Exchange market pressure in Sub-Saharan African countries – The role of imports and short-term external debt, 2002–2017

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The loss in the value of domestic currency could be destabilising in most developing countries. To avoid exchange rate crises, countries intervene in foreign exchange markets. While attempting to measure the exchange market pressure (EMP) that leads to a currency crisis, various studies discovered that international reserve variable alone or its variations perform well in explaining changes in the exchange rate variable in developing economies.

However, no study has used foreign reserve adequacy to derive an effective measure in capturing EMP in developing and emerging countries from 2002 to 2017. To measure this phenomenon, this study proposed innovative approaches based on the foreign reserve to import ratio, foreign reserve to short-term external debt ratio, and foreign reserve to broad money ratio. Using a generalised method of moments regression model and a ridge regression model, this study found that the new measures of the EMP index with the reserve variable adjusted for imports and short-term external debt are suitable for identifying EMP in Sub-Saharan Africa. This study recommends the combined use of these innovative approaches because a currency crisis can emanate from any account of a country's balance of payments.

Introduction

The pressure on a currency can come in the form of appreciation or depreciation. In developing countries, pressure caused by depreciation is common. These pressures significantly challenge countries whose economies are not robust to handle tensions of this nature. The consequence therein could be a full-blown exchange rate crisis, which can lead to the economy's collapse (Delbianco et al. 2019). Studies on the determinants of exchange rate crises recognise that exchange rate volatility cannot be

fully explained by the volatility of countries' macroeconomic fundamentals. Others recognise country differences in exchange rate volatility, which may be linked to a set of macroeconomic variables, capital control measures, foreign exchange regimes, and market structures. In addition, financial markets sophistication over the years means that balance sheet factors, such as external debt size, domestic market liquidity, and country size and development level matter (Nowak et al. 2004).

Table 1

Rules of thumb for foreign reserve adequacy monitored by credit rating agencies and investment banks, 2011–2017

Credit rating agencies and investment banks	Import rule	Guidotti type rule	M2 rule	Gross ext debt	Gross external financing needs
Fitch					
Moody's		*	*	*	
Standard & Poor's					*
Deutsche Bank	*	*	*		
Goldman Sachs			*		
Citibank		*	*		
Barclays		*			*

Source: Author's construction based on Antal–Gereben (2011) and Csom-Bíró–Csaba (2017).

Girton–Roper (1977) developed the exchange market pressure (EMP) index to capture pressure on currencies that would have been warded off by authorities' intervention. It is a simple average of exchange rate changes and a foreign reserve depletion indicator, and more recently, an interest rate indicator, to reflect policy reactions of monetary authorities. Studies also discovered that the EMP index, with the reserve variable alone or with the reserve variable adjusted for by broad money, clearly explains changes in the exchange rate variable (Fischer 2001, Nowak et al. 2004, Antal–Gereben 2011, Csom-Bíró–Csaba 2017, Hossfeld–Pramor 2018, Klutse 2019).

Foreign exchange reserves play a significant role in many economies. Countries hold reserves to improve confidence in the national currency, counter disorderly market conditions, support monetary policy, build assets for intergenerational purposes, or influence the exchange rate (IMF 2017). For financially integrated economies, the sudden disappearance of foreign exchange liquidity from the banking system presents the biggest threat, while capital flight and currency depreciation necessitate foreign exchange market intervention in other countries. While certain countries intervene in their exchange rate market for various reasons, their overarching goal is to meet the expectations of financial markets (Antal–Gereben 2011, Csom-Bíró–Csaba 2017).

Countries in Sub-Saharan Africa (SSA) face substantial shocks compared with those in industrial and other emerging market countries. The main shocks facing SSA

countries include a sharp change in their terms of trade due to exogenous movements in the prices of key exports or imports and a change in their net aid flows they received. In addition, they are at risk of capital flights in an ever-integrated global financial market due to their low reserve levels (Drummond–Dhasmana 2008). The introduction of the Heavily Indebted Poor Country (HIPC) Initiative in 1996 and the Multilateral Debt Relief Initiative (MDRI) in 2005 by the IMF and World Bank also mean that SSA countries will have unique characteristics in terms of their external debt vulnerability.

Because of SSA's uniqueness and the absence of studies that utilized the theory of reserve adequacy to develop an EMP index, this study attempts to develop and propose two new measures of the EMP index that will be robust in identifying EMP in SSA.

Using a **generalized method of moments (GMM)** estimation and ridge regression models, which are appropriate for handling variables with multicollinearity problems, as control experiments, this study found all three approaches to be significant in explaining changes in the exchange rate variable. The index with the reserve variable adjusted for imports of goods and services had the highest explanatory power, followed by the index with the reserve variable adjusted for broad money supply (the original EMP index by Girton–Roper [1977]).

Viewing these results more as indicative than definitive will mean that a combination of these indices will be more appropriate. As SSA economies become sophisticated, the causes of exchange rate crises may shift from current accounts to capital accounts. Therefore, depending on the sophistication of a country's economy, any of the proposed indices may be important, as they are all significant in determining changes in the exchange rate variable in SSA. The rest of the study discusses the theoretical and literature underpinnings, data and methodology, discussion of the results, and the conclusion.

Theoretical background and literature review

In reforming the Bretton Woods system, countries placed primacy on international reserves adequacy. 'The concern then was that inadequate global liquidity would eventually drive the world economy into recession and would prevent countries from effectively protecting the values of their currencies' (Bird–Rajan 2003: 873). The International Monetary Fund's (IMF) Special Drawing Rights was introduced to address this problem–an idea considered by Mendoza (2004) when he studied international reserve holdings in the developing world. During this period, studies focused on how countries can avoid exchange rate crises, even though Girton–Roper (1977), who combined changes in the exchange rate variable and international reserves to identify EMP in post-war Canada, had already considered such a phenomenon.

Emerging economies, such as Mexico, Thailand, Korea, Indonesia, Malaysia, Russia, Brazil, and Argentina, experienced currency crises during the 1990s and the early 2000s. Studies that investigated these crises pinpointed rapid reserve depletion as a defining feature, making the reserve variable significant in studies examining the predictability of currency crises (Bird–Rajan 2003, Kuncoro 2020). Hossfeld–Pramor (2018), while studying global liquidity and EMP in emerging market economies, used the EMP index exclusively with changes in the exchange rate and the reserve variable. Their decision was due to its high correlation with other variations of the index despite its ease of interpretation, and its availability over the full sample period. In testing new EMP measures in SSA, Klutse (2019) also found that the reserve variable plays an important role in SSA countries even though broad money is an intermediate target in most SSA countries. This was despite the different monetary policy frameworks (de jure) used by SSA countries. Klutse (2019) reached this conclusion after testing six variations of the EMP index based on the studies by Sachs et al. (1996), Eichengreen et al. (1994, 1996), Kaminsky–Reinhart (1999), Stavarek (2010), Hegerty (2018), and Hossfeld–Pramor (2018). Likewise, Lane–Burke (2001) learned that financial deepening is associated with an increase in the international reserves ratio. According to Lane–Burke (2001), smaller countries with more volatile foreign exchange rates have larger reserves than their larger less-volatile counterparts. Moreover, they found that indebted developing countries also tend to have smaller reserve ratios (Kiss–Pontet 2015).

In the era of capital mobility, developing countries cannot be faulted for prioritizing reserve accumulation, which is sometimes augmented through borrowings. Most developing countries do not control their capital sources. As a result, they are mostly guarding against economic and financial crises that occur because of volatile international capital flows. The problem is not the capital flow itself but the rapid reversal of capital, as has been happening in recent times. Countries with large reserves are better prepared to withstand currency crises than those with smaller reserves (Bird–Rajan 2003, Aizenman–Lee 2007, Jung–Pyun 2016, Silva Jr 2016). Nowak et al. (2004) confirmed this assertion when they studied the role of foreign exchange reserves in reducing currency volatility for 28 emerging market countries from 1986 to 2002. Their results supported the proposition that holding adequate reserves reduces the exchange rate volatility. They found this effect to be strong and robust, but nonlinear. It also appeared to operate through a signalling effect. Thus, in the presence of volatile borrowing conditions, indebted governments are expected to hold sizable international reserves (Bianchi et al. 2018).

The EMP index and the reserves ratio problem

When Girton–Roper (1977) developed the EMP index, they adjusted the reserve variable using the domestic monetary base. The purpose was to explain the quantity

of base money that the authorities are induced to create or destroy, while sacrificing autonomy, to stabilise the exchange rate. By deflating the rate of change of international reserves valued in domestic currency by the change in domestic base money, Girton–Roper (1977) obtained a real measure of the balance of payments, which they viewed as essential for converting the nominal measure of official intervention into real terms to determine the size of the balance of payments.

The choice of a variable to adjust international reserves has been debated by economists over the years. Acknowledging that international reserves are considered an inventory held against the uncertain future course of the balance of payments, the dynamics of the origin of a particular balance of payments deficit should be recognized. The balance of payments problem has evolved from being related to current account deficits to issues of capital and financial accounts in developing countries.

Since the currency crisis of the 1990s, the literature focused on two classes of benefits arising from a high level of reserves. It was an attempt to deal with crises that occurred from both the current account and capital and financial accounts of the balance of payments. According to these studies, a high level of reserve adequacy has reduced the likelihood of currency crises or a 'sudden stop', which is a sudden unwillingness by international lenders to renew their credit lines at times of market uncertainty. Additionally, higher reserve adequacy tends to be associated with lower external borrowing costs. This works through improved confidence and credit ratings on sovereign foreign currency debt since the government's default risk is perceived to diminish with higher reserves (Nowak et al. 2004). However, Aizenman–Lee (2008) argued that monetary mercantilism and precautionary hoarding may be mutually complementary. Thus, the benefit of holding reserves may reduce the effective cost of hoarding reserves and induce governments to prefer reserve-hoarding to the alternative.

Moore–Glean (2016) assert that reserve adequacy is not static and is intimately associated with the occurrence of financial crises and exogenous shocks. The traditional benchmark in international macroeconomics is that a country should maintain reserves that cover at least three months of imports. Therefore, reducing reserves below this benchmark is a sign of fragility. Moore–Glean (2016) found that, in small states, the optimal holding of foreign exchange reserves is approximately 25 weeks of imports, which is approximately 13 weeks higher than the traditional rule of thumb. They also found that countries with a prudent public expenditure management framework in place can hold smaller reserves. Bird–Rajan (2003), in studying the adequacy of international reserves in the aftermath of a crisis, recognised that the use of the reserves-to-imports ratio, which is derived from a trade-related approach to the balance of payments and reserve needs, became less relevant after the crises in 1990s. According to Bird–Rajan (2003), this opened the door for a superior and operationally expedient alternative. Pablo Guidotti, Argentina's former

Deputy Minister of Finance, observed that short-term indebtedness is a key indicator of illiquidity and predictor of financial crises. He proposed that 'countries should manage their external assets and liabilities in such a way as to be capable of living without foreign borrowing for up to one year' (Bird–Rajan 2003: 881).

The extreme reversibility of short-term debt in the event of a negative shock exposes borrowers to liquidity runs, leading to systemic crises. Using Pablo Guidotti's observation, proposals were made to resurrect the idea of expressing a country's reserves in relation to its short-term external debt–ratio of reserves-to-short-term external debt. It follows from currency theory that usable foreign exchange reserves should exceed the scheduled external amortisation for one year. However, this ratio is constrained by capital flights that occur only on external debts. With ever-increasing non-resident participation in the holding of domestic debt in developing countries, this ratio may not capture capital flight by both residents and non-residents in the domestic debt market. This shortfall has been addressed by adjusting the reserve variable using a broad money supply measure, such as that used by Girton–Roper (1977) in identifying EMP.

Since then, studies have attempted to incorporate these revisions into their examination of exchange rate volatility. Using a dataset of 112 emerging economies and developing countries, Bussière et al. (2015) addressed whether the accumulation of international reserves effectively protected countries during the 2008–2009 financial crisis. They found that the level of reserves matters and that countries with high reserves relative to short-term debt suffered less from the crisis, particularly when they had a less open capital account. Nowak et al. (2004) used the ratio of reserve assets to short-term debt, ratio of reserve assets to imports, and GDP as explanatory variables to determine the adequacy of reserves in emerging countries. Qian–Steiner (2017) confirmed the conclusions of Bussière et al. (2015) and found that international reserves positively affect the share of long-term external debt. According to Qian–Steiner (2017), this effect holds for both private and public external debt.

Chong et al. (2008) discovered that rapid reserve depletion appeared to be a prominent feature in developing a new early warning system for international currency crises. Using a threshold autoregressive model, they compared the ratios of reserves-to-imports, reserves-to-short-term external debt, and reserves-to-broad money to the EMP index estimated by Eichengreen et al. (1996), Frankel–Rose (1996), and Sachs et al. (1996), which added the interest rate variable to the original index developed by Girton–Roper (1977). Chong et al. (2008) suggested that when the reserves-to-short-term external debt falls by more than 29.1%, or if the Reserves-to-M2 ratio drops by more than 24.3% within six months, the likelihood of a crisis increases.

Hashimoto (2008) also studied these three ratios but divided imports, short-term debt, and the broad money supply by the reserve variable. Unlike Chong et al. (2008),

Hashimoto (2008) studied whether the Asian economies' actual foreign reserve accumulation was extraordinarily large compared to earlier levels, so they could recover from the rapid depletion that characterised the currency crisis in the late 1990s. Using a Brownian motion model with an absorbing barrier, Hashimoto (2008) discovered that most Asian economies appeared to have larger reserves–imports-to-reserves and broad money supply to-reserves ratios–than the estimated threshold during the 1997 crisis. However, reserves in terms of short-term external debt appeared insufficient to avoid speculative attacks (Terada–Hagiwara 2004).

Little attention has been given to SSA countries in existing studies. Drummond–Dhasmana (2008), among the few authors who conducted studies on SSA, studied the adequacy of reserves in SSA countries considering the shocks they face. Using a two-good endowment economic model, they concluded that the optimal level of reserves depends on the size of these shocks, probability, and the associated output cost. In addition, the high inflow of capital from developed countries to developing and emerging countries during and after the 2008–2009 crisis cannot be overlooked (Dooley et al. 2009).

Glocker–Towbin (2012) drew attention to the use of reserve adequacy (through broad money) by the central bank as an additional policy instrument by several countries. Using a vector autoregressive model for the Brazilian economy, they concluded that the reserve requirement policy can complement the interest rate policy in pursuing financial stability but cannot be a substitute for price stability.

Reserve accumulation to guard against currency crises is not easy. Reserves are an expensive insurance mechanism, with costs coming from many different sources, and are often difficult to quantify. Green–Torgeson (2007) in studying the motivations and costs of foreign exchange reserve accumulation among the world's largest emerging market holders of reserves, found that the net marginal return to additional reserves is low, supporting the proposition that the largest reserve holders are holding foreign exchange reserves exclusively for precautionary purposes. They advocated the removal of distortions, such as limited exchange rate flexibility, which leads to excess reserve accumulation. Rodrik (2006) discovered that the income loss of countries that accumulate reserves for insurance purposes is close to 1% of GDP, which does not seem exorbitant for holding foreign exchange reserves. The conclusion is that while reserves are accumulated as insurance and/or buffer against financial crises, they also attract foreign debt that arguably reduce vulnerability to sudden stops and capital outflows (Qian–Steiner 2017).

The IMF argued that the considerations underpinning a country's reserve needs depend on its economic and financial structure. To this end, the IMF (2015) grouped countries into mature markets, deepening financial markets, and constrained market access, which largely correspond to the commonly used per capita income classification to help assess their reserve adequacy for precautionary purposes. In addition, it also proposed a measure that combines the reserve-to-import ratio,

reserve-to-short-term external debt ratio, reserve-to-broad money ratio, and other liabilities to reflect other portfolio outflows. Alberola et al. (2016) also proposed a measure that can effectively capture the role of resident investors, whose overseas financial divestments are facilitated by international reserves.

The challenge for developing countries

Developing countries, such as SSA countries, cannot allow their exchange rates to be fully flexible, considering the significant impact shocks play in their economies. Moreover, these countries have fewer open capital accounts and are mainly commodity exporters, who mostly have no control over commodity prices. As a result, SSA countries intervene to reduce volatility or maintain a target exchange rate. As of 2007, SSA reserve levels were lower than those for the Middle East and North Africa, where resource-rich counties use reserves as a store of value. However, SSA reserves are generally higher than those of developing countries. With structural changes affecting the balance of payment flows and diverse macroeconomic settings, the other regions' experience only provides limited guidance for SSA countries about future reserve adequacy (Drummond–Dhasmana 2008).

The literature underscored the importance of reserve-to-import, reserve-to-short-term external debt, and reserve-to-broad money supply ratios in determining reserve adequacy, which is important in identifying EMP through the EMP index. The studies reviewed did not use a combination of these ratios to measure EMP. The EMP index developed by Girton–Roper (1977) only focused on the reserve-to-broad money supply ratio, as did other variations of the index. However, the literature also showed that the sophistication of developing economies means that the other two ratios must also be considered. To bridge this gap and improve the EMP index, this study considered the reserve-to-external debt and reserve-to-imports ratios since the reserve variable has been found to be significant in identifying EMP in SSA. Global experience also suggested that reserve levels may be significant in explaining and predicting currency crises (Fischer 2001). Unlike Chong et al. (2008), this study used these ratios to develop a new EMP index.

Data and methodology

This study focused on SSA because of the dynamic nature of the countries in the region. Most SSA countries are commodity exporters. In addition, they do not have developed capital markets compared to countries in other regions. Despite these characteristics, SSA countries have benefited from HIPC and MDRI since the early 2000s.

In SSA, countries with well-developed government bond markets, such as Ghana, Kenya, and South Africa, rely mainly on domestic bond issuance to finance budget

deficits, with some financing coming from non-resident investors (IMF 2018). The ability to attract new external funding from commercial sources to finance increased deficits is limited for most countries in SSA, except in project financing. However, with the timing of project financing likely to be closely linked to project needs rather than budget financing needs, countries can only rely on bilateral and multilateral loans during downturns. The countries' ability to raise additional financing from domestic sources has also become a function of both the depth of their domestic financial systems and the public sector's current role in the use of domestic credit. In countries characterised by significant financial deepening and lack of fiscal dominance in access to credit, governments are well positioned to tap credit markets for additional funding in a downturn (Petrakos et al. 2021).

Study area

In total, 26 out of 45 possible SSA countries were sampled for this study. The only limitation encountered while selecting the sample countries was data availability, where the remaining 19 countries not selected either had incomplete or no available data. Kenya, Mozambique, and Zambia have no explicitly stated nominal anchor, but they monitor various indicators in conducting monetary policy. Kenya, Nigeria, and the Democratic Republic of Congo maintain a de facto exchange rate anchor to the USD. Kenya and Mozambique have taken preliminary steps toward inflation targeting. Somalia is the only country without a monetary policy framework (IMF 2017).

Of these 26 countries, 9 did not take part in the HIPC initiative, with the remaining 17 having reached a completion point in the process (see Appendix Table A1). Most countries have different monetary and exchange rate regimes, which do not appear to have a significant effect on the importance of the reserve variable. Antal–Gereben (2011) and Csom-Bíró–Csaba (2017) noted that countries with fixed exchange rate regimes use foreign exchange reserves to support daily operations, as it is necessary to maintain the exchange rate at its target. Countries with clean, floating exchange rate regimes uphold the possibility of intervention in the exchange rate market if required by extraordinary market circumstances, ensuring liquidity and continuous operation of the foreign exchange market. In SSA, an extraordinary market circumstance seems to always warrant exchange rate intervention (Antal–Gereben 2011).

Table 2

De facto monetary and exchange rate regime (SSA), 2017

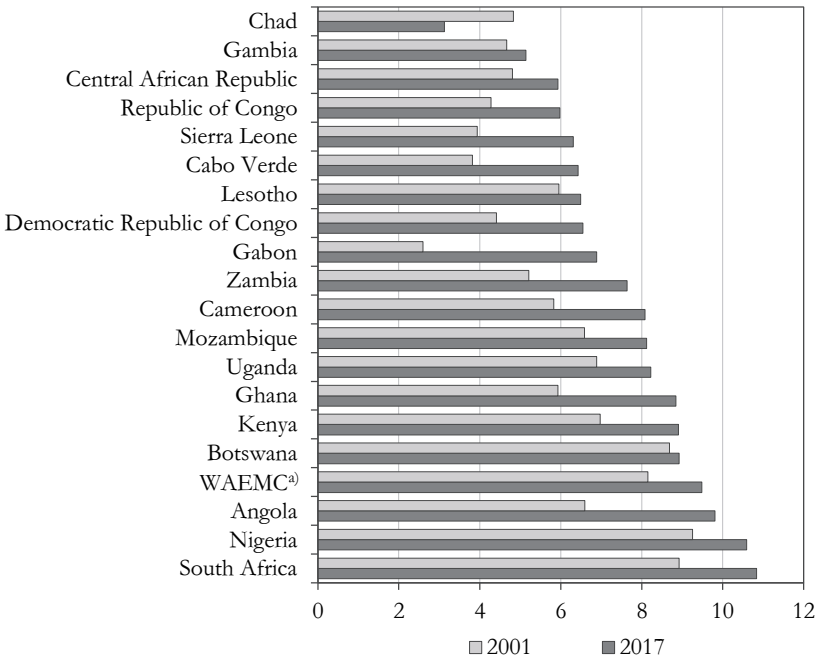
FX rate arrangement No. of countries	FX anchor				Monetary aggregate target	IT	Other
	USD	euro	composite	other			
No separate legal tender							
Currency board							
Conventional peg							
Stabilized arrangement	Angola	WAEMU[a], CEMAC[b]		Lesotho, Namibia	Tanzania, Malawi, Nigeria		Kenya
Crawling peg			Botswana				
Craw like arrangement					Burundi, Ethiopia, Rwanda		Mauritania
Other managed arrangement	Liberia, Zimbabwe				Democ-ratic Republic of Congo, The Gambia, Guinea, Sierra Leone		
Floating						Ghana, South Africa, Uganda	Mauritius, Mozam-bique, Zambia
Free floating							Somalia

a) Benin, Burkina Faso, Côte D'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo.
b) Gabon, Cameroon, Central African Republic, Chad, the Republic of the Congo and Equatorial Guinea.
Source: IMF 2017.

SSA's reserve levels are lower than its counterparts in the Middle East and North Africa, where reserves serve as a store of value in resource-rich countries. Usually, the central banks of SSA countries hold foreign reserves in trust with the government, making access to foreign exchange extremely controlled in most cases (Drummond–Dhasmana 2008). Among sampled countries, Nigeria and South Africa had the highest foreign exchange reserves in 2001 and 2017, respectively. In contrast, Gabon and Chad had the lowest foreign reserves in 2001 and 2017, respectively (Figure 1).

Figure 1

Foreign reserves level of sampled SSA countries in 2001 and 2017



a) Benin, Burkina Faso, Côte D'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo.

Variables and data source

The data for this study, obtained from both the IMF's international financial statistics and World Bank's international debt statistics, are yearly datasets from 2002 to 2017. One challenge for this study period was the limited availability of a comprehensive dataset, especially for short-term external debt. Short-term external debt, which includes all debt with a remaining maturity of one year or less and interest in arrears on long-term debt, were only reported yearly for the sampled countries. Total external debt is the debt owed to non-residents repayable in currency, goods, or services. The IMF defines it as the sum of public debt, publicly guaranteed and private non-guaranteed long-term debt, IMF credit, and short-term debt (see Appendix Table A2).

The study's variables include exchange rate, imports of goods and services, broad money, reserves, and short-term external debt. The exchange rate data used were the end-of-period values of the national currency per USD for all countries. The USD exchange rate was used because it is the largest trading currency and the universal reserve currency worldwide. All variables were converted to USD for data consistency, since countries employ different currencies.

Estimating the new index

Using the original form of the EMP index, this study developed new variations of the index, as shown in the equations below.

$$emp1_t = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{RES_t - RES_{t-1}}{Imp_{t-1}} \quad (1)$$

$$emp2_t = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{RES_t - RES_{t-1}}{SED_{t-1}} \quad (2)$$

$$emp3_t = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{RES_t - RES_{t-1}}{Mon_{t-1}} \quad (3)$$

where $\frac{e_t - e_{t-1}}{e_{t-1}}$ represents changes in the exchange rate variable e_t, $\frac{RES_t - RES_{t-1}}{Imp_{t-1}}$ represents the change in foreign exchange reserves scaled by the one-period-lagged value of imports of goods and services Imp_{t-1}, short-term external debt SED_{t-1} and broad money Mon_{t-1} for equations 1, 2, and 3, respectively. Equation 3 represents the index defined by Girton–Ropper (1977). However, the assumption is that a country will be able to ward off speculative attacks on its currency if it has reserves that can cater for the previous year's imports, short-term external debt, or broad money. Despite this assumption, Bianchi et al. (2018) advocated that the optimal amount of reserves should be able to cover 16 months of debt obligations. The focus of this study on variations of the reserve variable is based on the fact that Klutse (2019), after testing six variations of the EMP index based on studies by Sachs et al. (1996), Eichengreen et al. (1994, 1996), Kaminsky–Reinhart (1999), Stavarek (2010), Hegerty (2018), and Hossfeld–Pramor (2018), found that the variation of the index with only the reserve variable and the reserve variable adjusted for by the broad money variable had the most explanatory effect on exchange rate variable changes. This led to the conclusion that the reserve variable still plays a very important role in SSA, even though SSA is characterised by countries with different monetary policy frameworks.

After estimating these indices, their significance and explanatory power against changes in the exchange rate variable were tested. For this purpose, the exchange rate variable (dependent variable) was converted to a natural log and then differenced, which made achieving this study's main objective easier by determining how changes in the exchange rate variable reacted to the various EMP indices estimated in equations 1-3. Additionally, because most sampled countries participated in the HIPC initiative, their short-term external debt was significantly reduced after reaching the completion point. This necessitated the inclusion of an HIPC dummy (*dummy* 1) with a value of (1) for periods with no short-term external debt and value zero (0) elsewhere. This study employed a GMM estimation and a dynamic panel estimator regression model for this purpose. As a control experiment, ridge regression was used for the same purpose. The choice of these regression models was because of the inclusion of a variant of the dependent variable in the proposed indices. The reserve

variable was also a common variable in their computation. Consequently, multicollinearity could not be assumed. For instance, the GMM adds the lag of the dependent variable to the explanatory variables which has a limiting effect on the level of multicollinearity. On the other hand, the ridge[1] regression is designed to deal with models that suffer from multicollinearity problems by using the variance inflation factor (VIF). Ridge regression is more adequate than a more robust variant called lasso regression because of the focus on the explanatory effect of the proposed indices on the changes in the exchange rate variable. These are considered only after other ways of dealing with multicollinearity have been explored.

The GMM is an extension of models that can be estimated using panel techniques. The panel regression form of the problem can be written as:

$$Y_{it} = f(X_{it}, \beta) + \delta_i + \gamma_t + \epsilon_{it} \tag{4}$$

Assuming a linear conditional mean specification implies that:

$$Y_{it} = \alpha + X_{it}{}'\beta + \delta_i + \gamma_t + \epsilon_{it} \tag{5}$$

Where Y_{it} is the change in the natural log of the exchange rate variable – the dependent variable, and X_{it} is a k-vector of regressors – $emp1_t$, $emp2_t$, $emp3_t$ and $dummy\ 1$ – and ϵ_{it} are the error terms for $i = 1, 2, \dots, M$ cross-sectional units observed for dated periods $t = 1, 2, \dots, T$. α is the overall constant while δ_i and γ_t are cross-section or period specific effects – random or fixed. Because the estimation above did not automatically allow for coefficients of the regressors to vary across cross-sections or period-specific effects, this study employed a dynamic panel equation using a GMM technique (Wooldridge 2002, Baltagi 2005), as shown in equation 6 below.

$$Y_{it} = \sum_{j=1}^{p} \rho_j Y_{it-j} + X_{it}{}'\beta + \delta_i + \epsilon_{it} \tag{6}$$

First-differencing this specification (Equation 6) eliminated the individual effect (possible impacts of missing variables on the dependent variable) and produced the following equation:

$$\Delta Y_{it} = \sum_{j=1}^{p} \rho_j \Delta Y_{it-j} + \Delta X_{it}{}'\beta + \delta_i + \Delta\epsilon_{it} \tag{7}$$

For this equation to be efficient, several period-specific instruments corresponding to the second lag of the dependent variable were introduced. To handle cross-section and fixed effects, an orthogonal deviation suggested by Arellano–Bover (1995) was employed to remove individual effects from the specification. As the model accounts for cross-sectional fixed effects, a white period weighting matrix was used to compute the Arellano-Bond 2-step estimator. This was done by assuming a contemporaneous correlation between the cross sections. The

[1] It is used as a control experiment to confirm the relationship between the study variables.

dynamic instruments associated with the log of the exchange rate variable include available lags from two to the number of periods in the sample. A constant was added to the instrument list.

For the GMM regression estimate, J-statistics, which is simply the Sargan statistic of over-identifying restrictions, was considered. The Sargan statistic was used when the instrument rank was greater than the number of estimated coefficients. The J-statistic from a panel equation differed from that of an ordinary equation by a factor equal to the number of observations. Sargan statistic's null hypothesis was that over-identifying restrictions are valid. EViews software was used for this purpose because of its robustness in providing good estimation results.

Results and discussion

The literature review generally confirmed that reserve adequacy can vary among developing countries depending on their economic circumstances; hence, the reason to use the three approaches to determine reserve adequacy. Events in the 1990s and beyond also showed defects in earlier approaches to assessing reserve adequacy (Bird–Rajan 2003). Since reserve adequacy was used in this study, the regression results presented new perspectives on the subject matter, which differed significantly from most studies in this subject area.

Table 3 presents the results of the GMM and ridge regression models used in this study. The results indicated that all explanatory variables were significant. All had the expected positive signs (thus, increasing pressure on the exchange rate will mean an increase in the proposed index), except for EMP 3 which had a negative sign on the log changes of the exchange rate variable. Many see broad money as a measure of money. It is defined as the sum of currency, checking deposits, savings deposits, retail money market mutual funds, and small-time deposits. The negative relationship between EMP 3 and the log changes in the exchange rate variable could mean that the transmission mechanism does not work through the standard money multiplier model from reserves to money and bank loans in most SSA countries. Thus, open market operations which change reserve balances are not necessarily effective (Carpenter–Demiralp 2012). The frequency of the dataset can also be a factor because data is only available yearly rather than monthly.

EMP 1 explained most of the dependent variables, followed by EMP 3, EMP 2, and Dummy 1. The significance of the dummy variable confirmed the influence of debt forgiveness (HIPC) on SSA. EMP 2 had the least explanatory power, possibly because of the HIPC initiative's role in reducing SSA's external debt. Even if the HIPC dummy was combined with EMP 2, it still fell short of the explanatory effects of EMP 1 and EMP 3.

Table 3

Regression output for the changes in the log of the exchange rate

Explanatory variables	GMM	Ridge
DLNFX (–1)	0.025359	
	(5.142612)***	
EMP 1	0.381147	0.020125
	(22.20398)***	(3.36821)
EMP 2	2.85E-08	8.13E-09
	(2.933026)***	(0.924959)
EMP 3	–0.170155	0.003671
	(–13.28273)***	(3.369471)
DUMMY 1	0.014937	–0.007894
	(3.010565)***	(0.925975)
Instrument rank	26	
J-statistic	25.86409	
Prob (J-statistic)	0.211679	

Notes: For GMM, the t-statistics are in parentheses (). Symbols *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels. For ridge regression VIF is in parenthesis ().

The ridge regression, used as a control, resulted in all variables having a positive effect on the log changes in the exchange rate variable. Most of the explanatory effect came from EMP 1, with the others following the same order as in the case of the GMM regression model. The VIF of the explanatory variables was <5. This was after the lambda bias level was set to 0.04. Since the index, as estimated in equations 1, 2, and 3, includes the exchange rate variable itself, it meant any regression with the log difference of the exchange rate variable, as the dependent variable would likely to suffer from multicollinearity. These two models addressed this effect. Ridge regression was the last option for dealing with multicollinearity in any model. EMP 2 had the lowest VIF, considering that the HIPC initiative meant uneven completion points and debt relief among sampled countries in SSA.

The value of the J-statistic probability in this case was not significant; therefore, the null hypothesis that the over-identifying restrictions are valid was accepted. Instrument rank (26) was greater than the number of estimated coefficients, which was a key criterion in assessing the appropriateness of the GMM model.

Conclusion

SSA countries have utilized foreign exchange reserves to prevent currency crises. Based on the literature review, smaller countries with more volatile foreign exchange rates have larger reserves than their larger less-volatile counterparts (Lane–Burke 2001). Evidence suggested that countries with large reserves are more able to withstand currency crises than those with smaller reserves do (Bird–Rajan 2003,

Aizenman–Lee 2007, Jung–Pyun 2016, Silva Jr 2016). According to the literature, a shift to flexible exchange rate regimes and the ability to borrow in domestic currencies have been used as ways to ease pressure on reserve accumulation. Bird–Rajan (2003) and Nowak et al. (2004) pointed out that emerging economies struggle to maintain adequate reserve levels, except for some Asian countries. The literature review led to the proposal of two new variations – adjusting the reserve variable by either imports or short-term external debt – of the EMP. The results concluded that the EMP index with the reserve variable adjusted for imports of goods and services is more responsive to changes in the log of the exchange rate variable. It also confirmed the observations of Nowak et al. (2004) that the exchange rate crisis in the sampled countries emanates mostly from the current account of the balance of payments. This implied that the reserve adequacy of these SSA countries can be assessed by the size of trade flows, proxied by the value of imports. This conclusion notwithstanding, the significance and explanatory power of the other two indices, including the HIPC dummy, means that the other versions of the EMP index used in this study cannot be overlooked.

In an exchange rate crisis, implementing a theoretically superior approach to reserve adequacy can be difficult (Fischer 2001). Thus, the rule-of-thumb indicator may still have some operational advantages despite some theoretical shortcomings, confirming the results of this study. Its importance is further magnified if the indices proposed in this study are interpreted as merely indicative rather than definitive. This study recommends a combination of these indices because the phase of economic development is not static. As SSA economies become sophisticated, the causes of exchange rate crises may shift from current accounts to capital accounts. Additionally, as these countries deepen their domestic capital markets, the effect of capital flights cannot be overlooked. Therefore, depending on the sophistication of a country's economy, any of the indices proposed may be important, as they were all significant in determining changes in the exchange rate variable in SSA.

Accumulating reserves have some costs as it could sacrifice stimulating the economy through the issuance of domestic bonds and investments in essential infrastructure. Foreign exchange reserves in most SSA countries are managed and held by the government's central bank. Since foreign reserve levels are already low in SSA countries, the benefits of accumulating reserves outweigh the cost of holding the same because SSA countries are mainly commodity exporters and do not control commodity prices. All measures of reserve adequacy come with a provision that other economic fundamentals remain sound. This is rooted in the fact that reserve accumulation may create a false sense of security if fiscal deficits remain high, crowding out private sector investments or creating debt overhang problems. This may overwhelm the insulating effect of reserves and surprise a country previously considered secure (Green–Torgeson 2007). Therefore, further studies are needed on the effect of fiscal policy measures on the proposed EMP indices.

Appendix

Table A1

HIPC completion point of sampled countries, 2019

No.	Countries	HIPC completion point
1	Angola	
2	Benin	03 March
3	Botswana	
4	Burkina Faso	
5	Cabo Verde	
6	Cameroon	06 April
7	Central African Republic	09 June
8	Chad	15 April
9	Congo, Democratic Republic of	10 July
10	Congo, Republic of	10 January
11	Côte d'Ivoire	12 June
12	Gabon	
13	Gambia, The	07 December
14	Ghana	04 July
15	Guinea-Bissau	10 December
16	Kenya	
17	Lesotho	
18	Mozambique	01 September
19	Niger	04 April
20	Nigeria	
21	Senegal	04 April
22	Sierra Leone	06 December
23	South Africa	
24	Togo	10 December
25	Uganda	May-2000
26	Zambia	05 April

Source: IMF (2019).

Table A2

Variables and their definitions

Variable	Definition
Exchange rate	Exchange rates, national currency per USD, end of period, rate
International reserves	International reserves and liquidity, reserves, official reserve assets, USD
Imports of goods and services	National accounts, expenditure, gross domestic product, external balance of goods and services, imports of goods and services, nominal, domestic currency
Short-term external debt	External debt stocks, short-term (DOD, current USD)
Broad money	Monetary and financial accounts, monetary aggregates, broad money, domestic currency

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