} + \varepsilon_{it}$ ---------- (4.3)

The ECT coefficient (-0.157) was negative and statistically significant at the 1% level and elaborates how speedily the variables converge to equilibrium, indicating that the explanatory variables, despite the positive and negative shocks, speedily adjusted back to equilibrium at about 15.7 percent annually in the African Oil producing countries. The short-run exhibited that the positive and negative shock of the term of trade (TOT) and the inflation positive shock displayed the same sign – negative – while the positive shock of interest rate with the negative shock of money supply exercised a positive sign. The short-run findings revealed that the elasticity of TOT upsurges (declines) on RER is -0.4355 (-0.4246), indicating that *ceteris paribus*, a 1% rise (decrease) in TOT is expected to decrease (increase) RER by 0.4355% (0.4246%). Likewise, inflation-positive shock exhibited a significant negative impact on RER, pointing that *ceteris paribus*, the elasticity of INF upsurges about RER is -0.0356, suggesting that a 1% decrease in INF is expected to decrease RER by 0.0356%. Meanwhile, the interest rate (INTR) positive shock and money supply (MS) negative shock have a significant positive impact on RER with 0.1527 and 0.1768 magnitude, respectively, portraying that a 0.1527 % and 0.1768% increase in RER was as a result of a one percent increase in INTR positive shock and MS negative shock, respectively, *ceteris paribus.*

The next is testing for the long and short-run asymmetric impact of the explanatory variables on RER using the Wald test.

Table 4.5: Wald Test

	Long run			Short run		
Variable	**Chi2**	**Prob**	**Remark**	**Chi2**	**Prob**	**Remark**
LTOT	4.24	0.039**	Asymmetric	0.10	0.7543	Symmetric
LNFA	11.19	0.001***	Asymmetric	1.89	0.1687	Symmetric
LFD	2.83	0.0926*	Asymmetric	0.03	0.8739	Symmetric
LINF	20.67	0.000***	Asymmetric	0.14	0.7110	Symmetric
LGDP	25.70	0.000***	Asymmetric	0.06	0.8083	Symmetric
LINTR	0.18	0.6696	Symmetric	1.30	0.2541	Symmetric
LMS	3.29	0.0696*	Asymmetric	3.59	0.0580*	Asymmetric
LFDI	0.00	0.9886	Symmetric	0.86	0.3544	Symmetric

Source: Author's Computation from STATA 15 output

Note: ***, ** & * imply significance at the 1%, 5% and 10% levels, respectively

From Table 4.5, it could be ascertained that six out of the explanatory variables (economic fundamentals variables) which are term of trade (TOT), net foreign asset (NFA), foreign deficit (FD), inflation (INF), gross domestic product (GDP) and money supply (MS) – exerted asymmetric impact and nexus with real exchange rate (RER) in the African oil-producing countries, in the long run. Meanwhile, only money supply (MS) established an asymmetric relationship with RER in the short run.

Decision Rule

Following the report of asymmetry and symmetry association and impact as revealed via the Wald test in Table 4.5, we make a pronouncement on the acceptance or rejection of the null hypothesis using the rule of thumb that if the number of variables with asymmetry is equal to or more than that of symmetry, we reject the null hypothesis, if otherwise, we accept the null hypothesis.

From Table 4.5, it is established that six (6) variables of economic fundamentals – term of trade (TOT), net foreign asset (NFA), foreign deficit (FD), inflation (INF), GDP and money supply (MS) – out of the eight (8) explanatory variables were asymmetry in the long run; hence, we cannot accept the null hypothesis that states economic fundamentals does not have long-run effect on the real exchange rate in African oil-producing countries.

Meanwhile, since only one variable – money supply – possessed an asymmetric influence on RER in the short run, we cannot reject the null hypothesis that economic fundamentals do not have a shot-run asymmetric effect on the real exchange rate in African oil-producing countries. Hence, we conclude that economic fundamentals do not have an asymmetric short-run impact on real exchange rates in African oil-producing countries.

DISCUSSION OF FINDINGS

The findings of the study show that there is a significant asymmetric relationship between terms of trade and real exchange rate in African oil-producing countries which is in agreement with Kassouri & Altintas (2020) in a study on the commodity terms of trade shocks and real effective exchange rate dynamics in Africa's commodity-exporting countries. Similarly, Hadood & Saleh (2022) found that the influence of TOT on the AER in the Libyan economy shows that TOT has a negative effect on the AER of Libyan dinar against the US dollar in the short and long runs. This implies that a positive shock in TOT (i.e. an increase in TOT as a result of oil price increases comparatively to import prices) leads to an appreciation in the value of the Libyan dinner as the average of TOT during the study period using ARDL estimation.

Also, Jiang & Liu (2023) reveal the existence of a nonlinear relationship between trade balance and real exchange rate. The adjustment effect of RMB exchange rate fluctuations on the trade balance is asymmetric and the adjustment effect of RMB appreciation is greater than that of depreciation. Sambo, Farouq & Isma'il (2021) reveal that there is an asymmetric relationship between the real exchange rate and international trade. Non-linear ARDL has been applied to test the possibility of asymmetry in the effects of a money supply and appreciation/depreciation of the real exchange rate. In this context, the Wald test on the null hypothesis of symmetry is rejected at a 10% level of significance. Therefore, the study claims the existence of asymmetrical effects of LMS_t^+ and LMS_t^- in the long run. This is consistent with the study of Mahmood & Alkhateeb (2018), and Abdullah et al; (2021).

However, this study's findings show that foreign direct investment (FDI) does not have an asymmetric relationship with the exchange rate in African oil-producing countries and this is in agreement with the study of Wong (2022) using the generalized moment of moment (GMM) in the study on asymmetric real exchange rate and foreign direct investment determinants in Malaysia. Dhakal et al (2010), are also in line with the study which states that foreign direct investment has an impact on the real exchange rate. Also, interest rate (INT) does not have an asymmetric relationship with exchange rate in African oil-producing countries which is in line with Musa et al; (2019) on the study of asymmetric response of exchange rate to interest rate differentials in Big 4 African

countries. On the contrary, Karimi & Karameliki (2020), the result of the findings shows that there is an asymmetric relationship between interest rate and exchange rate in Turkey.

Additionally, the long-run coefficients of positive and negative change in the inflation rate are 0.257 and 0.229 respectively. It indicated that a 1 percent depreciation is likely to increase the real exchange rate (RER) by 0.257 percent. Similarly, appreciation of the real exchange rate is expected to increase inflation by 0.229 percent. This indicates that depreciation has relatively more inflationary effects than appreciation in the long run. The same results found by (Okolo et al; 2022, and Kayamo (2021) indicated that inflation has a positive impact on the real exchange rate. Another study by Woldie and Siddig (2019) showed that in the long-run devaluation of the exchange rate has an inflationary impact and contrary, Ambachew et al. (2012) indicated that the depreciation of the exchange rate decreases inflation. Similarly, Nigusse et al. (2019) in their study proved devaluation reduces inflation while an appreciation of the real effective exchange rate triggers inflation in Ethiopia.

The findings of the study show that there is a significant asymmetric relationship between net foreign assets and real exchange rate in African oil-producing countries which is in agreement with Gardberg (2021) in a study on Exchange Rate Sensitivity and the Net Foreign Asset Composition. The study found that net foreign asset composition is related to the exchange rate Similarly, Ayele (2022) found that the RER appreciates for an improved net foreign asset position. Also, Aliyu (2009) found out that the long run showed that the real exchange rate was positively affected by the net foreign assets in Nigeria.

The results of findings of the study clearly show evidence of an asymmetric effect in the relationship between gross domestic product (GDP) and real exchange rate (RER) in African oil-producing countries. This is in tandem with the studies conducted by Dada (2022), Dada (2020), Bahmani-Oskooee and Mohammadian (2017), Umaru 2018, Gala (2008) who found a negative effect of exchange rate appreciation on output, but contrary to the findings of Dada et al. (2020), Mejıa-Reyes et al. (2010), and Schnabl (2008) who found that appreciation of exchange rate increases productivity and economic growth.

Methodology wise, the empirical investigation using the generalized method of moments (GMM), Ahmad (2015) reports that macroeconomic factors have a significant impact on exchange rates. The results of the panel GMM and the OLS also specify the link between exchange rates and applied estimators. The expected signs are correct for all variables except the interest rate. Obi (2016), also reported that the negative sign of the coefficient during the whole period and the period of the exchange rate regulation regime is not consistent with economic theory. Dada (2020) reported the asymmetric components (positive and negative shocks) of exchange rate volatility have a negative and significant effect on trade in the region. Meanwhile, the effect of negative exchange rate volatility is higher on trade when compared with positive exchange rate volatility. Furthermore, the real exchange rate has a negative and significant effect on trade in sub-Saharan African countries. Another methodology used in investigating asymmetric is the Asymmetric Power Autoregressive Conditional Heteroscedasticity (APARCH) estimator, Ngalawa & Kutu (2017) reported that Brazil's exchange rates are significantly influenced by global shocks (interest rate).

CONCLUSION AND RECOMMENDATION

The result of the linear or symmetric model showed that all variables are insignificant except for inflation which is negative and statistically significant to the real exchange rate at 1% and gross domestic product is positively significant at 10% in the short run. In the long run inflation and foreign deficit are positively significant while interest rate and foreign direct investment are negatively significant at 1%. Terms of trade and net foreign assets are positively significant at 5% and 10% respectively. Gross domestic product and money supply are insignificant in the long run. The asymmetric model indicated that a positive coefficient of the terms of trade, inflation, and gross domestic product has a positive change (increase+) indicating that an increase in these economic fundamentals in the previous period has a positive and statistically significant impact on the real exchange rate (RER) in the current period. A negative coefficient for Inflation, foreign deficit, and foreign direct investment the positive change (increase+) indicates that a decrease in these economic fundamentals variables in the previous period has a negative and statistically significant impact on the real exchange rate in the current period. Therefore, policymakers in these countries are to pay more attention to their macroeconomic policies to reduce the production and transaction costs of foreign direct investment (FDI).

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