FOREIGN EXCHANGE RESERVES ACCUMULATION IN SELECTED COUNTRIES WITHIN A REGULATORY FRAMEWORK

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Abstract

Previous studies have reported mixed findings regarding the impact of variables such as gross domestic product (GDP), nominal exchange rate, oil markets, imports, foreign portfolio investment (FPI), and foreign direct investment (FDI) in the determination of reserve holdings. This study sought to evaluate the determinants of international reserves in emerging countries within a regulated macroeconomic framework using system generalized method of moments (S-GMM) method. The results reveal that currency devaluation and terms of trade shocks negatively affect reserve demand, with devaluation having an elastic effect and trade shocks being inelastic. The fixed exchange rate regime also had an unconditionally negative effect on the size of foreign reserves of oil-producing nations in sub-Saharan Africa (SSA). Governance and anti-corruption policies as measures of institutional quality in SSA had not been effective in attracting foreign capital inflows and possibly impacted the size of foreign reserves of those economies. Oil prices, however, had an elastic and positive effect on reserves. The positive impact of oil prices emphasized the importance of oil revenue in reserve accumulation. These research findings align with previous findings. The paper contributes to the dynamic causality between foreign reserve holdings and exchange rate devaluation, in addition to testing the law of proportionate effect, which seeks to find additional patterns to predict the level of countries' foreign currency reserves.

Keywords: Oil Prices, Size of International Reserve Holdings, Sub-Saharan Africa, Exchange Rate Devaluation, Institutional Variables, Corruption, Governance

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1. INTRODUCTION

Periods from the early 1990s until date have been characterized by a surge in the foreign exchange (FX) reserves of emerging market economies (Bank for International Settlement [BIS], 2019). These economies or nations have adopted such a rise in reserves with varied justifications for holding international or foreign reserves. Ehikioya et al. (2020) categorically state that the motive for reserves held by these countries is not just precautionary but a mercantilist motive (to drive export growth). Specifically, reserves are held for hedging against external shocks and other contingencies. However, the disadvantage of the time value of money comes into play for reserves, especially in economies characterized by hyperinflation and high exchange rate volatility. Furthermore, holding reserves comes with an opportunity cost, which is the public services that would have been created and enjoyed if reserves' resources were used up instead of being held (BIS, 2019). As expected, these reserves are dependent on certain factors peculiar to the countries or beyond them, but have a form of impact on the economic conditions of such countries.

Different authors have ascribed varying macroeconomic conditions as determinants of the level of international reserve holdings a country keeps. The central bank is in charge of these holdings and uses them in its regulatory functions, especially as capital control and response mechanisms when shocks arise from macroeconomic factors (Abdul-Rahaman & Yao, 2019). Some of the factors highlighted by previous literature include the gross domestic product (GDP), the nominal exchange rate (Bhakri & Verma, 2021), oil markets (Umoru et al., 2022), imports (Olomola & Ajayi, 2018), portfolio investments, and foreign direct investments (FDIs) (Jayathilaka et al., 2025; Fadol, 2022). Unfortunately, mixed findings have been recorded on the impact these factors have on international reserve holdings within the long and short-run periods. Also, most recent studies done for sub-Saharan Africa (SSA) countries neglected the role of institutional factors in reserve accumulation. This study thus seeks to provide empirical evidence on the effect of selected factors, including institutional variables, in driving or limiting the size of international reserves held by SSA countries using the most recent data available across ten countries that constitute a panel for statistical analysis.

SSA countries fall under the developing cadre and comprise oil- and non-oil-producing economies. Oil-producing nations have their economies affected by the volatility of oil prices, usually determined by the cartel, the Organization of the Petroleum Exporting Countries (OPEC). Low prices would mean a loss in budgeted revenue, while higher prices produce the opposite effect (Umoru et al., 2023). Additionally, Ehikioya et al. (2020) assert that beyond oil price fluctuations, nations in this region have also been negatively affected by exchange rate volatility, trade, and the suboptimal state of other macroeconomic variables that pose challenges to economic stability, growth, and development. SSA countries are also characterized by weak financial systems and the struggle of monetary authorities to stabilize exchange rates, making international reserve holdings an intervention tool used by the central or apex bank (Abdul-Rahaman & Yao, 2019).

In the resulting research questions (RQs):

RQ1: To what extent does exchange rate devaluation influence the demand for international reserve holdings in oil-producing countries of sub-Saharan Africa?

RQ2: What form of relationship exists between oil prices and the demand for international reserve holdings in oil-producing countries in sub-Saharan Africa?

RQ3: To what extent do previous levels of reserves (Gibrat's law) determine the current volume of reserve holdings in the oil-producing countries of sub-Saharan Africa?

RQ4: To what extent do terms of trade shocks predict the demand for international reserve holdings in oil-producing countries in sub-Saharan Africa?

In light of the RQs, we attempt to:

1) establish the influence of exchange rate devaluation on the demand for international reserve holdings in oil-producing countries of SSA;

2) determine the link between oil prices and the volume of international reserve holdings in oil-producing countries of SSA;

3) examine the effect of previous levels of reserves on reserve holdings in oil-producing countries of SSA;

4) determine the extent to which terms of trade shocks predict the demand for international reserve holdings in oil-producing countries of SSA.

We contributed to the regularities driving the size of official FX reserves. Its findings are relevant and useful to policymakers and governments of all countries covered by the study, as such countries are presently dealing with macroeconomics and economic policy matters regarding the volume or level of FX reserves. The findings of the research are significantly appealing, especially in the era of growing FX reserves and tumors on the international market, including the oil market. Also, the research findings are of immense benefit and significance both scientifically and practically to emerging countries, especially in the areas of reserve management, aligning reserve holdings, FDIs, and portfolio inflows. For example, the research highlighted the need for revenue from favorable changes in the prices of oil barrels to be channeled to financing re-investment in infrastructure and financing new capital projects to support the long-term reserve accumulation of countries in SSA. This study is also valuable to policymakers in the management of external reserves in the emerging countries of the SSA covered in this study. Accordingly, the paper contributes to the literature on dynamic causality between foreign reserve holdings and exchange rate devaluation, in addition to testing the law of proportionate effect, which seeks to find additional patterns to predict the level of a country's foreign currency reserves.

The structure of the research is ordered as follows. Section 2 reviews the existing and most recent literature, both theoretical and empirical. Section 3 discusses the methodology of the paper. Section 4 presents the results and Section 5 discusses them, while Section 6 concludes the paper.

2. LITERATURE REVIEW

Previous empirical studies regarding the effects of exchange rate devaluation on reserves can be reviewed as follows. Bindu et al. (2024) attributed

the growth of reserves in BRICS countries (Brazil, Russia, India, China, and South Africa) to financial development and remittances. The FX reserves in Nigeria depend on a number of factors, such as institutional changes in the economy, changing patterns of international trade, and structural shifts in production (Central Bank of Nigeria, n.d.). According to Kuncoro and Pardede (2024), the rebalancing measures had the optimal level of foreign reserve holding in terms of their opportunity cost in Indonesia. According to Céspedes and Chang (2024), during periods of financial stress, reserve accumulation is fundamentally determined by international liquidity. In Indonesia, Kuncoro (2024) found that stockpiling FX reserves and inflation are positively connected. Sreeram and Sayed (2023) found that foreign reserve accumulation in India was a function of FDI flows into the country and the increase in the broad money supply over a long period of time. In the short run, the vector error correction model (VECM) analysis reveals a very slow adjustment of international reserve holdings with respect to the aforementioned factors in India. Bhakri and Verma (2021) reported that the FX reserves in India were determined by debt, exports, FDI inflows, exchange rate, and exports. In Ethiopia, Gereziher and Nuru (2021) based their analysis on the autoregressive distributed lag (ARDL) model and found that reserve accumulation was substantially depressed by exchange rates and inflation in the short run, whereas the impact became considerably positive over the long period.

Recently, Umoru et al. (2023) reported significant asymmetric effects of exchange rate movements on the reserve holdings of African countries. By implication, Lee and Yoon (2020) proposed that the devaluation of the exchange rate will cause reserves to reduce as monetary authorities take from the 'pool' of foreign reserves to intervene in the forex market and salvage the negative economic shocks that will arise. According to Salan et al. (2023), the volume of reserve holding in Bangladesh is non-linearly determined by net foreign assets, total debt, net foreign assets, inflation, net domestic credit, net exports, FDI, and imports of goods and services, the official exchange rate, and personal remittances. Sreeram and Sayed (2023) found that in the long run, an upsurge in FDI inflows and a broad money supply are significant influencers of reserve accumulation in India, while in the short run, reserve accumulation is low in view of the same variables. According to Misztal (2021), the worth of China's foreign reserve holdings exceeded optimal values. The research conducted by Jena and Sethi (2021) and Ito and McCauley (2020) found a significant influence of the debt/GDP ratio, real rate of interest, inflation rate, per capita GDP, nominal exchange rate of currencies, current account balance, domestic private sector's share of GDP, and per capita GDP on international reserves. Czech and Niftiyev (2021) posited that falling oil prices trigger more deficits in the balance of payments of a country, which will in turn cause a significant decline in international reserve holdings either in the current period or periods. Andriyani et al. (2020) also established the significance of foreign debt, inflation rate, and exchange rate in the accumulation of reserves in Indonesia. Also, in Indonesia, Andriyani et al. (2020) found an insignificant impact of inflation on the accumulation of reserves and a significant negative role played by the nominal exchange rate. On the other hand, exports and external debts positively impacted the determination of reserves in Indonesia.

Bhakri and Verma (2021) examined a trade-related variable, exports, and its impact in determining the decision to stock up foreign reserves in India. Results revealed that a rise in exports would raise national income and cause the demand for international reserve holdings to rise. For Bhakri and Verma (2021), the position of local currencies relative to US dollars is a direct predictor of reserves in India after empirical analysis using log regression and two-stage least squares for time series that spanned from 1991 to 2017. In terms of the reserve-holding effect of other explanatory variables, Golder et al. (2020) asserted that there have been mixed findings as to whether the prices of crude oil influence a nation's economic decisions. While they support the significant influence of crude oil prices on macroeconomic indices, the nature of the influence is dependent on whether the country exports or imports oil. For oil-exporting nations, rising prices would increase revenue, but rather than pumping it into reserves, they argue that such revenue is usually used to finance investments and government expenditures for a closer-to-equilibrium budget deficit. In the same light, Oyeniran and Alamu (2020) used the ARDL methodology to ascertain the effect of imports, a component of terms of trade, in predicting foreign reserves in Nigeria from 2002 to 2016. They found that the demand for foreign reserve holdings did not respond significantly to shocks in import statistics. While previous studies used a component of terms of trade, Sanusi et al. (2019) provided evidence of the long- and short-run effects of imports and exports on the demand for FX reserves using 26-year time series data for several countries in Southern Africa. Results were significant at the 5% level, affirming significant predictive abilities of trade on demand for reserves in African nations. Dakhlallah (2019) also found that there is a weak link between the balance of trade and reserve holdings in the short run, after providing explanatory results from least squares and the VECM model. However, the narrative changes in the long run as the balance of trade is found to influence the demand for international reserve holdings significantly.

Sanusi et al. (2019), in a panel study of countries in Southern Africa, used the ARDL approach to identify the effect that exchange rates exert on the volume of reserves. They find that the impact of falling exchange rates on reserve holdings occurs only in the long run. Short-run dynamics establish that the volume of reserves is unaffected by such a downward turn in currency value. In addition, Sanusi et al. (2019) reported that FX reserve holdings were significantly positively determined by imports, the inflation rate, and exports, while imports negatively contributed to the volume of external reserve holdings in the long run. In the Middle East, the discoveries of Dakhlallah (2019) were consistent with those of Sanusi et al. (2019), though the VECM was employed rather than an ARDL. The Lebanese study showed that changes in the exchange rate would not have a significant effect on international reserve holdings in the short run. However, international reserve holdings would be altered in

the long run and move gradually to stability at a rate as measured by the error term. Bošnjak et al. (2019) reported that the elasticity of foreign reserves to changes in their determinants is higher, and at the 7th decile of reserve holdings, the elasticity of foreign reserves concerning exchange rates dies out. Relatively, by implementing the generalized least squares (GLS) estimator on the Koyck lag transformation. Ali et al. (2018) reported that the adequate value of foreign reserves is a prerequisite for the stabilization of developing economies. Benecka and Komarek (2018) reported that lack of financial growth is the major factor responsible for the decrease in foreign reserves.

In sum, the major gap identifiable in the reviewed literature can be explained thusly. The empirical section contains works that examined the impact of exchange rates, devaluation, portfolio investments, terms of trade shocks, and oil prices on international reserve holdings. Furthermore, there is weak evidence on the impact of portfolio investments and terms of trade shocks on the demand for reserve holdings, with minimal empirical work found. Most works related to portfolio investments either examined their impact on other measures of economic growth or investigated other macroeconomic indicators to which these investments respond. Concerning terms of trade shocks, existing literature was found to focus on the effect of components of trade in reserve holdings. These formed the gaps in the literature that we sought to fill using the generalized methods of moments (GMM) across panel data from selected SSA countries. Hence, we hypothesize the following:

H1: Exchange rate devaluation does not influence the size of international reserve holdings in oil-producing countries of sub-Saharan Africa.

H2: Oil price does not affect the demand for international reserve holdings in oil-producing countries of sub-Saharan Africa.

H3: Previous levels of reserves do not affect the demand for international reserve holdings in oil-producing countries of sub-Saharan Africa.

H4: Terms of trade shocks have no predictive power on the demand for international reserve holdings in oil-producing countries of sub-Saharan Africa.

3. RESEARCH METHODOLOGY

The data for this study were sourced from the World Bank and International Monetary Fund (IMF) databases. Foreign reserve holdings were calculated as total convertible FX plus special drawing rights (SDRs) in US dollars, excluding gold holdings. The international reserves are held in US dollars (IMF, 2013). The exchange rate devaluation was calculated as the change in units of each country's local currency per US dollar. For example, Kwanza (AOA)/dollar exchange rate, Naira (NGN)/dollar exchange rate, CFA/dollar exchange rate, Gabon CFA/dollar exchange rate, XOF/dollar exchange rate, Cedi (GHS)/dollar exchange rate, Congolese Franc (CDF)/dollar exchange rate, Sudanese Pound (SDG)/ dollar exchange rate, and Cameroon Franc/dollar exchange rate from the immediate past period to the present day period. Oil prices were represented by global OPEC oil prices per barrel, while terms of trade shocks were derived as residuals of TOT_t regressed on TOT_{t-1}. Money supply represented total money in circulation, including savings and time deposits; international reserve holdings are thus expected to be a given percentage of the money in circulation, and the short-term deposit interest rate was used as a proxy for the cost of holding reserves.

The two forms of exchange rate regime (ERR) — the fixed exchange rate regime (FERR) and the flexible exchange rate regime (FLERR) — were defined by using the de facto ERR categorization offered by Couharde and Grekou (2021) to sort the ERR data. The classification is supported by empirical evidence because it is consistent with the two most widely used classifications, Levy-Yeyati and Sturzenegger's (LYS) and Ilzetzki, Reinhart, and Rogo's (IRR) (Levy-Yeyati & Sturzenegger, 2016; Ilzetzki et al., 2019). As a result, it can overcome the divergence that has distorted earlier empirical studies because of their lack of reliability. Also, by offering a uniform structure of cataloging, it covers a wider range of exchange systems in addition to offering greater coverage. As a result, we combine the intermediate and floating ERRs into a flexible *ERR* and collapse it into a two-way categorization. We next created a dummy variable from this two-regime classification that is equal to 0 otherwise and 1 if the nation operates a *FERR* in year *t*.

$$ERR = i\begin{cases} i = 1, if\ SSA\ country\ j\ operates\ fixed\ ERR\ in\ period\ t \\ i = 0, if\ SSA\ country\ j\ operates\ flexible\ ERR\ in\ period\ t \end{cases} \quad (1)$$

It has been demonstrated empirically that the dummy variable modeling approach works well with panel data (Ilzetzki et al., 2022). Accordingly, a negative *ERR* coefficient denotes a negative effect of *FERR*, whilst a positive coefficient denotes a favorable effect of *FLERR*. Additionally, we account for institutional quality by taking into account a corruption index and a democracy measure that is derived from the quality of government (QOG) core dataset and world governance indices. While the degree of democracy was ranked from least to most democratic, corruption was ranked using a political corruption index that went from less to more corrupt. The rationale behind including the institutional variable was supported by the argument that sound economic policies and governmental stability both have an impact on international investors' decisions to invest in a nation.

The methodology adopted in this study was informed by the specific objectives of the research. The methodology of dynamic panel GMM was utilized just as recently deployed in a study of target capital by Iyoha et al. (2022). The study had to limit the number of years because the criterion for GMM is that the number of cross sections (in this study, 10 countries) has to be greater than the number of periods (the maximum was thus nine years). The 10 countries examined are Nigeria, Ghana, Cameroun, Sudan, Angola, Gabon, Mauritania, Congo, Equatorial Guinea, Cote d'Ivoire. Taking after Bhakri and Verma (2021), the study is anchored on the "reserve drainer approach" in determining the level of volume reserves to be held at a given point in time. This theory highlights trade, debt, and money supply as crucial indicators for determining optimal reserves level, see Eq. (2).

$$ARH = IRH/(M + SD + T) \quad (2)$$

where, ARH = adequate reserve holdings, M = money supply, and related indices, SD = debt; and T = trade (imports and exports). M influences liquidity and monetary policy, directly impacting reserve adequacy as noted in the reserve drainer approach. According to Benigno et al. (2022), SD is included because significant external liabilities limit the accumulation of reserves, indicating financial vulnerability. In line with Cezar and Monnet (2023), T, which includes imports and exports, influences reserve dynamics by resolving trade imbalances and guaranteeing sustainability. According to earlier research, exchange rate devaluation is crucial because it affects trade balances, the cost of imports, and the service of foreign debt. These variables provide a thorough understanding of monetary policy, external vulnerability, and macroeconomic stability, guaranteeing a solid model that captures the complex dynamics of reserve sufficiency and reactions to exchange rate devaluation. In line with the reserve drainer approach, in addition to the several theories on what macroeconomic factors influence FX reserves (Frenkel & Jovanovic, 1981; Kashif et al., 2017; Wang, 2019), the buffer stock model, due mainly to Frenkel and Jovanovic (1981), upholds that foreign reserves are buffer stocks.

According to Lee and Yoon (2020), reserve holding is a precautionary indemnity against declining reserve balances. International reserve holdings are desirous of a determination to adjust money market disequilibrium (Coulibaly et al., 2024). Largely, demand for foreign reserve holding has been necessitated on grounds of shock absorber against trade losses, exchange rate sustenance, and mitigating impulsive and unforeseen capital contingencies (Coulibaly et al., 2024). This study focused on specific factors raised in theory, namely, trade including terms of trade shocks, oil prices, ERR, exchange rate movements, and institutional variables, as determinants of the size of foreign reserves held by selected SSA countries. This forms the basis of our dynamic panel data model analysis based on the specification of the system GMM (SGMM) as given in Eq. (3):

$$\ln irh_{it} = \beta_0 + \beta_1 exd_{it} + \beta_2 \ln olp_{it} + \beta_3 \ln irh_{(it-1)} + \beta_4 \ln err_{it} + \beta_5 \ln crr_{it} + \beta_6 \ln dec_{it} + \beta_7 \ln msg_{it} + \beta_8 \varepsilon(tot)_{it} + \beta_9 \ln str_{it} + \gamma_i + \upsilon_t + e_{it} \quad (3)$$

where, irh is international reserves holdings, exd is exchange rate devaluation; opl is oil prices; $\varepsilon(tot)$ is terms of trade shocks; err is exchange rate regime, crr is corruption index, dec is the level of democracy, msg is the growth of broad money supply, str is the short-term interest rate, β_1–β_9 are coefficients of endogenous variables; e_{it} is the standard error of the model. Note that γ_i is the i^{th} country-specific effect, υ_t is the time effect, $i = 1,2,3,\dots,N$, $t = 1,2,3,\dots,T$. Eq. (3) has a lagged dependent variable and numerous predictors. It cannot be devoid of the bias component that is associated with dynamic panel data models as discovered by Baltagi (2021). Accordingly, we identify the individual-specific effect model as in Eq. (4):

$$\ln irh_{it} = \partial_1 + \partial_2 \ln irh_{it-1} + \partial_3 \ln X'_{it} + \gamma_i + e_{it} \quad (4)$$

where, X'_{it} is a vector of explanatory variables, namely, exd, opl, $\varepsilon(tot)$, err, crr, dec, msg, and str. In view of the bias component defined by $Cov(\gamma_i, \ln irh_{it-1}) \neq 0$, Eq. (4) can be re-specified as in Eq. (5).

$$\ln irh_{it-1} = \partial_1 + \partial_2 \ln irh_{it-2} + \partial_3 \ln X'_{it-1} + \gamma_i + e_{it-1} \quad (5)$$

According to Eq. (4), $\ln irh_{it}$ is a function of γ_i, it thus signifies that $\ln irh_{it-1}$ is also a function of γ_i as specified in Eq. (5). In effect, $\ln irh_{it-1}$ is correlated with the error component given as $\gamma_i + e_{it}$. So, even when taking into account data from many countries, the coefficient estimate for the lagged dependent variable is susceptible to downward bias when working with a small number of time series periods, leading to biased and inconsistent estimates. Accordingly, we have the following model specifications given in Eq. (6) in accordance with the methodology and specification advanced by Chillotti et al. (2020), and Arellano and Bond (1991):

$$\ln irh_{it} - \ln irh_{it-1} = \varphi'(\ln irh_{it-1} - \ln irh_{it-2}) + \delta'(\ln X'_{it} - \ln X'_{it-1}) + (e_{it} - e_{it-1})$$
$$\Delta \ln irh_{it} = \varphi' \Delta \ln irh_{it-1} + \delta' \Delta \ln X'_{it} + \Delta e_{it} \quad (6)$$

Despite the fact that the specific effect (γ_i) is eliminated by the aforementioned requirements, the GMM dynamic panel estimator employs the following moment conditions since the error components are linked and the explanatory variables have endogeneity bias, which GMM handles:

$$E[\ln irh_{i,t-q}\,(e_{it} - e_{it-1})] = 0 \forall q \geq 2;\ t = 3,\dots,T \quad (7)$$

$$E[\ln X_{i,t-q}\,(e_{it} - e_{it-1})] = 0 \forall q \geq 2;\ t = 3,\dots,T \quad (8)$$

With the use of moment equations derived from lagged levels of $\ln irh_{it}$ and the errors acquired via first differencing, we were able to address the problem of the lagged endogenous variable in our estimations. The difference GMM estimator, a two-step estimator, as proposed by Chillotti et al. (2020) uses the moment conditions provided in Eqs. (7) and (8). Consequently, the GMM estimator uses all lagged levels as

mathematical instruments and first-differencing to remove the country-specific effect. We applied the system GMM (SGMM) estimator, which was offered by Susilo et al. (2020), because the two-step estimator is downwardly biased when used for small-sample time observations, as in our case. The orthogonality of the lagged differences of the foreign reserves to the error terms involves extra moment constraints based on the studies of Behr (2003). Eqs. (9) and (10) further capture these conditions:

$$E[(ln\, irh_{i,t-q} - ln\, irh_{i,t-q-1})(\gamma_i + e_{it})] = 0 \forall q = 1 \tag{9}$$

$$E[(ln\, X_{i,t-q} - ln\, X_{i,t-q-1})(\gamma_i + e_{it})] = 0 \forall q = 1 \tag{10}$$

The SGMM solves the problems of endogeneity and weak instruments by using first differences with level regression and lagged first differences as instrumental variables, which increases efficiency. The statistical reliability of the instruments utilized in the model was examined using the Sargan test of over-identifying boundaries. Acceptance of underlying null hypothesis is an indication that the instruments are valid, and the model is correctly specified. Additionally, for residual serial correlation, we ran the Arellano-Bond (A-B) test for both first and second orders, or AR1 and AR2, respectively. The absence of autocorrelation is confirmed by the acceptance of the null hypothesis that underlies the second-order serial correlation AR2 test. For the GMM estimator to be consistent, serial correlation must not exist. The consistency of the GMM estimator depends on serial correlation being absent.

The Durbin-Wu-Hausman (DWH) test was also conducted as an augmented regression test for endogeneity. The system GMM estimator has been shown to improve the accuracy of estimating the effects of country growth in studies by Blundell and Bond (1998). The methodology of Toda and Yamamoto (T-Y) was implemented in this study in order to ascertain the dynamic causality between foreign reserves and currency devaluation. The T-Y method estimates an augmented vector autoregression (VAR) $k + dmax$, which generates an asymptotic Wald statistic in line with the Chi-square distribution. The short-run causality relationship between reserve holding and all explanatory variables was conducted based on the application of Toda and Yamamoto (1995), and this is a test of how much a current variable W_t is explained by the history (W_{t-1}). The T-Y causality system of two equations is specified as follows:

$$\begin{aligned} W_t &= \mu_0 + \sum_{i=1}^{p} \mu_i W_{t-i} + \sum_{i=p+1}^{p+dmax} \mu_i W_{t-i} + \sum_{i=1}^{p} \beta_i Z_{t-i} + \sum_{i=p+1}^{p+dmax} \beta_i Z_{t-i} + \upsilon_{1t} \\ Z_t &= \lambda_0 + \sum_{i=1}^{p} \lambda_i Z_{t-i} + \sum_{i=p+1}^{p+dmax} \lambda_i Z_{t-i} + \sum_{i=1}^{p} \vartheta_i W_{t-i} + \sum_{i=p+1}^{p+dmax} \vartheta_i W_{t-i} + \upsilon_{2t} \end{aligned} \tag{11}$$

The first was to calculate the highest order of integration, denoted by $dmax$, using the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. The KPSS is a superior test to augmented Dickey-Fuller (ADF) for non-stationary variables because the ADF test in the face of structural breaks within the sample period becomes weak. The second was to calculate the optimum lag length, and finally, we performed the T-Y causality test based on augmented var $k + dmax$, where k is the optimum lag length and $dmax$ is the max order of integration. Also, we tested for endogeneity. The problem of endogeneity arises from three different sources, namely, omitted variable bias, measurement errors in the dependent variable, and simultaneity, respectively (Fukushi et al., 2024). Going forward, we initially had to ascertain whether or not our predictor variables were endogenous by conducting the DWH test. The DWH test is a particularly augmented regression test for endogeneity. The data series spanned from January 1, 2016, to December 31, 2024.

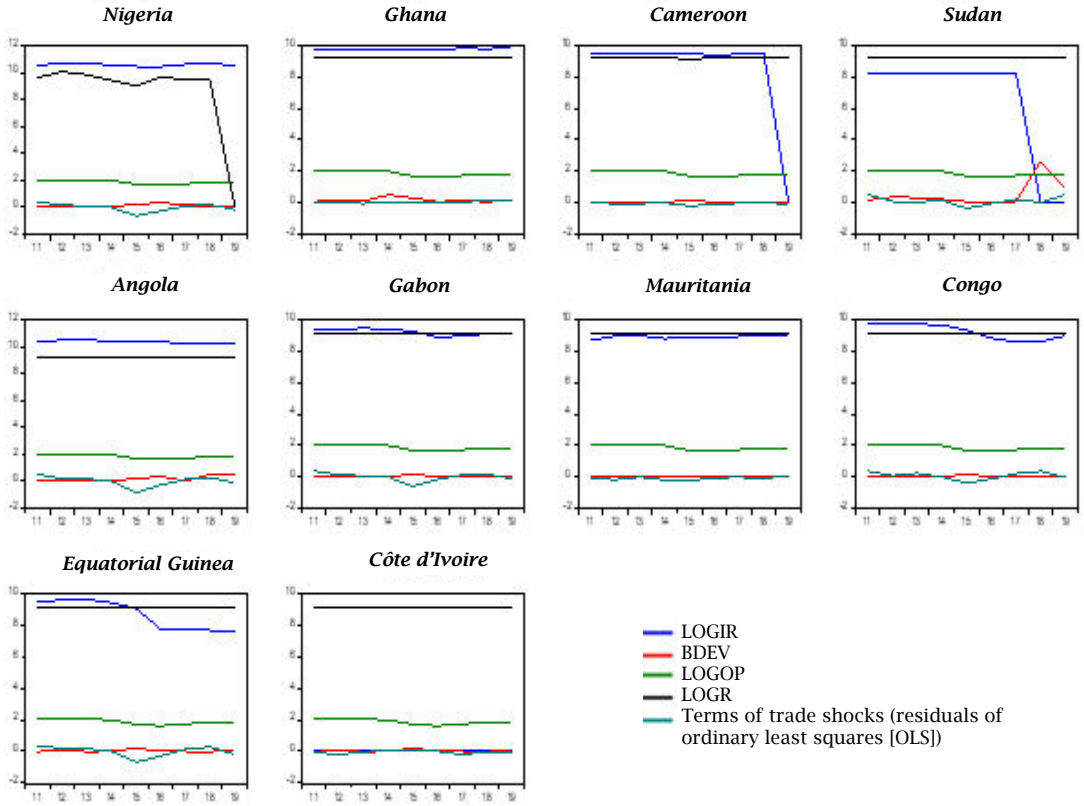
4. RESULTS

Figure 1 below shows the declining drive of the outcome variable and significant predictors in the individual cross-sections. All variables plotted to move along the same path, confirming the positive role of oil prices, institutional quality, ERR, money supply, devaluation, and terms of trade on the size of international reserves holdings.

Given that the study uses unbalanced panel data, the results of Fisher-type tests and Im, Pesaran, and Shin (IPS) tests are used, as these tests consider unbalanced panels, unlike others that assume balanced panels. Only terms of trade shocks and oil prices were stationary at this level. Others had to be subjected to first differencing.

From Table 2, the panel co-integration test allowed for heterogeneous variances across cross sections for each period for long-run testing in the panel while taking into consideration the varied short-run dynamics among groups. The output revealed that there is no evidence of co-integration with p of critical values greater than 5%. In other words, long-term relationships do not exist among the variables.

Figure 1. Plots of variables for studied countries in the panel



Source: Authors' estimation with Eviews 13.0.

Table 1. Unit root test results

Variable	*Levin, Shin, and Chu (LLC) t-statistic*	*Breitung t-statistic*	*IPS W-statistic*	*Phillips–Perron (PP)-Fisher Chi-square*
$ln\,irh$	-4.88306***	1.37394	-6.20046***	22.6749***
$d(ln\,irh)$	-4.29939***	1.61259	-1.65092	37.2033**
$ln\,olp$	-8.8827*	4.16347	-0.4411	3.68121**
$d(ln\,olp)$	-10.18793*	6.91835*	-2.3094	7.2469*
$ln\,err$	-1.3287	0.13689	-0.32879	4.58961***
$d(ln\,err)$	-3.4894**	0.38093	-2.38948**	10.32897**
$ln\,crr$	-1.33967	2.10557	-3.38917	4.32941**
$d(ln\,crr)$	-5.2893***	2.48719**	-3.28095**	3.27959**
$ln\,dem$	-1.32093	0.80926	-1.20037	2.39849
$d(ln\,dem)$	-9.26757***	2.38935**	-4.28921***	-6.14562***
$ln\,msg$	-9.4796***	0.24468	-0.72890***	53.4711
$d(ln\,msg)$	-40.7172***	0.21456	-4.67610***	60.553**
$ln\,str$	-4.5623*	0.19342	-2.34783*	20.37824
$d(ln\,str)$	-21.3781***	-1.37656	-9.37522*	34.5784***
exd	-7.4838***	-1.21230	-1.38133	61.4747
$d(exd)$	-13.7720***	2.29296*	-0.55786***	71.5208***
$\varepsilon(tot)$	-5.5584***	-0.81430	0.30137	25.6003***

*Note: ***, ** significant at 1%, 5% levels.*
Source: Estimation with Eviews 13.0.

Table 2. Panel co-integration test results

Test methods	*Statistic(s)*	*Weighted statistic(s)*	*Group statistic(s)*	*Statistic(s)*
Panel v-statistic	1.18205**	-1.42098	Group rho-statistic	2.80242***
Panel rho-statistic	2.1754***	1.55712**	Group PP-statistic	-1.30929**
Panel PP-statistic	3.09216***	-1.21835**	Group ADF-statistic	2.07034***

*Note: ***, ** indicates significance at 5% and 10% levels of significance.*
Source: Authors' estimation with Eviews 13.0.

The T-Y Granger (G)-causality test results are reported in Table 3 below. The optimal lag length chosen by information criteria (Schwarz criterion [SC], final predict error [FPE], Akaike information criterion [AIC]) is 2 (VAR $k = 2$) under the lag order selection that preceded the VAR estimation plus

maximum order of integration 2 ($dmax = 1$) as validated by the KPSS test of a null of stationary series equals 3 (VAR $k + dmax = 3$). Hence, we had T-Y Eviews specification of exogenous variables given by $log(irh\ _{t-3}), exd_{t-3}, msg_{t-3}, \varepsilon(tot)_{t-3}, gdp_{t-3}, str_{t-3}, c$. This yielded the T-Y causality test results, whereby exchange rate devaluation G-causes reserve holdings by the significance of the Chi-square statistic, just as devaluation G-causes reserves under the significance of exd as reported by a significant Chi-square value of 120.8. The same analysis holds for reserves and global oil prices, money in circulation, terms of trade shocks, growth of national income, and short-term interest rate, respectively. In effect, there is bi-directional causality between reserve holdings and explanatory variables.

Table 3. Toda-Yamamoto causality test results

Excluded	*Chi-square*	*df*	*Prob.*
$ln\,irh$			
exd	120.7666	2	0.000
exd			
$ln\,irh$	14.38947	2	0.682
$ln\,irh$			
$ln\,olp$	59.25380	2	0.000
$ln\,olp$			
$ln\,irh$	43.09897	2	0.000
$ln\,irh$			
$ln\,msg$	92.43670	2	0.000
$ln\,msg$			
$ln\,irh$	75.23504	2	0.000
$ln\,irh$			
$ln\,crr$	109.464	2	0.000
$ln\,crr$			
$ln\,irh$	122.357	2	0.000
$ln\,irh$			
$ln\,dem$	50.85097	2	0.000
$ln\,dem$			
$ln\,irh$	68.1785	2	0.000
$ln\,irh$			
$ln\,str$	81.65981	2	0.000
$ln\,str$			
$ln\,irh$	34.58674	2	0.000
$ln\,irh$			
$\varepsilon(tot)$	69.58612	2	0.000
$\varepsilon(tot)$			
$ln\,irh$	90.43658	2	0.000
$ln\,irh$			
$ln\,irh_{t-1}$	45.67309	2	0.000
$ln\,irh_{t-1}$			
$ln\,irh$	71.23940	2	0.000

Source: Authors' estimation with Eviews 13.0.

On correlated random effects, the study deployed Hausman's test to ascertain the random efficiency of the random effect equation. Table 4 presents the test results with a p-value of the Chi statistic of 0.0001 ($p < 0.05$). In regular panel regression, fixed effects panel regression would be suited for the dataset, given the significance of the Chi-square statistic.

Table 4. Hausman test results

Test	*Chi-square statistic*	*df*	*Prob.*
Cross-section random	11.268968	8	0.0001

Source: Authors' estimation with Eviews 13.0.

The DWH test results are reported in Table 5. With this test, we estimated a first-stage regression of the volume of reserves (the dependent variable) on the independent variables. In the second stage of regression, we deleted the dependent variable and regressed the endogenous regressor on the remaining regressors. Here, we generated residuals of the endogenous regressor and included the same in the original regression model of stage one and estimated. Thereafter, we conducted the Wald coefficient restriction test on the coefficient of the residuals of the endogenous regressor. The p-value of the Chi-square statistic was below 0.05; endogeneity was established for such an endogenous regressor, while a p-value exceeding 0.05 suggests the absence of an endogeneity problem.

Table 5. Durbin-Wu-Hausman test results for endogeneity

Test summary	*Value*	*df*	*Prob.*
$C(1) \times ln\,res\_exd$			
t-statistic	20.78891	3,265	0.0921
F-statistic	369.6967	(1,3,265)	0.0678
Chi-square	238.7952	1	0.2346
$C(2) \times ln\,res\_olp$			
t-statistic	123.7436	3,265	0.4356
F-statistic	912.4250	(1,3,265)	0.1234
Chi-square	765.3093	1	0.7659
$C(3) \times ln\,res\_err$			
t-statistic	167.3809	3,265	0.4874
F-statistic	568.2092	(1,3,265)	0.2235
Chi-square	673.4022	1	0.4672
$C(4) \times ln\,res\_crr$			
t-statistic	134.1956	3,265	0.5849
F-statistic	679.3094	(1,3,265)	0.6752
Chi-square	500.6233	1	0.3562
$C(5) \times ln\,res\_msg$			
t-statistic	62.7852	3,265	0.1345
F-statistic	234.7680	(1,126)	0.5902
Chi-square	219.3520	1	0.3576
$C(6) \times ln\,res\_\varepsilon(tot)$			
t-statistic	45.6987	3,265	0.7820
F-statistic	179.5634	(1,3,265)	0.1678
Chi-square	123.489	1	0.0630
$C(7) \times ln\,res\_gdp$			
t-statistic	67.90832	3,265	0.1278
F-statistic	250.7356	(1,3,265)	0.57901
Chi-square	200.5895	1	0.3256
$C(8) \times ln\,res\_str$			
t-statistic	36.5470	3,265	0.1650
F-statistic	220.41567	(1,3,265)	0.0964
Chi-square	165.67096	1	0.0123

Note: Restrictions are linear in coefficients.
Source: Authors' estimation with Eviews 13.0.

Table 6 presents results for panel difference GMM and system GMM estimation, respectively. The purpose of the different estimation methods was to compare and contrast results and to guarantee better estimates that could stand the test of time. A discussion of estimated results with different methods is done below.

Table 6. Panel and system generalized method of moments regression results

Variables	*Panel difference GMM*			*System GMM*		
	Coefficient	*p-value*	*Significance*	*Coefficient*	*p-value*	*Significance*
$ln\,irh_{t-1}$	0.437	0.002	***	0.156	0.000	***
exd	-0.568	0.006	***	-0.600	0.005	***
$ln\,olp$	0.132	0.256	-	0.151	0.007	***
$ln\,err$	-0.004	0.000	***	-0.006	0.000	***
$ln\,crr$	-0.015	0.036	***	-0.012	0.000	***
$ln\,dem$	-0.019	0.000	***	-0.145	0.002	***
$\varepsilon(tot)$	-0.064	0.050	***	-0.096	0.003	***
$ln\,msg$	0.048	0.173	-	0.057	0.000	***
$ln\,str$	-1.015	-0.002	***	0.003		***
Hansen J-statistic	0.2910	0.8345	-	1.2E-33	0.8339	-
Sargan	1.2456	0.6832	-	1.8169	0.8729	***
Instruments		17			39	
F-statistic (p)	109.07	0.000	***	1893.489	0.000	***

Source: Authors' estimation with Eviews 13.0.

The A-B serial correlation test as a diagnostic test for GMM revealed that errors in the model are serially uncorrelated of order 1 ($p = 0.1783 > 0.05$ and $0.7569 > 0.5$), as shown in Table 7 below. In effect, p-values of the A-B statistics show acceptance of the null hypothesis of the non-existence of first- and second-order serial correlation in the study model.

Table 7. Arellano-Bond serial correlation test results

Test order	*m-statistic*	*Prob.*
AR(1)	-1.346638	0.1783
AR(2)	0.293013	0.7569

Source: Authors' estimation with Eviews 13.0.

5. DISCUSSION

The system GMM evaluates the validity of model instruments using Sargan and the Hansen J-statistics, as opposed to OLS, which employs R-statistic for model reliability. The Hansen J-statistic of 0.29, with a p-value given by $0.8339 > 0.05$ confirms the validity of the GMM model, showing that over-identifying restrictions are satisfied. In addition, a Sargan test with a high p-value of 0.8729 suggests that the instruments were valid because it does not rule out the null claim that the instruments are exogenous and uncorrelated with the error term. In essence, there was not much of a violation of the over-identifying constraints. The variables in the GMM models are co-integrated. At the 5% significance level, Table 7 demonstrates that terms of trade, oil prices, and exchange rate devaluation are important factors influencing foreign reserve holdings. With a coefficient of -0.600 in the system GMM model, exchange rate devaluation has a negative effect; 1% devaluation causes reserve holdings to decrease by 1.6%. This compares favorably with the difference panel model where the estimated coefficient of exchange rate depreciation is given by -0.568. In all, devaluation significantly reduces reserves. This corresponds with Lee and Yoon (2020), and Caporale et al. (2017), who claim that emerging economies employ debt to manage devaluation without impacting reserves. The research results also support those of Olomola and Ajayi (2018), who applied the ARDL methodology to a panel of West African countries and provided evidence that exchange rate devaluation, which is the most common form of movement in West African nations, is a significant predictor of international reserve holdings. The finding underscores the elastic interaction between foreign reserves and currency devaluation especially in nations where the need for foreign reserves to stabilize the local currency rises as a result of currency depreciation. Umoru et al. (2022) back this position, pointing out that low reserves brought on by speculative activity and declining oil prices worsen the consequences of devaluation by devaluing the currency and causing inflation.

Across the GMM models, oil prices have a considerable and positive impact on reserves. Specifically, elastic and significant positive effects on reserves are indicated by oil price coefficients. With a coefficient of 0.151 for oil prices, the FX reserves of oil-producing SSA nations were directly impacted, suggesting that a 1.5% increase in demand for reserve holdings is linked to a percentage change in oil prices. This estimate compares favorably with the difference coefficient of 0.132. The result further suggests the importance of oil revenue for reserve accumulation in oil-exporting nations. Higher oil prices help oil-exporting countries build up reserves by boosting export earnings. This is in line with projections since rising oil prices allow these nations to expand their output and exports, increasing their oil export revenues. The outcome of this research on oil prices negates the results obtained by Olayungbo (2019), who showed that oil prices do not Granger-cause reserves in Nigeria.

Additionally, for every 1% rise in terms of trade shocks, reserves decline by 0.096%. This suggests that shocks to terms of trade have a large negative impact on the reserves of SSA countries in our sample. Although substantial in both models, terms of trade shocks have had a considerable adverse inelastic impact on international reserves. According to the latter, reserve demand is decreased by adverse trade shocks. At the 1% significance level, it was also revealed that the lagged (1 period-lag) international reserve holdings (0.437) were significant in explaining current international reserve holdings, indicating persistence in the variable. Because the autoregressive term coefficient in the fixed effects model (0.979) is higher than that of the difference GMM, the system GMM performs better than the difference GMM. This implies that the downward bias in the difference GMM is lessened by the system GMM. In both GMM estimators, the lagged value of reserves is positive and substantial. The system GMM shows a larger influence. This demonstrates how reserve demand is persistent and how historical reserve levels have a significant impact on current reserve accumulation.

The negative and significant coefficients of -0.012 and -0.145 estimated coefficients for the corruption index and democratic governance

suggests that SSA's significant depletion of FX reserves is linked to the prevalence of weak institutional quality and deplorable governance. This suggests that SSA's governance and anti-corruption initiatives have not been successful in drawing in foreign capital, and that could have boosted the size of FX reserves accumulated by these countries. This is also explained by the fact that most governments engage in fiscal irresponsibility, which leads to debt accumulation. The outcome of our research partly supports the findings of Law et al. (2021) who applied the two-step system GMM in their study and discovered that while enhancing institutional quality initially caused countries to hold more reserves, after a certain threshold was reached, the effect turns negative side, and the countries had fewer reserves.

The SGMM results show a negative coefficient of the ERR of -0.006, which indicates that the FERR has an unconditionally hostile impact on the level of foreign reserves in African oil-producing countries, as indicated by a negative coefficient of the ERR of -0.006. This suggests that the floating or intermediate ERRs are less detrimental to foreign currency reserves than the FERR. According to Gnimassoun et al. (2024), the research findings corroborate the strong detrimental impact that the FERR has on the size of the industrial sector. The authors found that an industrial cost associated with the FERR negatively and significantly reduces the manufacturing sector of a panel of 146 countries. Their research findings extended to the fact that fixed ERR exacerbated constraints in developing countries, keeping countries with low productivity growth in a state of structural reliance on imports of finished products to the disadvantage of the emergence of a strong indigenous industrial sector. The findings also substantiate Obstfeld et al.'s (2019) view that emerging market countries under the FERR are left with little financial space but limited ability to respond and that the exchange rate's fixity acts as an import subvention. The results of our study differ from those of Gereziher and Nuru (2021), who estimated the ARDL model and reported that Ethiopia has a controlled floating ERR in which a weakening of the exchange rate increases foreign reserves.

Our research's findings conflict with Faudot and Nenovsky's (2022) findings regarding the FERR's trade-stimulating effect. As central banks had to take an active role in the market to uphold the pegged exchange rate, the banks frequently needed large reserves to buy or sell currency when market forces pushed the exchange rate away from the target level. Our findings support the idea that obsession with fixed exchange rates hurts SSA countries by increasing demand for foreign reserves. In order to protect the fixed exchange rate, central banks are forced to spend their available foreign reserves to purchase domestic currency, putting burdens on the majority of African currencies. Nigeria, for instance, has been depleting its FX reserves and is under pressure to cut back on costly fuel subsidies. Unfortunately, the majority of SSA countries have had a persistent lack of external reserves and were compelled to devalue their currencies significantly between 2019 and 2024. Most countries of Africa were forced to default on their external and domestic debt repayment commitments during the coronavirus health crisis because they were unable to supply adequate foreign reserves to defend their fixed exchange rate. The current study's findings are consistent with those of Cabezas and De Gregorio (2019), who found that FERR considerably decreased reserve holdings for a panel of 52 nations in the wake of the financial crisis.

6. CONCLUSION

Using the system GMM estimators, this study aimed to provide empirical data about the impact of certain economic variables on the size of international reserve holdings in SSA nations. In order to determine the direction of causality between the variables in the study, we also performed the T-Y test. Particular conclusions include: Devaluation has had a detrimental and substantial impact on the demand for reserve holdings in SSA's oil-producing nations. The demand for reserves in SSA's oil-producing nations is positively and significantly correlated with oil prices. The SSA's oil-producing countries profit from rising oil prices and distribute a larger portion of their income to international reserves. Foreign reserve holdings in SSA's oil-producing nations are mostly determined by initial reserve volumes. Reserve demand in these nations is inelastic in terms of trade shocks, and it is negatively predicted by these shocks. Foreign reserve holdings in SSA's oil-producing nations are significantly adversely affected by democratic governance and corruption with the implication that the incidence of bad governance and pitiable institutional quality are associated with considerable depletion of FX reserves in SSA. The FERR had a manifestly detrimental impact on the foreign reserves of African oil-producing countries. This implies that the FERR is more harmful to FX reserves than the floating or intermediate ERRs.

Based on our findings, we suggest that monetary authorities should carefully weigh the opportunity cost of exchange rate depreciation against fiscal requirements to make sure that reserve withdrawals do not compromise the devaluation's economic goals. Instead of being kept only as reserves, a portion of the earnings from investments in diversified portfolios should be used for capital expenditures and reinvestment. In order to support sustainable reserve building, the money generated by positive fluctuations in the price of oil should be used to finance new capital projects and infrastructure development. Since terms of trade shocks are a reflection of economic cycle conditions and changes in imports and exports, they should be carefully watched. The study's conclusions are important because they shed light on the macroeconomic management of external reserves in SSA, especially in oil-producing nations, and highlight the interaction between terms of trade shocks, devaluation, oil prices, ERR, and institutions in the SSA region. The research holds significant relevance by providing insights into the macroeconomic management of reserves in SSA, particularly in oil-producing countries, and by highlighting both domestic and international factors influencing the external reserves of the countries in the study. The analysis is limited, nonetheless, by its narrow sample of SSA nations and its emphasis on reserve levels expressed in monetary terms. To provide additional findings of reserve accumulation, future research should expand the scope to include non-oil-producing countries and also expand the composition of reserves, taking into account both currency and investment structures.

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