ESTIMATING COVARIANCE BETWEEN EXCHANGE RATE DEVALUATION AND OIL PRICE VOLATILITY DURING COVID-19

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Abstract

The economies of West African Monetary Zone (WAMZ) countries have recorded a long trend of currency devaluation and hiking instability in oil prices. We estimated the covariance of currency devaluation and volatilities in global oil prices caused by the COVID-19 outbreak on WAMZ economies from January 30 to December 30, 2020. The BEKK model was estimated for analysis. The results from generalized autoregressive conditional heteroskedasticity (GARCH) show that all variance equation coefficients, are significant, suggesting strong volatility transmission and spillovers between the COVID-19 outbreak and oil price shocks on the economic performance of WAMZ. The estimates obtained for both current and lagged gross domestic product (GDP) equations are relatively similar. Consequently, all WAMZ economies weakly responded to shocks arising from fluctuations in international oil prices, volatility of inflation rate, and excess devaluation caused by the COVID-19 outbreak. The instabilities in oil prices and devaluation caused by the COVID-19 outbreak had decelerating consequences on the output growth of WAMZ economies. The estimated covariance effects of oil price shock and currency devaluation are negative for all countries in the study. A 1 percent devaluation-oil price shock caused by the COVID-19 pandemic resulted in negative output growth rates of 1.3 percent, 1.12 percent, 1.1 percent, and 1.09 percent in Nigeria, Sierra Leone, Ghana, and The Gambia, respectively.

Keywords: COVID-19 Outbreak, Oil Price Shock, National Output Growth, Devaluation, WAMZ, BEKK

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1. INTRODUCTION

Amid the COVID-19 outbreak, the economies of West African countries chronicled a long trend of currency devaluation and hiking prices. This had in the past led to a desire to establish a single currency for the Economic Community of West African States (ECOWAS) region since the organization for regional integration was founded. Given the existence of the West African Economic and Monetary Union (WAEMU), this was seen as a workable possibility. It was proposed that governments outside the WAEMU join a second West African Monetary Zone (WAMZ) to accelerate the ultimate unification and adoption of a single currency (Ilyas et al., 2022). The likelihood of adopting comparable monetary policies and currencies tended to decline when monetary policies had negative effects and showed non-compliance with convergence conditions. It has been suggested that the relative ineffectiveness of monetary policy may be used to determine the commencement date of the WAMZ instead of the macroeconomic convergence criterion test. These countries will imitate the WAMZ's unionization strategies, a collection of countries that ex-post established a faultless currency zone without imposing ex-ante conditions. The WAMZ members' external sectors have lagged behind the market as a whole ever since the 1980s. Low output growth and high inflation are signs of a failing external sector.

WAMZ as a regional body was birthed in 2000 to pull out a single common currency for Anglophone ECOWAS countries aside from the goal of economic integration. It comprises six countries: Sierra Leone, Ghana, The Gambia, Nigeria, Liberia, and Guinea. The body sought to use a common currency referred to as the eco for all member countries by 2015. WAMZ operates through its Technical Committee. The monetary policies of each country are to converge with the policies of the other as an economic integration union, hence the clamor for a single currency. Rather than achieving its goal of a generally accepted currency, most of the member countries are currently facing economic positions relating to budget deficits, weak currencies, and inflation (Central Bank of Nigeria [CBN], 2022). As in country-based analysis, monetary policies in WAMZ member countries are subject to changes that cause shocks to emanate from such changes. The shocks may or may not be significant given the inter-twined functionality of macroeconomic variables within monetary and fiscal spheres. Within the WAMZ, all member countries can be classified as developing economies and thus may face similar monetary challenges.

Examining the exchange rates of these member states within the past years, rates of the Nigerian naira, Gambian dalasi, Liberian dollar, Sierra Leonean leone, Ghanaian cedi, and Guinean franc have maintained a downward-patterned movement against the US dollar. In particular, devaluation in each of the WAMZ member countries has occurred continuously over the years but they differ in intensity. Inflation rates in these countries have also been consistently unstable with hyperinflation hitting economies, such as Nigeria. The study thus seeks to determine the impact of shocks from monetary policies on exchange rate devaluation and inflation volatility in the region. The contribution of the study derived from the fact that with the aim of economic and trade integration as paramount objectives of the regional-based union, the study identifies that a percentage point rise in the interactive effect of oil price shock and exchange rate devaluation weakened economies of WAMZ by 1.3% in Nigeria, 1.12% in Sierra Leone, 1.1% in Ghana, and 1.09% in The Gambia, respectively, during the COVID-19 outbreak. Given that the COVID-19 outbreak caused monetary authorities to adjust policies such as interest rates to ease the flow of economic activities, the study contributed to the relevance of the determination of how COVID-19 shock in terms of death and infectious rates have taken together and exchange rate devaluation exerted influence on the macroeconomic performance of WAMZ economies.

This study presupposes the following research questions to be answered:

RQ1: Is there a negative impact of oil price shock during COVID-19 on the macroeconomic balance of the WAMZ countries covered in this study?

RQ2: Is the impact of currency devaluation during COVID-19 on the macroeconomic balance of the WAMZ countries covered in this study negative?

RQ3: Are there negative covariance effects of oil price shock and currency devaluation during COVID-19 on the WAMZ countries covered in this study?

The remainder of this paper is structured as follows. Section 2 reviews the recent literature. The methodology and relevant research materials engaged are explained in Section 3. Results and discussions, comprised of tables that summarised estimation output with corresponding interpretations, and ensuing policy implications are covered in Section 4. Finally, the conclusions are given in Section 5.

2. LITERATURE REVIEW

Economic literature assumes that devaluation of exchange rates has an expansionary effect on the economy as it reduced dependence on imports as imports would be more expensive and cause increased exports. Exchange rate devaluation aims at financially adjusting foreign currencies for a current trade surplus (Umoru, 2022). Countries operate fixed or flexible exchange rates in which the former has regulatory authorities fix and the latter is free-flowing. For import-dependent countries, increased imports to fuel consumption would cause increased price levels or inflation.

Umoru, Effiong, Ugbaka, Iyaji, et al. (2023) estimated the threshold effects of currency devaluation and oil price movements on industrial production respectively without making provision for the COVID-19 effect. Similarly, Umoru, Odiwo, et al. (2023), Umoru, Effiong, Ugbaka, Akhor, et al. (2023), and Umoru, Effiong, Okpara, et al. (2023) have recently evaluated the effects movements in exchange rates vis-à-vis volume of foreign reserves available, currency devaluation, as well as volatilities in oil-exchange rate. There are studies regarding the oil price variation effect of the COVID-19 outbreak. According to Katsampoxakis et al. (2022), before the COVID-19 outbreak, no association existed between stock and crude oil prices, but during the period of COVID-19, high volatility periods, there was an interconnection that flows from stock markets to oil prices and this led to an increase in oil prices that affected all countries in a likewise manner. Basing analysis on the econometric panel model, Christopoulos et al. (2021) confirmed the negative influence of COVID-19 on economic and market uncertainty that distorts oil prices. Awan et al. (2021) reported decreasing oil prices due to seat at home and also the outbreak of COVID-19 that

activated volatility in all G7 stock markets. In this research, crude oil was used to hedge against fluctuations in oil prices. Mzoughi et al. (2020) reported that COVID-19 strongly impacted equity market unpredictability more than crude oil prices. Özdurak (2021) used the dynamic conditional correlation (DCC)-GARCH models and reported that whenever oil prices drop, the stock market volatility rises. According to Zhong et al. (2019), gas and oil markets have significant causation and the spillover between the two markets exhibited time-varying features.

The results of Gyamerah et al. (2022) established a one-way shock spillover from green bond prices to stock prices of renewable energy. Kanwal and Khan (2021) using the generalized orthogonal (GO)-GARCH model, found independence of the European renewable energy market and value addition. Dong et al. (2019) obtained a correlation between oil return risks and policy uncertainty, with heterogeneity in variations of the relation in different markets. According to Jadidzadeh and Serletis (2022), over 55% of the deviation in the price of natural gas liquids was due to structural shocks in oil supply. Zheng and Du (2019) established the role of excavating technology in predicting the trend of oil prices and piloting risk measurement in the oil market. Chen et al. (2019) recommended the need for a reduction of the volatility in the foreign exchange (FX) market of China. According to Eze and Okotori (2022), monetary policy shock had a significant long-run association with exchange rates but there was no short-run relationship. After a review of related studies, the gap that was found in the literature was that there was no simultaneous modeling methodology used to determine the relationship among the three variables in the study. This study thus seeks to formulate a simultaneous equation model for monetary policy shocks, inflation volatility, and exchange rate devaluation in WAMZ member countries. Rosli et al. (2022) obtained a negative effect of the volatility of the inflation rate on the growth performance of the Vietnam economy. In particular, the growth of the economy is weakened by a volatile rate of domestic inflation since high and fluctuating inflation dampens investors' confidence due to the ambiguity of impending prices and costs. According to Adeniyi (2020), inflation volatility hurt economic growth in Nigeria, Tanzania, Egypt, and Kenya. Mahawiya et al. (2020) used a panel smooth transition regression model in their separate investigations, they reached different conclusions regarding the importance of the inflation rate for economic development.

Hakim (2021) found negative short-run growth effects of inflation volatility in Iraq. According to Dinh (2020), inflation volatility had unfavorably affected the macroeconomy once the rate of domestic inflation rises above the speed of economic growth. The negative influence of the volatility of the inflation rate on macroeconomic performance was also reported by Mandeya and Ho (2021) in both the short and long runs. Okonkwo et al. (2017) and Selimi and Selimi (2017) did not have any issues accepting the county effects of exchange rate instability on gross domestic product (GDP). Tule et al. (2019) conducted a study on monetary policy shocks and macroeconomic fluctuations in four member countries of the WAMZ using quarterly data from 1980 to 2016. The authors re-counted that monetary policy shocks caused currencies to decline in value. Gambia and Sierra Leone, on the other hand, had exchange rate devaluation shrinking with monetary policy shocks. They also had similar results with Nigeria for inflationary pressures. Kesavarajah and Middleditch (2019) and Anidiobu et al. (2018) all reported that the volatility in the inflation rate had frequently weakened the purchasing power of the Naira. Similarly, Muhammad and Saleem (2018) adopted the panel estimation techniques and found the negative effects of inflation volatility on macroeconomic performance in five Asian countries.

Inflation rates are unstable with shocks from different variables impacting them. When they are unstable, they are said to be volatile. The view of Masson and Pattillo (2004) is linked to this study. They posit that Africa is not particularly ready for a single currency as WAMZ had first sought as members are independent sovereign states. However, countries could intentionally expand extant monetary policies to induce others to improve theirs. The model also pinpoints that each member state is peculiar with state-specific characteristics that may alter monetary policies and reactions of variables such as inflation volatility and exchange rate devaluation. A country regulates its macro-economy using monetary and fiscal policies aside from other structural policies. While fiscal policies are related to taxation and government expenditure, monetary policy involves money supply and factors that relate to money supply such as interest rate and other currency/money-related indices within that economy. Mathai (2012), in a similar view, expressed monetary policy as the rule over the money supply for the attainment of an optimum mix of output and inflationary level. When policies are adjusted, they emanate economic shocks that may influence other economic variables.

Central banks monitor inflation as a core mandate and churn out monetary policies capable of manipulating the behavior of domestic drivers of inflation rates (Omotosho & Doguwa, 2017). Fasanya and Adekoya (2017) state that inflation volatility may contribute to market inefficiencies; distort the exchange rates balance, enlarge risks, and breed worse inequality in wealth redistribution. According to Ndung'u (1999), a significant link between the inflation rate, exchange rates, and monetary policy measured by money supply exists in Kenya. Adeoye and Saibu (2014) found that innovations in monetary policies have a causality relationship with exchange rate devaluation in Nigeria. Asad et al. (2012), in a study in Pakistan, examined the extent to which exchange rates influence inflation with data from 1973 to 2007. It was found that the exchange rate positively and significantly influences inflation rates within the Pakistani economy.

Numerous studies have been done on how inflation affects GDP, but it is also well acknowledged that in emerging countries like those in the Southern African Development Community (SADC), it is especially important to keep inflation under control to avoid damaging economic growth (Phiri, 2018; Tung & Thanh, 2015). The Mundell–Tobin (Mundell, 1963; Tobin, 1965) hypothesis states that low to moderate inflation is good for an economy because it promotes greater investment and discourages the hoarding of cash and other financial assets through lower interest rates and a more effective capital accumulation process. According to research conducted in five Association of Southeast Asian Nations (ASEAN) nations, Thanh (2015) advocated

an inflation threshold of 7.8%; nevertheless, Mahawiya et al. (2020) predicted threshold inflation rates of 17.9% for ECOWAS and 14.5% for SADC. If the inflation rate rises over this limit, the financial and economic development of the area may be jeopardized. This is just more proof that developing countries, especially those in Africa, continue to be extremely concerned about the inflation-growth concept.

In sum, previous studies have centered on varied combinations of two of the study variables. Others that seem to have taken up three related variables have not used inflation rate volatility, but rather inflation rate itself. Other studies have used causality approaches to examine relationships or impacts of variables. This study assumes that all three variables might have a tripartite directional relationship among them and thus uses simultaneous equation modeling in defining models for the six-member WAMZ. This study is of theoretical significance as it contributes to the extant literature on monetary economics and introduces simultaneous econometric modeling to the explanation of the association among inflation rate fluctuations, exchange rate declines, and shocks from monetary policies. Additionally, policymakers and regulatory authorities would find this academic work useful in decision-making relating to the suitability of monetary policies within specific macroeconomic conditions. They would also grasp the implications of the state of the study variables on one another. Next is the literature review section which gave short explanatory subsections of study variables and discussed theoretical propositions related to exchange rate devaluation, inflation rate volatility, and monetary policy shocks. Furthermore, past works were reviewed to provide a base for apriori expectations of the study findings. The methodology section contains the study models, data sources, and analytical tools to answer the formulated research questions.

3. METHODOLOGY

The study used the daily series of exchange rates, oil price variations, COVID-19 deaths/infectious rates, and inflation data of all WAMZ, viz., Nigeria, The Gambia, Sierra Leone, and Ghana. The period of data analysis ranged from January 30, 2020, to December 30, 2020, which makes up a total of 364 daily observations. The Kwiatkowski–Phillips–Schmidt–Shin (KPSS) and augmented Dickey–Fuller (ADF) unit root test methods were implemented to test for stationary variables stationary. Given that, the KPSS is superior to the ADF, particularly in a small sample size, the study relied on KPSS in concluding the order of integration of each variable. The co-integration test of the Johansen method was implemented to establish the level of a long-run link between variables. The United States dollar served as the world currency in terms of which other currencies of the WAMZ region were compared and measured. COVID-19 was measured as the number of deaths and infections from the COVID-19 outbreak from the publications of the World Health Organization (WHO).

Inflation data was sourced from the publications of the International Monetary Fund (IMF) while inflation volatility was calculated using the rule of a stochastic differential equation (SDE) under mathematical simulation. This measures the persistence of the time-varying volatility component of inflation. The series of exchange rates were sourced from the database of the IMF. Data estimation was done using EViews 10.0 econometric software. The model estimated was the BEKK-GARCH as discussed here. The BEKK model due to Baba et al. (1990) and Engle and Kroner (1995) was deployed to analyze the interactive relation between the variables in the study. Defining $(n \times n)$ matrices B_{ik}, W_{ik}, and an upper triangular matrix D_0, the general BEKK model can be specified as follows:

$$\sum\nolimits_t = D_0^T D_0 + \sum\nolimits_{k=1}^{K} \sum\nolimits_{i=1}^{q} B_{ik}^T e_{t-i} e_{t-i}^T B_{ik} + \sum\nolimits_{k=1}^{K} \sum\nolimits_{i=1}^{q} W_{ik}^T \sum\nolimits_{t-i} W_{ik} \quad (1)$$

where, B_{ik} and W_{ik} are $(n \times n)$ matrices; D_0 is an upper triangular matrix. For the purpose of estimating a simple dynamic BEKK model, $p = q = k = 1$ and $n = 2$, so that the components of the covariance matrix denoted by $\sum_t$ yield the dynamic system of BEKK equations:

$$Var_{11,t} = d_{11} + a_{11}^2 e_{1,t-1}^2 + 2a_{11}a_{21}e_{1,t-1}e_{2,t-1} + a_{21}^2 e_{2,t-1}^2 + \beta_{11}^2 \sigma_{11,t-1} + 2\beta_{11}\beta_{21}\sigma_{21,t-1} + \beta_{21}^2 \sigma_{22,t-1} \quad (2)$$

$$\begin{aligned} Var_{21,t} = {} & d_{21} + a_{11}a_{22}e_{1,t-1}^2 + (2a_{21}a_{12} + a_{11}a_{22})e_{1,t-1}e_{2,t-1} + a_{21}a_{22}e_{2,t-1}^2 + \beta_{11}\beta_{22}\sigma_{11,t-1} + \\ & + (\beta_{21}\beta_{12} + \beta_{10}\beta_{22})\sigma_{12,t-1} + \beta_{21}\beta_{22}\sigma_{22,t-1} \end{aligned} \quad (3)$$

$$Var_{22,t} = d_{22} + a_{12}^2 e_{1,t-1}^2 + 2a_{12}a_{22}e_{1,t-1}e_{2,t-1} + a_{22}^2 e_{2,t-1}^2 + \beta_{12}^2 \sigma_{11,t-1} + 2\beta_{12}\beta_{22}\sigma_{21,t-1} + \beta_{22}^2 \sigma_{22,t-1} \quad (4)$$

Moving from theory to modeling, the implied covariance matrix becomes:

$$Covaraince, \sum = \begin{bmatrix} a_{11}^2\sigma_{11} + \psi_{11}(a_{11}^2\beta_{21} + a_{11}a_{21})\sigma_{11} + & (\beta_{21}^2 a_{11}^2\sigma_{11} + 2\beta_{21}a_{11}a_{21} + a_{21}^2)\sigma_{11} + \\ + \beta_{21}\psi_{11}a_{11}\sigma_{11} & + \beta_{21}^2\psi_{11} + \psi_{22}\beta_{21}a_{11}\sigma_{11} + a_{21}\sigma_{11} \end{bmatrix} \quad (5)$$

Alternative methods that could be deployed to estimate covariance effects of devaluation and oil price volatility on the macroeconomic performance of WAMZ economies include 2SLS, 3SLS, generalized least squares (GLS), nonlinear autoregressive distributed lag (NARDL) estimation methods, vector error corrections (VEC) estimation techniques, variance decomposition and impulse response functions of the Bayesian value at risk (VaR) structural model estimation, policy simulation base on computable general equilibrium (CGE) model estimation. The BEKK modeling approach that we implemented for this study was deemed apt because when postulating time-varying instabilities,

a multivariate model framework is more appropriate to take cross-sectional data into account. Specifically, the covariance between exchange rate devaluation and oil price variability or movements is needed to estimate the direction of such multivariate volatility measures. This was captured as the interactive effect of devaluation-oil price shock. Also, the BEKK model offers a stronger dynamic formulation, unlike the restricted methods of the VEC-GARCH model. Lastly, the fact that the matrices B_{ik} and W_{ik} are not mandated to be diagonal, the BEKK-GARCH model usefully permits cross forces of conditional covariances. The parameters of BEKK-GARCH models can be estimated using the maximization of the log-likelihood function:

$$L(v) = -TN/2Log2\pi - 1/2\sum_{t=1}^{T}(Log/H/ + \varepsilon_1' H_{t-1}\varepsilon_t) \quad (6)$$

We hypothesize an interactive and dynamic relationship between oil price shock (*OLCVOL*), and currency devaluation (*EXCVD*), while simultaneously evaluating the individual effects of each variable on the level of macroeconomic performance during the COVID-19 outbreak in the WAMZ, which includes The Gambia, Ghana, Nigeria, and Sierra Leone.

4. RESULTS AND DISCUSSION

The focus of this section is on empirical analysis. The study empirically estimated the dynamic and simultaneous linkages between oil price shocks, exchange rate devaluation, the COVID-19 outbreak, and inflation volatility in the WAMZ. The analysis begins with the preliminary unit root test of stationarity. The results for KPSS and ADF unit root test show that all other variables are stationary at first difference. Given that, the KPSS is superior to the ADF, particularly, in a small sample size, the study relied on KPSS in concluding that all the series are I[1]. The co-integration results also endorse the existence of long-term interactions between all the variables in the study. These results are not presented since they are the only evidence of data cleaning. The empirical results are presented successively.

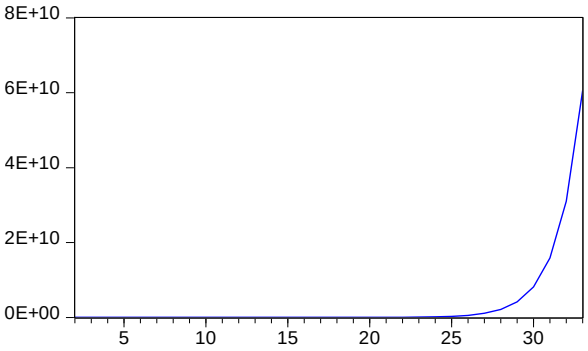
4.1. Nigeria

The results of the covariance coefficients of the BEKK are displayed in Table 1. A positive *M(1,1), M(1,2),* and *M(2,2)* mean that simultaneous negative shocks in either exchange rate devaluation or oil price volatility lead to a situation where these negative shocks increase the variance in the next period. Invariably, volatility (fluctuations) in the macro economy in Nigeria tends to be exacerbated. Thus, shocks in the economy are persistent over time. Any volatile movement in the economy takes time to be restored. There is also evidence of leverage effect in future economic activities during the sample period with volatility transmission and spill-overs in the Nigerian economy.

Table 1. Transformed variance coefficients (for Nigeria)

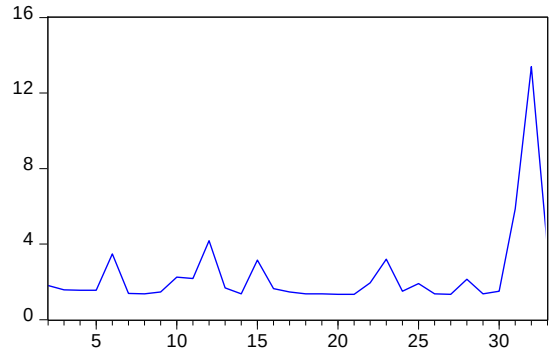
Variable	*Coefficients*	*z-stat.*	*Prob.*
M(1,1)	16708286	6.469727	0.0000
M(1,2)	1.11E + 08	6.903195	0.0000
M(2,2)	1.76E + 08	7.204647	0.0000
A1(1,1)	-0.002392	-5.002706	0.0000
A1(2,2)	1.619887	4.663803	0.0000
B1(1,1)	0.932745	5.770768	0.0000
B1(2,2)	-0.006659	-10.009142	0.0000

Figure 1. Devaluation shock of the exchange rate in Nigeria under COVID-19



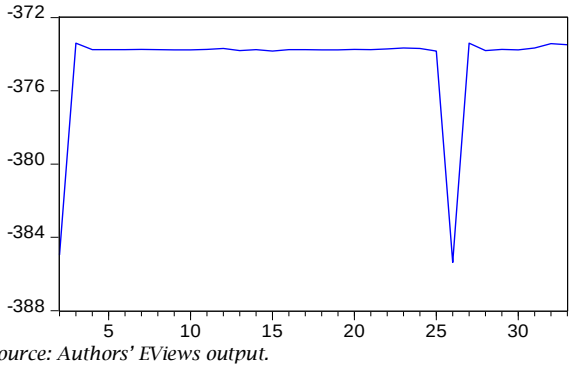
Source: Authors' EViews output.

Figure 2. Oil price shock under COVID-19 (for Nigeria)



Source: Authors' EViews output.

Figure 3. Covariance of oil price shock and exchange rate devaluation under COVID-19(for Nigeria)



Source: Authors' EViews output.

The results of the dynamic system estimation are displayed in Table 2. The goodness of fit (R-squared value) for both equations is indicative

of poor performance. The D.W. statistic of the exchange rate model of 2.03 is acceptable in terms of the absence of autocorrelation in the estimates, making the model a reliably fit for structural and policy analysis. The *COVID-19* coefficient (-0.644) was found to be significant at the 1% level given a t-value of -11.107. The negative coefficient is an indication that the outbreak of the virus disrupted the oil supply by 0.6% following a 1% increase in the number of deaths and infections of the virus. This could have been reflected in the low prices of oil during the peak period of COVID-19. For the GDP model, the coefficient of currency devaluation, and global oil price were all negatively significant at the 1% level. The estimated interactive effects of oil price shock and devaluation are -1.3105 and a z-value of -76.347. The negative coefficient is significantly related to current macroeconomic activities in Nigeria. A 1% devaluation-oil price shock caused by the COVID-19 pandemic resulted in negative output growth rates by 1.3%. A 1% shock to devaluation itself resulted in negative growth rates by 0.51%, while a 1% shock to global oil prices led to a 1% decline in national output. By implication, past fluctuations in oil prices and exchange rates caused by the COVID-19 outbreak had strong negative effects on the macroeconomic performance in Nigeria.

Exchange rate devaluation is negatively and significantly related to GDP implying that currency devaluations had a direct hostile effect on the performance of the country. Given that the Nigerian economy is highly hooked on the production and exports of crude oil, an upward movement in oil prices in the immediate past period tends to create higher price expectations for business, trade, investment, and economic activities, leading to favorable economic growth. The characteristics of the multivariate GARCH equation show that all variance coefficients are significant, an indication of a strong volatility pattern in the economy, arising mainly from inflation, exchange rate, and growth volatilities. Consequently, the Nigerian economy is inherently unstable in the focus period, characterized by pronounced macroeconomic fluctuations induced mainly by external factors such as oil price fluctuation in the international market and the FX market. For instance, swings in world oil prices and instability in exchange rates tend to have simultaneous effects on each other and growth/national output.

Table 2. System results for Nigeria

Variable	*National output (GDP) equation*		*Variable*	*National output (GDP(-1)) equation*	
	Coef.	*z-stat.*		*Coef.*	*z-stat.*
C	-1439.2	6.095	*C*	-1.075	15.613
EXCVD	-0.511	-14.005	*EXCVD*	-1.026	-23.459
OLCVOL	-1.049	-39.004	*OLCVOL*	-1.075	-16.670
*EXCVD * OLCVOL*	-1.3105	-76.347	*EXCVD * OLCVOL*	-1.245	-49.128
COVID-19	-0.764	-30.028	*COVID-19*	-0.644	-11.107
D.W.	2.031		*D.W*	2.109	

Source: Authors' EViews output.

4.2. Sierra-Leone

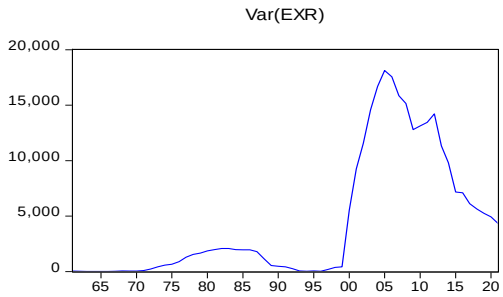
The results of the covariance coefficients of BEKK are displayed in Table 3. BEKK parameter estimates show strong evidence of shocks and volatility transmission and spillovers in the Sierra-Leone economy. Thus, volatilities or fluctuations in the economy, if not appropriately curtailed with strong fiscal and monetary policies tend to be dispersed in the economy, with reverberating effects. As in the case of Nigeria, the variance equation coefficients are significant, an indication of a strong volatility pattern in the economy, arising mainly from volatilities due to global oil prices and inflation shocks. Thus, the Sierra-Leone economy is inherently volatile with evident macroeconomic fluctuations. Being a somewhat developing economy, this pattern is unfavorably unexpected.

Table 3. Transformed variance coefficients (for Sierra Leone)

Variable	*Coefficients*	*z-stat.*	*Prob.*
M(1,1)	16708286	4.469727	0.0000
M(1,2)	1.11E + 08	56.903195	0.0000
M(2,2)	1.76E + 08	67.204647	0.0000
A1(1,1)	5.72E-06	42.001353	0.0000
A1(1,2)	-0.003874	-12.002706	0.0000
A1(2,2)	2.624034	24.331902	0.0000
B1(1,1)	0.870014	20.885384	0.0000
B1(1,2)	-0.006211	-40.009139	0.0000
B1(2,2)	4.43E-05	20.004571	0.0000

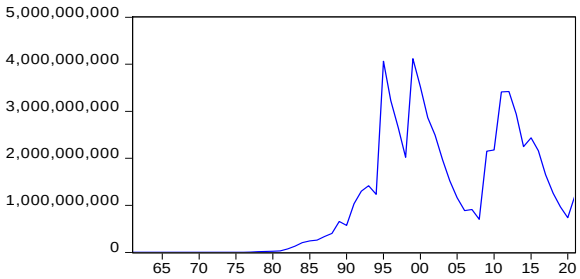
Source: Authors' EViews output.

Figure 4. Devaluation shock of the exchange rate in Sierra-Leone under COVID-19



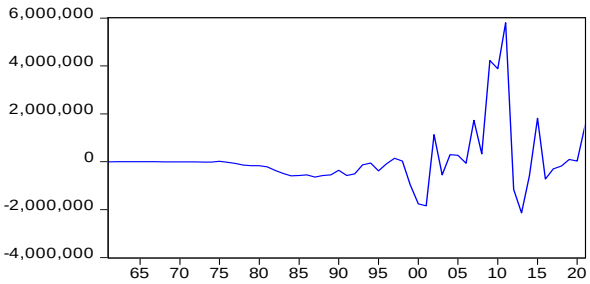
Source: Authors' EViews output.

Figure 5. Oil price volatility shock under COVID-19 (for Sierra Leone)



Source: Authors' EViews output.

Figure 6. Covariance of oil price volatility shock and exchange rate devaluation under COVID-19 (for Sierra Leone)



Source: Authors' EViews output.

As in the case of Nigeria, 1% shocks to the devaluation of the Sierra-Leone currency, world oil price movement, and inflation prompted negative growth rates in Sierra-Leone by 0.023%, 0.158%, and 0.12%, respectively. For the current GDP equation, inflation volatility, and devaluation are all negatively and considerably related to macroeconomic performance. A 1% shock to devaluation led to 1.023% negative growth rates in Sierra Leone. Relatively, the coefficient of oil price variation during COVID-19 stood at -0.158, while that of devaluation stood at -0.023, suggesting very strongly that 1% fluctuations in oil prices and exchange rates instigated by the COVID-19 outbreak had strong negative effects on macroeconomic performance in Sierra Leone. In specific terms, national output declined by 0.02% and 0.16% due to COVID-19-induced fluctuations in oil prices and exchange rates. The coefficient of COVID-19 is -1.024 with a z-value of -23.0122. As it were, the significant negative coefficient is an indication of a deleterious effect of a pandemic on national growth. Hence, GDP in the current period declined by 1% as a result of 1% of death and cases of the COVID-19 pandemic throughout 2020. The interactive effects of oil price shock and exchange rate devaluation are negatively and considerably related to the current macroeconomic performance given the estimated coefficients of -1.119 and a z-value of -20.347. A 1% devaluation-oil price shock triggered by the COVID-19 pandemic declined output growth in Sierra Leone by 1.2%.

Table 4. System results for Sierra Leone

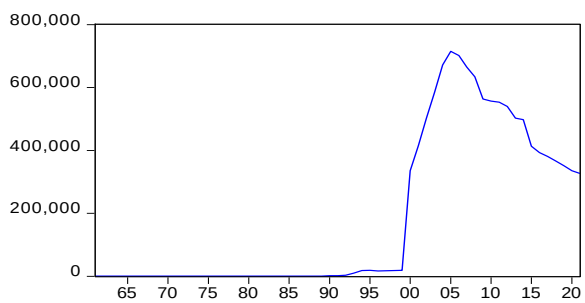
Variable	*National output (GDP) equation*		*Variable*	*National output (GDP(-1)) equation*	
	Coef.	*z-stat.*		*Coef.*	*z-stat.*
C	0.138	5.095	*C*	-1.075	15.613
EXCVD	-1.023	-14.235	*EXCVD*	-1.038	-23.459
OLCVOL	-0.158	-96.124	*OLCVOL*	-0.064	-70.109
*EXCVD * OLCVOL*	-1.119	-20.347	*EXCVD * OLCVOL*	-1.016	-25.448
COVID-19	-1.024	-23.0122	*COVID-19*	-1.025	-13.872
D.W.	2.035		*D.W.*	2.142	

Source: Authors' EViews output.

4.3. Ghana

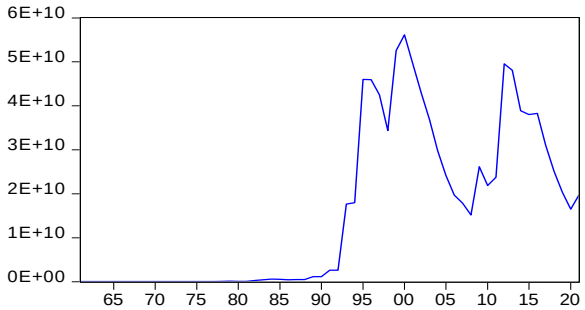
The results of the dynamic BEKK system estimation and the variance equation coefficients for Ghana are displayed in Table 5 and Table 6, respectively. As in the previous case with other WAMZ member and African countries, the variance equation coefficients are significant, an indication of a strong volatility pattern in the economy, arising mainly from macroeconomic volatilities due to monetary policy shocks, inflation volatility, and exchange rate fluctuations. The Ghanaian economy is volatile and highly susceptible to exogenous fluctuations in oil prices and exchange rates.

Figure 7. Devaluation shock of the exchange rate in Ghana under COVID-19



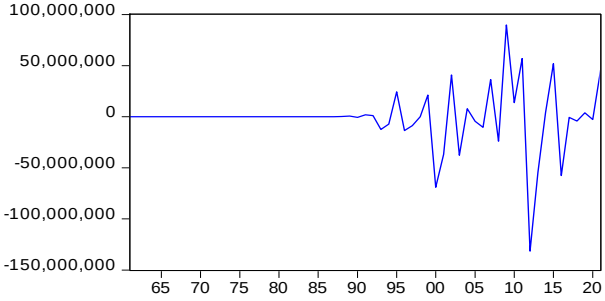
Source: Authors' EViews output.

Figure 8. Oil price volatility shock under COVID-19 (for Ghana)



Source: Authors' EViews output.

Figure 9. Covariance of oil price volatility shock and exchange rate devaluation under COVID-19



Source: Authors' EViews output.

The results of the variance and covariance coefficients of the BEKK are displayed in Table 5. The results of the BEKK parameter estimates show significant evidence of shocks and volatility transmission, as well as spillovers in the Ghanaian economy. Invariably, exchange rate depreciation and inflation volatility combine to generate instabilities in the economy in a dynamic feedback pattern.

Table 5. Transformed variance coefficients (for Ghana)

Variable	*Coefficients*	*z-stat.*	*Prob.*
M(1,1)	9.039226	213.109441	0.0000
M(1,2)	-562.0448	-513.065865	0.0000
M(2,2)	5880.916	203.186223	0.0000
A1(1,1)	1.199362	43.788132	0.0000
A1(2,2)	0.840529	43.242986	0.0000
B1(1,1)	0.392688	434.191324	0.0000
B1(2,2)	0.873564	314.99285	0.0000

Source: Authors' EViews output.

In the system results, coefficients of oil price movement, devaluation, and the volatility in the inflation rate are all negative and meaningfully associated with the growth rate of GDP. In effect, a one percent rise in the volatility of global oil prices, devaluation of the cedi, and volatility of the inflation rate induces a 1.0%, 0.41%, and 0.1% weakening of the Ghanaian economy. With a 1% rise in cedi supply, 1% unfavorable macroeconomic performance was realized for the Ghanaian economy. Consequently, the Ghanaian economy weakly responds to shocks or impulses arising from variations in global oil prices, volatility of inflation rate, and excess devaluation. By implication, COVID-19 triggered oil price instability and devaluation of the Ghanaian cedi and it resulted in a 0.41% and 1% decline in national output growth in Ghana. In effect, COVID-19-induced instabilities in oil prices and exchange rates had strong negative effects on the macroeconomic performance of Ghana. What this implies is that in Ghana, oil price variations initiated by COVID-19 had a negative consequence on national output. Such fluctuations in oil prices and domestic price levels together induced slow growth rates in the Ghanaian economy. Being an exporter of primary products, this outcome is not surprising, as in the previous case of other WAMZ and African countries examined.

The *COVID-19* coefficient stood at -0.768. It is significant at the 1% level with a z-statistic of -4.0792. Similarly, the coefficient of currency devaluation interacted with oil price shock is negatively and significantly related to the current macroeconomic performance given the estimated coefficients of -1.101 and a z-value of -16.547. The negative coefficient is indicative of the adverse effect of the pandemic overriding the Ghanaian economy. Given a 1% rise in the number of deaths and infected persons taken together with the sharp drop in crude oil prices, national output dropped by 0.768%. This could have been reflected in the low prices of oil during the peak period of COVID-19. In all, the coefficients of oil price volatility shock and devaluation of the Ghanaian cedi are also both negative. These estimates are very much similar to those obtained for the GDP-lagged equation. Consequently, positive shocks to exchange rates of the cedi/US dollar and oil prices stimulated an increase in the drop in economic activities in Ghana which led to slow growth. This is in line with the theory that, past negative economic signals and performance tend to create a strong negative expectation effect in an economy, with the resultant impact of stimulating unfavorable outcomes.

Table 6. System results for Ghana

Variable	*National output (GDP) equation*		*Variable*	*National output (GDP(-1)) equation*	
	Coef.	*z-stat.*		*Coef.*	*z-stat.*
C	1.002	26.095	*C*	-1.075	12.657
EXCVD	-1.013	-43.005	*EXCVD*	-0.369	-14.034
OLCVOL	-0.409	-96.004	*OLCVOL*	-1.2091	-9.1256
*EXCVD * OLCVOL*	-1.101	-16.547	*EXCVD * OLCVOL*	-1.131	-50.230
COVID-19	-0.768	-4.0792	*COVID-19*	-0.357	-20.610
D.W.	2.035		*D.W.*	2.342	

Source: Authors' EViews output.

4.4. The Gambia

Consistent with previous results, the variance equation coefficients are significant, an indication of a strong volatility pattern and persistence in the Gambian economy, arising mainly from macroeconomic volatilities particularly, inflation volatility and exchange rate instability. The implication is that the Gambia economy is volatile rising from the dynamic causal relationship among oil price shocks, exchange rate devaluation, and inflation volatility. The estimates of the covariance coefficients of the BEKK are displayed in Table 7. The results of the BEKK parameter estimates, as in earlier results indicate strong evidence of shocks and volatility transmission spillovers in the Gambian economy. By implication money policy shocks, exchange rate depreciation, and inflation volatility combine to generate instabilities in the economy. Similar results are obtained for Nigeria, Sierra Leone, and Ghana. Results uphold the fact that these countries are bedeviled with macroeconomic volatilities driven by inflation volatility and exchange rate devaluations.

In the same vein, the economies tend to face similar monetary policy challenges, with similar monetary responses to curtail the inherent challenge, leading to similar monetary policy shocks. This is mainly because, apart from Botswana and South Africa, which are relatively diversified, the remaining African countries are highly undiversified, with huge dependence on the export of few primary commodities that are largely subjected to external vagaries/developments in the international market, leading to externally generated and transmitted shocks in these economies.

Table 7. Transformed variance coefficients (for Gambia)

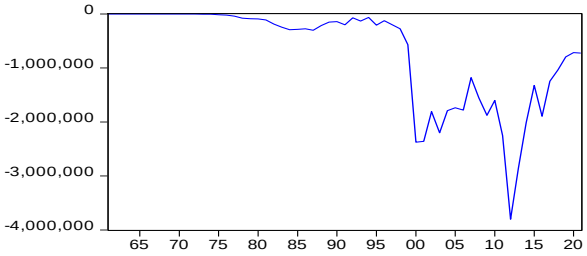
Variable	*Coefficients*	*z-stat.*	*Prob.*
M(1,1)	9.039	-40.148	0.0000
A1(1,1)	-562.045	20.307	0.0000
A1(2,2)	5880.916	10.305	0.0000
B1(1,1)	1.1993	-10.413	0.0000
B1(2,2)	0.841	121.686	0.0000

Source: Authors' EViews output.

The result of the system estimation shows that one lag of oil price, devaluation, and inflation volatility all had negative coefficients and these coefficients are significant; 1.4%, 0.35%, and 1.1% negative growth rates of the Gambian economy were made eminent by a 1% rise in the devaluation of the Gambian currency, volatility in oil prices, and volatility in the inflation rate, respectively. Accordingly, the response of the Libyan economy to shocks or impulses due to fluctuations in oil prices, inflation, and exchange rates is adversely strong. Invariably, oil prices and output and their fluctuations induced a decline in the rate of macroeconomic performance of the Gambian economy. Being a predominantly exporter of the primary product, oil, the outcome is expected as in the previous case of other WAMZ and African countries examined.

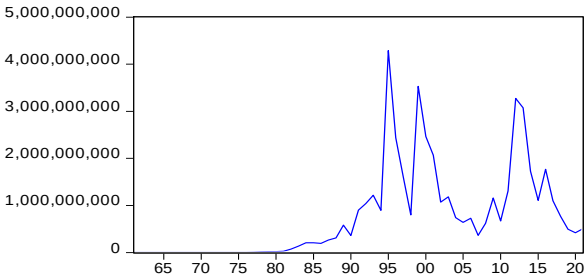
For the current GDP equation, the *COVID-19* coefficient (-0.1274) was significant at the 1% level given a z-value of -56.091. The negative coefficient implied the outbreak of the COVID-19 virus disrupted national output by 0.126% following a 1% increase in the number of deaths and infections of the virus. This could have been reflected in the low slow growth rate in Gambia during the peak period of COVID-19. The coefficient of currency devaluation, and global oil price were all negatively significant at the 1% level. The interactive effects of oil price shock and exchange rate devaluation are negatively and meaningfully related to the current macroeconomic performance given the estimated coefficients of -1.092 and a z-value of-42.289. A 1% devaluation-oil price shock triggered by the COVID-19 pandemic resulted in negative output growth rates by 1.1%. Consequently, positive shocks to oil prices in the international market and devaluation of the exchange rate of the Gambian currency stimulated a decline in the GDP growth rate. By implication variations in oil prices and exchange rates caused by the COVID-19 outbreak had strong negative effects on the macroeconomic performance in Gambia. The finding is consistent with extant theory and evidence that past negative signals in macroeconomic outcomes tend to create a strong negative expectation effect, generating slower prospects for macroeconomic performance.

Figure 10. Devaluation shock of the exchange rate in Gambia under COVID-19



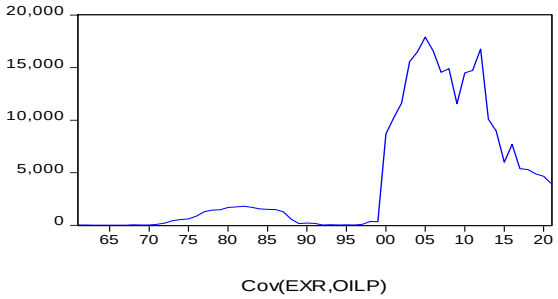
Source: Authors' EViews output.

Figure 11. Oil price volatility shock under COVID-19 (for Gambia)



Source: Authors' EViews output.

Figure 12. Covariance of oil price volatility shock and exchange rate devaluation under COVID-19 (for Gambia)



Source: Authors' EViews output.

Table 8. System results for Gambia

Variable	*National output (GDP) equation*		*Variable*	*National output (GDP(-1)) equation*	
	Coef.	*z-stat.*		*Coef.*	*z-stat.*
C	0.256	25.095	*C*	1.072	10.358
EXCVD	-1.445	-24.209	*EXCVD*	-1.011	-65.928
OLCVOL	-0.347	-33.394	*OILPVOL*	-0.257	-81.075
*EXCVD * OLCVOL*	-1.092	-42.289	*EXCVD * OILPRICE*	-1.145	-72.104
COVID-19	-0.1274	-56.091	*COVID-19*	-1.063	-10.243
D.W.	2.004		*D.W.*	2.640	

Source: Authors' EViews output.

4.5. Policy findings

In terms of policy findings, COVID-19 contagion further exacerbated the macroeconomic instability on the defenseless economies of WAMZ. Such macroeconomic imbalance was made manifest in shortage of food supply and higher consumer prices. For example, as of September 2020, Nigeria's CPI stood at 339.4 ("The economist intelligence", 2020). Compared to September 2019, the CPI increased by 13.71% which signifies a high inflation rate over the period. Presently, real estate in Nigeria is 22% more expensive than in other African countries such as Gabon, Ghana, Malaysia, Malawi, Zambia, Zimbabwe, Kenya, Tanzania and Libya, Botswana, Rwanda, and South Africa. In particular, the monthly rent for a three-bedroom apartment in a Nigerian city is 74% more expensive than in South Africa. In terms of salaries and financing, the average monthly net salary (after tax) in Nigeria is 467.90% lower than that of South Africa and 97.65% lower than that of Ghana. For example, the COVID-19-induced shutdown policy intended at restraining the pandemic had led to seven million Nigerians suffering from excessive hunger (United States Agency for International Development [USAID], 2020). As reported in the Food Assistance Fact Sheet for Nigeria by the United Nations (UN), an estimated 1.8 million Nigerians were chased out of their homes in Yobe and Adamawa states (Adeniran & Onyekwena, 2020; Nwagbara, 2020). This has amplified the call for humanitarian assistance to meet the daily food needs of all displaced persons in camps. The UN also reported that there is a risk of famine (IPC 5) that continues in regions that assistance actors cannot reach, meanwhile, the food scarcity in such areas is worse than the scarcity outcomes in nearby accessible zones.

5. CONCLUSION

The study evaluated the interactive impact of shocks from currency devaluation and oil price volatility shock on the macroeconomic performance of WAMZ economies during COVID-19 based on the BEKK-GARCH model analysis. The BEKK analysis shows that the WAMZ countries under study responded to shocks due to fluctuations in oil prices and currency devaluation as triggered by the COVID-19 outbreak. Oil price volatility shock and exchange rate devaluation are both negative and significant. The interactions of devaluations and global oil price shocks had strong decelerating effects on macroeconomic performance in WAMZ. Such decelerating effects strongly diminished the growth rate and hence, weakened the economies of WAMZ. By implication, COVID-19 induced exchange rate depreciation and oil price volatility shock combined to generate instabilities in the region. WAMZ countries are bedeviled with macroeconomic volatilities driven by COVID-19, volatility in global oil prices, and exchange rate devaluations.

In sum, we found that the devaluation-oil price shock caused by the COVID-19 outbreak led to a significant deceleration in the growth rate of national output in all countries. In other words, oil price instabilities and currency devaluation prompted by the COVID-19 outbreak had negative concerns on output in WAMZ economies. Our results validated the findings of Wu and Ma (2021), Adu et al. (2019), and Awan et al. (2021). Wu and Ma (2021) found that oil price variations triggered by COVID-19 had a negative consequence on inflation and economic growth. In their study, Adu et al. (2019) found significant variances in the response of real exchange rate to real oil price shock across WAMZ economies with the implication that WAMZ countries are structurally different, and asymmetric shocks with insufficient fine-tuning mechanisms pose a costly monetary union. Also, Awan et al. (2021) found that the COVID-19 outbreak caused significant volatility in crude oil prices and stock markets. The variance equations are significant for all countries, an indication of strong volatility transmission and spillover pattern in the economy arising mainly from macroeconomic volatilities, arising mainly from macroeconomic volatilities due to oil price shock, and devaluation shock. Consequently, the response of the four economies of WAMZ considered in this study to shocks is adversely robust. The WAMZ countries should diversify its economy to respond positively to any external shocks from oil price movements, volatile inflation rates, and devaluation. All WAMZ economies will be able to harness fully their revenue and then rely minimally on revenue from external sources. Also, the monetary authorities of WAMZ countries should look outward at how monetary policies in advanced countries are being conducted. This will enable replication in theirs to have sound monetary policies that could ensure stable macroeconomic variables. Considering the limited nature of our sample, further studies should implement a dynamic stochastic general equilibrium (DSGE) model to estimate weighted estimates of the interactive impact of currency devaluation and inflation volatility in an enormous sample of countries during the COVID-19 outbreak.

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