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Determinants of foreign exchange reserves in sub-saharan Africa

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ABSTRACT

Driven by the lack of literature on the nature of the association between foreign exchange reserves and institutions for Sub-Saharan Africa, this study examines the determinants of foreign exchange reserves in 19 Sub-Saharan African countries over the period 2000–2019. The study applies the panel autoregressive distributed lag methodology. The empirical discussion considers the role of the institution and its effect on the flow of foreign exchange reserves across the selected countries. Results from the empirical analysis indicate that the main determinants of foreign exchange reserves in Sub-Saharan Africa are trade openness, broad money to GDP, CPI, and exchange rate. Strikingly, we find that of institution, political stability and absence of terrorism, government effectiveness, control of corruption and voice and accountability significantly affect reserves in the long run, while control of corruption and regulatory quality negatively affect reserves in the short run. The implication of these findings is that policymakers must have a keen awareness of both institutional factors and other macroeconomic phenomena.

Introduction

The accumulation of foreign exchange reserves has increased globally over the years. These foreign exchange reserves entail "external assets that are available immediately and controlled by central banks to finance balance of payments needs, to intervene in foreign exchange markets and for other related purposes'' [1]. The events around the global financial crisis of 2008 are particularly instructive. During the crisis, many countries fell into debts due to external borrowing, experienced declines in export trade, and depletion of reserves [2]. Therefore, countries build reserves as insurance against unexpected shocks and to maintain price stability in their economies. Certainly, for developing countries, like those in Sub-Saharan Africa, the role of foreign exchange reverses as insurance for financial crises and oft concomitant default risk is especially important [3].

Sub-Saharan Africa is endowed in natural resources such as oil, diamonds, copper, and uranium, through which countries export and earn revenues. The countries have accumulated reserves over the years mainly from export earnings, aid, and foreign direct investment [4].However, the region is faced by challenges of shortage of investments, lack of trust in institutions and massive development needs [5]. Notwithstanding, as of 2019, we find that Sub-Saharan Africa's total foreign reserves were only 27.3% of external debt [6]. Consequently, given the consequences of possessing insufficient reserves, it is critical for countries to understand the factors that increase their reserves.

Studies looking at the determinants of foreign exchange rate reserves largely arise out of the seminal work of Worrel [7], wherein they sought to develop a framework that arrives at a level of foreign exchange rate that is consistent with maximum economic growth rates. Noting that the determinants of foreign reserves should be well suited to the macroeconomic situation of the country being

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examined, the study identified money supply, export earnings, government expenditure, and capital flows form abroad. For context, recent studies using panel data have been conducted to understand the reasons behind holding reserves, but most of these have focused on emerging and developed economies. To the best of our knowledge, only two panel studies have focused on Sub-Saharan Africa (see, [4,8]). Additionally, earlier studies focused on homogeneous panels without considering heterogeneity effects across countries and this may produce biased results since heterogeneous models produce better results compared to a homogeneous panel.

Against this background, the paper aims to identify the factors that determine international reserves in Sub-Saharan Africa. Moreover, of these factors, examining the role of institution[1] on the flow of foreign exchange reserves in Sub-Saharan Africa is imperative. Certainly, although previous research identified some macro-economic indicators that affect the demand for reserves, they have not provided insight on the role that institution in Sub-Saharan Africa affects accumulation of reserves. The ineffectiveness of governments in implementing set policies, the barriers to businesses by foreign companies in a country, corruption, and dysfunctional legal systems are likely to chase away potential investors, which is detrimental to the growth of the Sub-Saharan economies. Considering this, our primary contribution is examining the effect of institution and other factors on foreign exchange rate reserves in a Sub-Saharan context.

The study has five sections, with introduction as section one. Section two covers the literature review, section three specifies the model and description of data, section four is empirical analysis, and section five concludes the study.

Brief literature review

In pursuit of a deeper understanding of the determinants of foreign exchange reserves, several studies have analyzed the association among various macro-factors and foreign exchange reserves. These studies have, however, differed in scope. Among these, one strand of research has focused on single country studies. For example, Jena and Sethi [9] used time series data to investigate the determinants of foreign exchange reserves in Brazil observing period 1960–2018. They found that current account, per capita GDP, domestic credit to private sector, trade and real interest rates have positive and significant effects on foreign exchange reserves in the long run while debt has a negative effective. Meanwhile, focusing on Ethiopia, Gereziher and Nuru [10] investigated determinants of foreign exchange reserves using annual data from 1981 to 2017. They employed the autoregressive distributed lag approach. External debt, CPI and current account balance positively and significantly determine reserves while exchange rate significance is negative in the long run. This study is country-specific and provides insight into managed floating exchange rate system used in Ethiopia. Similarly, Dash et al. [11] analyzed macroeconomic factors affecting foreign exchange reserves in India using quarterly data from 2001 to 2014. An autoregressive distributed lag model was applied, and the authors found that short term external debt to GDP ratio positively and significantly influences reserves while CPI negatively and significantly affects reserves in the long run. They found that the exchange rate is the only significant factor in the short run, and it positively affects reserves. Thus, policy makers should focus on achieving stable inflation rate and intervene in foreign market exchange for export competitiveness to maintain a significant amount of foreign exchange reserves.

Pertinently, like the present study, another strand of research has employed a panel approach. Among these, Sanusi et al. [8] investigated the determinants of foreign exchange reserves in Southern Africa, using the Autoregressive Distributed Lag panel econometric model from 1990 to 2015. The results assert that exports, CPI, and exchange rate significantly and positively affect foreign reserves while imports have a significantly negative effect on reserves in the long run. In the short run, exchange rate is the only significant variable that confirms the hypothesis of the study that countries in Southern Africa hold foreign reserves to defend the external value of their currencies. This study highlighted the unique economic problems faced by countries in Southern Africa and their vulnerability to shocks due to their dependence on natural resources, barriers to access to ports, and slow economic growth. However, they did not consider other problems like the quality of institution which is good for attracting foreign investment. On the other hand, panel data for 52 emerging and developed markets, for the period 2000–2013 were used by Cabezas and De Gregorio [12] to examine the accumulation of reserves. To capture the impact of the global financial crisis, the data were separated into two sections: 2000–2008 before the crisis and 2009–2013 after the crisis. The findings reveal that terms of trade, comparative hoarding[2] and broad money to GDP significantly and positively determine reserve accumulation while opportunity cost (interest rate differential) reduces reserve holding before the financial crisis. Post-crisis, fixed exchange rate regimes[3] significantly reduced reserve holding while volatility of trading partners' output had a positive effect on reserves. The impact of crises on economies cannot be undermined, and thus it is commendable for the authors to separate the post-crises and after-crises effects on the foreign exchange reserves of the selected economies. Similarly, analyzing the determinants of international reserves in West African states from 2005 to 2014, Ajayi and Olomola [13] used the panel ARDL methodology. The findings indicate that in the short run, imports, and exchange rates (appreciation in the nominal exchange rate) negatively affect pooled reserves. Exports, population, and Gross Domestic Product have a significant positive effect on pooled reserves. However, the long run results reveal that only population and real GDP per capita are significant determinants of pooled reserves in the West Africa states and have a positive effect.

Interestingly, Law et al. [14] explored the nonlinear impact of institutional quality on international reserves for 67 countries (developing and developed) applying the two-step system of Generalized Method of Moments from 1996 to 2016. Their argument was that institutional quality has two impacts on international reserves in the sense that there is a U-inverted relationship: improving

[1] For this study, institution is proxied by the indices from the World Governance Indicators.
[2] Demand for reserves that are dependent on reserve holdings of other countries to avoid currency speculative attacks, [12]
[3] Exchange rate regime: 1 = fixed exchange rate 0= otherwise

institutional quality has an initial reaction of motivating countries to hold more reserves, but beyond a certain threshold, the relationship becomes negative, and the country will hold less reserves. Additionally, trade openness and financial openness coefficients are positive and significant while exchange rate volatility is significant and negatively affect international reserves. This study is commendable for considering institutional quality, which is crucial for economic growth. However, the use of Generalized Method of Moments for mixed countries (developing and developed) could produce biased results on the outcomes of the research in the sense that some countries are more advanced than the others, and they face different economic problems.

The literature reviewed above has mixed results on the determinants of foreign exchange reserves and the motives for holding them. The authors have shown that reserves are held for insurance purposes against future unforeseen crisis, to escape borrowing loans from financial institutions such as International Monetary Fund and to manage exchange rate, as countries with stable exchange rates are viewed as competitive in international markets. Additionally, reserves accumulate because of countries promoting export growth which in turn increases domestic income. Variables such as exchange rates, exports, external debt, CPI, and openness to trade among others have been examined in single country studies and panel studies.

Most of the research conducted was single country studies, and panel studies which focused more on emerging economies and developed countries, with little attention given to research on Africa. The role of quality of institution has not been critically analyzed, except for a study by Law et.al [14], who utilized the International Country Risk Guide index to represent institutional quality, which averaged indices of the components, thus leaving a gap to identify the effect of each component which this study pursues.

Against this background, the aim of this study is to examine the factors determining reserves in Sub-Saharan Africa, considering the role of quality of institutions, using the world governance indicators, and applying panel autoregressive distributed lag estimation technique

Methodology and data

This section discusses the analytical framework of the study, specifies the model to be used and indicates different tests conducted. The section further states the data used in the study and its sources.

Model specification

Following Worrell [7], we appeal to our reason in identifying macroeconomic fundamentals that are expected to affect foreign exchange reserves in Sub-Saharan African countries.

$$FR_{i,t} = \beta_1 FR_{i,t-1} + \beta_2 M2_{i,t} + \beta_3 CPI_{i,t} + \beta_4 ER_{i,t} + \beta_5 TO_{i,t} + \beta_6 INST_{i,t} + \varepsilon_{i,t} \quad (1)$$

where, subscripts *i,* and *t,* are cross-section and time respectively, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ *and* β_6 are coefficients of the variables and FR, M2, CPI, ER, TO, INST are foreign exchange reserves, broad money to GDP, consumer price index, exchange rate, trade openness, and institution, respectively and ε_t is the error term.

Estimation techniques

Panel unit root tests

The tests for stationarity are conducted before any data analysis is done. The panel unit roots tests to be done are Fisher (ADF and PP), Im-Perasan and Shin (IPS), and Levin, Lin and Chu (LLC) tests. It is customary in the literature on panel analyses to consider these unit root tests simultaneously on account of their differences. For example, unlike the LLC, which assumes homogeneity in cross sections, the IPS allows for heterogeneity in the cross section. This is because the imposition of the homogeneity assumption, when there is coefficient heterogeneity in the panel data, may lead to incorrect conclusions.

Panel autoregressive distributed lag model

To find factors that determine the foreign exchange reserves in Sub-Saharan Africa, the main empirical estimation relies on the dynamic heterogeneous panel regression which is merged into the error correction model through the ARDL (p, q) model. The panel ARDL model is stated as:

$$\begin{aligned}\Delta FR_{it} = {} & \vartheta_{0i} + \sum_{j=1}^{p} \alpha_{ij} \Delta FR_{i,t-j} + \sum_{j=0}^{q} \beta_{ij} \Delta M2_{i,t-j} + \sum_{j=0}^{m} \varnothing_{ij} \Delta CPI_{i,t-j} + \sum_{j=0}^{r} \varphi_{ij} \Delta ER_{i,t-j} + \sum_{j=0}^{s} \gamma_{ij} \Delta TO_{i,t-j} + \sum_{j=0}^{u} \partial_{ij} \Delta INS_{i,t-j} \\ & + \vartheta_{1i} FR_{i,t-1} + \vartheta_{2i} M2_{i,t-1} + \vartheta_{3i} CPI_{i,t-1} + \vartheta_{4i} ER_{i,t-1} + \vartheta_{5i} TO_{i,t-1} + \vartheta_{6i} INS_{i,t-1} + \varepsilon_{it} \end{aligned} \quad (2)$$

where $i = 1, 2, 3,\ldots,N$; $t = 1,2,\ldots,N$, FR, M2, CPI, ER, TO, INST are foreign exchange reserves, broad money to GDP, consumer price index, exchange rate, trade openness, and institution, respectively and ε_t is the error term. Δ is the first difference operator, *p, q, m, r, s,* and *u,* are the optimal lags on the first-differenced variables by some information criterion such as the Schwarz Information Criterion (SIC) and μ_i captures the specific effects. The long run coefficients for the intercept and the regressors are computed as:

$\delta_{0i} = -\frac{\vartheta_{0i}}{\vartheta_{1i}}$, $\delta_{1i} = -\frac{\vartheta_{2i}}{\vartheta_{1i}}$, $\delta_{2i} = -\frac{\vartheta_{3i}}{\vartheta_{1i}}$, $\delta_{3i} = -\frac{\vartheta_{4i}}{\vartheta_{1i}}$, $\delta_{4i} = -\frac{\vartheta_{5i}}{\vartheta_{1i}}$, *and* $\delta_{5i} = -\frac{\vartheta_{6i}}{\vartheta_{1i}}$, for broad money to GDP, CPI, exchange rate,

trade openness, and institution, respectively, since it is assumed that $\Delta FR_{i,t-j} = \Delta M2_{i,t-j} = \Delta CPI_{i,t-j} = \Delta ER_{i,t-j} = \Delta TO_{i,t-j} = \Delta INS_{i,t-j} = 0$ in the long run. α_{ij}, $\beta_{ij}, \varnothing_{ij}$, φ_{ij}, γ_{ij}, *and*, θ_{ij} are the short-run coefficients.

The error correction term of Eq. (2) is specified as:

$$\Delta FR_{it} = \vartheta_{0i} + \sum_{j=1}^{p} \alpha_{ij} \Delta FR_{i,t-j} + \sum_{j=0}^{q} \beta_{ij} \Delta\, M2_{i,t-j} + \sum_{j=0}^{m} \varnothing_{ij}\, \Delta CPI_{i,t-j} + \sum_{j=0}^{r} \varphi_{ij} \Delta ER_{i,t-j} + \sum_{j=0}^{s} \gamma_{ij} \Delta TO_{i,t-j} + \sum_{j=0}^{x} \theta_{ij} \Delta INS_{t-j} + \rho_i ect_{i,t-1} + \mu_i + \varepsilon_{it} \tag{3}$$

where the error correction term for each cross-section is defined as $ect_{i,t-1} = FR_{i,t-1} - \delta_{0i} - \delta_{1i} M2_{i,t-1} - \delta_{2i} CPI_{i,t-1} - \delta_{3i} ER_{i,t-1} - \delta_{4i} TO_{i,t-1} - \delta_{5i} INS_{i,t-1}$.

The error correction term measures the adjustment speed along the time path of the variables to the long-run equilibrium. The coefficient of the error term, ρ_i, must be statistically significant, negative and less than one in absolute for the long-run relationship to exist among the variables. Its expected negative value indicates convergence, with a positive value suggesting a divergence from equilibrium. Furthermore, if the value exceeds one in absolute term, it suggests an over-adjustment which has no meaningful intuition.

The panel ARDL model in Eq. (2) is estimated using three different dynamic heterogeneous estimators which are the mean group (MG) developed by Pesaran and Smith [15], the pooled mean group (PMG) developed by Pesaran et al. [16], together with the dynamic fixed effects (DFE) estimator. They are each estimators of long-run equilibrium computed by the maximum likelihood and can account for heterogeneity in the relationship among underlying variables.

It important to note that, although Phillips and Hansen [17] and Johansen [18] posit that long-run relationships only exist when the variables which are cointegrated have the same integration order, Pesaran and Shin [19] argue for the ability of panel ARDL to handle variables that are all integrated of order zero I(0) or one I(1) or a mixture of both I(0) and I(1).

The other attractive qualities of the panel ARDL model is that it is suitable for a panel with large cross sections (N) and time periods (T), or usually panel with $T > N$ dimension, and it allows for the simultaneous estimation of both short- and long-run relationships. Second, it provides consistent estimates in the presence of endogeneity. According to Pesaran et al. (1999), the endogeneity bias is accounted for with the inclusion of the lags of the dependent and independent variables.

The MG estimator proposed by Pesaran and Smith [15] computes distinct regressions for each cross-section and then calculates the coefficients as the unweighted averages of the computed coefficients for the individual cross sections. This makes the coefficients to be heterogeneous, over both the short- and long-run. The performance of this estimator, however, hinges on the condition that both the cross sections (N) and time periods (T) of the panel must be adequately large. In cases of small N, Favara [20] notes that the estimator becomes sensitive to the presence of outliers and reduced model permutations.

The PMG estimator on the other hand, relies on the assumption that the long-run slope coefficients are homogeneous across the cross-sections, hence the idea of pooling. However, the short-run coefficients, including the error variances, intercepts, and error correction mechanisms, are allowed to differ across the cross-sections. The long-run homogeneity assumption is valid when there are sufficient grounds to believe the cross sections have similar long-run equilibrium. For the heterogeneous nature of the short-run coefficients, the adjustment process is allowed to be specific to each cross section since different economic agents (such as countries in this study) are affected by various factors including financial crises and other exogenous shocks, at least in the short-run.

Lastly, the DFE estimator tends to be similar to the PMG estimator by restricting the long-run slope coefficients and error variances to be equal across all the cross sections. Also observing some features of the MG estimator, it imposes restrictions on the short-run coefficients and speed of adjustment. However, the intercepts are made to be heterogeneous across the cross sections. One main benefit of this estimator, as pointed out by Blackburne and Frank [21] is that it provides an option for the estimation of a within-group correlation with the standard error. However, if the sample size is small, the estimator is vulnerable to simultaneous equation bias resulting from endogeneity.

The panel ARDL model in Eq. (2) is estimated using the MG, PMG and DFE estimators, after which the Hausman test is applied to see the presence of significant differences among their estimates. The model adjudged by the Hausman test as the most efficient is then fully paid attention to for discussion.

Data sources and description

The study constructs a panel dataset for nineteen selected African countries, for the period 2000 to 2019. Annual data utilized in this study is sourced from World Development Indicators and World Governance Indicators of the World Bank. The choice of time and the country depends on availability of data on the selected variables of interest.

The selected countries for the study are as follows; Angola, Burundi, Botswana, Republic of Congo, Cabo Verde, Gabon, Ghana, Equatorial Guinea, Kenya, Madagascar, Mauritius, Nigeria, Rwanda, Sudan, Eswatini, Seychelles, Chad, Tanzania, and South Africa.

Foreign exchange reserves are defined as holdings of monetary gold, special drawing rights, reserves of International Monetary Fund (IMF) members held by the IMF, and holdings of foreign exchange under the control of monetary authorities [22]. The foreign exchange reserves are the dependent variable and are in US Dollars. The independent variables of the study, based on surveyed literature are defined below. The study adds a new independent variable institution proxied by indices from the world governance indicators.

Consumer price index: It shows how much prices have changed to acquire a basket of goods and services. A negative sign is expected. Theoretically, when prices of goods and services rise sharply, the foreign exchange reserves reduce as they are used to increase money

supply into the economy.

Exchange rate: is the official exchange rate determined by national authorities, [22]. It is in local currency units per US dollar. Depreciation of local currencies against the US Dollar are expected to weaken the local currencies thus reducing the reserves, while currency appreciation strengthens local currencies which supports an increase in reserves.

Trade openness: calculated as the sum of exports and imports relative to Gross Domestic Product. It measures the extent to which a country participates in the global trading market. A positive coefficient of trade openness is expected for countries where exports exceed imports, and a negative sign is expected for countries which import more than they export.

Broad money to GDP ratio: the sum of currency outside banks; demand deposits; time, savings, and foreign currency deposits of resident factors other than the central government; bank and traveler's checks and other securities such as commercial paper, [22]. It measures financial sector depth.

Institution proxied by the six dimensions of governance; voice and accountability, government effectiveness, regulatory quality, rule of law, political stability and absence of violence/terrorism, and control of corruption. The estimates are approximately from −2.5 for weak governance to 2.5 for strong governance. The expected results are mixed, in the sense that the different dimensions of governance have diverse effects on the reserves, say for example, strong political stability and effective government are expected to have a positive impact on reserves when they attract foreign investors into the economies.

Empirical analysis

Preliminary analysis

The section discusses the statistical properties of the panel data used in the study. Descriptive statistics is followed by correlation matrix, where the relationship between the variables is observed. The data is checked for stationarity to verify that there are no variables integrated of order two because the panel ARDL methodology would then be not suitable for the study. Cointegration tests are then done to examine the existence of a long run relationship between the variables. The tables and the full descriptions of the properties are done below. Table 1 below reports the characteristics of the data for the selected variables of interest. The variables have been logged except for the world governance indicators to improve the robustness of the estimated model and for consistency of the residual.

In Table 2, trade openess and exchange rate are negatively correlated with foreign exchange reserves, that is, increases in these variables coincides with a decrease in the reserves. This may mean that unfavourable trade balances lead to depletions in the foreign reserves of Sub-Saharan countries. Since the values are closer to zero, they show a weaker relationship with the dependent variable (reserves). Broad money to GDP, CPI, and the institution variables have a positive correlation with reserves, meaning the variables increase together. The values are also closer to zero than one, so it can be concluded that the linear relationship between the variables and reserves is weak.

The data is analyzed to investigate whether the variables are stationary or not, and verify that there are no I(2) variables in. The panel unit root tests used are the Im-Perasan and Shin (IPS), Fishers' Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP), Levin, Lin & Chu (LLC). The null is that of a unit root.

The results of the unit root tests indicate that foreign exchange reserves are stationary at level, therefore integrated of order zero at 5 percent level of significance. Broad money supply, trade openness and exchange rate are stationary after first differencing for all the unit root tests, therefore they are integrated of order one at 5 percent level of significance. CPI is stationary at level for the LLC unit root test, but it is stationary after first difference for all the other tests as shown in Table 3.

The data has been verified to be stationary and that there are no I (2) variables, then cointegration tests are done to examine long run relationship between variables. The study will use the Kao and Fisher cointegration tests.

Table 1
Descriptive statistics.

Variables	Obs	Mean	Std.Dev	Minimum	Maximum
Foreign Reserves(FR)	380	20.996	1.875	15.918	24.732
Trade openness (TO)	380	4.212	0.730	0.198	5.721
Broad money to GDP(M2)	380	3.337	0.676	1.747	4.794
Exchange rate (ER)	380	4.527	2.220	−0.607	8.194
Consumer Price Index (CPI)	380	4.537	0.550	1.068	7.204
Control of corruption(COC)	361	−0.549	0.742	−1.826	1.217
Govt Effectiveness(GE)	361	−0.545	0.719	−1.697	1.057
Political stability(POL)	361	−0.399	0.975	−2.665	1.282
Rule of law(ROL)	361	−0.521	0.734	−1.663	1.077
Regulatory Quality(RQ)	361	−0.453	0.712	−1.799	1.127
Voice & accountability(VA)	361	−0.521	0.871	−2.000	0.998

Note: Obs; number of observations, Std.dev is standard deviation.

Table 2
Correlation Matrix.

	LFR	LTO	LM2	LER	CPI	COC	GE	POL	ROL	RQ	VA
LFR	1.000										
LTO	−0.050	1.000									
M2	0.178	0.191	1.000								
LER	−0.179	−0.094	−0.453	1.000							
CPI	0.174	−0.363	0.113	0.108	1.000						
COC	0.125	0.266	0.633	−0.449	−0.073	1.000					
GE	0.233	0.271	0.774	−0.480	−0.067	0.915	1.000				
POL	0.050	0.590	0.534	−0.223	−0.030	0.702	0.711	1.000			
ROL	0.153	0.272	0.768	−0.421	−0.021	0.896	0.944	0.789	1.000		
RQ	0.253	0.234	0.739	−0.346	−0.006	0.819	0.913	0.677	0.917	1.000	
VA	0.309	0.240	0.792	−0.365	−0.040	0.726	0.854	0.618	0.866	0.870	1.000

Source: Authors calculations.

Table 3
Unit root tests.

Variable	IPS *W-statistic*	FISHER-ADF *Chi-Square*	FISHER-PP *Chi-Square*	LLC *t* statistic*	Remark
FR	−3.746***	80.220***	70.470***	−7.246***	I(0)
	(0.000)	(0.000)	(0.001)	(0.000)	
TO	−9.893***	174.552***	242.812***	−12.097***	I(1)
	(0.000)	(0.000)	(0.000)	(0.000)	
CPI	2.309	25.394	59.807**	−6.382***	I(1)
	(0.990)	(0.942)	(0.014)	(0.000)	
M2	−7.429***	126.187***	233.890***	−7.833***	I(1)
	(0.000)	(0.000)	(0.000)	(0.000)	
ER	−7.105***	122.634***	165.406***	−8.615***	I(1)
	(0.000)	(0.000)	(0.000)	(0.000)	

P-values are in parenthesis. ***, **,* indicate the levels of significance at 1%, 5% and 10% respectively.

Panel cointegration tests

Based on the preliminary results of unit roots tests, which showed that some variables are non-stationary, cointegration tests are done to check whether the variables have long run relationship. The null hypothesis is that there is no cointegration, against the alternative that cointegration exists. The test was done for each of the models as shown in the table. The results of the Kao and Pedroni test are given in Table 4.

The results of the cointegration tests for model 1 reject the null hypothesis of no cointegration and therefore the conclusion is that a long relationship exists between the variables. Institution variables are added one after another to examine the long run relationship with the other variables. When adding control of corruption to the variables, the results show that there is cointegration between the variables, but the null hypothesis is not rejected for the Pedroni panel ADF test.

Government effectiveness, regulatory quality and voice and accountability tests all reject the null hypothesis of no cointegration and suggests that a long run relationship exists at the 1 percent, 5 percent and 10 percent levels of significance. Rule of law and political

Table 4
Cointegration results.

Variables/Test	Panel ADF-stat	Group PP-Stat	Kao test
Model 1: fr,er,inf,trade,m2	−3.791***	−2.696***	−4.086***
	(0.000)	(0.004)	(0.000)
Model 2: fr,er,inf,trade,m2,coc	−1.445	−3.851***	−4.486***
	(0.074)	(0.000)	(0.000)
Model 3: fr,er,inf,trade,m2,ge	−2.243**	−2.853***	−4.511***
	(0.012)	(0.002)	(0.000)
Model 4: fr,er,inf,trade,m2,pol	−3.125***	0.945	−4.674***
	(0.001)	(0.828)	(0.000)
Model 5: fr,er,inf,trade,m2,rol	−0.591	−1.577*	−4.402***
	(0.277)	(0.057)	(0.00)
Model 6: fr,er,inf,trade,m2,rq	−1.558*	−1.547*	−4.526***
	(0.060)	(0.061)	(0.000)
Model 7: fr,er,inf,trade,m2,va	−3.614***	−2.192**	−4.629***
	(0.000)	(0.142)	(0.000)

P-values are in parenthesis. ***,**,* indicate levels of significance at the 1%,5% and 10% respectively.

and absence of violence fail to reject the null hypothesis for the panel ADF and group PP tests respectively, but they reject it for the other tests, hence a conclusion that there is a long run relationship between the variables. Overall, the results show that there exists a long run relationship between the variables.

Estimation results

The panel ARDL is estimated with the mean group, pooled mean group and dynamic fixed estimates whose results are presented in seven columns (adding institution variables in succession) for Tables 5 to 7. The columns are models 1–7 introduced in Table 4 above.

The Hausman test was employed to determine the most efficient estimator, with a null hypothesis that the PMG is more efficient estimator than the MG estimator, at 5 percent level of significance. The second test compares the PMG and DFE and the last test compares MG to DFE. Hausman test results are displayed in table 8, and results analysis follows afterwards based on the outcomes of the test.

The results of the Hausman test show that comparing the MG and PMG, the probability value is greater than 5 percent for all the regression models, therefore PMG is preferred estimator over the MG. Comparing the PMG and DFE has mixed results. Models 1, 2,3, and 5 have probability value greater than the 5percent level of significance and therefore the results choose PMG as the best estimator. Models 6 and 7 show probabilities less than the 5 percent level of significance meaning the DFE is preferred. The results for the model

Table 5
Panel ARDL results for Mean Group estimates.

Long-run	1	2	3	4	5	6	7
LTO	1.435	1.994	−3.631	1.413	4.230*	7.675*	−13.515
	(1.051)	(2.281)	(22.048)	(1.877)	(2.199)	(4.010)	(9.210)
LM2	1.567	0.966	11.498	3.843*	2.020	15.063*	17.500*
	(1.626)	(4.131)	(37.331)	(2.300)	(1.543)	(8.732)	(8.765)
LER	−3.023	−5.016	2.975	−2.284	−5.460**	0.554	4.738
	(1.848)	(2.790)	(12.636)	(2.841)	(2.241)	(5.965)	(5.326)
LCPI	0.213	6.488	1.379	−1.434	1.479	12.835	−6.773
	(1.368)	(7.377)	(14.361)	(2.200)	(1.660)	(13.636)	(6.543)
COC		3.001					
		(3.797)					
GE			46.368				
			(36.535)				
POL				−0.215)			
				(1.940)			
ROL					0.192		
					(1.013)		
RQ						−5.349	
						(6.625)	
VA							7.960
							(10.790)
Short-run							
ΔTO	−0.142	−0.887	−0.800	−0.841	−1.241***	−0.713	−0.987
	(0.279)	(0.477)	(0.565)	(0.527)	(0.478)	(0.551)	(0.528)
ΔM2	0.322	−0.168	−0.093	−0.270	0.300	0.032	0.181
	(0.434)	(0.442)	(0.538)	(0.457)	(0.557)	(0.494)	(0.720)
ΔER	1.283**	1.751*	1.409*	1.652*	2.017	1.108*	2.244
	(0.655)	(0.868)	(0.851)	(0.908)	(0.913)	(0.653)	(1.297)
ΔCPI	−0.658	−3.901	4.706	−3.055	−3.378	−3.526	−1.893
	(1.781)	(2.863)	(3.680)	(3.036)	(3.004)	(2.782)	(1.885)
ΔCOC		−0.538					
		(0.342)					
ΔGE			−0.692*				
			(0.397)				
ΔPOL				0.046			
				(0.207)			
ΔROL					−0.538		
					(0.422)		
ΔRQ						−0.171	
						(0.319)	
ΔVA							−0.577
							(0.616)
ECT	−0.473***	−0.468***	−0.427***	−0.444***	−0.459***	−0.397***	−0.412***
	(0.104)	(0.113)	(0.120)	(0.116)	(0.120)	(0.102)	(0.103)
Constant	18.547**	4.885	7.372	12.553*	12.046*	5.324	10.327
	(7.365)	(5.379)	(7.838)	(6.973)	(4.771)	(5.815)	(7.317)

Note: the columns 1–7 are the estimated models explained in table 4 above. Standard errors are in parenthesis. ***,**,* indicate levels of significance at the 1%,5%and 10% respectively.

4, which incorporates government effectiveness are inconclusive for the PMG and DFE Hausman test.

The comparison of the DFE and MG estimates shows probability values greater than the 5 percent level of significance for all models, hence a conclusion that DFE is the preferred estimator. The Hausman test confirms that the PMG is most preferred over the other two, and therefore in interpreting results, the focus will be the PMG estimates as recommended by the Hausman test.

Discussion of results

Based on the outcomes of Hausman test, the results extensively discussed are for the PMG estimation. The discussion is in two parts to focus on long run and short run results separately. Table 6 shows that in the long run, CPI is positive and the main determinant of foreign exchange reserves in Sub-Saharan Africa as the coefficients of the variable are all strongly significant across the seven models, at 1 percent level of significance. This positive relationship between foreign exchange reserves and CPI can be attributed to the objectives of central banks as they aim to maintain stable inflation in their economies The results are consistent with findings of Sanusi et al. [8] who also found positive and significant effect of inflation on foreign reserves for Southern African countries.

Trade openness is positive and significant determinant of foreign exchange reserves in Sub-Saharan Africa for all models except one where government effectiveness is added. The results of positive impact are in line with studies which found evidence that openness of an economy to trade significantly increases reserves [9,23]. The results of the six South East Asia selected countries by Shrestha and Wansi [24] however show mixed outcomes which are significant, that the trade coefficient is positive for Singapore and Korea, while it

Table 6
Panel ARDL results for Pooled Mean Group estimates.

Long-run	1	2	3	4	5	6	7
LTO	1.724***	2.473***	−6.276**	1.139***	3.407***	4.867***	2.539***
	(0.259)	(0.336)	(3.060)	(0.180)	(0.628)	(0.524)	(0.347)
LM2	0.844***	−0.699***	−19.644***	1.593***	−3.036***	−0.740**	2.662***
	(0.306)	(0.251)	(7.478)	(0.250)	(0.711)	(0.328)	(0.480)
LER	−0.932**	−1.016***	−12.766***	0.435	−8.188***	−1.568***	−2.701***
	(0.448)	(0.147)	(3.909)	(0.269)	(1.229)	(0.356)	(0.688)
LCPI	3.77***	2.103***	20.327***	0.737***	9.909***	2.384***	6.602***
	(0.406)	(0.138)	(6.677)	(0.204)	(1.159)	(0.376)	(0.724)
COC		11.243***					
		(1.870)					
GE			−6.157**				
			(2.681)				
POL				−3.497***			
				(0.674)			
ROL					1.148		
					(0.724)		
RQ						29.069	
						(.)	
VA							−4.597***
							(0.754)
Short-run							
ΔTO	0.013	−0.671***	0.091	0.063	−0.358	−0.822***	0.0622
	(0.409)	(0.209)	(0.285)	(0.301)	(0.265)	(0.240)	(0.279)
ΔM2	0.853***	0.924***	0.974**	0.789***	0.904***	1.111***	0.381
	(0.299)	(0.284)	(0.392)	(0.281)	(0.325)	(0.332)	(0.345)
ΔER	−0.835**	0.048	−0.927**	−1.087**	−0.336	0.268	−1.029*
	(0.371)	(0.266)	(0.407)	(0.511)	(0.309)	(0.408)	(0.369)
ΔCPI	2.166*	0.780	1.294	1.785	2.304*	1.136	1.736
	(1.152)	(0.692)	(1.249)	(1.754)	(1.157)	(1.137)	(0.944)
ΔCOC		−2.131***					
		(0.732)					
ΔGE			−0.258				
			(0.164)				
ΔPOL				0.233			
				(0.180)			
ΔROL					0.269		
					(0.382)		
ΔRQ						−5.769***	
						(1.585)	
ΔVA							−0.464
							(0.432)
ECT	−0.091	−0.251***	−0024	−0.006	−0.086	−0.195***	−0.278
	(0.073)	(0.000)	(0.015)	(0.050)	(0.055)	(0.056)	(0.065)
Constant	−0697	2.307***	1.589	−0.232	0.414	−0.869	−0.994
	(0.495)	(0.715)	(1.131)	(0.425)	(0.975)	(0.616)	(1.778)

Standard errors are in parenthesis. ***,**,* indicate levels of significance at the 1%,5% and 10% respectively.

Table 7
Panel ARDL results for Dynamic Fixed Effects.

Long-run	1	2	3	4	5	6	7
LTO	0.940*	1.038*	1.046**	1.029**	1.077**	1.004**	1.000*
	(0.429)	(0.443)	(0.447)	(0.420)	(0.447)	(0458)	(0.433)
LM2	−2.927**	−3.932***	−4.107***	−4.193***	−4.085***	−4.028***	−4.035***
	(0.965)	(0.000)	(1.119)	(1.062)	(1.125)	(1.23)	(1.076)
LER	−1.625*	−0.367	−0.331	−0.491	−0.151	−0.200	−0.725
	(0.830)	(0.000)	(0.953)	(0.894)	(0.973)	(0.979)	(0.930)
LCPI	2.341***	1.042	1.028	1.103	0.825	0.871	1.256
	(0.652)	(0.000)	(0.784)	(0.736)	(0.803)	(0.815)	(0.764)
COC		0.970					
		(0.762)					
GE			0.844				
			(0.875)				
POL				1.324**			
				(0.565)			
ROL					0.656		
					(0.927)		
RQ						0.563	
						(0.864)	
VA							2.132*
							(0.957)
Short-run							
ΔTO	0.122	−0.022	−0.020	−0.020	−0.022	−0.200	−0.020
	(0.143)	(0.132)	(0.132)	(0.131)	(0.132)	(0.132)	(0.131)
ΔM2	0.841***	0.833***	0.884***	0.877***	0.850***	0.846***	0.928***
	(0.242)	(0.229)	(0.230)	(0.229)	(0.230)	(0.229)	(0.229)
ΔER	−0.488	−0.169	−0.163	−0.157	−0.183	−0.180	0.151
	(0.292)	(0.274)	(0.276)	(0.272)	(0.275)	(0.275)	(0.273)
ΔCPI	0.282	0.435	0.467	0.446	0.385	0.449	0.463
	(0.471)	(0.528)	(0.532)	(0.526)	(0.532)	(0.539)	(0.526)
ΔCOC		0.036					
		(0.222)					
ΔGE			−0.042				
			(0.219)				
ΔPOL				−0.081			
				(0.118)			
ΔROL					0.211		
					(0.268)		
ΔRQ						0.102	
						(0.196)	
ΔVA							−0.249
							(0.560)
ECT	−0.196***	−0.183***	−0.181***	−0.191***	−0.181***	−0.179***	−0.186***
	(0.033)	(0.032)	(0.032)	(0.032)	(0.032)	(0.032)	(0.317)
Constant	4.674***	5.061***	5.067***	5.505***	5.030***	4.985***	5.454***
	(0.947)	(0.925)	(0.931)	(0.946)	(0.944)	(0.925)	(0.943)

Standard errors are in parenthesis. ***,**,* indicate levels of significance at the 1%, 5% and 10% respectively.

Table 8
Hausman test.

Hausman tests	1	2	3	4	5	6	7
MG vs PMG	7.67	4.34	1.44	2.12	2.45	0.5	0.41
	(0.105)	(0.501)	(0.920)	(0.833)	(0.785)	(0.974)	(0.995)
PMG vs DFE	6.27	10.07	1.02	−16.72	7.32	9.96	11.77
	(0.180)	(0.073)	(0.961)	(Inconclusive)	(0.198)	(0.041)	(0.038)
DFE vs MG	0.20	0.08	0.02	0.05	0.08	0.04	0.02
	(0.995)	(0.999)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)

Probability values are in parenthesis.

is negative and for Malaysia. This positive impact of trade openess to reserves could be due to the involvement of the countries in trading their commodities with developed economies and in exchange gain foreign currency. The negative relationship of trade openess when government effectiveness is added possibly means that if government is not fully commited to implementation of formulated policies and there is poor service delivery (weak governance), then taking part in global trade might not yield fruitful results. Therefore, an increase in trade openess and government effectiveness by 1% will cause a 6% decline in foreign exchange

reserves of the Sub-Saharan African countries, all things held constant.

On the other hand, exchange rate has a negative and significant impact on reserves in six of the regressed models except for model 4, which includes political stability and absence of terrorism. This indicates that a deterioration in the value of local currencies of Sub-Saharan African countries leads to a fall in foreign reserves. This may be related to the actions of policymakers and other government agencies in trying to stabilize the currency. The insignificance in model 4, could be related to wars, conflicts and instability which are a concern to the leadership of countries and potential investors. If a country is not politically stable and there is possibility of terrorism/violence, then exchange rate is not effective in accumulating reserves as potential investors and trade partners would not be willing to engage with such a country. .This observation is in agreement with the work of Sanusi et al. [8] who concluded that exchange rate is a positive and significant determinant of foreign exchange reserves in Eswatini and Southern Africa, respectively. The other six models where exchange rate is negative and significant, are supported by [10]. The consistent negative effect of exchange rate in the long run for the Sub-Saharan countries, could be associated with these countries holding onto foreign exchange reserves for currency defending purposes.

Broad money to GDP is significant to foreign exchange reserves across all models. It is positive at 1 percent level of significance for models 1,4 and 7 and negative a 1 percent level of significance for models 2, 3 and 5. Model 6 is negative and significant at 5 percent level of significance. The positive and significant impact of broad money to foreign exchange reserve accumulation is supported by findings of Cabezas and Gregorio [12] when studying 52 emerging and developed markets. Sub-Saharan Africa countries with good banking sector are more likely to accumulate more reserves than those slacking behind in the financial development. Meanwhile, in examining the role of institution to the flow of foreign exchange reserves, the results show that control of corruption, political stability, and voice and accountability are significant at 1 percent level and government effectiveness is significant at 5 percent level of significance. The only positive determinant is control of corruption, which means that for Sub-Saharan Africa countries that put in place measures that fight against abuse of power for private gain will attract foreign investment and more trading partners to work on activities that will increase foreign exchange reserves holding. It has the highest positive coefficient amongst all the variables, which implies that in the long run, institution plays an important role in determining foreign exchange reserves.

For the short run, we observe that broad money to GDP is positive and significant across all models except model 7 with inclusion of voice and accountability. This suggests that countries hold onto reserves for protection against potential capital flight. Furthermore, the freedom of expression, media, association, and ability of citizens to freely choose their government does not significantly influence foreign exchange reserves. Furthermore, exchange rate is negative and significant in the short run for four of the seven models. These findings are supported by Gereziher and Nuru [10] for the Ethiopia study, Ajayi and Olomola [13] for the West African states and Sanusi et al. [8] for the Southern Africa studies. The results suggest that Sub-Saharan countries accumulate foreign exchange reserves to defend their currencies. However, exchange rate is positive and significant in the short run for India as found by Dash et al. [11], therefore contradicting this study.

In contrast to what we observe in the long run, trade openness in the short run is significant and negative for two models at 1 percent level of significance, where control of corruption and regulatory quality are also negative and significant at the 1 percent level. The latter are the only two governance indicators that are significant in the short run. Their negative outcome implies that a 1% increase in control of corruption and regulatory quality cause foreign exchange reserves of Sub-Saharan African countries to fall by approximately 2% and 6% respectively, all else constant. Interestingly, these results are not consistent with long run outcomes that control of corruption increases reserves. It could be that it takes time for the government to fully tackle issues against corruption, hence in the short term, reserves could be decreased by being spent on personal/private interests than serving the nation. As for regulatory quality, the results suggests that as governments improves on policies and promotes private sector development, they tap into foreign exchange reserves for domestic use. This implies that if Sub-Saharan African countries uses foreign exchange reserves to enhance the private sector, then their reserve holdings will decrease.

We also observe that CPI is positive across the models, however, it is significant for two models in the short run at 10 percent level of significance. This suggests that in the short term, rising prices are significant to a certain degree in determining foreign exchange reserves. This may be an indication that policymakers are incentivized to increase foreign reserves during inflationary periods. That is, fearing that expenditures of these reserves may worsen inflation, the authorities do nothing. This may not be as incredible as it seems given that Sub-Saharan countries are endowed with natural resources (crude oil and precious metals, for example) that can earn foreign currency. Therefore, if during these periods, reserves may steadily increase. The results of this study agree with the findings of previous studies [8,12,13] that indeed trade openness, broad money and CPI and exchange rate significantly determine foreign exchange reserves. Cabezas and Gregorio [12] found that broad money had a positive effect on foreign exchange reserves for the emerging economies before the 2009 global financial crisis. Pertinently, the depth of the financial sector in Sub-Saharan African countries is crucial to their accumulation of reserves as they need to be more open to stimulate savings, encourage efficient investments and have improved productivity in the economy. Sanusi et al. [8] found that in Southern Africa, inflation and exchange rate had significant impact on reserves, which is consistent with the results of this study as the variables are very significant across the regression, (with only one insignificant result for exchange rate out of seven). Ajayi and Olomola [13] found that for the West African states, exchange rate had a significant and negative effect on reserves only in the short run which compares to four of the seven regression results of this study.

The error correction term is the speed of adjustment along the time path of the variables to the long-run equilibrium, it is negative across all models, which depicts the convergence of the variables in the long run. However, it is negative and statistically significant at 1 percent level of significance only for the two models which include control of corruption and regulatory quality. The coefficients (-0.25 and -0.20) indicate that about 25% and 20% respectively of this disequilibrium is corrected each year in the long run.

Conclusion

Focusing on the determinants of foreign reserves in Sub-Saharan Africa, the study employed the panel autoregressive distributed lag technique on 19 selected countries for the period between 2000 and 2019. Based on the structure of the Sub-Saharan economies and the problems they encounter; the study explored the role of institution on the flow of reserves and determined the other main factors that influence reserves in the region.

The findings of the study show that foreign exchange reserves in Sub-Saharan Africa are mainly determined by trade openness, broad money, inflation, exchange rate, control of corruption, government effectiveness, political stability and absence of terrorism, voice and accountability and regulatory quality. Inflation coefficient is positive and significant at 1 percent level, across the seven models run indicating that it is an important component that economies in the region should carefully manage to have stability and adequate reserves, which is supported by findings of [8].

The effects of institution on the flow of reserves in Sub-Saharan Africa show that governance is crucial on how much reserves the economies gain, in the sense that improving the quality of institution has potential to attract investors and advance the growth of economies. Control of corruption variable is statistically significant in both the long run and short run, implying that this variable plays a critical role in increasing and decreasing investments into the economies. Consequently, these results show that policymakers should take care to strengthen institutions in addition to macroeconomic phenomena.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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