EXCHANGE RATE VOLATILITY TRANSMISSION IN EMERGING MARKETS

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Abstract

Exchange rate volatility, or a continuous fluctuation in the currency rate has been a major concern in recent years due to its impact on economic activities. No wonder concerns have been raised regarding the connection between exchange rate fluctuations and their effects on the overall economy. The motivation for the study is based on the fact that most emerging economies experiencing inflationary tendencies are more likely to experience a high degree of exchange rate volatility persistence. Such a scenario seems catastrophic to developing economies where large currency movement are more frequent. BEKK-GARCH and DCC-GARCH models were utilized to estimate volatility transmission and persistence respectively in selected African countries. Results show there is presence of spill-over effect in exchange rates of all countries. BEKK-GARCH estimates show that negative effects of exchange rate of one country had deleterious effect on exchange rate of another. We found evidence in favour of bidirectional exchange rate volatility transmission amongst all exchange rates of countries in the study. Dynamic conditional correlation (DCC) model estimates further revealed Ghanaian cedi top list of countries exchange rate volatility persistence followed by naira with a value of 1.0974. Efficient structural transformation is needed to mitigate structural problems that generate inflation in these countries.

Keywords: Emerging African Countries, BEKK-GARCH Model, DCC-GARCH Model, Exchange Rate, Volatility Pass-Through, Persistence

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1. INTRODUCTION

When it comes to exchange rate volatility, which is described as the instability currency rate, Kilicarslan (2018) observes that users of affected currency are exposed to currency risk. A hazardous exchange rate engenders inflation. The exchange rate volatility among emerging African countries has exacerbated the inflationary spiral. It is because most of these countries depend on imported goods while only exporting primary products such as cocoa, coffee, etc. At best, the country exports crude oil and uses the same money to import finished petroleum products. Therefore, the study recommends ensuring a consistent exchange rate management policy through a managed float system to reduce exchange rate volatility within the sub-region. Volatility is a sequence of large, comprehensive, and persistent fluctuations (Gujarati & Porter, 2008). Differences exist between volatility and exchange rate fluctuations. According to definitions, volatility is either a considerable deviation from the exchange rate's fundamental value or transient changes within long-term trends (Agiomirgianakis et al., 2014, Morina et al., 2020).

Exchange rate volatility or a continuous fluctuation in the currency rate has been a major concern in recent years due to its impact on economic activities. No wonder concerns have been raised regarding the connection between exchange rate fluctuations and their effects on industrial output, oil prices, foreign reserve holdings, and the overall economy (Umoru et al., 2023a; Umoru et al., 2023b; Umoru et al., 2023c; Alagidede & Ibrahim, 2017). Exchange rate volatility transmission or passed-through is synonymous with imported inflation (Campa & Goldberg, 2005). The degree and speed to which domestic prices adjust to exchange rate movement are fundamental to understanding inflation dynamics, leading to adequate monetary policy guidelines by different economies. Countries have implemented policies to check a complete exchange rate pass-through to inflation. The motivation for this study is that when exchange rate volatility transmission is high, there is more transmission of inflation between countries. Such a scenario would be potentially catastrophic to emerging and developing economies such as ECOWAS (Economic Community of West African States), where large currency movements are more frequent (Ball & Reyes, 2018).

The effect of currency volatility transmission may be more on the local market when there is a high inflationary environment. Hence, the need to evaluate the size of exchange rate pass-through to consumer prices in developing countries given the implications it has on their macroeconomic policies, especially on inflation targeting policies (Mihaljek & Klau, 2008, Bada et al., 2016). Most research on exchange rate volatility transmission has been undertaken in developed countries, especially countries that are not import dependent. Most studies have also concentrated on economies that operate either a floating exchange or a fixed exchange separately. In contrast, this study employs data from selected West African countries that serve both the set sale and the floating trade at the same time. Finally, no literature has yet attempted to study exchange rate pass-through to inflation in low-income economies with similar characteristics, such as emerging nations experiencing inflationary inflation.

Therefore, the study estimated the degree of exchange rate volatility transmission and persistence respectively in selected emerging countries where the autoregressive conditional heteroskedasticity (ARCH) effects were identified. The sample of countries includes Ghana, Guinea-Bissau, Nigeria, Gambia, and Guinea. All countries belong to the same region of Western Africa. The economic integration of these countries can be explained by the fact that all countries belong to the same economic community of West African States (ECOWAS) formed in 1975 to resolve to realize a monetary union for the sub-region. In economic analysis, it is impossible to discard the possibility that exchange rate volatility plays a fundamental role in investors' and policymakers' decision-making. Measuring the level of exchange rate volatility helps predict plausible reasons for exchange rate instability and identify its ramifications, which may impact the entire economy. Analyzing exchange rate volatility transmission in Africa is of great relevance and significance for emerging African countries, given that any global shocks and volatilities of world currencies such as the US dollar (USD), euro (EUR), and sterling (GBP) influence the exchange rate and the performance of these economies. Mainly when it is the case that such volatilities of foreign currencies directly affect both trade patterns, consumption and production patterns of African economies. The study contributes to the literature on empirical regularities within the context of volatility co-movements, volatility clustering, leverage effect, and asymmetric effects (non-normality, trading/non-trading periods) of the foreign exchange market.

The structure of this paper is as follows. Section 2 reviews the relevant literature. Section 3 involves the methodology and the data sources. Section 4 analyses the research results followed by the discussion of the findings in Section 5. Finally, Section 6 presents the conclusion and recommendations.

2. LITERATURE REVIEW

The exchange rate pass-through theoretical base is a dynamic theory (Iyoha et al., 2022). It is rooted in the law of one price and purchasing power parity (PPP), which states that the price of an identical asset or product has the same price globally regardless of location, considering the absence of trade frictions under free competition and price flexibility (Ben Cheikh, 2012). Economic policymakers have demonstrated that currency movements are transmitted to domestic prices through the production chain (Burstein & Gopinath, 2014). It has also been argued that exchange rate pass-through is incomplete because many structural factors are associated with the degree of sensitivity of domestic prices to exchange rate movements. At the same time, we cannot rule out the extent of competition among importing and exporting firms, trade volume, the share of trade invoiced in foreign currencies, the use of currency hedging instruments, and global trade involvement (Georgiadis et al., 2019), the percentage of business invoiced in foreign currencies and the use of currency hedging instruments (Amiti et al., 2016).

According to Razafimahefa (2012), in countries with high per capita income, the economic intermediaries usually will not adjust prices swiftly in response to exchange rate movement because they know that high per capita income creates an opportunity for a higher degree of competition in the local market. It results in a constriction of the pricing ability of the firm. But for low per capita income countries, the same scenario may not hold. Equally, Bada et al. (2016) observed that contractionary monetary policy lowers the degree of exchange with pass-through while expansionary monetary policy leads to significant exchange rate pass-through. In the same vein, expansionary fiscal policy is associated with large exchange rate pass-through because economic agents understand that government will address the resulting accumulated deficit through an increase in taxes and cutting expenditures. It diminishes the market and reduces the firm's profitability. On the other hand, contractionary fiscal policy is associated with low exchange rate pass-through.

The empirical literature on exchange rate volatility transmission to inflation has shown mixed outcomes (Mihaljek & Klau, 2008). The most empirical literature on exchange rate pass-through (EPT) to inflation (CPI) has provided evidence of considerable cross-country differences in the magnitude of the transmission effects. In contrast, most literature has shown that it is incomplete (Mihaljek & Klau, 2008). Unlike Akofio-Sowah (2009), Razafimahefa (2012) extended the exchange rate pass-through analysis to thirty-four sub-Saharan African countries on a quarterly time series from 1980 to 2005 using the value at risk (VAR) framework. He noticed declining pass-through in the 1990s due to better macroeconomic reforms.

Researchers such as Taylor (2002), Campa and Goldberg (2005) have observed an asymmetric and declining exchange rate pass-through to prices over the years, especially in developed economies. Takhtamanova (2010) validated Taylor's proposition of a declining volatility transmission under a low inflationary situation during the 1990s in fourteen developed economies. In Germany, the study by Berner (2010) established an incomplete non-linear transmission which was higher during the depreciation of the euro than appreciation, differing across trade partners. Bhundia (2002) found a lower pass-through effect for South Africa using the VAR framework (1976Q2–2000Q3). Overall, the results suggest the presence of non-linearities in the relationship between exchange rate pass-through and inflation, especially in emerging economies such as ECOWAS (Caselli & Roitman, 2016).

According to Hung (2021), the EGARCH model provides adequate observations into how information is transmitted and disseminated across CEEs-5 foreign exchange markets. Morina et al. (2020) concluded that a low exchange rate dynamic captured as volatility was necessary for economic growth after studying the effects of absolute exchange rate instability. According to Latief and Lefen (2018), the relationship between exchange rate volatility and trade volume is positive and significant for Nepal, Maldives, and Bhutan, while it is significantly negative for the Pakistani economy. A positive and significant association between foreign direct investment (FDI) and exchange rate volatility was reported for India and Pakistan, whereas a highly negative relation was found for Nepal and Bhutan.

Both Chamunorwa and Choga (2015) and Ngondo and Khobai (2018) found that exchange rate volatility had a detrimental effect on South Africa's export output while using different approaches (the former using GARCH and the latter ARDL). Katusiime et al. (2016) found that exchange rate shocks increased Uganda's gross domestic product (GDP) using the ARDL model. Exploration of inflation and the effects of fluctuating exchange rates took place in both Nigeria and South Africa. South African prices were more consistent than Nigerian prices, according to research by Balcilar et al. (2019). Mahonye and Zengeni (2019) reported that a real exchange rate depreciation could cause inflation and encourage economic growth. This finding emanated from the study embarked upon by the authors in their attempt to examine how volatile currency rates affected inflation and economic development in Zimbabwe. According to Ehigiamusoe and Lean (2019), financial deepening had long-term beneficial implications on GDP. It suggests that in the absence of a stable and falling real exchange rate, the anticipated influence of economic development on GDP may not manifest.

Iyke and Odhiambo (2014) investigated the effects of various exchange rate regimes on economic growth in the Democratic Republic of the Congo (DRC), Malawi and Mozambique. The study found that when a managed-floating exchange rate regime was formed, exchange rate volatility adversely affected the growth rate. In-depth trend analysis and growth rate projections were all used in the research. It illustrates how fluctuating currency rates' impact varies based on the exchange rate used. The relationship between currency value and economic development has been thoroughly investigated in recent research (Morina et al., 2020).

Yilmaz and Ünlü (2018) applied this idea to Turkey and found that changes in the value of the lira reduce the short-term outflow of the GDP's export components but have mixed effects on the influx of imports. Janus and Riera-Crichton (2015) found a weak correlation between changes in the real effective exchange rate and GDP after looking at data for a panel of OECD countries from 1980 to 2011. According to the traditional theory of growth, the authors further reported that changes in currency rates prevent economic growth by discouraging investment, limiting international trade, and making it harder to guarantee human capital.

3. RESEARCH METHODOLOGY AND MODELLING FRAMEWORK

The modelling framework upon which this analysis depends is an asymmetric relation between exchange rate volatility and inflation (Kassi et al., 2019). The take-off point of our modelling is the conditional variance equation which is a dynamic evolution of innovation variance as given:

$$\sigma_t^2 = \text{var}[e_{t-1}^2, e_{t-2}^2, \dots, e_{t-p}^2 | \sigma_{t-1}^2, \sigma_{t-2}^2, \dots, \sigma_{t-q}^2] \quad (1)$$

Equation (1) models conditional variance (σ_t^2) as a function of history defined as the totality of past innovations e_{t-p}^2 and past variances σ_{t-q}^2. Accordingly, GARCH (*p, q*) model due to Bollerslev (1986) is specified as follows:

$$\sigma_t^2 = \phi_0 + \phi_1\sigma_{t-1}^2 + \phi_1\sigma_{t-2}^2 + \cdots + \phi_q\sigma_{t-q}^2 + \alpha_1 e_{t-1}^2 + \alpha_1 e_{t-2}^2 + \alpha_q e_{t-p}^2 \quad (2)$$

For positivity and stationarity, Eq. (2) has the following properties:

$$\phi_i \geq 0, \quad \alpha_j \geq 0, \quad \sum_{i=1}^{p} \phi_i + \sum_{j=1}^{q} \alpha_j < 1 \tag{3}$$

The corresponding conditional variance-covariance matrix (*S*) from Eq. (2) is derived as:

$$Var - Cov(\sigma_t^2) = \begin{bmatrix} \sigma_{11}^2 & \sigma_{12}^2 & \sigma_{13}^2 \\ \sigma_{21}^2 & \sigma_{22}^2 & \sigma_{23}^2 \\ \sigma_{31}^2 & \sigma_{32}^2 & \sigma_{33}^2 \end{bmatrix} \tag{4}$$

The elements of *Var-Cov* depend on lagged values of the squared innovations, the cross-product of innovations and lagged values of past variances. There are copious alternative methods that would be suitable for conducting this research. These include the likes of the autoregressive fractionally integrated moving average (ARFIMA) model, ARMA-GJR-GARCH, dynamic equicorrelation multivariate GARCH model (DECO-MGARCH), conditional distribution models such as Markov-switching ARCH (SWARCH), Markov-switching models, Regime-switching models, VECH, Monte Carlo methodology to non-normal and non-linear state-space modeling, autoregressive integrated moving average (ARIMA), time-varying VAR model methodology that estimates volatility shocks and its time-varying effect, exponential weighted moving average (EWMA), etc. The models above and the underlying techniques can also be functional for assessing realized volatility transmission. Nevertheless, we resorted to using the BEKK model due to its asymptotic and robust properties in modelling and estimating the volatility of exchange rates across countries. In addition, the dynamic conditional correlation (DCC) modelling technique is the most efficient in modelling and calculating the conditional and unconditional correlation of exchange rates. Specifically, amongst the different versions of multivariate GARCH models, we have chosen to base our analysis on BEKK-GARCH and DCC-GARCH models developed by Engle and Kroner (1995), Engle (2002), respectively. Both BEKK and DCC models are better off for dealing with the inconsistencies associated with other versions. According to Engle (2002), the DCC-GARCH model is specified as follows:

$$\begin{gathered} B_t = D_t R_t D_t \\ \text{where } D_t = diag\left(\sqrt{hit}\right) \\ R_t = diag(G_t)^{-1} G_t diag(G_t)^{-1} \\ G_t = (1 - \mu_1 - \mu_2)\bar{G} + \mu_1\left(\varsigma_{t-1}\varsigma_{t-1}^{!}\right) + \mu_1 G_{t-1} \end{gathered} \tag{5}$$

where, R is the conditional correlation matrix of the exchange rates vector, D is a 5×5 diagonal matrix $G_t = \{\rho_{ij}\}$ and is a $n \times n$ time-invariant constructive matrix with unit diagonal items. The first-order and general diagonal BEKK-GARCH models are also specified in Eq. (6) and (7), respectively.

$$H = ZZ^! + D^! e_{t-1} e_{t-1}^! D + Q^! H_{t-1} Q \tag{6}$$

$$H = ZZ^! + \sum_{j=1}^{q} \sum_{j=1}^{k} D^! e_{t-j} e_{t-j}^! D + \sum_{j=1}^{q} \sum_{j=1}^{k} Q^! H_{t-j} e_{t-j}^! Q \tag{7}$$

where, Z is a lower triangular matrix that imposes the positive definiteness of *H, D, E*, and Z are $n \times n$ matrices of constant. Given that the DCC-GARCH model has the inherent structure of dynamic conditional correlation coefficients among different variables, its parameters are efficiently estimated using the maximum likelihood estimation (MLE) method with the log-likelihood function given as:

$$L = -\frac{1}{2} \sum_{t=1}^{NT} (n\log(2\pi) + 2\log|D_t| + \log|R_t| + e_t^! R_t e_t) \tag{8}$$

The study used monthly data, from 1990M1 to 2021M12, on the exchange rate of the five countries in our sample. It gives a total of 1,920-panel observations used in our analysis. The US dollar served as the standard currency with which we related exchange rates of other countries. Data on countries' exchange rates were obtained from International Financial Statistics (IFS) published by the International Monetary Fund (IMF) for various years. The exchange value of the following West African countries to the dollar was Ghanaian cedi, represented as GC. Guinea-Bissau franc is captured as XOF; Nigerian naira is described as NN; Gambian dalasi is designated as GMD, and the Guinean franc is fixed as GNF. The preceding currencies were used in the analysis because they are the main trading partners of Nigeria within the West Africa sub-region. In all, the calculations of exchange rates volatility persistence and volatility spill over estimates were computed under the theory of currency fluctuation or volatility in the currency exchange rate as an aftermath of floating exchange rates, and results are discussed in the next section.

4. EMPIRICAL FINDINGS

The descriptive statistics of our variables are presented below in Table 1. The time frame of the research is 1990M1 to 2021M12 as presented in the data sample above. This yields a total of 1,920 observations that were used for estimation.

Table 2 shows the presence of the ARCH effect Table 3 provides the DCC-GARCH model results with the exchange rates of the countries covered in the research.

Table 1. Summary statistics

Variable	*F*	*NN*	*GC*	*XOF*	*GMD*	*GNF*
Maximum	1325.6	-8.1426	732.6793	-42.6193	38.7729	148.9682
Minimum	-89.41	-318.61	-154.63	-375.66	-148.71	-114.14
Mean	478.80	-157.46	165.97	-159.21	-49.40	-21.72
Std. dev.	747.52	155.57	492.19	187.64	94.24	147.99
Skewness	0.590	-0.139	0.689	-0.701	-0.214	0.699
Kurtosis	-1.5	-1.5	-1.5	-1.5	-1.5	-1.5
Coefficient of variation	1.56	0.99	2.97	1.18	1.91	6.81
Obs.	3784	3784	3784	3784	3784	3784

Source: Authors' computation using EViews 10 software.

Table 2. ARCH test results

Lagrange multiplier statistic	CHSQ(1) = 96.6929	[0.000]***
F-statistic	F(1,3777) = 99.0450	[0.000]***

*Note: *** and ** indicate significance at 1%, and 5% respectively. 3,784 observations were used for estimation from January 1, 2011 to May 11, 2021.*
Source: Authors' computation using EViews 10 software.

Table 3. DCC-GARCH (1, 1) model estimates

Exchange rates of countries	*Parameter*	*Coefficient*	*t-value*	*p-value*
Ghanaian cedi, GC	mu	0.7655	12.408	0.000***
	gama	0.0004	0.1945	0.659
	alpha	0.9952	1.0199	0.182
	beta	0.1022	12.1957	0.000***
Guinea-Bissau franc, XOF	mu	0.2585	2.9620	0.011**
	gama	0.0712	0.0005	0.985
	alpha	0.8946	16.269	0.000***
	beta	0.1090	13.109	0.000***
Nigerian naira, NN	mu	0.7252	11.800	0.000***
	gama	0.0002	0.0581	0.655
	alpha	0.9780	1.5780	0.165
	beta	0.1046	13.909	0.000***
Gambian dalasi, GMD	mu	5.6295	1.2890	0.0261
	gama	1.0482	0.0985	0.987
	alpha	0.8756	12.970	0.000***
	beta	0.1290	8.690	0.000***
Guinean franc, GNF	mu	0.7985	129.000	0.000***
	gama	0.0000	0.0129	0.485
	alpha	0.1946	16.540	0.000***
	beta	0.1008	14.897	0.000***

*Note: *** and ** indicate significance at 1%, and 5% respectively.*

Tables 4, 5 and 6 contain results of volatility spillover based on the triangular matrix, ARCH effects and GARCH effects using the BEKK-GARCH model.

Table 4. Volatility spillover based on an estimated triangular matrix of the BEKK-GARCH model

Variables	*Coefficient*	*t-value*	*p-value*
D_{11}	1.564	19.748	0.000***
D_{21}	2.178	1.784	0.086
D_{22}	0.574	0.216	0.165
D_{31}	-1.187	-17.884	0.000***
D_{32}	-0.955	-56.578	0.000**
D_{33}	-2.461	10.4582	0.000***
D_{41}	-11.556	14.767	0.000***
D_{42}	7.619	18.578	0.000***
D_{43}	1.4658	12.962	0.000***
D_{44}	45.109	1.098	0.245
D_{45}	-29.742	-1.452	0567
D_{51}	0.165	19.457	0.000***
D_{52}	1.028	67.189	0.000***
D_{53}	15.769	11.182	0.000***
D_{54}	1.048	10.761	0.000***
D_{55}	1.025	11.790	0.000***

*Note: *** and ** indicate significance at 1%, and 5% respectively.*

$$D = \begin{pmatrix} 1.564 & 0 & 0 & 0 & 0 \\ 2.178 & 0.574 & 0 & 0 & 0 \\ -1.187 & -0.955 & -2.461 & 0 & 0 \\ -11.556 & 7.619 & 1.4658 & 45.109 & -29.742 \\ 0.165 & 1.028 & 15.769 & 1.048 & 1.025 \end{pmatrix} \quad (9)$$

Table 5. Volatility spillover based on estimated ARCH effects of BEKK-GARCH model

Variables	*Coefficient*	*t-value*	*p-value*
B_{11}	-0.782	-40.899	0.000***
B_{12}	-4.289	-21.687	0.000***
B_{13}	-1.064	-51.018	0.000***
B_{14}	-0.879	-10.189	0.000***
B_{15}	-4.451	-19.048	0.000***
B_{21}	-0.108	-4.2912	0.024**
B_{22}	-2.765	-11.025	0.000***
B_{23}	-5.809	-12.098	0.000***
B_{24}	-20.568	-10.846	0.001**
B_{25}	-1.0897	-7.097	0.000***
B_{31}	-12.494	-8.021	0.000***
B_{32}	-2.7859	-14.178	0.000***
B_{33}	-19.568	-20.019	0.000***
B_{34}	-4.215	-12.498	0.000***
B_{35}	-0.172	-90.112	0.000***
B_{41}	-1.284	-21.749	0.000***
B_{42}	-0.756	-19.574	0.000***
B_{43}	-1.826	-20.268	0.000***
B_{44}	-9.614	-1.192	0.0256
B_{45}	-0.192	-41.729	0.000***
B_{51}	-0.281	-21.028	0.000***
B_{52}	19.658	24.009	0.000***
B_{53}	-2.595	-40.292	0.000***
B_{54}	-10.578	-16.018	0.000***
B_{55}	-1.246	-17.027	0.000***

*Note: *** and ** indicate significance at 1%, and 5% respectively.*

$$B = \begin{pmatrix} -0.782 & -4.289 & 1.064 & -0.879 & -4.451 \\ -0.108 & -2.765 & -5.809 & -20.568 & 1.087 \\ -12.494 & -2.785 & -19.568 & -4.215 & 0.172 \\ -1.284 & -0.756 & -1.826 & -9.614 & -0.192 \\ -0.281 & 19.658 & -2.595 & -10.578 & -1.246 \end{pmatrix} \quad (10)$$

Table 6. Volatility spillover based on estimated GARCH effects of BEKK-GARCH model

Variables	*Coefficient*	*t-value*	*p-value*
C_{11}	-0.124	-2.871	0.021**
C_{11}	-1.782	-14.581	0.000***
C_{13}	-0.789	-2.560	0.0156**
C_{14}	-1.928	-11.409	0.000***
C_{15}	-0.871	-1.964	0.014**
C_{21}	-0.917	-1.996	0.010**
C_{22}	-1.289	-82.145	0.000***
C_{23}	0.827	9.288	0.000***
C_{24}	-1.278	-2.546	0.019**
C_{25}	-1.009	-16.684	0.000***
C_{31}	-0.972	-2.007	0.024**
C_{32}	-0.109	-22.271	0.000***
C_{33}	-6.650	-21.045	0.000***
C_{34}	-0.457	-2.699	0.001**
C_{35}	-0.198	-19.785	0.000***
C_{41}	0.762	-17.201	0.000***
C_{42}	1.082	1.097	0.000***
C_{43}	12.479	2.011	0.017**
C_{44}	15.784	50.971	0.000***
C_{45}	11.198	50.182	0.000***
C_{51}	-0.512	-41.191	0.000***
C_{52}	0.871	14.028	0.000***
C_{53}	1.051	60.178	0.000***
C_{54}	1.082	7.197	0.000***
C_{55}	0.281	6.786	0.000***

*Note: *** and ** indicate significance at 1%, and 5% respectively.*

$$C = \begin{pmatrix} -0.124 & -1.782 & -0.789 & -1.928 & -0.871 \\ -0.917 & -1.289 & 0.827 & -1.278 & -1.009 \\ -0.972 & -0.109 & -0.65 & -0.457 & -0.198 \\ 0.762 & 1.082 & 12.479 & 15.784 & 11.198 \\ -0.512 & 0.871 & 1.051 & 1.082 & 0.281 \end{pmatrix} \quad (11)$$

5. DISCUSSION OF RESULTS

Table 4 demonstrates that the greater the level of past volatility in the currency rate, the higher today's volatility. This result upholds the findings of Rohan and Wayne (2004), who reported that the significance of past shocks authenticates the lengthy persistence of the sequence of swings of foreign exchange rates. It implies that shocks to the exchange rate of currencies continue for a long time. This calls for financial markets' stability, provided monetary authorities implement policies to respond instantaneously to tremors arising from currency markets. Apart from the Guinean franc, the alpha and beta estimates of all countries' exchange rate series exceeded one, meaning that the conditional volatility transmission for each exchange rate series has a permanent effect. In effect, volatility transmission in Guinea is temporary.

Significant coefficients of gammas confirm the asymmetry in the exchange rate volatility. The correct coefficient sign is harmful to the gamma coefficient, and it implies that negative news leads to the excessive transmission of volatility in the foreign exchange market of all countries. In other words, there is volatility transmission feedback with the implication that any shock to volatility in the exchange rate induces a higher cost of trading together with currency risk premia. According to Rohan and Wayne (2004), once a higher interest rate differential does not compensate for such risk, volatility rises beyond limits since foreign investors adjust portfolios to hedge against currency risk.

Nonetheless, the DCC results further revealed that Ghanaian cedi had the highest volatility persistence value of alpha plus beta, equal to 1.0974, followed by naira, with a value of 1.0826, and Gambian dalasi, with a persistence value of 1.0046. After that, Guinea-Bissau franc (XOF) took the lead with high exchange rate volatility persistence value of 1.0036, and Guinean franc had the most negligible volatility persistence value of 0.2954. It further confirms that volatility is a sequence of persistent fluctuations. The volatility spillover results of Table 5 show that the diagonal estimates C_{11}, C_{22}, C_{33}, C_{44}, and C_{55} all passed the significance test at the 5% level. By implication, the variance currency exchange rates of the countries mentioned above are influenced by their history of volatility and the exchange rates' past volatility of other countries in this study.

Similarly, the t-values of all off-diagonal elements of the B matrix are significant, implying a spillover effect in exchange rates of the Ghanaian cedi, Nigerian naira, Gambian dalasi, Guinean franc, and Guinea-Bissau franc. Those off-diagonal elements capture cross-exchange rate shocks of countries in our sample. In addition, it indicates that the negative effects of one country's exchange rate had a concurrent impact on the exchange rate of another. It is because high exchange rate fluctuation translates to fluctuations in short-term capital flows, with adverse consequences for foreign reserve assets (Umoru et al., 2023b; Hassan et al., 2017; Nwude, 2012; Mayowa & Olushola, 2013). The previous analysis upholds that depreciation or exchange rate appreciation affects other macroeconomic variables' performance. A devaluation of the exchange rate exacerbates domestic inflation while higher costs of production inputs are transmitted to goods prices. It is because prices of imported goods and services rise during the expansion of aggregate demand, and the attendant increases in employment result in higher wages and costs. Though, households and firms spend ample time adjusting their spending patterns. The extent and timing of the responses become a function of substitution between locally produced and imported. A strong exchange rate reflects a resilient economy, while a weak one reflects a susceptible one. Hence, a volatile exchange rate introduces high uncertainty, making the domestic economy vulnerable and weak.

According to the results of Table 6, the off-diagonal element of the matrix C shows significant t-values of all the pairs C_{12} and C_{21}, C_{13} and C_{31}, C_{14} and C_{41}, C_{15} and C_{51}, C_{23} and C_{32}, C_{24} and C_{42}, C_{25} and C_{52}, C_{34} and C_{43}, C_{35} and C_{53}, and, C_{45} and C_{54} respectively. Given that matrix C off-diagonal entries capture the exchange rate volatility transmission, it thus implied that there is a bidirectional exchange rate volatility transmission between Nigerian naira and Ghanaian cedi, Nigerian naira and Gambian dalasi, Ghanaian cedi and Guinean franc, Guinean franc and Guinea-Bissau franc, respectively. Relatively, we found no significant t-values for the same coefficients of their corresponding entries; it suggests an absence of a unidirectional exchange rate volatility transmission between the exchange rates of countries in the study. The unconditional correlation results in Table 7 below corroborate the bidirectional volatility transmission. The GMD and XOF had the highest unconditional correlation coefficient of 0.99917; the coefficient of NN and XOF closely followed this. All correlation ranged between zero and unity and was positive for the exchange rates of all countries. It places faith in high correlations, evidenced by Çağlayan et al. (2013).

Table 7. Unconditional correlations

Currency	*GC*	*GMD*	*GNF*	*NN*	*XOF*
GC	1	0.51242	0.65833	0.65117	0.64130
GMD	0.51242	1	0.40409	0.42686	0.99917
GNF	0.65833	0.40409	1	0.35950	0.42171
NN	0.65117	0.42686	0.35950	1	0.92871
XOF	0.64130	0.99917	0.42171	0.92871	1

Source: Authors' computation using EViews 10 software.

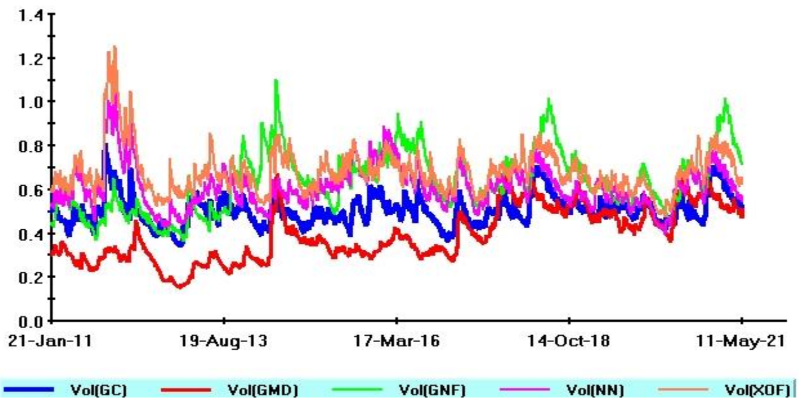
The unconditional volatilities on diagonal elements are reported in Table 8. For the five sets of exchange rates, the volatility ranking of exchange rates is presented in Table 8. These values show that the GMD is less volatile within the period under study, while GC has been more volatile, followed by the Nigerian naira within the period under review. The XOF is pegged to the French franc; hence, its apparent volatility is not surprising because studies such as Bada et al. (2016) have indicated that currencies with fixed exchange rates tend to be more volatile than currencies with a floating exchange rate.

Table 8. Conditional volatilities of currencies

S/N	*Currency*	*Conditional volatilities*
1.	GC	0.98400
2.	XOF	0.51466
3.	NN	0.69241
4.	GMD	0.66773
5.	GNF	0.41604

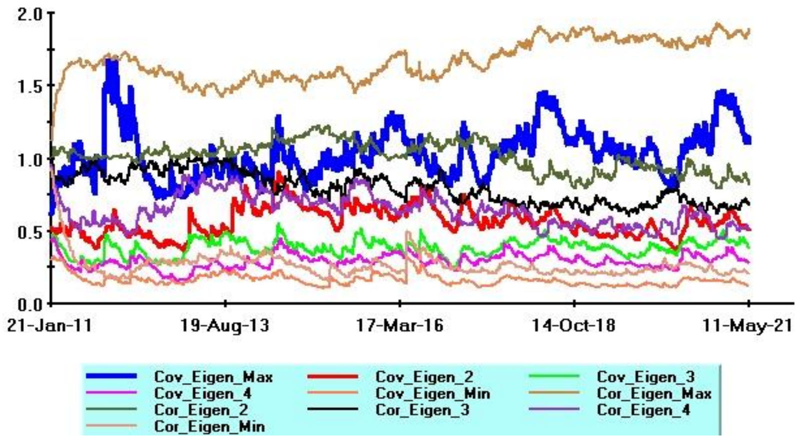
The conditional volatilities and correlations graphs are presented in Figures 1 to 3. The volatility scales show that GC has the highest volatility, followed by NN, while GNF has the least volatility.

Figure 1. A plot of conditional volatilities and correlations



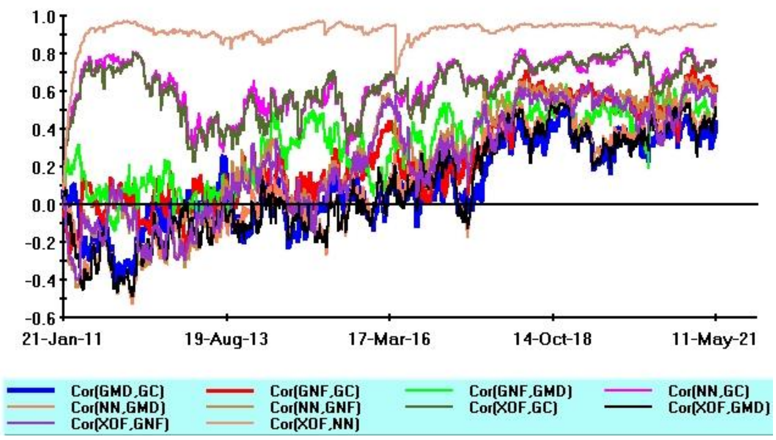
Source: Authors' elaboration.

Figure 2. A plot of conditional volatilities and correlations



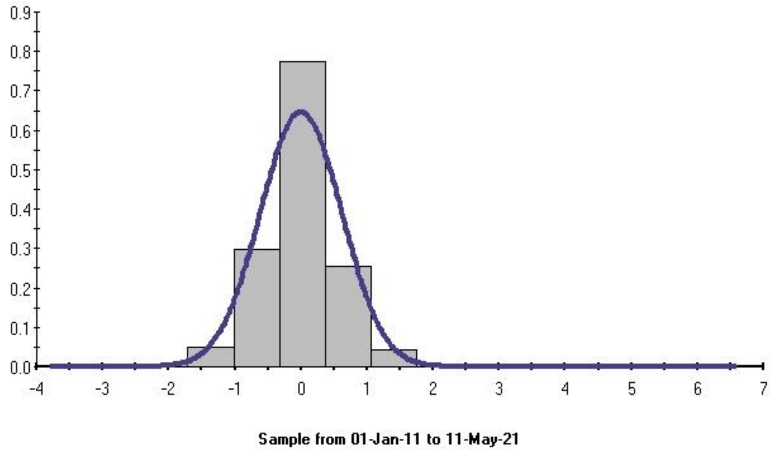
Source: Authors' elaboration.

Figure 3. A plot of conditional volatilities and correlations



Source: Authors' elaboration.

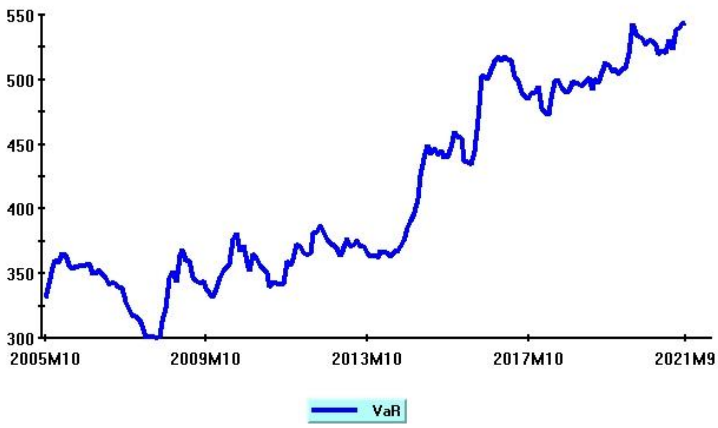
Figure 4. Histogram of residual series



Source: Authors' elaboration.

A plot of VAR shown in Figure 5 demonstrates an increasing pattern, indicating that exchange rate volatility would likely increase over the short run.

Figure 5. Plot of VAR



Source: Authors' elaboration.

6. CONCLUSION

This study uses BEKK-GARCH and dynamic conditional correlation (DCC-GARCH) models to model and estimate volatility transmission and persistence in selected developing countries. Own history of conditional volatility, together with exchange rates' past volatility of other nations in this study, played a role in the volatility of currency rates of Nigeria, Guinea, Gambia, and Ghana.

Similarly, we found that the negative effects of one country's exchange rate had a contemporary impact on the exchange rate of another. In contrast, a bidirectional exchange rate volatility transmission exists between Nigerian naira and Ghanaian cedi, Nigerian naira and Gambian dalasi, Ghanaian cedi and Guinean franc, Guinean franc and Guinea-Bissau franc, respectively. The paper contributes to the literature on volatility spillovers. Besides, the study provides how volatility in currency rates is transmitted to financial flows and overall global trade between African countries and other countries. It is essential to the central banks of the countries involved because it provides a policy guide on how best to conduct exchange rate policies. The significance of past shocks authenticates the lengthy persistence of volatility of foreign exchange rates, just as reported earlier by Rohan and Wayne (2004). The negative effects of one country's exchange rate had a contemporary impact on the exchange rate of another. What this implies is that there are spillover effects from global currency markets. It is because high exchange rate fluctuation translates to fluctuations in short-term capital flows, with adverse consequences for foreign reserve assets (Raza et al., 2021; Ishfaq et al., 2018; Joshi et al., 2020; Nwude, 2012; Mayowa & Olushola, 2013).

Accordingly, our findings uphold that depreciation or exchange rate appreciation affects other macroeconomic variables' performance. A devaluation of the exchange rate exacerbates domestic inflation just as nominal exchange rate movements result from price changes in trading economies. It is because prices of imported goods and services rise during the expansion of aggregate demand, and the attendant increases in employment result in higher wages and costs. Higher costs of production inputs are primarily passed on to goods prices. Though, households and firms spend ample time adjusting their spending patterns. The extent and timing of the responses become a function of substitution between local and foreign goods. There is a need for structural transformations to mitigate the structural problems, such as effective institutions and good governance, that may also transmit to inflationary situations in West African countries. Considering that our findings are limited to African countries, future researchers should focus on research on (volatility shocks) transmission between European and African financial markets with high-frequency time-varying integrated data using VAR-enhanced DCC-GARCH models and VAR-enhanced CCC-GARCH. These techniques would enable the comparison of empirical findings with our study.

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