MODELLING AND ESTIMATING VOLATILITIES IN EXCHANGE RATE RETURN AND THE RESPONSE OF EXCHANGE RATES TO OIL SHOCKS

David Umoru [*], Solomon Edem Effiong [**], Malachy Ashywel Ugbaka [***], Sadiq Oshoke Akhor [****], Danjuma Iyaji [*****], Francis Ejime Ofie [**], Chineleobi Chris Ihuoma [******], Emmanuel Steelman Okla [*******], Muhammed Adamu Obomeghie [********]

* *Corresponding author,* Department of Economics, Edo State University, Uzairue, Iyamho, Edo State, Nigeria
Contact details: Department of Economics, Edo State University, Km7, Auchi-Abuja Road, Iyamho, Edo State, Nigeria
** Department of Economics, Wellspring University, Benin City, Edo State, Nigeria
*** Department of Economics, University of Calabar, Calabar, Nigeria
**** Department of Accounting, Edo State University, Uzairue, Iyamho, Edo State, Nigeria
***** Department of Economics, Nigerian Army University Biu, Borno State, Nigeria
****** United Bank for Africa, Lagos, Nigeria
******* Department of HIS, Edo State University, Uzairue, Iyamho, Edo State, Nigeria
******** Department of Economics, Edo State University, Uzairue, Iyamho, Edo State, Nigeria

How to cite this paper: Umoru, D., Effiong, S. E., Ugbaka, M. A., Akhor, S. O., Iyaji, D., Ofie, F. E., Ihuoma, C. C., Okla, E. S., & Obomeghie, M. A. (2023). Modelling and estimating volatilities in exchange rate return and the response of exchange rates to oil shocks. *Journal of Governance & Regulation, 12*(1), 185–196. https://doi.org/10.22495/jgrv12i1art17

ISSN Print: 2220-9352
ISSN Online: 2306-6784

Received: 30.08.2022
Accepted: 17.02.2023

JEL Classification: C53, C54, C58
DOI: 10.22495/jgrv12i1art17

Abstract

Developing countries have persistently witnessed volatile exchange. Such volatility triggered instability in their exchange rates which induced colossal fluctuations in currency rates leading to uncertainty for both the consumers and firms. All these have instigated changes in official exchange rates that are harmful to underlie trade patterns in these countries. This study estimated fluctuations in daily exchange rate returns of ten African countries using generalized autoregressive conditional heteroskedasticity (GARCH) models, having ascertained the significance of autoregressive conditional heteroskedasticity (ARCH) effects. Structural vector autoregression (SVAR) estimator was utilized. Results showed Kenya shilling is the most relatively stable currency, whereas the Malawian kwacha is the most volatile among the currencies. There had been a series of random spikes in the exchange rate of Ghanaian cedi. Ghana and Kenya exchange rates are best projected using EGARCH, whereas SGARCH may be more efficient in estimating the volatility of Morocco and Zambia exchange rates. Leverage effects indicated a considerable magnitude of the adverse impact of bad news in the foreign exchange (FX) markets of Ghana and Zambia. Volatility shocks are expected to last in the future in those countries.

Keywords: Monthly Exchange Rates, Shocks, EGARCH, SGARCH, Leverage Effects

Authors' individual contribution: Conceptualisation — D.U.; Methodology — D.U., S.E.E., M.A.U., S.O.A., C.C.I., E.S.O., and M.A.O.; Software — D.U., S.E.E., M.A.U., F.E.O., and C.C.I.; Validation — S.E.E., S.O.A., D.I., F.E.O., and E.S.O.; Formal Analysis — D.U., S.E.E., M.A.U., D.I., and M.A.O.; Investigation — D.U., D.I., E.S.O., and M.A.O.; Data Curation — D.U., M.A.U., F.E.O., C.C.I., and M.A.O.; Writing — Original Draft — D.U., S.O.A., D.I., F.E.O., C.C.I., E.S.O., and M.A.O.; Supervision — D.U., S.E.E., S.O.A., D.I., F.E.O., and E.S.O.

Declaration of conflicting interests: The Authors declare that there is no conflict of interest.

Acknowledgements: Many thanks for kind and helpful criticisms go to Prof. B. Iganaiga, Prof. B. Imimole, Dr. Idris Abubakar. We are grateful to Dr. B. O. Abere of Economics Department, EDSU, Nigeria, for his valued suggestions that enhanced the final version of the paper.

1. INTRODUCTION

Across the global space, market gossip, often known as speculations of different magnitudes, characterises the foreign exchange market, resulting in volatility. The volatility of exchange rates has been a thorn in the flesh of most developing African nations. These volatilities are vehemently problematic to the growth of international trade and inflows of foreign investments. The fundamental reason has been that the exchange rate is a price variable that occupies the centre of international transactions and macroeconomic activities. Hence, concerns about exchange rate swings have primarily emerged in emerging countries due to their influence on foreign trade, international commerce, investments, inflation, and economic prowess. Exchange rate changes may impact investment and economic development in various ways. Based on that, the sign of the relationship might vary. Several studies (Hansen & Lunde, 2005; Olowe, 2009; Ramasamy & Munisamy, 2012; Rofael & Hosni, 2015; Umaru et al., 2018) support the theory of rise in exchange rate volatility reducing transnational commercial flow and economic development because most global businesses are conducted in the currency of the exchange countries.

Volatilities tend to generate market distortions and exchange rate bubbles. These distortionary effects create devaluation or overvaluation beyond theoretical expectations, causing exchange losses, deterring foreign investment inflow, and fuelling capital outflows through its tendency to situate circumstances of exchange rate misalignments. For example, African countries have persistently witnessed volatile exchange rates from second to second daily every year. Such volatility triggered instability in their exchange rates which induced enormous fluctuations in currency rates leading to uncertainty for both the consumers and firms. This uncertainty adversely affected investments and global trade escalated exchange rate risk and resulted in trade losses, especially in the countries described above. Moreover, it has generated a series of speculations. All these have instigated changes in the official exchange rate that are harmful to the underlying trade patterns in these countries.

Exchange rate volatility may reflect new significant events that influence respective economies. Modelling exchange rate volatility is weighty due to its economic implications when deciding on financial and oil markets. According to Umoru (2022), in financial econometrics, shocks are reported as news (in the form of exchange rate speculations) but measured as volatility in a series that could be economic or macroeconomic time series. The volatility is gauged from the variance angle of measurement based on generalized autoregressive conditional heteroskedasticity (GARCH) models (T-GARCH, EGARCH), etc. Nevertheless, the variance is modelled conditionally on its history. The reason is that the homoscedasticity, the constant variance assumption in econometric analysis, is challenging to observe in real-life situations because of the heterogeneity and variation characterising the behavioural patterns of cross-sectional units. For example, each member of Organization of the Petroleum Exporting Countries (OPEC) has some country-specific characteristics that could be measured in terms of geographical location, trade policy, economic reforms, and policy regime shift (floating exchange rate system or fixed exchange rate regime, low-interest rate regime or high-interest rate regime as the case may be).

Though exchange rates constantly move based on supply and demand, the movement also reflects variations in international competitiveness and interest rate differentials in different countries. This study attempts to identify the autoregressive conditional heteroskedasticity (ARCH) effect and estimate the corresponding volatility results in the daily exchange rates of ten African countries. In line with study objectives, we hypothesise that no heteroscedasticity exists in the daily exchange rates of the selected African countries. The findings of the study, when added to the extant literature, the study's findings will be a valuable guide to various economies and currency markets on policies to embrace and execute to enhance their exchange rates.

This study is significant because it contributes to the literature on volatility in the exchange rate. Consequently, understanding the risk associated with fluctuations in the exchange rate, with empirical emphasis on the magnitude, is essential. The study is also relevant as it adds to the literature on the worth of the exchange rate as an instrument of economic policy, considering it as both an international trade variable and a macroeconomic policy variable (Moosa, 2000). Accordingly, the research provides a policy guide to monetary authorities and governments on ascertaining volatility persistence in local currency rates. By modelling volatility using daily frequency series, the study further contributes to the intensity of swings in exchange rates. Another contribution and significance of this research are that it advises the governments on the necessity to implement applicable policies that provide for equilibrating factors of demand and supply of foreign exchange.

The structure of this paper is as follows. Section 1 reviews the introduction which discusses the problem, research objectives, and expected contributions. Section 2 reviews the relevant literature. Section 3 analyses the methodology, data analysis, and interpretation. Section 4 is about the findings and results. Section 5 deals with a discussion of the result. Section 6 consists of conclusions.

2. LITERATURE REVIEW

Exchange rate volatility, described as persistent variations in currency values, has recently attracted much interest in the literature. There is a vast literature regarding exchange rate volatility or shocks in the form of speculations (news). However, we have chosen to review only a few for brevity. Deploying GARCH modelling techniques, Olowe (2009) obtained persistent volatility of the naira/US dollar exchange rate. In the case of Olowe (2009), the leverage effect in the Nigerian foreign exchange (FX) market could not be established upon applying APARCH/TSGARCH models. However, exchange rate volatility persistence was validated for the naira-USD rate with monthly data. Another study that rejected the leverage effect but validated volatility persistence in the exchange rates was by Bala and Asemota (2013). Abounoori and Zabol (2020) reported that RGARCH models yield better and more precise estimation results when conditional variance is used to measure volatility. Ha et al. (2019) empirically established the presence of regional effects of exchange rate volatility on inflation and gross domestic product (GDP). Basing their analysis of daily currency rates, Rofael and Hosni (2015) reported volatility clustering in Egypt's exchange rate returns using space models. The actual exchange rate volatility was established for Kenya by Musyoki et al. (2014). The study found Kenya's RER unveiled appreciation and volatility tendencies, which mirrored a negative impact on the growth rate of Kenya.

Brooks and Burke (1998) assessed several out-of-sample models and discovered that the models' out-of-sample forecasting accuracy was comparable to that of frequently used GARCH (1,1) models on mean absolute errors. Pelinescu (2014) reported ARCH processes for Romanian exchange rates. Hansen and Lunde (2005) conducted an out-of-sample analysis of 330 distinct GARCH models. Different models were determined to be the most effective at forecasting the volatility of the two categories of assets (Ramasamy & Munisamy, 2012). The GARCH (1,1) model had superior predicting accuracy, while models with leverage effects outperformed GARCH for IBM stock prices.

Herwartz and Reimers (2002) used the GARCH model and discovered structural changes were susceptible to variation in monetary policy in the US and Japan from 1975 through 1998. Adeoye and Atanda (2011) used asymmetric GARCH models to predict the exchange rate volatility of Indonesia, Mexico, Turkey and South Korea against the dollar. They investigated leverage effects and fat-tailed characteristics using monthly exchange rate data from 1993 to 2013 and reported that the exchange rates of MIST (Mexico, Indonesia, South Korea, and Turkey) nations versus the US dollar had uneven and leveraging effects. A literature review reveals that research has been conducted on individual countries' exchange rate volatility; the present study uses the GARCH and structural vector autoregression (SVAR) to determine the heteroscedasticity in monthly exchange rate movements in ten African countries.

Twice Stavarek explored the asymmetric impact of the exchange rate volatility in Europe, namely, Stavarek (2007) and Stavarek (2010). For all the countries covered, asymmetry was established in the volatility effects on the exchange rates of the currencies. A suggestion of rational bubbles in USD/Mexican $, USD/SGD, USD/rupiah, and USD/peso was given by Hu and Oxley (2017). According to Omotosho (2015), fundamental exchange rate misalignment increases the probability of a currency crisis, as established by the logistic probability model in Nigeria. Basing analysis on the EGARCH-M model, Itodo et al. (2017) also found empirical evidence that showed asymmetric outcomes of shocks to the rand-dollar exchange rate. In particular, the study confirmed the incidence of asymmetric effect in the time path of explosiveness in the exchange rate to its sales value.

The research attempts to fill the gap in the empirical literature as it relates to modelling and estimating volatilities in exchange rate return and the response of exchange rates to oil shocks in developing African countries. Too many studies on exchange rate volatility have been conducted on developed countries, and the findings from such research may not necessarily apply to emerging nations of Africa, given their low income per head and lack of economic diversification. Most importantly, not too many researchers have estimated volatilities in exchange rate return and the response of exchange rates to oil shocks in developing African countries after the outbreak of the COVID-19 pandemic in 2020. Few studies for Africa show weak evidence of the relationship between exchange rate returns and the most volatile currencies, namely, the Kenyan shilling, Malawian kwacha, Moroccan dirham, and Zambian kwacha. This gap is being filled by the present study using the maximum likelihood estimation of the GARCH model and structural vector autoregression (VAR) estimation technique that isolates the influence of oil price fluctuations on the exchange rates of African countries.

3. RESEARCH METHODOLOGY

3.1. Model specification

The study estimated the GARCH model (Bollerslev, 1986) specified as given in equation (1):

$$\sigma_t^2 = b + \sum_i^p \mu_i e_{t-i}^2 + \sum_j^q \rho_j \sigma_{t-j}^2 \quad (1)$$

where, ρ is the GARCH effect while the moving average is represented by the ARCH effect/term, σ_t is the standard deviation, and its square is the variance b is constant, μ_i is the ARCH effect term, which is the coefficient of the estimated residual from the exchange rate mean equation, ρ_j is the GARCH effect. An alternative to equation (1) is the EGARCH model offered by Nelson (1991). The specification is as follows:

$$\ln(\sigma_t^2) = b + \sum_j^p \rho_j \log(\sigma_{t-j}^2) + \sum_i^q \mu_i \frac{|e_{t-i}^2| + \emptyset_i \omega_{t-i}^2}{\sigma_{t-i}} \quad (2)$$

where, ln is the logarithm of the volatility $\emptyset_i$ is the leverage effect. The EGARCH is different from standard GARCH, with the introduction of long-run target leverage (Iyoha et al., 2022). So, the equation is asymmetric GARCH while equation (1) is symmetric. Both models are adopted based on the one best suits each country's modelling of heteroscedasticity. We begin with a VAR model specification specified as

$$M_t = \partial_{ij} M_{t-j} + G\epsilon_{it} \quad (3)$$

where, M_t is a 3 by 3 vector matrix. The variable adopted are exchange rate, average crude oil price, and oil supply, ∂_{ij} is a vector of 3 by 3 coefficient matrix and j is the lag order of the VAR, G is an identity matrix of the error term, ϵ_{it} is the error term. The restriction imposed on equation (3) is recursive. Accordingly, an SVAR model with recursive identification restriction is presented in matrix form:

$$\begin{bmatrix} e_1^{oil\ price} \\ e_2^{oil\ supply} \\ e_3^{excrrrrrr} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ G_{21} & 1 & 0 \\ G_{31} & G_{32} & 1 \end{bmatrix} \begin{bmatrix} e_1^{oil\ price} \\ e_2^{oil\ supply} \\ e_3^{excrrrrrr} \end{bmatrix} \tag{4}$$

Oil price is the average oil price, *oil supply* is oil production, and *excrrrrrr* is the exchange rate. The SVAR model specification is in line with Basher et al. (2016). The recursive identification of our SVAR is in line with existing studies like Basher et al. (2016). Our assumptions include that shocks to oil prices have a contemporary impact on the exchange rate while a surprise to oil production, which serves as a proxy for world oil supply, has a contemporary effect on exchange rate returns, also similar to the identification of Basher et al. (2016).

3.2. Estimation techniques

Several different econometric techniques abound for modelling feedback effects between volatilities in the exchange rate and prices. We have the multivariate Markov switching model, state space (SS) models, generalised method moments (GMM), vector error correction (VEC) and the VAR model, gravity modelling technique, and quantile regression. Each of the econometric methods has its merits and demerits or weaknesses. The Markov-switching VAR model found no relevance in this study as we do not envisage a regime-dependent FX market. Also, volatility clustering may not be readily established where it exists by vector error correction technique, VAR approach, and the gravity modelling technique. The study estimated the GARCH model (Bollerslev, 1986) and an SVAR model as introduced by Sims (1980). The enormity of our sample observations for which we needed to evaluate the volatility of returns on exchange rates necessitated using the GARCH model. It enhances the accuracy of the volatility forecast by accounting for errors in the previous prediction. Following Altun (2020) and Augustyniak et al. (2018), the maximum likelihood estimation techniques were utilised to estimate our GARCH models. The SVAR is used to analyse fluctuations in oil prices and identify such changes' influence on the exchange rates of African countries. The SVAR model was used to examine the structural impact of oil price shocks on exchange rate volatility among the nations. Our VAR innovations are converted into uncorrelated structural shocks (EViews software) utilising identifying restrictions and structural matrices.

3.3. Data

Daily data from January 1, 2000, to December 20, 2021, were used in this study for 10 developing and emerging African economies. These countries include Nigeria, Ghana, Kenya, Namibia, Mauritius, Zambia, Malawi, Egypt, South Africa, and Morocco. The exchange rate of all countries was measured as a bilateral exchange rate concerning the USD as the most traded global currency. We have US dollar/naira, USD/cedi, USD/shilling, USD/N$, USD/Rs, USD/ZK, USD/kwacha, USD/EGP, USD/rand, and USD/dirham exchange rates. Volatility was calculated as the standard deviation of the logarithm of daily returns, measured in percentage. Daily returns were calculated as the gain or loss of a currency pair in a particular period. Daily returns are also regarded as the gains or losses of a currency pair for a specific period. In this paper, we obtained returns of two consecutive days, calculated the ratio, and took the logarithm of the balance between those two values. The ten countries examined are countries we had data readily available for this research. Besides, these countries were explicitly included in our sample, given their weak and underdeveloped financial systems, which made it possible for oil price variability to have harmful effects on the exchange rates of their local currencies concerning the American greenback. Hence, it has become a massive struggle for monetary authorities in these nations to stabilise exchange rates for enhanced returns. Considering our small country sample, the use of daily data is justified. It was done to enable the study to consume high-frequency data needed to improve the accuracy of our estimation by lessening sample noise.

Exchange rates were sourced from the international financial statistics of the International Monetary Fund (IMF). Data on oil prices was obtained as daily prices of crude oil in $USD from the commodity index database of the World Bank, while oil supply was obtained from Energy International Agency as daily US field production of crude oil in thousand barrels per day. The volatility of crude oil prices was obtained from the crude oil price volatility metric, which calculates variations in crude oil prices in terms of the actual cost per barrel (in real 2000 dollars). The data on price volatility for any day was arrived at by averaging the variation in a particular day and the variations in the previous two successive days.

4. RESULTS

Summary statistics are reported in Table 1. The mean value of Malawi's nominal exchange rate to a dollar is the largest compared to other emerging and developing countries. With mean values of 487.44 for Nigeria, 186.42 for Kenya, and 131.86 for Mauritius, respectively, the nation with the least mean value are Ghana and Zambia, having the mean value of 12.34 and 17.2, respectively. Nevertheless, South Africa has the lowest volatility, with a standard deviation of 9.75. It shows South Africa's exchange rate to the dollar is the most relatively stable currency in terms of variability among the reviewed countries. In addition, Ghana's domestic currency is the most volatile currency among the studied countries.

Table 1. Descriptive statistics (returns on exchange rate)

Countries	Mean	SD	Min	Max	Kurtosis
Egypt	27.42	13.06	22.09	120.15	-2.14
Ghana	12.34	1819.75	0.36	5.9	-0.98
Kenya	186.42	13.06	62.03	113.14	-1.14
Malawi	333.43	22.93	46.6	822.17	-1.32
Mauritius	131.86	13.95	25.35	43.53	0.42
Morocco	119.17	10.99	7.26	11.97	0.1
Namibia	110	43.29	5.63	18.13	-1
Nigeria	487.44	187.23	98.9	411.25	-0.08
South Africa	210	9.75	5.63	18.06	-1.01
Zambia	17.2	14.69	2.66	22.64	1.98

Source: Authors' results using EViews 10.0.

The unit root test is presented in Tables 2 and 3 below. The country's exchange rates are represented with the respective countries' names. Other variables considered are average crude oil price and oil production in the US. The results from the augmented Dickey–Fuller (ADF) test showed variables are stationed at first difference. Further, the Phillips-Peron (PP) test also showed and corroborated the conclusion the variable is stationary at first difference.

The panel unit root test was conducted based Breitung unit root method over a sample of 2000M01 to 2021M12. The results are shown in the following tables. The Breitung test for the unit root test is presented in the appendix. The null hypothesis implies a panel time series has a unit root process indicating the variable is not stationary. The results for the exchange rate suggest that the level exchange rate is not fixed. After differencing, the variable becomes stationary. Oil price is standing at the level and same time stationary at first difference. Oil production has a unit root at the level. But after differencing, it becomes stationary.

Table 2. Breitung panel unit root test

Variable	Statistic	Probability **
d(exrate)	-11.2313	0.0000
d(oil price)	-10.9162	0.0000
d(oil prod.)	-7.86603	0.0000

*Note: ** Probabilities are computed assuming asymptotic normality.*
Source: Authors' results using EViews 10.0.

Table 3. ADF & PP unit root test

Variable	ADF		PP	
	Constant	Constant & Trend	Constant	Constant & Trend
d(excrrrrrr)	-11.32**	-11.31**	-15.28**	-15.25**
d(oil price)	-10.67**	-10.65**	-11.37**	-11.35**
d(oil prod.)	-13.63**	-13.69**	-18.64**	-18.73**

*Note: ** (5%) significance level.*
Source: Authors' results using EViews 10.0.

Unlike the research of Çakërri et al. (2021), where the M-VAR model and VEC model were deployed to investigate underlying relations between variables, the co-integration test was conducted based on the Pedroni residual co-integration method. The results are presented in Table 4 below:

Table 4. Pedroni residual co-integration results

Methods	Statistic	Prob.	W-statistic	Prob.
v-statistic	0.957697	0.1691	-0.007823	0.5031
rho-statistic	-105.8799	0.0000	-107.5023	0.0000
PP-statistic	-44.61277	0.0000	-44.32707	0.0000
ADF-statistic	-43.57093	0.0000	-42.25527	0.0000
rho-statistic	-111.0293	0.0000	-	-
PP-statistic	-53.82496	0.0000	-	-
ADF-statistic	-49.07713	0.0000	-	-

Source: Authors' results using EViews 10.0.

The panel test for co-integration is presented in the table above. The null hypothesis is no co-integration. This research rejects the absence of co-integration at a 5% level. The conclusion is that the variables utilised in this study are co-integrated. The test for heteroscedasticity is of relevance when conducting GARCH modelling analysis. A series without any ARCH effect cannot be examined using the GARCH modelling. The Breach LM test for heteroscedasticity was adopted to know if a series has an ARCH effect, having the null hypothesis of no ARCH term or impact. The result is accessible in Table 5 below.

Table 5. Volatility test results

Countries	stat [p-val]	stat [p-val]	stat [p-val]
	lag 1	lag 2	lag 3
Ghana	0.06[0.002]	1.23[0.000]	0.107[0.002]
Kenya	4.99[0.026]	34.58[0]	34.52[0]
Malawi	0[0.984]	0.02[0.99]	0.03[0.999]
Mauritius	0.37[0.544]	7.37[0.025]	8.54[0.036]
Morocco	0.83[0.002]	34.09[0]	37.3[0]
Namibia	1.4[0.238]	1.66[0.435]	2.26[0.52]
Nigeria	1.15[0.284]	1.19[0.553]	1.21[0.751]
South Africa	1.44[0.23]	2.06[0.357]	2.7[0.44]
Zambia	2.06[0.002]	8.33[0.016]	8.27[0.041]

Source: Authors' results using EViews 10.0.

The results in Table 5 show Ghana, Kenya, Morocco, and Zambia's exchange rate poses heteroscedasticity worthy of being examined using the GARCH models. Other countries like Egypt, Malawi, Mauritius, Namibia, Nigeria and South Africa do not possess any ARCH term that can be examined in GARCH specification. The countries whose exchange rate poses ARCH term are thus examined using the standard GARCH and the exponential GARCH. The best mean and variance equations are presented in Table 6.

This section is devoted to GARCH model estimates. Table 6 below shows a variety of GARCH models estimated, and the distribution involved accordingly. From Table 6, both Akaike information criterion (AIC) and Bayesian information criterion (BIC) show for Ghana and Kenya, the exponential GARCH is more efficient than the standard GARCH. Also, for Morocco and Zambia, the AIC and BIC unanimously indicated the simple standard GARCH model performs well in examining the heteroscedasticity of the exchange rate. What it implies is that for Ghana and Kenya, the exponential GARCH is more efficient than the standard GARCH, which is more efficient in estimating the volatility of Morocco and Zambia exchange rates.

Table 6. Volatility test results

Country	*Information criteria*	*Mean model*	*Variance model*	*Distribution*
Ghana	BIC	ARMA(1,1)	EGARCH(1,1)	Std
Kenya	AIC	ARMA(1,0)	EGARCH(1,1)	Std
Kenya	BIC	ARMA(1,0)	EGARCH(1,1)	Std
Morocco	AIC	ARMA(0,0)	SGARCH(1,1)	Std
Morocco	BIC	ARMA(0,0)	SGARCH(1,1)	Std
Zambia	AIC	ARMA(0,0)	SGARCH(1,1)	Std
Zambia	BIC	ARMA(0,0)	SGARCH(1,1)	Std

Note: Std is the student t-distribution.
Source: Authors' results using EViews 10.0.

Table 7 reports estimates of the mean and variance equation for the emerging and developing economies using the most suitable GARCH models presented in Table 5. Beginning with Ghana, the ARCH and GARCH effects are both significant. Accordingly, exchange rate volatility is influenced by its forecast errors, and previous volatility shocks affect the current volatility. The level of persistence of this volatility shock is exceptionally high, namely, 0.978, 0.979, and 0.999 for Kenya, Morocco and Zambia, respectively. It indicates that volatility does not decay very fast; rather, such volatility shocks would endure into the future. Our results also supported the findings of persistent volatility shocks on returns, leverage effect, and asymmetric influence of shocks earlier reported by Youssef and Rowe (2021).

On the asymmetric impact of good and bad news in emerging market volatility, the significant leverage effect shows that the higher volatility magnitude is associated with bad news (by way of public perception) than the same volatility that characterises good news. For Kenya, the ARCH and GARCH effects are both significant. The leverage effect for Ghana and Kenya shows that the magnitude of good news's impact in this market is significantly different from bad news.

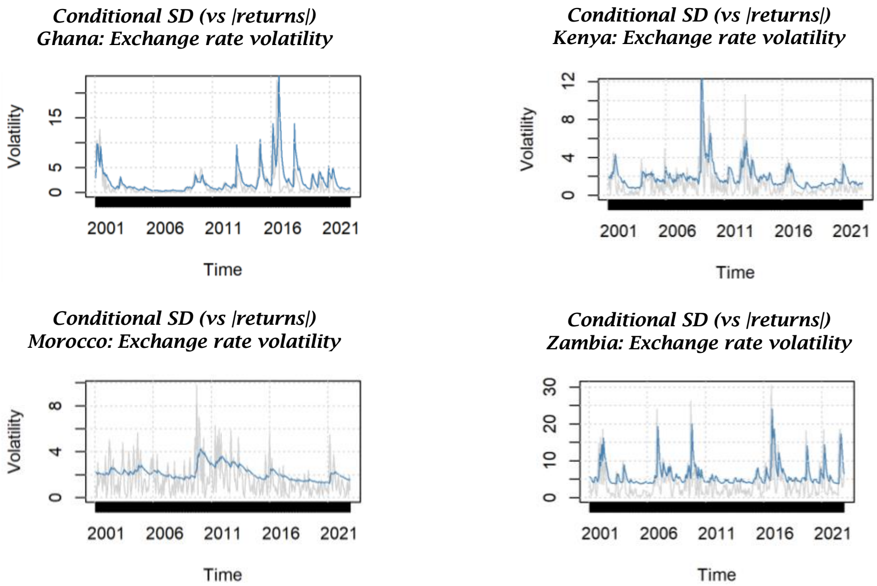
Table 7. Estimated GARCH and ARMA equations

Parameters	*Ghana*	*Kenya*	*Morocco*	*Zambia*
Arma const	0.189*	0.161*	-0.071	0.538**
	(0.08)	(0.06)	(0.11)	(0.19)
First_order AR	0.759	0.171**	0.189**	0.198
	(0.49)	(0.06)	(0.02)	(0.45)
First_order MA	-0.329	0.110*	0.421	0.124**
	(0.93)	(0.00)	(0.23)	(0.10)
Variance_ const	-0.034	0.126	0.114	8.357
	(0.09)	(0.09)	(0.14)	(5.42)
ARCH effect1	0.364*	0.163*	0.093	0.58
	(0.18)	(0.08)	(0.05)	(0.32)
GARCH effect	0.913***	0.878***	0.886***	0.419
	(0.06)	(0.05)	(0.06)	(0.25)
Leverage	0.838*	0.683***	5.476*	0.892**
	(0.36)	(0.19)	(0.08)	(0.10)
Shape	2.461***	3.006***	5.577**	2.652***
	(0.46)	(0.62)	(1.81)	(0.33)
Persistence	0.999	0.978	0.929	0.959
Total observations	261	263	263	263
Log-likelihood	-360.092	-458.6	-557.637	-755.253
AIC	2.821	3.541	4.279	5.781
BIC	2.93	3.636	4.347	5.849

*Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$ significance level.*
Source: Authors' results using EViews 10.0.

Standard GARCH is applicable for Morocco and Zambia. For Morocco, the ARCH effect is not significant, whereas the GARCH effect is statistically significant. The significance of the GARCH effect point to shock in previous volatility of Morocco's foreign exchange market affects the current volatility. The level of persistence of this shock is 0.98. It is high. For Zambia, the ARCH and GARCH effects are not significant. The lack of significance of the GARCH effect denotes that the shock in previous volatility of Zambia's foreign exchange market does not affect current fluctuations. The level of persistence of this shock is close to 1, indicative that the exchange rate in Zambia may yield inconclusive forecasting results because the GARCH model might not have reliable estimates. The SVAR results are plotted impulse response and variance decomposition shown below.

Figure 1. Volatility plots

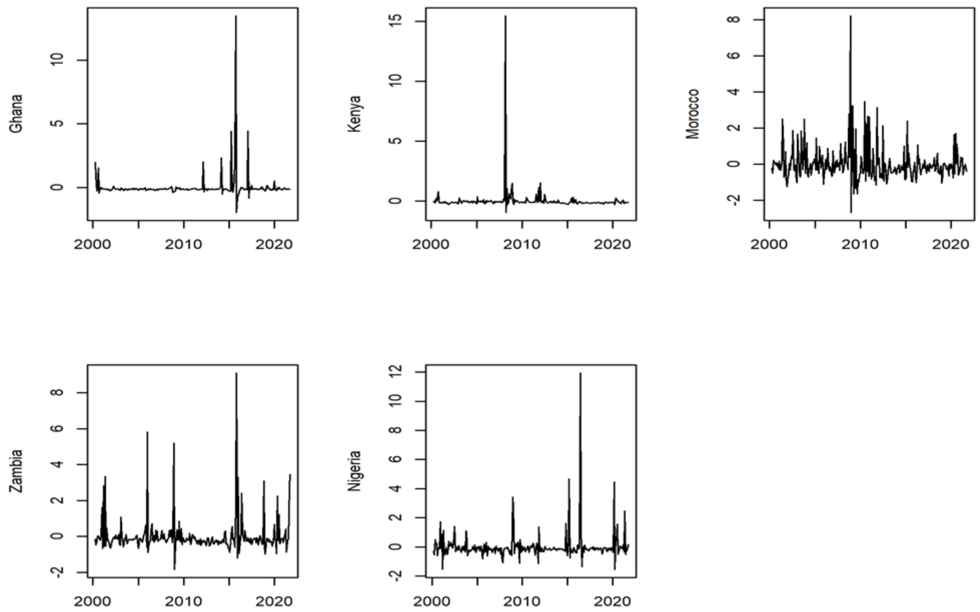


Source: Authors' plot using EViews 10.0.

The graphs for volatility are presented in Figure 1. The exchange rate volatility in Ghana exhibited some dangerous spikes around 2008. From 2011 onward, there had been a series of random spikes in exchange rate volatility. The Kenya shilling exchange rate had a much more substantial spike with the 2008 financial crisis. However, there is relative tranquillity during the 2020 COVID-19 crisis compared to the previous financial crisis. Morocco's exchange rate is relatively stable, with no significant spike in volatility compared to countries like Ghana, Kenya and Zambia. In the case of the latter country, there tends not to be much-prolonged volatility clustering. Nevertheless, the volatility spike coincides with the significant economic and health crisis recorded within the sample range.

Figure 2 shows the various trends of exchange rate returns, with the Ghana exchange rate having a relatively stable movement between 2001 and 2010. Subsequent periods had a significant fluctuation in its movement. It further confirms the Ghanaian cedi as a highly volatile currency. For Kenya, the spike in exchange was more prominent around 2008. The volatility of the Kenya shilling had an initial spike with soft clustering in the part of the sample. Later it maintained stability between 2003 and the pre-2008 financial crisis, while Morocco's exchange rate had significant random fluctuations. The Zambia exchange rate movement has had an episode of ups and downs though not prolonged for long months. The same movement appeared in Nigeria.

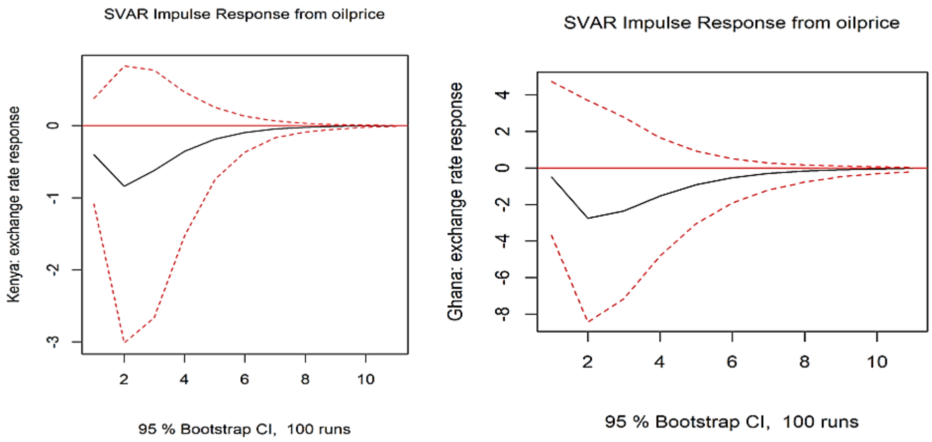
Figure 2. Shocks to exchange rate among the emerging economies in Africa



Source: Authors' plot using EViews 10.0.

However, the fluctuation is mild compared to Zambia. Similarly, a significant spike in the exchange rate after the first major spike, which coincided with the 2008 crisis occurred around 2016. The Nigerian economy suffered a recession during the study period. Regarding impulse response results, the results of the exchange rate response to one standard deviation shock to oil price are exhibited in Figures 3 and 4. The exchange rate of Kenya, Ghana, Zambia, and Morocco adopted in the SVAR was obtained from the GARCH estimation except for Nigeria.

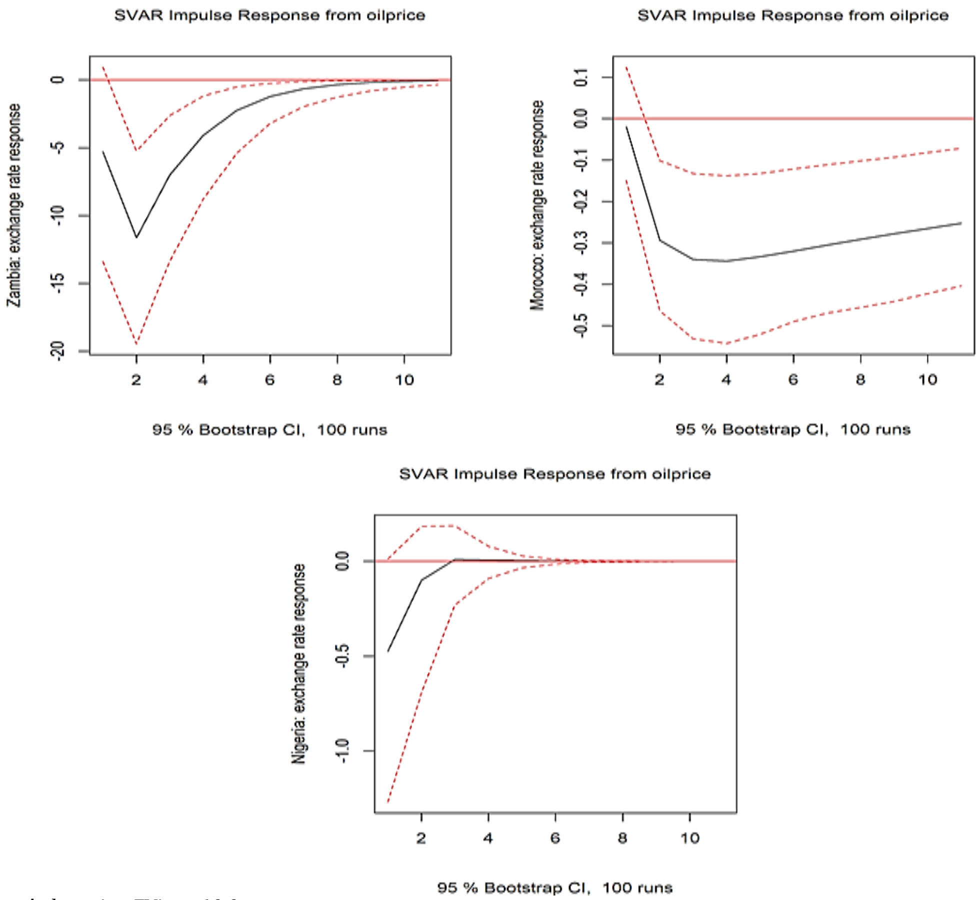
Figure 3. Impulse response for Kenya and Ghana



Source: Authors' results using EViews 10.0.

A standard deviation shock to oil price produces, though statistically insignificant, appreciation of Kenya and Ghana exchange rates within the sample period in the first and second periods. Subsequently, this impact dies out around the 6th period for Kenya and 7 periods for Ghana.

Figure 4. The impulse response of exchange rate in Zambia, Morocco and Nigeria



Source: Authors' plot using EViews 10.0.

Figure 4 also shows the response of exchange rates of Zambia, Morocco and Nigeria to oil price shocks. From what can be deduced from the graphs, there is a contemporary appreciation of the exchange rate in Zambia following a one-standard-deviation positive shock to the oil price. Nigeria and Morocco had identical results. Nonetheless, the Zambian shockwave fizzles out subsequently after some lags. Morocco's exchange rate response stabilises around 0.3 deviations, whereas Nigeria's exchange rate contemporaneous decrease fizzles out afterwards, rendering the positive increase in oil price transitory.

Table 8 presents the variance decomposition for Innovation in oil prices and shows that Innovation in oil prices had a strong direct impact on its movement throughout the period. Innovation in oil prices had no contemporaneous effect on oil production. Oil production maintains a stable 0.0013 changes in oil production starting from the third period. For exchange rate, innovation in oil price had no direct impact on the exchange rate in the first and second periods. Afterwards, the exchange rate response ranged around 0.0004 for Ghana, 0.005 for Zambia, and 0.006 for Nigeria.

Table 8. Variance decomposition results

Period	*Oil price*	*Oil production*	*Exchange rate*	*Oil price*	*Oil production*	*Exchange rate*
		Ghana			***Kenya***	
1	1.000	0.000	0.000	1.000	0.000	0.000
2	0.9985	0.0013	0.0002	0.9970	0.0012	0.0018
3	0.9984	0.0013	0.0003	0.9959	0.0013	0.0028
4	0.9983	0.0013	0.0004	0.9955	0.0013	0.0032
5	0.9983	0.0013	0.0004	0.9954	0.0013	0.0033
6	0.9983	0.0013	0.0004	0.9954	0.0013	0.0033
7	0.9983	0.0013	0.0004	0.9954	0.0013	0.0033
		Zambia			***Nigeria***	
1	1.0000	0.0000	0.0000	1.0000	0.0000	0.0000
2	0.9957	0.0016	0.0026	0.9939	0.0015	0.0046
3	0.9940	0.0019	0.0041	0.9929	0.0016	0.0055
4	0.9934	0.0019	0.0047	0.9928	0.0016	0.0056
5	0.9932	0.0019	0.0049	0.9928	0.0016	0.0056
6	0.9931	0.0020	0.0049	0.9928	0.0016	0.0056
7	0.9931	0.0020	0.0050	0.9928	0.0016	0.0056

Source: Authors' results using EViews 10.0.

The structural VAR was adopted to examine the exchange rate responses to shocks in key variables like oil price while incorporating other variables like oil production as endogenous variables. To proceed, we begin with the VAR estimation. The results (Table 9) indicated the VAR models for all the countries are stable since the root of the models is less than unity. So, the estimates are stable and robust.

Table 9. VAR stability results

Countries	*root1*	*root2*	*root3*
Ghana	0.56	0.29	0.1
Kenya	0.47	0.3	0.1
Morocco	0.95	0.29	0.1
Zambia	0.53	0.26	0.09
Nigeria	0.26	0.19	0.11

Source: Authors' results using EViews 10.0.

5. DISCUSSION

First, a standard deviation shock to oil prices produced a little appreciation of Kenya and Ghana exchange rates. There is a contemporary exchange rate appreciation in Zambia, Nigeria and Morocco following a one-standard-deviation positive shock to the oil price. Also, the South African Rand is the most relatively stable currency in terms of variability among all the currencies investigated in the study. Global trade and investment are induced. The stability of the South African rand boosted the incentive for firms and individual investors to invest in the South African economy. It could also indicate a low inflation rate in South Africa compared to other countries in this study. In addition, Ghanaian domestic currency (cedi) is the most volatile currency among the currencies examined. In effect, the rand responded more strongly to volatility than the cedi, demonstrating cedi devaluation under less tranquillity. By and large, volatility in cedi was more responsive to depreciation in the value of the cedi than when it appreciated. These findings contradicted the earlier obtained for South Africa by Itodo et al. (2017).

We found volatility persistence which is consistent with the findings of Olowe (2009), Adeoye and Atanda (2011), Bala and Asemota (2013), and Oshinloye et al. (2015). The compounding effects of higher volatility lead to lower regular average exchange rate returns, thereby significantly lowering the returns of the most volatile currencies, namely; the Ghanaian cedi, Kenyan shilling, Nigerian naira, Malawian kwacha, Moroccan dirham, and Zambian kwacha. By implication, the exchange rate returns of the currencies of Ghana, Kenya, Nigeria, Malawi, Morocco and Zambia are meagre. This precarious influence of volatility on the slope of the risk-return relation negates trade and investment expansion, and by extension, growth of the national economies as persistence in exchange rate volatility could be magnified into a depression if not timely averted. The level of endurance of volatility shock is 0.999, 0.978, 0.929, and 0.959 for Ghana, Kenya, Morocco and Zambia, respectively. It indicates the volatility does not decay very fast. Instead, these countries will feel volatility shocks in the future. The underlying consequence is that volatility stimulates more significant uncertainty by plummeting the incentive for firms to invest in export. Ghana, Kenya, Morocco and Zambia are less desirable nations to invest in. For example, incessant currency appreciation could be detrimental to aggregate export by local industries, making such exports uncompetitive. However, devaluation escalates the costs of imports for local industries relying on imported capital goods for production, negatively affecting profitability. These changes in the price of exports and imports destabilised the economies of Ghana, Kenya, Morocco and Zambia. The highly persistent exchange rate had created superfluous transnational capital movements, heartening speculative activities that spawned far-reaching capital flight more than capital inflows.

The leverage effect in our findings against those of Olowe (2009) and Bala and Asemota (2013) denotes a negative link between daily exchange rate returns and realised volatility. It implied that high volatility is associated with bad news in the FX market of Ghana, Kenya, Morocco and Zambia than good news. The leverage effects in these countries indicated a considerable magnitude of the adverse impact of bad news in their exchange markets. In Morocco, the present-day volatility of the exchange rate is not considerably swayed by shocks to its Innovation. Our research findings serve the interests of portfolio managers, governments, policymakers, monetary authorities, and investors.

6. CONCLUSION

This study model estimates variations in monthly exchange rates and the response of exchange rates to global oil prices in ten African countries from January 2000M1 to December 2021M12. Heteroscedasticity was modelled using GARCH models. SVAR was adopted to examine the response of exchange rates to shocks in global oil prices and oil production quota. The summary of the findings showed Kenya's shilling exchange rate to the dollar is the most relatively stable currency in terms of variability among the reviewed countries. In addition, Malawi's domestic currency is the most volatile among the countries examined. Present-day volatility of the exchange rate is significantly swayed by its shock in previous volatility in Malawi and Ghana. In effect, the values of these currencies, namely, Ghanaian cedi and Malawian kwacha, responded positively to volatility, a demonstration of kwacha devaluation, under conditions of less tranquillity. Specifically, volatility in kwacha and cedi was more responsive to depreciation in the value of the kwacha and cedi than when these currencies appreciated.

With significant compounding effects, higher volatility leads to lower regular average exchange rate returns, significantly lowering the returns of the most volatile currencies, namely, Ghanaian cedi, Malawian kwacha, Moroccan dirham, and Zambian kwacha. By implication, the exchange rate returns of these currencies are meagre. This precarious influence of volatility on the slope of the risk-return relation negates trade and investment expansion, and by extension, growth of the national economy as persistence in exchange rate volatility could be magnified into a depression if not timely averted. Volatility does not decay very fast in Kenya, Malawi, Morocco, and Zambia. The volatility stimulates more significant uncertainty by plummeting the incentive for firms to invest in export. In these countries, relentless currency appreciation could be detrimental to aggregate export by local industries and makes its exports uncompetitive, whereas devaluation escalates the costs of import for local industries relying on imported capital goods for production, negatively affecting profitability. These changes in the price of exports and imports destabilise these countries' economies. The leverage effect shows the higher magnitude of volatility is associated with bad news than good news in the forex markets of Ghana, Malawi, Morocco and Zambia.

We recommend governments implement economic policies that provide for demand and supply equilibrating factors in the foreign exchange market. It has the propensity to position the exchange rate for stability. Given that most of the countries investigated in this study are predisposed to country-specific volatility hazards, governments have to defend against impending shock factors to guard against possible spill-overs from global shocks and transmissions that stimulate the volatilities of currencies in the domestic FX markets. The strength of this paper derives from the fact that it contributes to the literature on volatility in the exchange rate, especially as it relates to understanding the risks accompanying variations in the exchange rate, with empirical emphasis on volatility persistence in exchange rates of local currencies as against the US dollar. The study further contributes to providing an economic policy guide to the governments on the necessity to implement applicable policies that provide for equilibrating factors of demand and supply of foreign exchange. However, because our study covers a panel of countries using daily series, further comparative research between daily and weekly returns on the exchange rate concerning volatilities could be done for both developing and developed countries, utilising the logarithm of daily and weekly returns data set. Future studies could model and estimate two regimes of foreign exchange markets, namely, high volatility and low volatility regimes using the Markov-switching VAR model.

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