African Review of Economics and Finance | ISSN 2042-1478 |

Determinants of demand for international reserves in the SADC region

Laston Petro Manja*, Exley BD Silumbu and Regson DC Chaweza

Department of Economics, University of Malawi, Zomba, Malawi
*Corresponding author email: lmanja@unima.ac.mw

Abstract

What explains the unprecedented high levels of foreign reserves accumulated in the Southern African Development Community (SADC)? This study seeks to econometrically establish the key determinants of such high levels of reserves. To do so, the study adopts two panel estimation techniques: the Blundell-Bond System Generalized Method of Moments (GMM) and the Bias-Corrected Least Squares Dummy Variable (LSDVC). The regression results show evidence of precautionary (mainly reserves volatility) but not mercantilist motives in the SADC region. Inertial and opportunity cost elasticities of reserves demand are observed to be inelastic in both econometric models at about 0.85 and -0.70 respectively. The GMM identifies membership to the Common Monetary Area (CMA) as a significant factor, as member countries of these sub-groupings demand more reserves to meet subsequent reserve targets. In addition, while GMM results reveal a U-shaped relationship between reserves hoarding and national income, the LSDVC finds income to have no influence on demand, an observation attributed to strength of instruments within the GMM. From the regression results, the study finds that empirical works on demand for reserves need to clearly distinguish between the alternative measures of reserves - either including or excluding gold; a measurement difference that has typically been ignored in the literature. Various policy implications are drawn from the results.

Keywords: International Reserves; Buffer Stock Model; GMM; LSDVC; SADC.

JEL Classification: C23; E58

Article history:
Received: 28 July, 2020
Accepted: 12 March, 2022

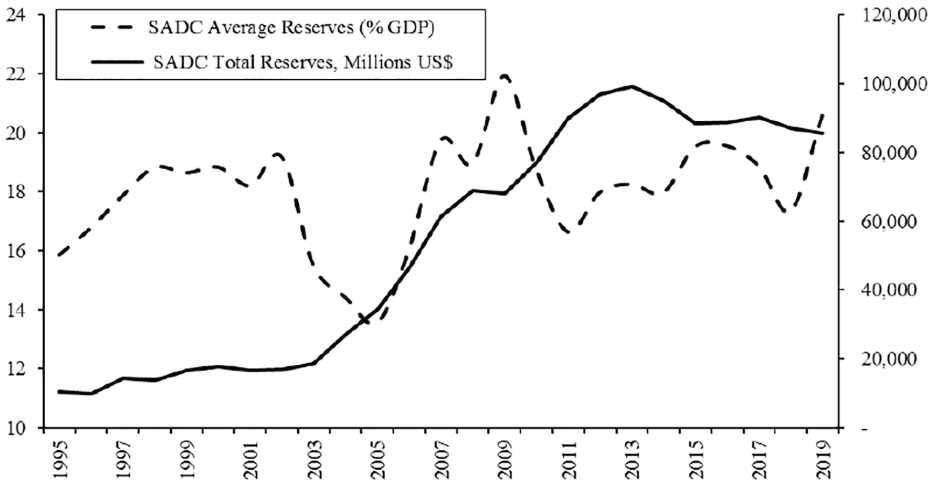
1. Introduction

One notable characteristic of the global official foreign reserve accumulation is that although central banks of Asian economies hoard the biggest proportion of global foreign reserves, African economies' central banks particularly those in the Southern African Development Community (SADC) have experienced an increasing share of reserves overtime. Precisely, since the year 2000, the increasing demand for reserves has been unprecedented with the regional average sometimes reaching about 22 percent of GDP. The rationale for such reserve hoardings, nonetheless, remains a debate for all countries (Ra, 2007). Though these countries gradually amassed enormous reserves with time, all economies including those in the SADC have become more market-oriented than centrally regulated. This has defied key tenets of the central bank intervention model which postulates that the wish to hold international reserves is justified only when countries pursue fixed exchange rate regimes in which case central banks are expected to intervene in the market to counteract any speculative attacks and defend parities (Bastourre, Carrera & Ibarlucia, 2009; Batten, 1982; Flood & Marion, 2002). This means that as SADC countries become more liberalized, other things held constant, stocks of reserves are expected to decline as shocks will be self-absorbing and hence there will be little or no need for market intervention. However, in spite of increased floating of currencies, reserve hoarding has been more pronounced for instance with the national conflicts around 1995-2003 and the global financial crisis of 2007-2009. This is seen in Figure 1 which shows the trend of reserve hoarding in terms of both the average ratio of reserves (excluding gold) to GDP and total reserves from the year 1995 to 2019.

Against this background, we investigate factors that influence demand for international reserves in the SADC region. International reserves are defined as those external assets that are readily available to and controlled by monetary authorities for direct financing of payments imbalances through intervention in exchange markets in order to influence the currency exchange rate, among others (IMF, 2009). The study finds that hoarding of international reserves in the SADC region is mainly influenced by the need to take precaution, rather than for mercantilist motives, and to satisfy sub-regional reserve targets.

To flesh out these findings, the rest of the paper shows how the research was carried out. The next section provides a brief background so as to motivate the study within the context. While Section 3 reviews existing empirical literature on the demand for reserves, Section 4 provides an overview of the SADC region

Figure 1: Trend in Average (% of GDP) and Total Reserves for SADC (1995-2019) - excluding Zimbabwe



Note: Reserves (% of GDP), LHS, and Total Reserves (Millions, US$), RHS
Source: IMF, IFS.

and a synopsis of international reserves both on the global front and among SADC countries. With the econometrics approach and results presented in Section 5, Section 6 concludes the paper.

2. Theoretical background

Foreign reserves are hoarded around the world, inter alia, to manage monetary and exchange rate policies; to abate the negative effects of external shocks especially in the face of limited access to international financial markets; to finance imports and to meet foreign debt for borrowing economies; as well as to reduce the cost of borrowing (Sinem & Nebiye, 2014; Bhattacharya, Mann & Nkusu, 2019). However, these benefits of reserve hoarding come at a cost. Theoretically, based on the quantity theory of money, if monetary expansion that corresponds to the hoarding of reserves is not fully sterilized and exceeds growth of money demand, reserves hoarding tends to be inflationary, both for fixed and flexible exchange rate regimes (Steiner, 2009). Additionally, holding excessively large quantities of reserves is costly because the yield from them, usually invested in bonds, is much lower than the opportunity cost of holding such reserves, although this cost is lower than the potential cost of another crisis (Ra, 2007). Massive reserves accumulation also represents large foregone consumption and investment in countries which would possibly have good

growth prospects. Further, the IMF (2009) observed existence of the Triffin dilemma, whereby reserves hoarding poses a risk on stability of the international monetary system (International Monetary Fund (IMF), 2009; Triffin, 1964).

The above points show that reserves hoarding markedly has its pros and cons. Yet, regional motives for the tendency remain unclear. Historically, a number of studies have been conducted, and the determinants mostly fall within four categories: transactionary, precautionary (risk factors), mercantilist or collateral asset motives. Analysis of the studies shows that an understanding of the determinants is essential for reserve management, especially since there are plans to launch a SADC central bank in the near future. Some previously conducted studies in Africa observe that reserves are hoarded to satisfy domestically set legal restrictions, to sustain domestic currency credibility in the face of crises and to help with foreign borrowing (SADC, 2011), among others. However, the continued reserve buildup is observed to have a weak return effect besides posing a risk on stability of the international monetary system, according to the IMF (2009). Such studies, however, have mainly considered traditional variables, mostly transactionary, without concern for other areal-specific determinants (Bhattacharya *et al*., 2019; Sanusi, Meyer & Hassan, 2019; Elhiraika & Ndikumana, 2007). The studies have also ignored differences in the alternative measures of reserves – either including or excluding gold. Why has reserve accumulation in the SADC region been on the rise when investments in some of the countries are below optimal? Is it self-insurance, protectionism or other factors? Does the measure of reserves used in empirical analysis matter in understanding the determinants? This study set out to answer these questions. Compared to prior studies, this paper offers not only improvements in the scope of countries covered within the region so as to have a better view of the entire SADC region, but it also uses improved econometric techniques and variable measurements, alongside a more robust model specification. The buffer stock model of money demand (Frenkel & Jovanovic, 1981; Ra, 2007; Sinem & Nebiye, 2014) is applied in this case, defining reserve demand as a Weiner process.

3. Previous empirical studies

While many studies have dedicated efforts to understand international reserves since the field gained ground in the mid-1900s, studies done for African developing economies remain scanty, with focus mainly on those countries outside of Africa. These studies differ in terms of methodologies, assumptions and what they focus on.

The empirics of demand for international reserves were initialized mainly by Machlup (1966) and Heller (1968) who found variability of trade to be a much better measure of reserve demand, and not necessarily its level. It was around this period that studies on the determinants of demand for international reserves sparked remarkable interest amongst researchers. One notable study was by Heller (1966) who revealed that international reserves are hoarded to reduce adjustment costs that would be incurred if no reserves were held, though the cost is balanced against the opportunity cost of holding these reserves. This confirmed key tenets of the buffer stock model of demand. Additionally, a higher marginal propensity to import (MPI) was found to reduce reserves demand since the marginal cost of adjustment is lowered. Factors that quickly surfaced in the search for determinants of international reserves include variability of international receipts and payments (Clower & Lipsey, 1968; Kenen & Yudin, 1965); propensity to import (Clark, 1970; Heller, 1966; Kelly, 1970); and the size of international transactions (Frenkel, 1978). However, like in many other previous studies, propensity to import – representing the degree of openness – appeared with a positive coefficient, contrary to popular expectations.

Later, Frenkel (1981) in a stochastic framework to explore optimal international reserves used the Ordinary Least Squares (OLS) estimation technique for 22 developing countries from 1971 to 1975 and found imports as well as opportunity and adjustment costs to be significant determinants, in line with both Hume's (1752) price-specie-flow and the buffer stock model. Building on the work by Heller (1966), Frenkel and Jovanovic (1981) proposed reserve volatility as a proxy for adjustment costs. Although Frenkel (1983) discovered that international reserves were increasing even with the floating of currencies in 1973, it was later observed that the likely cause of the paradox was the prevalent capital account liberalization (Grimes, 1993). These studies only considered traditional determinants and focus was mainly on developed economies.

Edwards (1985) later observed that most studies on demand for international reserves fail to find the expected negative statistically significant coefficient of the opportunity cost because of incorrect measurements of the variable that were employed in different studies. It was observed that opportunity cost must be defined as the spread between the interest rate at which countries can borrow from abroad and the London Interbank Offered Rate (LIBOR). Later studies include Flood and Marion (2002) who presented a comprehensive extension of Frenkel and Jovanovic's (1981) study by modifying not only how volatility is measured, but also incorporating financial crises. Volatility was found to have a

significant positive impact on reserve hoardings from this study. Finding similar results, and surprisingly that countries with flexible exchange rate regimes have higher ratios of reserves to GDP, Bastourre *et al*. (2009) found trade openness, regional imitation, persistence, development level and financial and exchange rate deregulation to be significant factors affecting hoarding of reserves. These results are in line with what was discovered by Aizenman and Marion (2003), Aizenman and Lee (2007), Cheung and Ito (2009), and Hur and Kondo (2016) who confirmed precautionary motives and found that the exchange-rate arrangement, political considerations as well as size of international transactions and their volatility are biggest determinants of demand for international reserves. The results slightly contrast findings by Dooley, Folkerts-Landau and Garber (2004) who found existence of the mercantilist motive in China.

Bernard (2011) discovered a new contextual factor, called 'keeping up with the Joneses' effect, where Central American countries' policies were found to consider reserve accumulation of large emerging markets in Latin America. However, this effect is not expected for SADC countries as most of them are just target oriented. More recently, studies have moved towards including more financial variables in the models, owing to Obstfeld, Shambaugh and Taylor (2010) who adopted a financial stability view for reserves demand. In that spirit, Jung and Pyun (2015) employed difference-GMM and system-GMM estimators and found that financial deepening is positively associated with reserves, whereas Oktay, Öztunç and Serín (2016) confirmed significance of scale, precautionary, mercantilist motives and financial variables for G-7 countries. Most recently, Mahraddika (2019) observed that reserve accumulation is positively associated with domestic private investment in the long-run. Interestingly, Bhattacharya *et al*. (2019) and Sanusi *et al*. (2019) attested to the existence of precautionary motives, with the former focusing on low-income countries in general and the latter only focusing on 10 selected southern African countries. These studies confirm plausibility of, among others, the buffer stock model, thereby directing on possible determinants of demand. In fact, beyond these previous empirical works (including the closely related Sanusi *et al*. (2019)), this study goes a step ahead for the SADC region by adopting a more exhaustive model specification with better-defined variables (including the definition of foreign reserves), covering a longer time frame for almost all SADC countries and employing better econometric techniques.

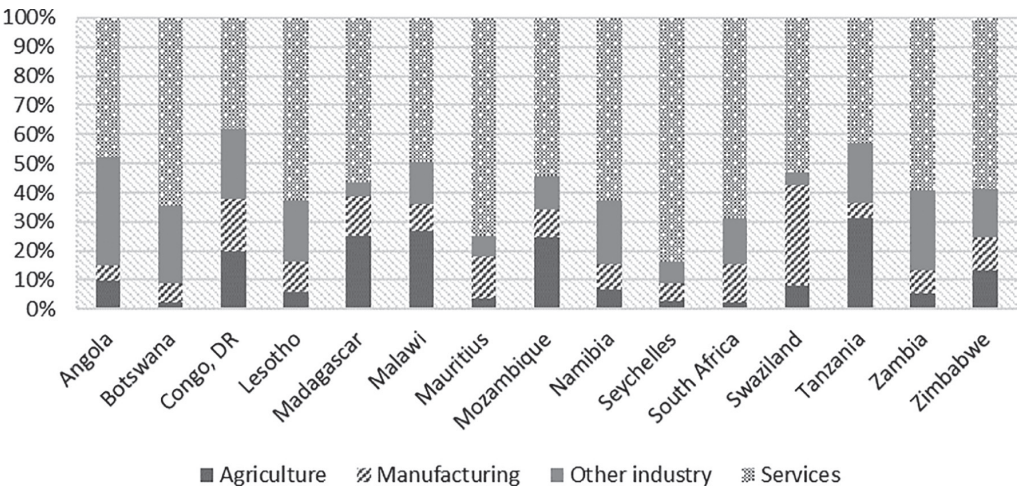
4. International reserves in the SADC region

The SADC is an inter-governmental organization with 16 countries as of 2021 including Angola, Botswana, Democratic Republic of Congo (DRC), Eswatini (formerly Swaziland), Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania, Zambia, Zimbabwe and most recently (since 2017) the Comoros. For development, the SADC region is guided by the Regional Indicative Strategic Development Plan (RISDP), first adopted in 2003. The first RISDP was a 15-year regional integration development framework aimed at deepening integration in the region, detailing a timeline for the transition of SADC from a free trade area (FTA) (achieved in 2008) to an Economic and Monetary Union [EMU] (SADC, 2017). Later, the RISDP 2020-2030 was formulated guided by lessons learnt from the Revised RISDP 2015–2020. In this case, economic transition was prearranged to move from the FTA to Customs Union in 2010, then to common market in 2015 and monetary union by 2016. Overall, the region was expected to have a single currency by 2018, although other targets were set for percentage growth rates, inflation rates, fiscal deficits, percentages of public debt and current account deficits. For the milestones, it was observed that member states only managed to achieve the 2008 targets for indicators, and macroeconomic convergence (MEC) targets were best reached for public debt. Interestingly, worst performance for MEC targets was for international reserves, mainly because the targets were observed to be highly ambitious (Burgess, 2009; SADC, 2017; Simwaka, 2016).

In terms of economic performance, the SADC region represents the largest regional structure in sub-Saharan Africa (SSA) in economic terms, being home to one of Africa's largest economies, South Africa. The region is the richest, with a real per capita income higher than the continental average. In spite of this, the SADC harbors some of Africa's, and indeed world's, poorer economies indicating presence of disparities across the countries. For example, while Seychelles ranked as a high-income economy using the 2015 World Bank classification, countries such as Malawi and Tanzania remained as low-income economies. Apart from the income differences highlighted above, SADC countries also vary in their economic structures. While on a regional level economic growth in the SADC is mainly driven by the services sector which contributes more than half of GDP, some countries are highly dependent on agriculture. Regionally in 2013, for example, the services, manufacturing and agriculture sectors contributed respectively about 55, 31 and 14 percentages to GDP. Nationally, Madagascar, Malawi, Mozambique and Tanzania reported the

highest dependence on agriculture (over a quarter), while Seychelles had only 2 percent from agriculture and 82 percent from services due to its vibrant tourism sector. Angola had the greatest share of industry at about 57 percent. In 2015, Madagascar and Mozambique had about 23 percent of GDP from agriculture, with Seychelles still at 2 percent. Regional GDP decompositions by sectors in 2015 are illustrated by Figure 2.

Figure 2: SADC Countries' GDP Decomposition by Sectors for 2015 (in million US$, current prices)[1]

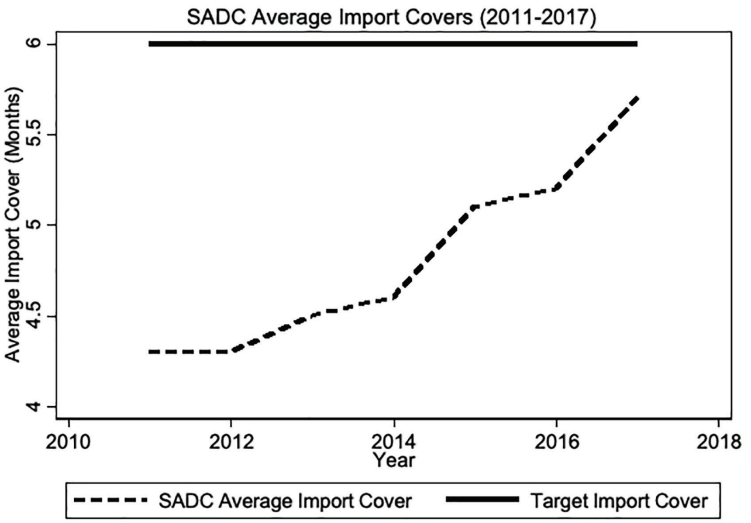


Note: 2012 figures used for Malawi data due to date availability.
Source: SADC Statistical Yearbook 2015 and WDI.

The SADC region managed to accumulate international reserves of about US$88 billion by 2016, from about US$51 billion in 2006. In terms of months of import cover, the statistics indicate that only Angola, Botswana and Mauritius managed to achieve the 6 months RISDP target in 2016, though Zimbabwe, Malawi, DRC and Namibia consistently struggle to attain the internationally recommended 3 months of import cover. Nonetheless, the SADC average import cover has been improving with time since 2011, as captured by Figure 3.

[1] Other industry includes construction, mining and quarrying, electricity, gas and water. Services include transport and communication, finance, insurance, real estate and business activities, general government services, wholesale and retail trade, restaurant and hotels and other services.

FIGURE 3: MACROECONOMIC CONVERGENCE: SADC AVERAGE IMPORT COVERS



Source: SADC Database.

Figure 3 shows that the regional average import cover has consistently been below the RISDP target, though the region could soon meet the convergence criterion in terms of import cover. This is the case though some of the countries (such as Zimbabwe) are far from meeting the national target level.

5. Economic approach

Having seen the qualitative relationship between various factors and reserves hoarding, this section quantitatively explores the determinants of demand for international reserves in the region. These determinants are mainly classified as scale, precautionary or mercantilist factors. Scale variables included are real GDP per capita (GDPc) and its square ($GDPc^2$). Precautionary variables, capturing the desire to self-insure again risks, were represented mainly by degree of openness (API), capital inflows (CapInf) and volatility measures in terms of exchange rate volatility (ERVOL) and reserves volatility (ResVOL). Mercantilism is about accumulating reserves in order to prevent or mitigate appreciation of the local currency with the ultimate goal of increasing export growth. This means reserves hoarding aims at maintaining export competitiveness and so is a deliberate policy for an economy to exert negative externalities on trading partners. This study measured the mercantilist motive using lagged export growth (ExpGrowth). Other variables also included in the study include inflation (InfRat), the opportunity cost of hoarding reserves (OPP) as well as dummies

for membership in the Malawi-Mozambique-Zambia-Tanzania (MMZT) and the common monetary area (CMADum) regions. These regressors are selected based on literature and data availability.

5.1. Methodology

The study sought to explore factors that determine demand for international reserves in the SADC region. Demand for reserves was measured by external assets that are readily available to and controlled by monetary authorities, as per the IMF's (2007) definition of international reserves. Given that this is the level of official international reserves that monetary authorities (central banks) wish to hoard, whereby the authority's wish is a demand function, these assets have been used in this study and in the literature alike to represent demand for reserves (Aizenman & Marion, 2003; Aizenman & Lee, 2007). This study made use of dynamic panel data techniques. Apart from offering more informative data, increasing degrees of freedom and improving efficiency, panel models allow for the capturing of dynamics of adjustment so as to estimate intertemporal relations (Hsiao, 2003). These form the benefits of panel models, and the rationale for using the methodology. Capturing dynamics of adjustment was of essence in this study because reserves are dynamic in nature such that the level of reserves at any point in time is a function of the immediate previous level. Additionally, accumulation of reserves is heterogeneous both in time and across countries. This calls for adoption of panel models so as to control for individual heterogeneity to avoid obtaining biased results if the data was simply pooled, ignoring the panel data structure. This would produce consistent yet inefficient OLS estimates compared to Feasible Generalized Least Squares (FGLS) estimates (Baltagi, 2005).

5.1.1. Blundell/Bond System GMM Estimator

Since reserves are dynamic in nature, a model of demand for reserves (y) must have as one independent variable the level of reserves in the previous period, to be given as in equation 1:

$$y_{it} = \delta y_{i,t-1} + x'_{it}\beta + u_{it} \tag{1}$$

where $i = 1, \ldots, N$ for N cross-sectional units and $t = 1, \ldots, T$ for T time-periods; δ is a scalar and x'_{it} a vector of 1 x K independent variables. In this case, the error component is assumed to be one-way, such that:

$$u_{it} = \mu_i + \varepsilon_{it} \tag{2}$$

where the error components are independent even with each other; u_{it} denotes the

unobservable individual-specific effect and denotes the remainder disturbance.

In the dynamic model, the dynamic component ($y_{i,t-1}$) is correlated with μ_i. This correlation makes the use of OLS or linear static panel (Fixed and Random effects) models yield biased and inconsistent estimates. As a solution, Arellano and Bond (AB) (1991) derived a consistent GMM estimator for the model. This estimator uses orthogonality conditions of the lag component and the remainder error term to obtain additional instruments for estimation of a dynamic panel data model. The resulting AB one-step GMM consistent estimator of δ with B, a matrix of instruments, and G, an $MA(1)$ Balestra matrix, is given by Baltagi (2005), as:

$$\hat{\delta} = [(\Delta y_{-1})' B [B'(I_N \otimes G) B]^{-1} B' (\Delta y_{-1})]^{-1} \times (\Delta y_{-1})' B [B'(I_N \otimes G) B]^{-1} [B'(\Delta y_{-1})] \quad (3)$$

However, the AB estimator can perform poorly if the autoregressive parameters or the ratio of variance of the panel-level effect to variance of idiosyncratic error are too large. This prompted Blundell and Bond (1998), building on the work of Arellano and Bover (1995), to develop a system estimator that uses additional moment conditions. This, known as the Arellano-Bover/Blundell-Bond linear dynamic panel-data estimator, was employed in this study for estimation of demand for international reserves, because it can capture dynamics of adjustment and outperforms the AB estimator.

5.1.2. Bias-Corrected Least Squares Dummy Variable (LSDVC) Estimator

It was further observed that the traditional dynamic panel models, including those by Arellano and Bond (1991) and Blundell and Bond (1998), may produce biased and imprecise estimates when the number of cross-sectional units is small or moderately large. An alternative approach to IV-GMM estimation in this case is the Bias-Corrected Least Squares Dummy Variable (LSDVC) estimator which was found to outperform the IV-GMM estimators in terms of bias and root mean squared error (RMSE) (Judson & Owen, 1999). As such, the study also employed Bruno's (2005) LSDVC which extends the bias approximations in Bun and Kiviet (2003) by allowing for estimation of unbalanced panels. In the SADC context, it is important to accommodate the use of an unbalanced panel knowing that some countries have missing observations in some periods. Therefore, the LSDVC was more appropriate than alternative techniques as used in other studies, such as panel ARDL models (see Sanusi et al. (2019)). For the LSDVC, from the dynamic model expressed in Equation 1, a selection

indicator r_{it} equals 1 if (y_{it}, x_{it}) is observed and 0 otherwise. That is;

$$s_{it} = \begin{cases} 1, & \text{if } (y_{it}, x_{it}) = (1,1) \\ 0, & otherwise \end{cases} \quad i = 1, \ldots, N \text{ and } t = 1, \ldots, T \tag{4}$$

The (possibly) unbalanced dynamic panel data model is expressed as

$$Sy = SD\eta + SW\delta + S\epsilon \tag{5}$$

Consequently, the LSDV estimator with bootstrapped standard errors is defined by:

$$\delta_{LSDV} = (W'M_sW)^{-1}W'M_sW \tag{6}$$

Where, $M_s = S(I - D(D'SD)^{-1}D')S$ is symmetric and idempotent.

Knowing that the LSDVC does not estimate coefficients of time-invariant regressors, this study made use of both the system GMM (to estimate coefficients of dummy variables) and the LSDVC. In this case, the LSDVC was used to check if the system GMM estimates are biased or imprecise.

5.2. Variable measurement

The independent variables employed in the study were defined as follows:

Scale Variables: Real GDP per capita and its square were included to capture a country i's level of development at time t and the respective quadratic effects.

Precautionary variables: Volatility measures (reserves and exchange rate volatility) were measured by the standard deviation of 12 monthly values within each year, and their inclusion was in consonance with the Prebisch literature on the consequences of unpredictable fluctuations in earnings of raw material exports. This measurement was adopted because data gaps in some countries under observation could not permit the estimation of GARCH variances, as was proposed by Mishra and Sharma (2011). Though, this approach is better than that taken by Sanusi *et al.* (2019) who proxied the measure by the nominal exchange rate. The degree of openness was measured as a ratio of imports to GDP (average propensity to import – API) which is used in place of marginal propensity to import. Beyond these, to check for robustness of the results, capital inflows – measured as the percentage of foreign direct investment [FDI, net inflows] to GDP – were also included following after Sanusi *et al*. (2019).

Opportunity Cost of Holding Reserves: The cost of foregone imports, expressed in terms of the foregone investment, is measured by the difference between the real return on reserves and the real return to domestic investments (that is, the spread between domestic lending interest rate and real US Treasury bill rate)

following Edwards (1985).

Mercantilist Factors are measured using export growth (ExpGrowth) (lagged twice) as was done by Aizenman and Lee (2005).

Common Monetary Area (CMA) Dummy: This is a dummy taking a value of 1 for country in the Common Monetary Area and 0 for country not in the Common Monetary Area at any time. Members of the CMA in the sample are Lesotho, Namibia, South Africa and Swaziland.

MMZT Dummy: This dummy for Malawi, Mozambique, Zambia and Tanzania was included in the study because of the countries' preferential treatment in terms of trade waivers, which is expected to reduce their exposure to risks and eventually reserves demand. These countries were given a value of 1 for the entire period, except for Zambia which also took a value of 0 after its reclassification from low to lower middle-income countries in 2011.

Beyond these measures, the study also controlled for inflation, following after Sanusi *et al*. (2019), measured as the annual percentage change in consumer prices.

5.3. Empirical specification

The study adopted a specification and functional form by Jung and Pyun (2015) who, in extension of the buffer stock model of demand, collected widely regarded important determinants of international reserves from various studies (Aizenman & Lee, 2007; Cheung & Ito, 2009; Obstfeld *et al*., 2010; Steiner, 2009). To allow for comparability of results from GMM estimation and the LSDVC (which does not estimate the intercept coefficient), an intercept-less model was estimated in both cases. This should not be problematic in this study given that it is meaningless to talk about all regressors being equal to zero anyways. The regression equation was specified as follows:

$$ln\frac{R_{it}}{GDP_{it}} = \alpha_1 GDPc_{it} + \alpha_2 GDPc_{it}^2 + \alpha_3 InfRat_{it} + \alpha_4 CapInf_{it} + \alpha_5 OPP_{it} + \alpha_6 API_{it} + \alpha_7 ExpGrowth_{i,t-2} + \alpha_8 CMADum_i + \alpha_9 MMZT_{it} + \alpha_{10} ERVOL_{it} + \alpha_{11} ResVOL_{it} + \varepsilon_{it} \quad (7)$$

where R is Total Reserves (With or Without Gold) and ε_{it} is the disturbance term.

5.4. Econometric results

The study proxies demand for reserves by the level of official international reserves that monetary authorities (central banks) need to hoard, whereby the authority's wish is a demand function. Throughout history, various measurements have been used, such as the level of international reserves or the import cover

(Edwards, 1984; Flanders, 1971; Frenkel, 1978; Frenkel, 1981). However, while the level-of-reserves measure does not allow meaningful comparisons across countries, months of import cover are not only less variable across countries but also, they may not permit the inclusion of propensity to import as a factor in the model (Bastourre *et al*., 2009; Bhattacharya *et al*., 2019; Cheung & Ito, 2009). As such, the reserves to GDP ratio was used in this study. Given that within the SADC some countries may hold significant amounts of gold reserves (such as South Africa, DRC and Mauritius), separate models with and without gold were estimated in this study, to make recommendations for future studies seeking to model the demand for reserves. This goes beyond the standard tradition of just focusing on reserves without any regard for gold (Bhattacharya *et al*., 2019; Sanusi *et al*., 2019; Bastourre *et al.*, 2009; Bernard, 2011).

5.5 Data properties

Analyzed using Stata software version 15, the study employed an unbalanced dynamic panel model for 15 SADC countries ($N = 15$) from 1980 to 2019 ($T = 40$). Choice of years in the sample not only rested on data availability, but also given that during the Bretton Woods system of fixed exchange rates and immediately thereafter, reserve accumulation was inspired by other motives than what is of interest in modern studies (Bhattacharya *et al*., 2019). Out of the 16 SADC countries as of 2019, Zimbabwe was excluded from the analysis mainly due to issues of data availability. Although the panel is unbalanced, randomness of such missing observations means this is not worrisome. The data was mainly sourced from the IMF's International Financial Statistics (IFS) and the World Bank's World Development Indicators (WDI). Data on US Treasury Securities was sourced from the Federal Reserve[2]. Appendix A shows a list of series, their descriptions and sources. All main regressions in the study were based on the full sample period for the 15 countries.

In standard microeconometric panel data models with $N \rightarrow \infty$ and fixed T, the assumption of stationarity of the variables is justifiable. However, stationarity becomes more evident as the time dimension increases. Since the data used in this study (with $T = 40$) starts to mimic the characteristics of a macro panel, it was crucial that unit root properties of the variables employed in the empirical model be tested in order to avoid the problem of spurious regressions among non-stationary variables that are not cointegrated. To the best of our knowledge, it is only Sanusi *et al*. (2019) who check for stationarity of the variables before

[2] https://www.federalreserve.gov/releases/h15/

adopting panel models. Of course, Sanusi *et al*. (2019) adopt a panel ARDL technique on their sample of 10 southern African countries from 1990 to 2015. Aside paying particular attention to the whole SADC region over almost the entire post-Bretton woods institutions' regime ahead of the planned regional central bank, this study goes a step further to employ better definitions of the different variables. In addition, on top of the traditionally hypothesized determinants, the study also includes more regionally contextual variables, in terms of the CMA membership dummy and the MMZT dummy. By doing this, this study is better able at uncovering the dynamics of reserve management over the time period so as to make policy recommendations towards the setting up of the SADC central bank. Given that the number of cross-sectional units in the study is small and less than the time dimension, cross-sectional dependence was no concern.

While a lot of unit root tests have been proposed for panel models, only a few of them can be applied to unbalanced data without inducing bias to the test results. As proposed by Maddala and Wu (1999), this study adopted the Fisher-type testing approach using the Phillips-Perron, rather than the Augmented Dickey-Fuller (ADF) test, specifying a null hypothesis of non-stationarity. Within this literature, the current study is the first to adopt such unbalanced-panel-friendly unit root testing approaches. Results of the Fisher-type test are presented in Table 1.

The Fisher-type test results indicate stationarity in levels at 5 percent for all variables except for reserves with gold as well as opportunity costs. For the non-stationary variables, the cross-sectionally ADF (CADF) test from Pesaran (2007) was used for validation. Here, with the null hypothesis specified that the series is stationary, it is verified that all the variables are stationary in levels at 5 percent.

TABLE 1: FISHER-TYPE AND PESARAN PANEL UNIT ROOT TESTS

	Fisher-type Test χ^2-Statistic (p-value) [H_0: Series is non-stationary]	
Series	**Constant without trend**	**Constant and time trend**
Total Reserves (Incl. Gold)	42.1097 * (0.0700)	72.7994*** (0.0000)
Total Reserves (Excl. Gold)	45.6866 ** (0.0333)	62.0783*** (0.0005)
GDP per capita	46.1263 ** (0.0302)	87.4191*** (0.0000)
Squared GDP per capita	74.8798 *** (0.0000)	101.4461*** (0.0000)
Import-GDP	60.6074 *** (0.0008)	64.1435*** (0.0003)
Lagged Exports Growth	330.9098 *** (0.0000)	297.6141*** (0.0000)
Exchange Rate Volatility	204.1975 *** (0.0000)	270.4732*** (0.0000)
Reserves Volatility	105.7816 *** (0.0000)	241.6390*** (0.0000)
Opportunity Cost	66.9768 *** (0.0001)	41.4144* (0.2946)
Inflation Rate	220.7344 *** (0.0000)	297.9905*** (0.0000)
Capital Inflows	160.9468 *** (0.0000)	184.8706*** (0.2946)
	Pesaran CADF Test Z[t-bar] (p-value) [H_0: Series is stationary]	
Total Reserves (Incl. Gold)	0.718 (0.764)	-
Opportunity Cost	-	-1.371* (0.085)

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Authors' estimates.

5.6. Results and interpretations

Noting that the Blundell/Bond dynamic panel data model makes non-stationary variables stationary through the differencing, a few tests were employed to ensure that the results are reliable. First, the Sargan test was conducted to check if over-identifying restrictions, and consequently moment conditions, are valid so that GMM estimators are consistent. In this case, with the null hypothesis specifying that over-identifying restrictions are valid for models with and without gold reserves, chi-square statistics (345.266 and 321.807 respectively) were observed to be statistically insignificant signifying that moment conditions are valid and that there is no heteroskedasticity since the null hypothesis was not over-rejected.

The Arellano-Bond test of serial correlation was conducted to ensure that there is no serial correlation in the idiosyncratic errors so that moment conditions are valid. With the null hypothesis, in this case, specified that there is no serial correlation in first-differenced errors, results from the AB test of serial

autocorrelation for the system GMM with robust standard errors indicated that although there is serial correlation in first-differenced errors at the first order for both models at 5 percent significance level, there is no serial correlation at the second order, as desired.

Before conducting the multivariate analysis, a test of multicollinearity was also conducted to check independent variables against perfect collinearity (>0.8) to avoid obtaining, among other things, indeterminate regression coefficients and infinite standard errors. The variance-covariance matrix showed that there is no significantly high linear relationship between any regressors and the estimated model is satisfactory.

While separately estimating the system GMM estimator, the LSDVC estimator was also specified with the Blundell/Bond to initialize bias correction with maximum accuracy of approximation. Bootstrapped standard errors were also specified for the LSDVC since estimated asymptotic standard errors may provide poor approximations in small samples, such that obtained t-statistics and confidence intervals are often not reliable (Bruno, 2005). If GMM and LSDVC estimators gave similar results, then the system GMM estimates would be deemed unbiased and precise, and so would be interpreted, otherwise LSDVC estimates would be chosen. Table 2 presents the regression results.

Having estimated total reserves demand models with and without gold reserves, the numbers of instruments were less than the groups in system GMM, and chi-square statistics for the system GMM estimator were 3849.19 and 4068.16 respectively (both with P = 0.000). These statistics are strongly significant, showing that the independent variables included in the models are jointly significant. Comparing the models with and without gold, not much difference was observed in statistical significance, coefficient signs and magnitudes. However, some difference is observed for inflation in the system GMM model whereby the coefficient for the inflation rate is statistically significant with inclusion of gold reserves, yet insignificant without gold. This shows that although most SADC countries hold low levels of gold reserves, gold significantly changes the dynamics in as far as the demand for reserves is concerned. This empirically fails to vindicate studies that only focus on reserves without gold. A comparison of system GMM and LSDVC estimators shows similarity of the estimates, hence the system GMM estimates were deemed unbiased and precise, and therefore interpreted. For the logged regressand, individual coefficient interpretations employ the techniques of a log-lin model for most regressors.

Table 2: Model Estimation Results for SADC Countries

	System GMM		LSDVC	
	With Gold	**Without Gold**	**With Gold**	**Without Gold**
Inertia	0.7986***	0.8436***	0.8971***	0.9119***
GDP per capita	-0.0001***	-0.0001***	-0.0000	-0.0000
Sq. GDP per capita	0.0000***	0.0000***	0.0000	0.0000
Inflation Rate	-0.0052**	-0.0028	-0.0004	0.0006
Capital Inflows	-0.0026	0.0003	-0.0023	-0.0001
Opportunity Cost	-0.0078***	-0.0057***	-0.0078***	-0.0062***
Degree of Openness	0.0018	0.0490	0.1641	0.1624
Lagged Export Growth	0.0011	0.0011	0.0007	0.0008
CMA Dummy	0.3708***	0.3364***	-	-
MMZT Dummy	-0.0320	-0.0031	-	-
ER Volatility	0.0009*	0.0010*	0.0008	0.0009
Reserves Volatility	0.0000***	0.0000***	0.0000***	0.0000***
Wald x^2	3849.193	4068.158	-	-
P	0.000	0.000	-	-
N	316	316	316	316

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Authors' estimates.

On the one hand, significant determinants of demand for reserves in the SADC region include previous reserve levels, income, opportunity cost of holding reserves, inflation, reserves volatility and the CMA membership dummy. On the other hand, degree of openness, capital inflows, membership to the MMZT dummy, exchange rate volatility and lagged export growth are found to be insignificant, implying a higher prevalence of precautionary rather than mercantilist motives to hoarding reserves. This is in line with some findings by Bastourre *et al*. (2009), Sanusi *et al*. (2019) and Bhattacharya *et al*. (2019) for low-income countries.

The results in Table 2 show that for both models there is a positive impact of inertial forces on reserves demand at 1 percent level of significance. This is an elasticity whereby, *ceteris paribus*, a 1 percent increase in the previous ratio of reserves to GDP leads to approximately 0.80 and 0.84 percentage increases in the current demand for reserves with and without gold respectively for the GMM model, and respective 0.90 and 0.91 percentage increases for the LSDVC. This

shows that the inertial elasticity of reserves demand is inelastic. This result is similar to what was found by, among others, Edwards (1984), Bastourre *et al*. (2009) and Jung and Pyun (2015) in developing countries.

Income variables are statistically significant at all levels. For the system GMM estimator, a US dollar increase in GDP per capita results in decreased reserve accumulation as measured by the reserves-GDP ratio. The variable satisfies the *a priori* expected sign in line with Baumol's (1952) square-root rule for transaction demand as well as empirical findings by Cheung and Ito (2009) for both developed and developing countries. In this case, countries with higher incomes are often more stable and therefore less critical of potential external shocks whereas poorer economies are more prone to external shocks and hence likely to demand more reserves. The square of income is also found to be highly statistically significant, though not economically significant, exactly as found by Aizenman and Marion (2003) and Bastourre *et al*. (2009). With significance of income only observed in GMM and not LSDVC estimator, it is evident that the GMM adopts strong instruments capable of detecting original relationships, hence adoption of system GMM estimates is justified (Bastourre *et al.*, 2009). The result depicts a U-shaped relationship between income and reserves accumulation.

Of the three risk factors in the model, it is reserves volatility that is found to be statistically significant at the 5 percent level. The positive coefficient in all models is in line with the prediction of the buffer stock model of international reserves (Frenkel & Jovanovic, 1981). Reserves volatility was included as a proxy for adjustment costs incurred by an economy that was not hoarding enough reserves in the wake of a crisis. From all models it can be observed that higher adjustment costs for an economy increase demand for reserve holdings. This rightly aligns with findings by Ben-Ltaifa, Kaendera and Dixit (2009) and Bhattacharya *et al*. (2019) though it contrasts what was found by Bernard (2011) and Bastourre *et al.* (2009). For example, within the SADC in light of the high volatility, Lesotho and Swaziland as members of the Southern African Customs Union (SACU) have been encouraged overtime to deal with revenue volatility by building adequate reserve buffers to augment their resilience to risks from volatility (AfDB, 2018). In addition, violent conflicts such as the Mozambican war of 1989-1992, DRC hostilities of 1996-1997 and Lesotho post-election conflicts of 1998 were always followed by depleted reserve buffers amidst an increasing demand for economic restoration. Countries consequently demand more reserves to survive such risks.

Contrary to expectations, the GMM results reveal that membership to the CMA increases demand for reserves by about 35 percent. This is likely the case because members of the CMA (Lesotho, Namibia, South Africa and Swaziland) constantly set themselves targets to be met in terms of reserves accumulation, led mainly by the regional *de facto* Central bank, the South African. For example, smaller economies in the CMA are required to maintain foreign reserves of at least equivalent to the total amount of local currencies they issue (Wang, Masha, Shirono, & Harris, 2007). Similar to this is the requirement placed by France on French colonies in Africa to hold 50 percent of foreign reserves in the Bank of France. Such targets increase reserve demand. The special treatment that Malawi, Mozambique, Zambia and Tanzania (MMZT dummy) get in trade agreements due to their income ranking was found to have no effect on their reserve management practices though the expectation was that this makes it less risky for them, inclining them to demand less reserves for precaution.

For opportunity cost, the results confirm the *a priori* expected negative coefficient. Precisely, the opportunity cost elasticity of reserves demand is about -0.70. As an example, due to low interest rates in 2016, the Central Bank of Seychelles reported to have increased investment and demand in foreign currency (CBS, 2016). This shows that improvements in domestic investment earnings reduce countries' demand for reserves to be used in foreign earnings, especially knowing that reserves are usually held in the form of short-term interest-bearing assets.

5.7. Robustness checks

Various checks for robustness of the results were performed by estimating the models while, among others, excluding countries with unique characteristics that might affect the results. For example, Angola, being a net exporter of petroleum, may have different experiences in balance of payments compared to the other economies. In addition, while South Africa and Mauritius typically hold higher proportions of reserves, the DRC has outlying indicators especially for inflation. As such, the models were estimated again in the absence of these 4 economies, as shown in Table 3.

For all models, no significant differences in the estimates were observed, alluding to the robustness of the results.

Table 3: Model Estimation Results Excluding Angola, Mauritius, South Africa and DRC

	System GMM		LSDVC	
	With Gold	**Without Gold**	**With Gold**	**Without Gold**
Inertia	0.7619***	0.7590***	0.9160***	0.9241***
GDP per capita	-0.0001***	-0.0001***	-0.0001	-0.0000
Sq. GDP per capita	0.0000***	0.0000***	0.0000	0.0000
Inflation Rate	0.0028	0.0028	0.0043	0.0046
Capital Inflows	0.0048	0.0052	0.0008	0.0007
Opportunity Cost	-0.0036*	-0.0037*	-0.0063*	-0.0054
Degree of Openness	-0.0553	-0.0603	0.1146	0.1415
Lagged Export Growth	-0.0006	-0.0005	-0.0001	-0.0001
CMA Dummy	0.5916***	0.6055***	-	-
MMZT Dummy	-0.0601	-0.0700	-	-
ER Volatility	0.0005	0.0007	0.0006	0.0007
Reserves Volatility	0.0000***	0.0000***	0.0000***	0.0000***
Wald x^2	3824.595	3703.514	-	-
P	0.000	0.000	-	-
N	228	228	228	228

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Authors' estimates.

6. Conclusion and policy recommendations

This study set out to empirically investigate factors that influence demand for international reserves in the SADC region from 1980 to 2019. Demand for reserves is measured in terms of external assets that are readily available to and controlled by central banks. During the study period, it is observed that reserve demand generally increased in the SADC region as countries sought to actively take precaution against risks, including the various national conflicts between 1995 and 2003 as well as the global financial crisis of 2007-2009. This is the case in spite of the fact that these countries have grown more liberal over time. Given the nature of the dependent variable, as well as the (unbalanced) nature of the panel itself, both Blundell/Bond system GMM and LSDVC estimators were employed. Apart from including the key traditional factors adapted other empirical studies, this study adds regional-specific dummies and uses improved methodologies (including stationarity testing, among other diagnostic tests) and

variable measurements. The study weighs in on a decision which is typically taken for granted by empirical studies; that is, whether to ignore the gold component of reserves or not. Particularly, it is observed from this study that in spite of making up only a small proportion of foreign reserves, gold holdings actually influence dynamics for the demand for foreign reserves, and hence future studies should model reserves with and without gold separately. From the diagnostic tests, regression models were deemed to be well specified. The long-run results were then estimated using the system GMM estimator whose estimates' unbiasedness and precision was verified by the LSDVC.

In terms of the econometric results, it is observed from the system GMM model (with gold) that income (as measured by GDP per capita), inflation, opportunity cost, CMA dummy, as well as reserves volatilities play a role in influencing reserve hoarding. Precisely, income, inflation and opportunity cost have negative effects on demand for reserves, while CMA membership and volatility have positive effects. One variable that is unexpectedly found to be statistically insignificant using both estimators is the degree of openness. This is the case for the SADC region probably because the picture is too mixed, with some countries being net importers, suffering BOP deficits, yet others enjoy positive trade balances (such as Angola, South Africa and Zambia). In that regard, the traditional determinant has no effect on demand for reserves. Generally, obtained results are supported by, *inter alia*, the buffer stock model.

Several policy recommendations can be made from the results. Given that reserves are accumulated for precautionary motives, it is evident that improving stability of the monetary system is essential, in order to maintain a sustainable demand for reserves. One way to do this is to put in place sound reserve management policies which in turn effect on macroeconomic performance in terms of, among others, economic growth and price stability by reducing various costs, including opportunity and adjustment costs. It is also observed from this study that high opportunity costs reduce demand for reserves. This calls for improvement of returns that central banks get in the case that they decide to invest and not hoard reserves, through among other things reducing risk and offering secure and rewarding financial assets. Promotion of trade zones and unions is also a key policy implication from the results. It is pivotal for countries to increase stability and economic performance by opening up to regional unions from which they gain through trade and the set agreements.

Biographical notes

Laston Petro Manja is a Lecturer of Economics at the University of Malawi. He is also a pre-doctoral research fellow and a UMAPS (University of Michigan African Presidential Scholars Program) scholar at the University of Michigan, Ann Arbor. He has vast work and consulting experience, including with the World Bank. He is a Malawian citizen.

Exley BD Silumbu is currently a Senior Lecturer in Economics at the Economics Department, University of Malawi. He holds a PhD in Economics from the University of Notre Dame, Indiana, USA. His specializations include International Economics, Macroeconomics and Development Economics. He has worked as Principal Economist in the Malawi Civil Service; Chief Economist at the Malawi Confederation of Chambers of Commerce and Industry (MCCCI); and has also served as a member of the Monetary Policy Committee (MPC) of the Reserve Bank of Malawi.

Regson DC Chaweza holds a PhD in Development Economics and an MA in Economics and is currently a Lecturer in Economics at the Economics Department, University of Malawi. He previously held senior national policy advisory position as a member of the MPC of the Reserve Bank of Malawi. He has conducted various consultancy projects funded by the Government of Malawi, international donors and development partners including UNDP and the World Bank.

Acknowledgements

We are thankful to the handling Editor, Associate Professor Franklin Obeng-Odoom and for the anonymous reviews which made this article better.

Conflicts of interest

The authors declare no conflict of interest.

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Appendix A: Data Sources

Variables	Description	Source
Total Reserves (Including Gold)	Natural log of the ratio of reserves (with gold) to the value of current GDP (in US$)	IFS
Total Reserves (Excluding Gold)	Natural log of the ratio of reserves (without gold) to the value of current GDP (in US$)	IFS
GDP per capita	Taken on PPP basis (constant 2017, int'l $)	WDI
Squared GDP per capita	Square of the GDP per capita	WDI
Imports	Imports of goods and services as a ratio to current GDP (in US$)	WDI
Lagged Exports Growth	Lags the annual percentage growth of exports of goods and services by 2 periods	WDI
Lending Rates	Lending Rates	IFS
10yr Market Yield on U.S. Treasury Securities	10yr Market Yield on U.S. Treasury Securities	Federal Reserve
Opportunity Cost	Real US treasury bill rate minus the domestic lending interest rate	-
CMA Dummy	Takes 0 for country in the CMA at time t and 1 for country not in the CMA at the time	-
MMZT Dummy	Takes 1 for Malawi, Mozambique, Zambia and Tanzania and 0 otherwise	-
Exchange Rate Volatility	Standard deviation of monthly (period average) exchange rates in each year	IFS
Reserves Volatility	Standard deviation of reserves (excl gold)	IFS
Inflation Rate	Inflation, consumer prices (annual %)	WDI
Capital Inflows	Foreign direct investment, net inflows (% of GDP)	WDI

Notes: Federal Reserve data is obtained from https://www.federalreserve.gov/releases/h15/. IFS - International Financial Statistics; WDI - World Development Indicators.

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