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Macroeconomic Effects of Global Shocks: Policy Lessons for the SADC Region

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Abstract

The impact of global shocks proxied by US real GDP (global growth), federal funds rate (foreign interest rates), commodity price index (commodity prices) as well as rainfall and temperature (climate change) on the macroeconomic performance of the SADC region is assessed using country level data during the 2010q1–2022q4 period. The empirical results reveal that commodity price and global growth shocks tend to have a broader and significant impact on the region. Climate change shocks adversely impact the region via the agricultural and hydropower generation channels. The impact of foreign interest rate shocks is pronounced for countries that are more integrated in the global financial system. These results point to the strengthening of resilience to shocks in the region. This in part entails building fiscal buffers in times of commodity price booms and strong growth to help smooth out expenditures during downturns; more investments in the agriculture and energy sectors to mitigate the adverse effects of climatic change shocks, including accelerating efforts towards energy transition; and diversifying economies as well as scaling-up value addition to reduce dependance on primary commodity exports. Further, there is a role for monetary authorities to adopt an appropriate monetary policy stance during periods of shocks, build foreign exchange reserves during commodity price booms and spearhead as well as implement green finance incentive programmes in response to climate-related shocks.

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1 Background

Most economies in the Southern African Development Community (SADC) region are small, open and commodity-dependent. This makes them vulnerable to external shocks whose fortunes are inextricably tied to the strength of the international economy (Krznar and Kunovac, 2010). External shocks are broadly economic, social and environmental in nature and tend to influence output and production patterns (Prestorious et al., 2022). For instance, the global financial crisis (GFC) of 2008/09 led to the deterioration in the macroeconomic environment for developing countries, including those in SADC (Prestorious et al., 2022). During this period, the SADC region experienced significant volatility in exchange rates and increases in consumer prices.

Aside from external economic tremors, shocks that manifest through social disturbances may also adversely impact economic development and put pressure on the resilience of countries. One such disturbance is the coronavirus (COVID-19) pandemic, which resulted in public health emergencies and weighed on growth and development (Prestorious et al., 2022). It pushed the global economy into a recession in 2020. Despite the COVID-19 shock being non-financial in nature, it has had huge financial consequences globally. The containment measures to limit the spread of the virus caused a dramatic decline in economic activity due to supply-chain disruptions. With constrained economic activity, financial conditions tightened at unprecedented speed, exposing some "cracks" in global financial markets. Market volatility spiked and borrowing costs surged on expectations of widespread default (IMF, 2020). This led to sharp declines in commodity prices, which exacerbated challenges in some of the largest resource-intensive economies in sub-Sahara (IMF, 2020). As sub-Saharan Africa (SSA) struggles to recover from the recession, the region is confronted with a myriad of economic growth challenges exacerbated by the Russia-Ukraine conflict (World Bank, 2022). The conflict has pushed global energy and food prices higher resulting in the escalation of inflation around the globe and eliciting synchronised tightening of financial conditions that have weighed on global demand and put pressure on currencies in emerging market and developing economies to depreciate due to portfolio outflows (IMF, 2022). Erratic climatic patterns have also taken a significant toll on agricultural production and hydropower generation.

The health pandemic, geopolitical tensions and adverse climatic pattern have contributed to volatility in the SADC region's macroeconomic conditions (SADC, 2021; IMF, 2022). This has been exacerbated by the fact that most SADC countries are net commodity exporters and importers of crude oil and fertilisers and depend substantially on rainfall for agricultural production and hydropower generation.

In summary, SADC region was adversely impacted by tight global financial condition, reduced foreign financial flows, amid challenges of new COVID-19 variants, global inflation, supply disruptions and climate shocks. Further, the ramifications of higher food and energy prices caused by the Russia-Ukraine conflict translated into higher inflation across the region and hurt livelihoods.

The adverse impact of external shocks presents a major challenge among most SADC countries as they continue to struggle to meet macroeconomic convergence (MEC) obligations. Primary and secondary indicators are used to monitor MEC within the SADC region. The primary convergence criteria indicators are inflation, budget deficit and debt while secondary indicators are current account balance, central bank credit to government, external reserves and real GDP growth. Specifically, the COVID-19 pandemic, Russian-Ukraine conflict and climate challenges impede the ability of countries in SADC to meet the macroeconomic convergence targets. For instance, Mato et al. (2011) demonstrate how GDP varies in SADC when faced with adverse externals shocks and Senbeta (2012) presents evidence on the significance of the contribution of external shocks to GDP growth rate in SSA. In addition, Chileshe et al. (2018), Zgambo and Funyina (2022) and Olamide et al. (2022) highlight the significance of external shocks on macroeconomic performance of African countries in the East African Community and Zambia.

This study, therefore, seeks to examine the impact of the recent global shocks, including COVID-19, Russia-Ukraine conflict and climate change, on selected macroeconomic variables in the SADC region. To capture the impact of recent shocks such as health (COVID-19) and geopolitical (Russia-Ukraine war), the analysis assumes that the transmission is through foreign GDP, foreign interest rates and commodity prices. Panel regression and structural vector autoregression (SVAR) approaches are used to draw policy lessons that may provide remedial measures that the SADC region may implement to strengthen resilience so as to meet commitments towards macroeconomic convergence.

The empirical results reveal that commodity price and global growth shocks have the most pronounced impact on macroeconomic performance in the SADC region. Climate change shocks (rainfall volatility) affect the region through the agricultural and hydropower generation channels. The impact of foreign interest rate shocks is pronounced for countries that are more integrated in the global financial system.

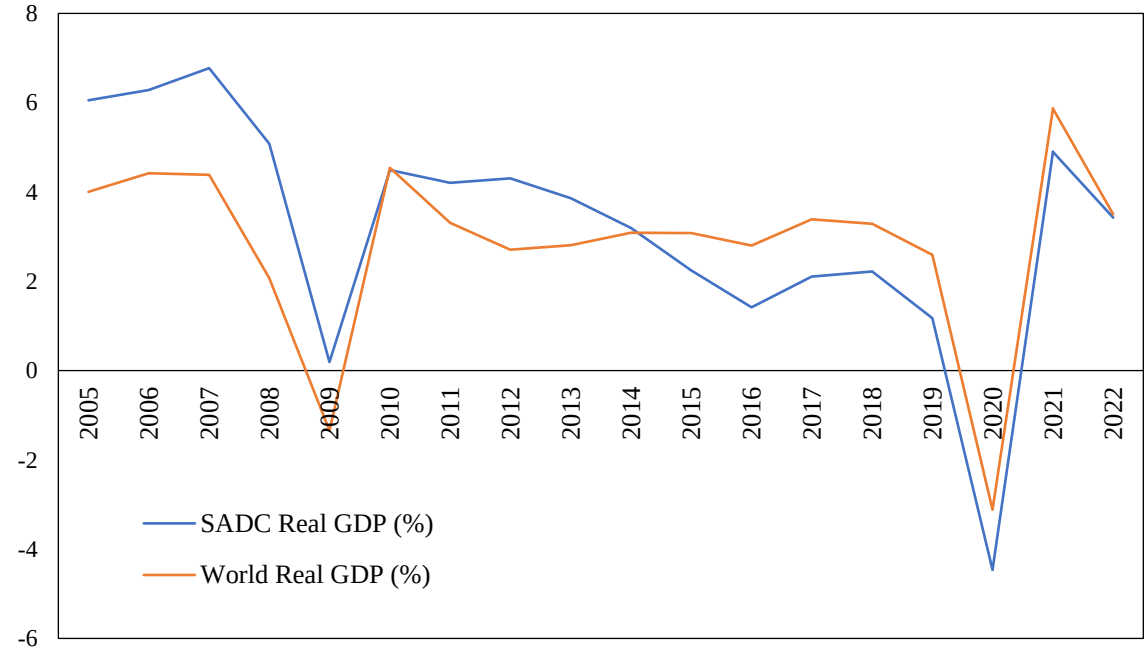
The rest of the study is organised as follows. Section 2 provides an overview of macroeconomic performance in SADC in crisis periods. Section 3 reviews relevant literature while Section 4 specifies the empirical model and describes the estimation method. Section 5 is data description and sources. Section 6 discusses the empirical results. Section 7 concludes and provides policy recommendations.

2 Overview of Macroeconomic Performance in SADC in Crisis Periods

In view of the recent shocks, mainly the global financial crisis of 2008/09, COVID-19 and Russia-Ukraine conflict, an assessment of trends indicates a deterioration in macroeconomic indicators—real GDP, inflation, fiscal balance, current account and exchange rate in SADC economies during these periods. For instance, the adverse effects of COVID-19 highlighted the pandemic's financial and economic consequences that caused significant increases in fiscal deficits and public debt as well as economic slump in 2020. The Russia-Ukraine conflict also highlights its consequences on global consumer prices, especially with regard to energy and food prices and the fiscal implications thereof in developing and emerging market economies.

Figure 1 provides an overview of economic performance in the SADC region. Regional GDP growth was generally positive except for 2009 and 2020 during the global financial crisis and onset of the COVID-19 pandemic, respectively. As a result of the financial crisis, real GDP growth fell to 0.2 percent in 2009 from a regional average of 5.1 percent in 2008. In 2020, COVID-19 led to the deepest contraction in GDP by 4.6 percent. However, growth rebounded in 2021, underpinned by the easing of pandemic lockdowns, favourable weather and a rise in mining output as the global market for minerals recovered. The Russia-Ukraine conflict and the rapid spread of COVID-19 in China dampened global growth in 2022, moderating to 3.5 percent (World Bank, 2023). Overall, figure 1 shows that the pattern of boom and subsequent slowdown observed in the SADC bloc was also observed globally, including among SADC's key trading partners. The high degree of synchronisation in output fluctuations suggests that common external factors are at work as key drivers of the SADC business cycle as documented in Matos et al. (2011) and Zgambo and Funyina (2022).

Figure 1: SADC and World Real GDP Growth (percent): 2005-2022

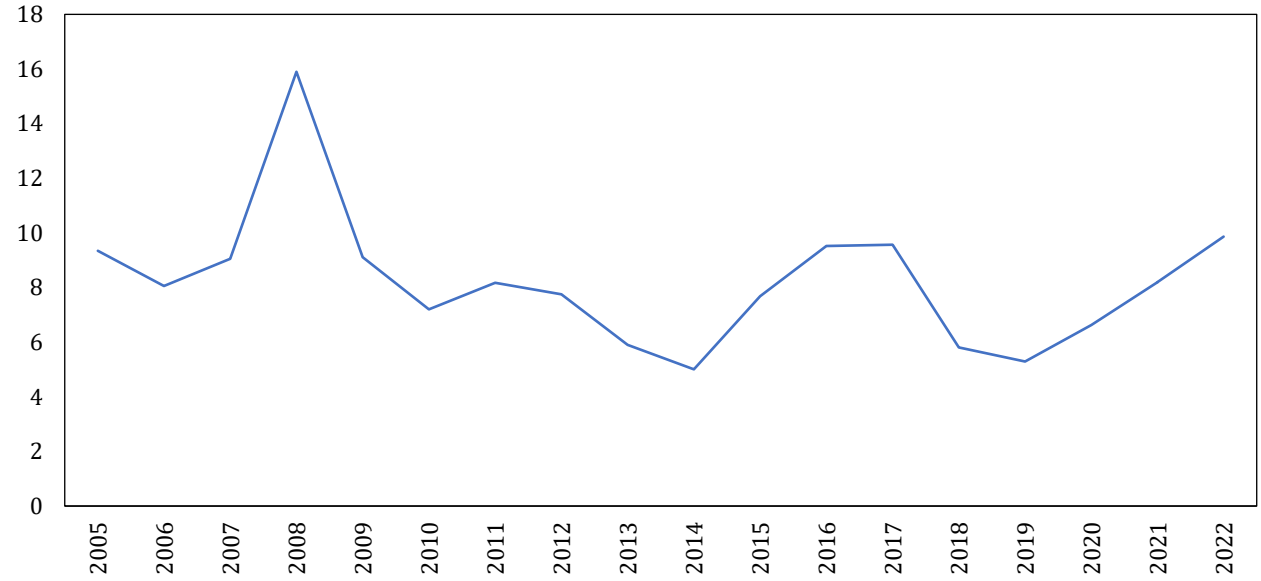


Source: IMF 2022 and author compilation

Figure 2 depicts price developments (excluding Zimbabwe)[2] in the SADC region. Annual inflation averaged 8.1 percent during the period 2005-2020. The 2008/09 global financial crisis resulted in the region's average inflation rate soaring to 15.9 percent in 2008 from 9.0 percent in 2007. Similarly, inflationary pressures in the SADC region started rising during the COVID-19 era as global supply-chains were disrupted. This was worsened in 2022 as another shock—Russia-Ukraine conflict—manifested in high global energy and food prices, triggered higher freight costs and further supply-chain disruptions. Climate change has also contributed to food and other necessity shortages, adding to the upward pressure on consumer prices (IMF, 2022; World Bank, 2023).

[2] Zimbabwe is excluded from the analysis to avoid data outliers.

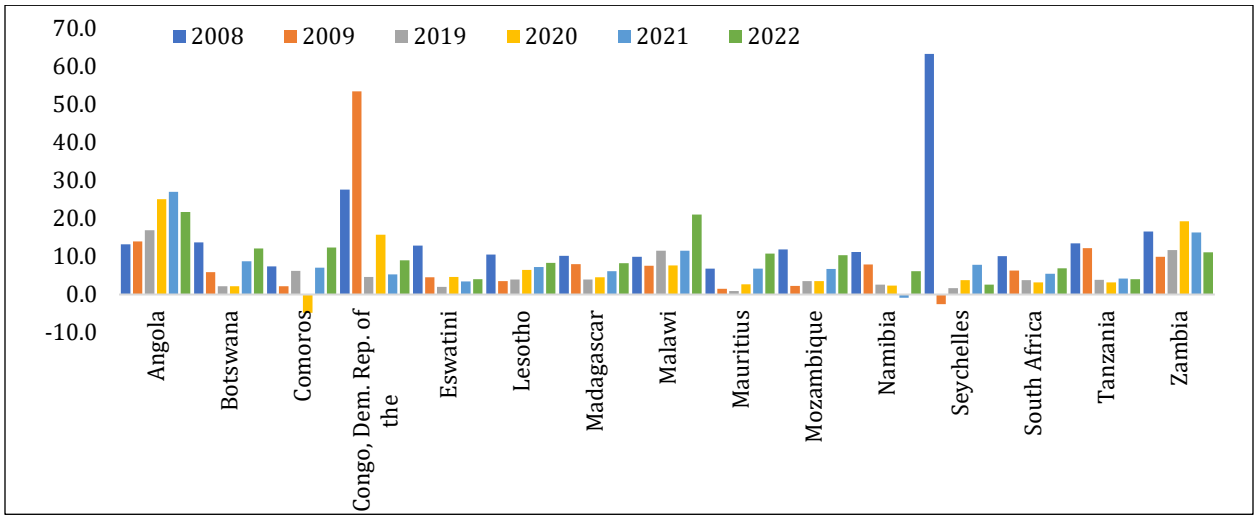
Figure 2: SADC Annual Inflation Rate (percent): 2005-2022



Source: IMF 2022 and author compilation

Notably, during the COVID-19 pandemic, some SADC countries experienced relatively higher inflationary pressures. For instance, the Democratic Republic of Congo (DRC), Zambia and Angola recorded significant increases in annual inflation rates to 15.8 percent, 19.2 percent and 25.1 percent in 2020 compared to 4.6 percent, 11.7 percent and 16.9 percent in 2019 (figure 3).

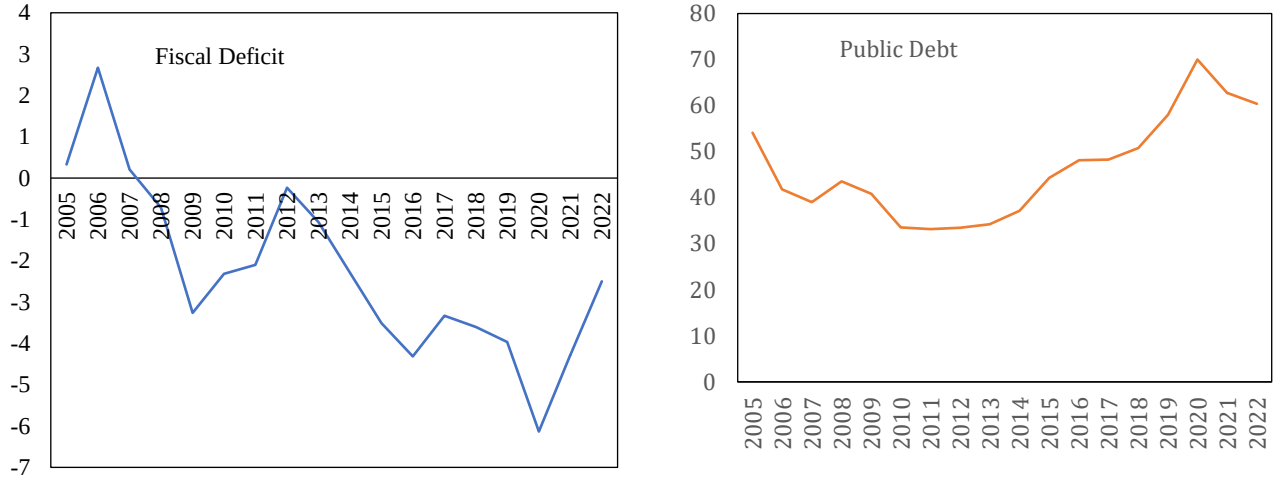
Figure 3: SADC Country Specific Annual Inflation Rate Developments (percent): 2008-2009 and 2019-2022



Source: IMF 2022 and author compilation

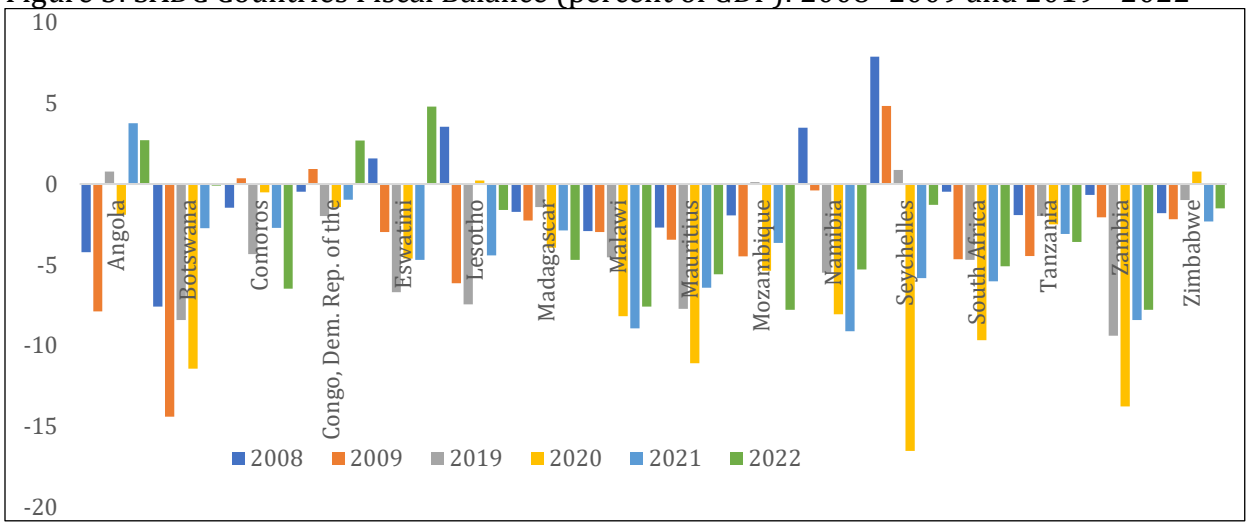
The region's fiscal balance and public debt have been deteriorating since 2013 (figure 4). Following the 2008/09 global financial crisis, most SADC countries' fiscal positions deteriorated. The COVID-19 pandemic exacerbated fiscal deficits, recording a decade high of 6.1 percent of GDP in 2020, with most SADC countries registering a significant deterioration, albeit at varying magnitudes (figure 5). The increase in fiscal deficits was partly due to low revenue as commodity prices slumped amid increased public spending related to response measures taken to curb the spread of COVID-19 (SADC, 2022). While the fiscal deficit fell slightly in 2021 and 2022 on the backdrop of a pick-up in economic activity, the Russia-Ukraine conflict worsened the fiscal position of the SADC region through higher global energy and food prices.

Figure 4: SADC Fiscal Balance and Public Debt (percent of GDP): 2005-2022



Source: IMF 2022 and author compilation

Figure 5: SADC Countries Fiscal Balance (percent of GDP): 2008 -2009 and 2019 - 2022

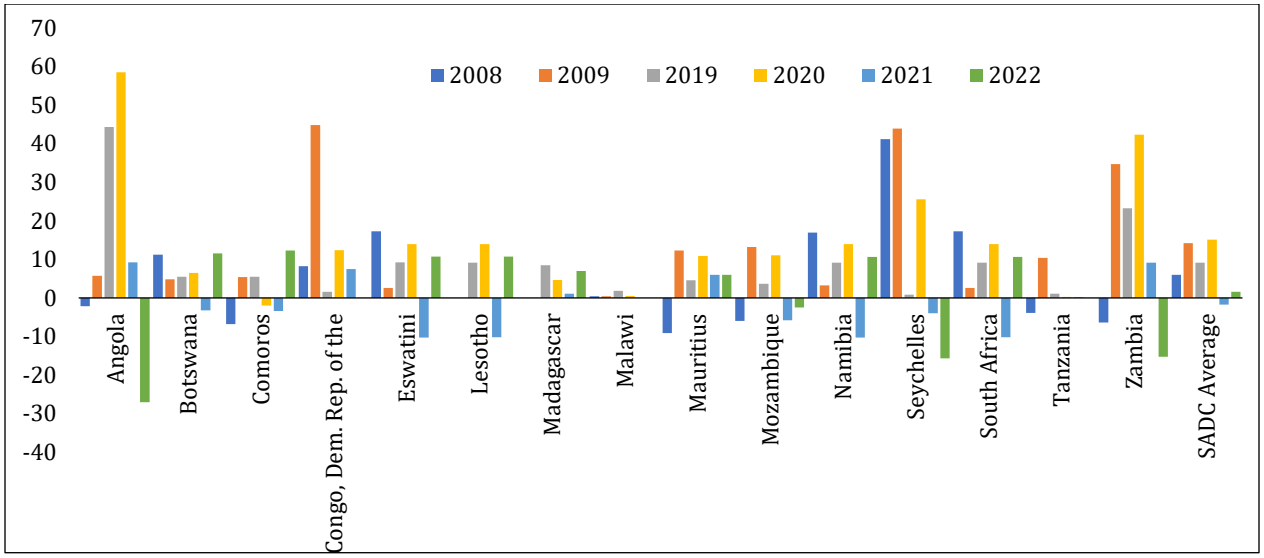


Source: IMF 2022 and author compilation

In terms of exchange rate developments, the SADC region experienced increased volatility during recent crisis periods. The global financial crisis manifested itself through currency

fluctuations, especially against the US dollar. The depreciation of some currencies in the SADC region was attributed to the impact of the financial crisis on commodity prices and the decline in foreign exchange reserves (Kasekende et al., 2009). Similarly, the impact of COVID-19 resulted in exchange rate depreciating at varying magnitudes in the first half of 2020. Currencies depreciated due to a downward revision of economic growth projections, power supply interruptions and the COVID-19 outbreak which resulted in a massive sell-off of risky assets and capital flows to safe haven assets such as the US dollar (SADC, 2020). The Angolan Kwanza, Zambian Kwacha and Seychelles Rupee were the most volatile currencies in 2020 (figure 6). The least volatile currencies were the Tanzanian Shilling and Malawi Kwacha (SADC, 2020). The Russia-Ukraine conflict also triggered exchange rate pressures due to a stronger US dollar as central banks in advanced economies hiked policy rates to contain inflation. As a result, US dollar denominated assets became attractive thereby negatively affecting portfolio flows to developing and emerging market economies and in turn weighed on domestic currencies (IMF, 2022).

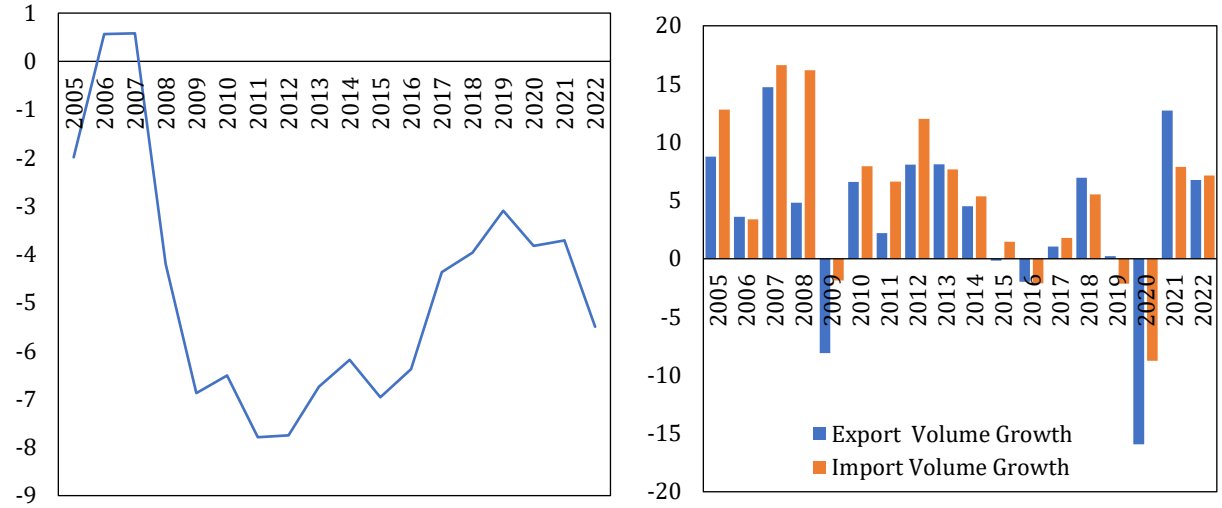
Figure 6: SADC Nominal Exchange Rate Percentage Changes (percent): 2008-2009 and 2019-2022



Source: IMF 2022 and author compilation

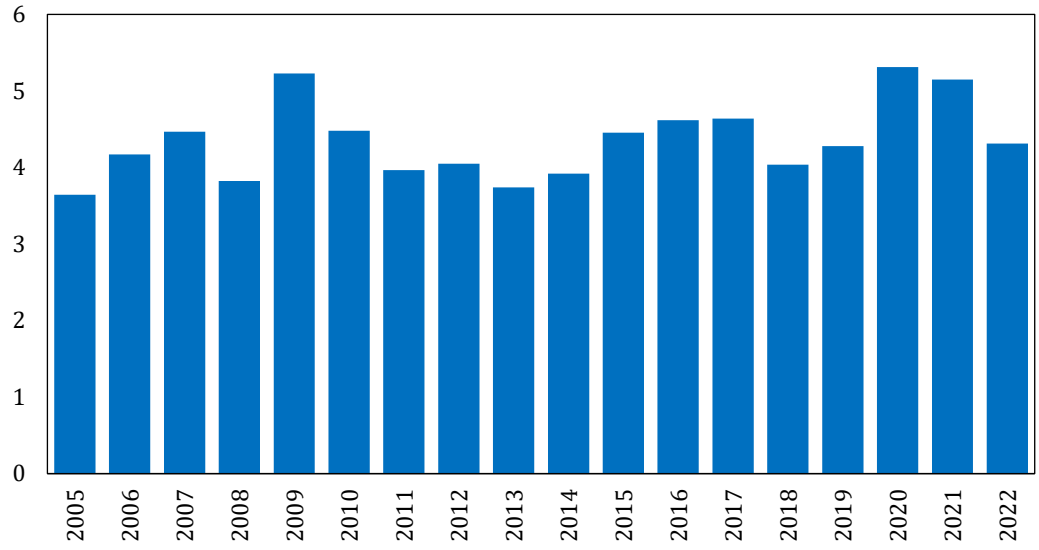
With regard to external sector resilience, key indicators in the SADC region have fluctuated over time. Given the region's heavy reliance on commodity exports, the external sector deteriorated following the 2008/09 global financial crisis. Similarly, with COVID-19, the current account balance deteriorated in line with weak commodity prices, slowdown in global economic activity, escalated global trade tensions and ensuing supply-chain disruptions (figure 7). The region's external sector resilience improved with global economic recovery in 2021, particularly as economic activity in China, a key destination for most SADC exports picked up. Further, the International Monetary Fund Special Drawing Rights general allocation in 2021 supported the reserve position of SADC countries (figure 8). However, the Russia-Ukraine conflict, which resulted in sanctions on Russia and further disruption to the global economy, weighed heavily on the region as most countries rely mostly on crude oil imports, which is critical for the manufacturing sector (SADC, 2021).

Figure 7: SADC - Current Account Balance (percent of GDP), Exports and Imports Growth (percent)



Source: IMF 2022 and author compilation

Figure 8: External Reserves (Months of Import Cover): 2005-2021



Source: World Bank and author compilation

3 Literature Review

Supply and financial shocks are likely to affect the performance of macroeconomic variables in emerging and developing economies (Buckle et al., 2007). For instance, the unprecedented rise in crude oil prices is one of the major supply shocks that has generated adverse effects in oil importing economies. This is on the back of most oil importing countries being relatively non-diversified, sector-dependent, with oil having a significant share in production processes and affects their fiscus (OECD, 2020; Bourghelle et al., 2021). Oil supply shocks

raise production costs for firms as it is a critical input in the manufacturing and transportation sectors (Blanchard et al., 2007) and tend to weaken the exchange rate due to increased demand for foreign exchange to facilitate oil imports and in turn exert domestic inflationary pressures (Zgambo and Funyina, 2022).

Dizioli et al. (2016) posit that financial flows are one of the major transmission channels to emerging market and developing economies. These economies have significant direct financial exposure to advanced economies via portfolio flows and foreign direct investments (FDI). Thus, financial shocks from developed economies tend to impact domestic financial conditions in developing and emerging economies. For instance, global financial shocks that trigger portfolio outflows and reduce FDI tend to weaken exchange rates, raise inflation and slow growth in emerging market and developing economies. Supporting this argument, Mackowiak (2007) and Aleem (2010) recognize increases in global interest rates as a significant financial shock that can adversely affect the performance of developing and emerging market economies. They conjecture that an increase in global interest rates escalates sovereign borrowing costs and in turn external debt servicing burden for economies with large foreign denominated debts. This is in addition to the weakening of domestic currencies induced by capital flight that might amplify inflationary pressure and depress growth in these economies.

Further, trade, commodity prices and financial markets are identified as other transmission channels for external shocks to emerging market and developing economies (Dizioli et al., 2016). According to this argument, trade is the most important transmission channel since large and developed economies are key trading partners for emerging market and developing economies. Trade integration helps promote economic growth, but for open markets, it has increasingly become a primary channel of transmission of external shocks. External trade shocks for developing countries and economies in transition usually result from economic downturns in advanced economies that cause sharp contractions in global demand or supply-chain disruptions. The size of such shocks varies considerably across regions and individual countries depending on their pattern of export specialization (UNCTAD, 2013). Thus, a slowdown in global economic activity, particularly in large economies, will almost certainly result in lower global trade, translating into lower global demand for exports (Zgambo and Funyina, 2022). The impact of trade is generally manifested through the commodity price channel, particularly for economies that rely on commodity exports. Lower global growth rates, which reduce global demand, put downward pressure on commodity prices and consequently make them extremely sensitive to global economic developments (Dizioli et al., 2016). This also tends to depreciate currencies. Overall, key macroeconomic variables in emerging market and developing economies are likely to fluctuate as a consequence of significant changes in global trade.

The impact on developing economies of recent external shocks, the 2008 global financial crisis and COVID-19 pandemic, has mainly occurred through the trade channel. A sharp fall in international trade affected all countries in the world during both crises. Most African least developed countries (LDCs) are exporters of primary commodities (oil, mineral and agricultural products). In most African countries, the share of food and fuel in merchandize imports is more than 50 percent, which creates pressure on the current account balance

when faced with higher oil and food prices during a supply-side induced crisis (Audiguier, 2011).

Transmission of external shocks via financial channels is mainly due to international integration of financial markets. The increasing international integration of countries around the globe through trade, income and capital flows has enabled countries to benefit from the growth and financing of partners, but also provides increasing channels through which global and regional shocks are transmitted to domestic economies (World Bank, 2009). As the financial crisis deepened from September 2008, mounting concerns over liquidity risk, asset quality, counterparty credit risk and enhanced risk aversion resulted in significant deleveraging and attempts to reduce portfolio risk by financial institutions. This not only affected the ability of financial institutions and corporates in developed economies to obtain financing, but also led to a retrenchment of the international exposures of banks, and for many countries, a sharp reduction in their ability to access international finance. As a result, gross capital flows to emerging and developing economies fell significantly.

Regional equity and exchange rates came under pressure during late 2008 as foreign investors drew back funds from the region and concerns over the domestic impact of the financial crisis mounted (World Bank, 2009). In the foreign exchange market, exchange rates in SSA were under pressure due to portfolio outflows triggered by increased risk aversion and deleveraging, sharp decline in foreign direct investment and the unwinding of commodity trade (Ho, 2016).

In the case of most African countries, this channel tends to be relatively less impactful compared to advanced economies. This stems largely from several factors: weak integration into the global financial system, weak exposure to complex financial instruments, high banking liquidity and weak dependency on external financing. For instance, at the beginning of the crisis, the financial system of SSA countries seemed to be safe (Nkendah et al., 2009). As the crisis spread into the global economy, the effects on SSA financial system became more exposed through the contraction of credit and higher cost of credit due to difficulties in accessing financing by financial institutions in the region. In addition, the natural linkage between financial assets of regional subsidiary banks and their parent banks overseas could lead to an increase in risk of investors if parents fall into bankruptcy.

While these shocks have been impacting the SADC region's macroeconomic fundamentals, climate change, a shock whose impact has widespread implications on the SADC region, has gained momentum. Climate change in the region has mainly manifested through volatility in rainfall and temperature whose impact on the region's economies is transmitted through the agriculture and energy sectors. In turn, this has attendant effects on various economic activities that have implications on the cost of production. Agriculture is a dominant economic activity in the region while hydropower is the main source of energy (SADC, SARDC, 2018). Since agriculture accounts for most of the economic activity in the SADC region, low agricultural production limits economic growth. Similarly, hydropower is a vital conduit for macroeconomic performance, representing a large portion of renewable energy in most of the countries in Southern Africa (SADC, SARDC, 2018).

Empirical literature examining the impact of global shocks on SADC as a region is scanty. Most of the countries in the SADC region are commodity-dependent, making them highly vulnerable to global shocks. Thus, it is rational to expect global shocks to significantly impact macroeconomic performance of these economies. Notable studies that show that global shocks affect macroeconomic performance in African countries include Kose and Riezman (2001), Raddatz (2007, 2009), Matos et al. (2011), Senbeta (2012), Chileshe et al. (2018), Amu et al. (2021), Bank of Botswana (2021), Zgambo and Funyina (2022) and Olamide et al. (2022).

Kose and Riezman (2001) examined the role of external shocks in explaining macroeconomic fluctuations in African countries. They constructed and calibrated a small open economy model using dynamic stochastic general equilibrium (DSGE) with trade and financial shocks.[3] Relative to financial shocks, trade shocks explain a large fraction of about 50 percent of aggregate output fluctuations in African countries. In contrast, Raddatz (2007), for a sample of 40 low-income countries of which 32 are SSA and using a panel vector autoregression approach, established that external shocks[4] explain only a small fraction (about 11 percent) of the variation in output (with commodity prices accounting for a significant share followed by aid shocks, climatic disasters, humanitarian crises, GDP fluctuations in high-income countries and global interest rates). The remaining 89 percent is attributed to domestic shocks. Raddatz (2007) further argues that while the output effect of external shocks is typically small in absolute terms, it is significant relative to these countries' historical performance.

Matos et al. (2011) focused on the SADC region and used correlation analysis and panel regressions. They established the existence of synchronization of economic activities between SADC and more developed countries. They indicated that the extent of variation in SADC GDP is broadly similar to the rest of the world, with a coefficient of 0.57 with the global economy and 0.44 with the European Union. They further found that, while adverse external shocks affect current accounts of SADC countries, there is a weak link from financial shocks given the low financial interconnection between the SADC region and advanced economies. The impact of geopolitical shocks shows have detrimental macroeconomic ramifications for the SADC region (Bank of Botswana, 2021).

A further assessment of the relative importance of external shocks on GDP growth in selected SSA was undertaken by Senbeta (2012) using a Bayesian VAR model.[5] The results reveal a wide contribution of external shocks to the variation in GDP growth across countries. That is, the response of GDP growth rate to some shocks is consistent with economic theory while the response to others is counter-intuitive. For example, the terms of trade shock accounts for most of the variation in GDP growth rate in Kenya and Nigeria whereas external factors

[3] In the model, the trade shock was modeled as fluctuations in prices of exportable primary commodities and imported capital goods while the financial shock was modeled as fluctuations in the world real interest rate.
[4] External shocks included commodity price fluctuations and natural disasters.
[5] External shocks relating to global growth, LIBOR, FDI inflows, aid inflows and terms of trade are considered for five SSA countries: Botswana, Ethiopia, Kenya, Mauritius and Nigeria.

contribute relatively little to the variation in GDP growth in Botswana. There are also differences in the magnitude of the fraction in GDP growth rate across countries that can be attributed to such shocks. However, the terms of trade shock was found to be the most important external factor in explaining GDP growth across all the countries considered. Senbeta (2012), therefore, argued that generalizing the impact of external shocks to the entire SSA region could be misleading. Similarly, Amu et al. (2021) examined the impact of real shocks (terms of trade, commodity price and government spending) on macroeconomic fluctuations in selected SSA using the Bayesian panel vector autoregression (BPVAR) technique. The study highlighted that exogenous real shocks are sources of macroeconomic fluctuations in Africa. They observed that commodity prices and government spending lead to a negative impact on real output and other macroeconomic variables such as private consumption and gross fixed investments. In contrast, terms of trade shocks had a positive impact, particularly on real GDP, while government expenditure has the highest negative impact among the three selected real shocks across the SSA region.

Chileshe et al. (2018), Zgambo and Funyina (2022) and Olamide et al. (2022) used a structural vector autoregression (SVAR) approach to highlight the significance of external shocks on fluctuations in macroeconomic performance of African countries in the East African Community and Zambia. These studies revealed that commodity price, financial and global growth shocks significantly explain fluctuations in macroeconomic conditions similar to Sato et al. (2009) and Roch (2017). Sato et al. (2009) found that the global oil price shock and the US growth shock were dominant and important in influencing the stability of real output growth in East Asian countries while Roch (2017) established that a positive shock to commodity prices is associated with higher GDP growth and public revenue in Chile, Columbia and Peru. Moreover, studies show that SSA economies are highly vulnerable to external shocks and have limited capacity to deal with them making such shocks not only disruptive, but also persistent (Naude, 2010; Senbeta, 2012).

A distinct body of literature has explored the impact of natural disasters on macroeconomic performance. While literature is based on case studies rather than systematic econometric evidence (Raddatz, 2007; World Bank, 2017), a handful of researchers have begun to explore these dynamics. Raddatz (2009), using panel time series techniques, estimated short- and long-run impact of climatic and other disasters on growth across groups of countries around the globe divided into low, middle and high incomes. He highlighted that increased incidence of these disasters in recent decades entail important macroeconomic costs: climate-related disasters have a negative impact on per capita GDP while the impact of geological events is limited. He pinpointed that among climatic disasters, drought has the largest average impact, with cumulative loss of 1 percent of GDP per capita followed by extreme temperatures. The effect is greater for low-income countries as they are more vulnerable, especially to climatic related disasters. Among these countries, a climatic disaster results in a 1 percent decline in per capita GDP compared to output loss of 0.5 percent and 0.25 percent among middle and high-income countries, respectively. A related study by Berlemann and Wenzel (2018) used a large panel dataset of more than 150 countries from 1951 to 2013 and established extensive and highly strong empirical evidence for long-term negative growth consequences of rainfall deficits in developing countries. In a more recent study by Khurshid et al. (2022),

climate change (represented by carbon emissions, mean temperature and precipitation) had adverse impact on growth in Pakistan.

A notable limitation of the highlighted studies is that none has conducted a systematic examination of a diverse set of external shocks, including climate disasters, health pandemics, geopolitical tensions, as well as global economic and financial shocks especially in the SADC region. The SADC region economies are indeed linked via numerous channels and the extent to which they respond to external shocks varies depending on the nature of the shock. To address this limitation, this study uses a comprehensive set of external shocks and attempts to quantify their impact on the SADC region. Climate, health pandemic (COVID-19), geopolitical (Russia-Ukraine conflict), global growth, financial shock and commodity price shocks are the external shocks considered in this study. More specifically, the study examines the impact of these shocks on macroeconomic performance in the SADC region. The impact and relative importance of external shocks are determined using trend analysis (Section 2) and panel regressions. This makes it permissible to compare the rate of variation of the selected macroeconomic indicators in the SADC region prior and post recent global shocks consistent with Matos et al. (2011) and Ivanovic (2016). Further, given the general problem with respect to data availability and length of time series in SSA countries, panel models help to overcome such drawbacks by increasing the degrees of freedom in estimations.

4 Model Specification and Estimation Method

Similar to Matos et al. (2011), this study uses panel regression to analyse the impact of recent global shocks on selected macroeconomic variables in the SADC region for the period 2010Q1 – 2022Q4. The sample is split into pre-shock (2010Q1–2019Q4) and post-shock (2020Q1-2022Q4) periods. This approach is consistent with Ivanovic (2016) and Affinito et al. (2019) who estimated panel regressions to evaluate the effect of the global financial crisis by splitting the sample in two sub-samples: pre-crisis and post-crisis periods. Splitting of the sample allows the coefficients to differ between the two periods, hence capturing the possible effects of crises. Individual group panel regression models are also estimated assuming heterogeneity with respect to economic dynamics and response to external shocks in the SADC region. In this regard, SADC countries are split into three income categories: low-income (LI), lower-middle income (LMI) and upper-middle income (UMI) economies[6]. Using the World Bank Atlas method, the classification for the fiscal year 2023 is as follows: Low-income - DRC, Madagascar, Malawi, Mozambique and Zambia; Lower-middle income - Angola, Comoros, Eswatini, Lesotho, Tanzania and Zimbabwe; and Upper-middle income - Botswana, Mauritius, Namibia, Seychelles and South Africa.

[6]The classification is based on the World Bank Atlas method for the fiscal year 2023 with low-income economies defined as having a GNI per capita of US$1,085 or less in 2021; lower-middle income economies having a GNI per capita between US$1,086 and US$4,255; upper middle-income economies having a GNI per capita between US$4,256 and US$13,205; and high-income economies having a GNI per capita of US$13,205 or more.

By re-estimating equation (1) and allowing the slope coefficients to differ between the two sub-sample periods, this study demonstrates interesting insights for a deeper understanding of the impact of recent global shocks on selected macroeconomic variables in the SADC region:

$$Y_{it} = \alpha_i + X'_{it}\beta + \varepsilon_{it},\ i=1,\ldots,\ N;\ t=1,\ \ldots\ ,T \qquad 1$$

where Y_{it} is the dependent variable measuring macroeconomic performance (proxied by real GDP)[7] in the SADC region; X'_{it} is a 1 × k vector of observations on explanatory variables (i.e. global growth, financial, commodity price and climate shocks); β is a k×1 vector of parameters to be estimated on explanatory variables; subscript i denotes cross-section; t represents time series dimension; and ε_{it} denotes unobservable factors effect in the panel data modelling.

Equation 1 is based on the ordinary least squares (OLS) method, which considers all the observations for the time periods as a single sample. The OLS model ignores the data panel nature and assumes that there is no serial correlation. However, panel data may have country effects, time effects or both. These effects can either be fixed or random (Green, 2008). In this study, a choice is empirically made between fixed and random effects model in line with Ivanovic (2016) and Affinito et al. (2019).

A fixed effects (FE) model assumes differences in intercepts across groups or time periods. In the FE model where the subscript i denotes an individual country and t refers to the time period, the intercept α is different for each country and is subscripted by i:

$$Y_{it} = (\alpha + \mu_i) + X'_{it}\beta + \varepsilon_{it} \qquad 2$$

where Y_{it}, X'_{it}, β and ε_{it} are as defined in equation 1. In the FE, α_i (i=1…n) is the unknown intercept for each entity (n entity-specific intercepts). Thus, $\alpha_i = \alpha + \mu_i$ such that α is the intercept and μ_i is the unobserved country-specific effect. In this regard, in the FE model, the unobserved country-specific effects are absorbed by the intercept.

In contrast, a random effects (RE) model explores variations in error variances. Unlike the FE model, the variation across entities in the RE model is assumed to be random and uncorrelated with the predictor or independent variables in the model. Green (2008) observes that the fundamental difference between fixed and random effects is whether the unobserved individual effect contains elements that are correlated with model regressors and not whether these effects are stochastic or not. Thus, if there is reason to believe that differences between entities influence the dependent variable, RE are used. Therefore, the model is expressed as:

$$Y_{it} = \alpha + X'_{it}\beta + (\mu_{it} + v_{it}) \qquad 3$$

[7] Real GDP is widely used to gauge the response of domestic economic performance to external shocks (Raddatz, 2007, 2009; Matos et al., 2011; Senbeta, 2012; Amu et al., 2021).

where Y_{it}, X'_{it}, and β are as defined earlier in equation 1; μ_{it} represents between-entity errors and v_{it} represents within-entity errors. In this case, the term "μ_i " is assumed to be random. Hence, $\mu_i \sim$ IID (0, σ_μ^2), $v_{it} \sim$ IID (0, σ_v^2) and that the values of μ_i are independent of the values of v_{it}. In addition, the values of X'_{it} are independent of μ_i and v_{it}.

The Hausman test is used to decide whether fixed or random effects is appropriate with the null hypothesis that RE is preferred over FE (Green, 2008). The Hausman test determines whether the unique errors (μ_i) are correlated with the regressors and the null hypothesis is that they are not.

Further, a panel structural vector autoregressive (SVAR) model is used to gain a better understanding of the dynamics in the SADC region macroeconomic performance in response to global shocks while also taking a theory-guided look at the data. Following the approach by Raddatz (2007, 2009), Sato et al. (2009), Allegret et al. (2012), Kim and Mehrotra (2018), Chileshe et al. (2018) and Zgambo and Funyina (2022), this study estimates equation 4 using the SVAR model, assuming that the SADC region economy *i* (i = 1,2,...,N) is described by the following structural form equation:

$$G(L)y_t^i = d^i + C(L)x_t + \varepsilon_t^i \qquad 4$$

where G(L) and C(L) are matrix polynomials in the lag operator; L, y_t^i is an M × 1 data vector of endogenous variables for country *i* at time *t*; x_t is a K ×1 data vector of exogenous or global variables; d^i is a M × 1 constant matrix; M and K are number of endogenous and exogenous variables in the model, respectively; and ε_t^i is a vector of structural disturbances.

By assuming that structural disturbances are mutually uncorrelated, $var(\varepsilon_t^i)$ can be denoted as Λ, which is a diagonal matrix where the diagonal elements are the variances of structural disturbances. The individual fixed effect, d^i, is introduced to control for country-specific factors that are not considered in the model.

The following reduced form panel VAR with individual fixed effects is estimated:

$$y_t^i = c^i + B(L)y_{t-1}^i + D(L)x_t + \mu_t^i \qquad 5$$

where c^i is an M ×1 constant vector; B(L) and D(L) are matrix polynomials in the lag operator L; μ_t^i is an M × 1 vector of reduced form residuals; and $var(\mu_t^i) = \Sigma$. The parameters of the structural form equation can be recovered from the estimated parameters of the reduced form equation in several ways. The identification schemes under consideration impose recursive zero restrictions on contemporaneous structural parameters by applying Cholesky decomposition to the variance–covariance matrix of reduced form residuals, Σ, as espoused in Sims (1980).

In the empirical model, y^i = ($RGDP^i$, FD^i, EXR^i, CPI^i, R^i) where $RGDP^i$is real gross domestic product, FD^i is fiscal deficit (as a percentage of GDP), EXR^i is nominal exchange rate[8], $CPI^i$is the consumer price index measuring inflation and R^i is the policy interest rate of individual SADC countries – capturing the monetary policy stance. The vector for x_t= ($USRGDP_t$, FFR_t, CP_t, $CLIM_{it}$) where $USRGDP_t$ and FFR_t are respectively real GDP and the federal funds rate for the United States of America, CP_t is the commodity price index, $CLIM_{it}$ refers to climatic disasters relating to precipitation (rainfall in mm) and mean temperature recorded in individual SADC countries. To capture the impact of adverse climate change, we compute rainfall volatility reflecting both floods and drought while temperature volatility captures extreme heat and cold using the standard deviation approach consistent with Noth and Schüwer (2018) and Odongo et al. (2023). The effect of volatility in rainfall and temperature mainly affects the agriculture and energy sectors with attendant effects on various economic activities that have implications on the cost of production. To capture the effect of the recent shocks relating to COVID-19 and the Russia-Ukraine conflict, the study assumes that the transmission is through foreign GDP, foreign interest rates and commodity prices. With regard to the commodity price shock, we make use of the commodity-based terms of trade index similar to Raddatz (2007, 2009). This is on the back of SADC countries having varied dominant commodity exports relevant to their economies ranging from energy, non-energy to metals and minerals. In this study, commodity price shock is proxied by the commodity terms of trade index, which uses trade data at country-commodity level to weight the change in the international price of up to 45 individual commodities. Because the weight of each commodity is determined by its share of net exports in aggregate output, changes in the commodity terms of trade index provide an estimate of windfall gains and losses associated with changes in global prices. Gruss and Kebhaj (2019) demonstrate that commodity terms of trade shocks affect key macroeconomic aggregates in a large panel of economies and provide evidence that they can be considered exogenous from the perspective of individual countries.

The primary identification assumption in this study, as in Raddatz (2007, 2009), is that the variables in x_t do not respond to the variables in y^i at any lag, equivalent to imposing a block diagonal structure in all A matrices. This assumption entails that external shocks ($USRGDP_t$, FFR_t, CP_t and $CLIM_{it}$) are not affected by the current or past macroeconomic performance of any SADC country, but that all of these variables have a contemporaneous and lagged effect on this performance. Thus, a panel SVAR, in which domestic shocks have no effect on external variables, either immediately or with lags, is employed to examine the impact and relative importance of external shocks in the SADC region. Models of such nature display dynamic responses that are consistent with theoretical expectations that could be linked to an open economy framework. Moreover, as demonstrated by Buckle et al. (2007), Sato et al. (2009) and Allegret et al. (2012), such models make it possible to impose restrictions thereby allowing for the inclusion of additional variables. In turn, the inclusion of a diversity of shocks affecting domestic economies while reducing the number of parameters to estimate, is made possible. Consequently, such a model may yield robust estimations (Allegret et al., 2012). Since the model assumes that the SADC region is an open economy, it is thus feasible

[8] In terms of the external sector, the impact of the global shocks on the current account is assumed through the exchange rate.

to estimate how much of the region's macroeconomic fluctuations are attributable to external shocks. This study uses this framework to determine the nature and magnitude of various external shocks affecting the SADC region.

In terms of the VAR approach, Sato et al. (2009) and Allegret et al. (2012) estimate SVAR for each country in the East Asian economic bloc similar to Chileshe et al. (2018) and Zgambo and Funyina (2022) in the case of Zambia. On the other hand, Raddatz (2007) and Kim and Mehrotra (2018) estimate a single panel VAR assuming some symmetry among countries. Raddatz (2009) modified the approach and used various sets of panel VARs based on country income status classification. In this study, we estimate two sets of panel SVAR models in line with Raddatz (2009). The first set is a single panel SVAR model representing the SADC region as a unit, assuming all member countries have similar economic dynamics and their response to external shocks is identical consistent with Raddatz (2007) and Kim and Mehrotra (2018). Secondly, we estimate individual group panel SVAR models assuming heterogeneity in line with Raddatz (2009) and also as highlighted in the case of panel regression models above. Accordingly, SADC countries are split into three income categories reported earlier.

5 Data Description and Sources

The study uses quarterly data spanning 2010Q1 – 2022Q4[9] for 14 SADC countries, namely, Angola, Botswana, Democratic Republic of Congo (DRC), Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Tanzania and Zambia. Zimbabwe is excluded from the analysis to avoid data outliers.[10] Zimbabwe has experienced hyperinflation and extreme exchange rate volatility since the 2000s. Further, Comoros is not included in the analysis due to lack of data.

Data variables include growth in US real GDP (global growth shock), federal funds rate (financial or foreign interest rate shock), commodity price index (commodity price shock), precipitation and mean temperature (climate shock) while selected macroeconomic indicators in SADC relate to growth in real GDP, fiscal deficit, exchange rate, inflation and interest rate (policy rate to reflect monetary policy response). The SADC statistical database is the primary source of data. The other sources used are World Bank and IMF databases.

6 Empirical Results and Discussion

Prior to running regressions, we conducted a correlation test, one of the prerequisites to empirical analysis. The correlation matrix in table 1 shows low coefficients between explanatory variables. This confirms that the problem of multicollinearity is not a concern in this study, and, therefore, strengthens the simultaneous incorporation of the selected variables in the same model.

[9] The study period is post-2008 economic crisis and only covers recent shocks.
[10] This is consistent with Matos et al. (2011) who indicated similar challenges with analysis inclusive of Zimbabwe.

Table 1: Correlation Matrix

	Domestic Real GDP	US Real GDP	Federal Funds Rate	Commodity Price Index	Volatility in Temperature	Volatility in Rainfall
Domestic Real GDP	1					
US Real GDP	0.37	1				
Federal Funds Rate	-0.02	0.00	1			
Commodity Price Index	0.27	0.27	-0.11	1		
Volatility in Temperature	-0.01	-0.01	0.00	0.00	1	
Volatility in Rainfall	-0.11	-0.02	0.02	0.01	0.10	1

Source: Author Computations

Further, before proceeding to empirical analyses, particularly panel SVAR, unit root tests were performed to ascertain the stationarity properties of variables. In this regard, the Levin et al. (2002) and Im et al. (2003) unit root tests, commonly abbreviated as LCC and IPS, were used.[11] The tests results in table 2 indicate the presence of a unit root in US real GDP, federal funds rate, commodity price index, domestic real GDP, exchange rate, domestic CPI and domestic policy rate while volatility in rainfall and fiscal balance were stationary in level. Variables that exhibited unit roots in level were first differenced and found stationary (Table 2). Further, keeping data constraints in mind, a panel SVAR with two lags was cautiously chosen as it turned out to be the most stable with a proper behaviour of residuals (Brzoza-Brzezina et al., 2010) as can be seen in appendices I and II.

[11] The LCC assumes a common unit root process while the IPS assumes individual unit root process. Though the LCC test is robust in balanced panel data set, the IPS test performs better than the LCC and does not require a balanced panel data set (Maddala and Wu, 1999).

Table 2: Unit Root Test Results

	Levin, Lin & Chu (LLC) p-value			Im, Pesaran & Shin (IPS) p-value		
Variable	Level	First Difference	Order of Integration	Level	First Difference	Order of Integration
US Real GDP	0.229	0.000	I (1) c	1.000	0.000	I (1) c
Federal Funds Rate	1.000	0.000	I (1) none	0.530	0.000	I (1) c
Commodity Price Index	0.994	0.000	I (1) c & t	0.999	0.000	I (1) c & t
Volatility in Rainfall	0.000	0.000	I (0) c & t	0.000	0.000	I (0) c & t
Domestic Real GDP	0.095	0.000	I (1) c & t	0.161	0.000	I (1) c & t
Fiscal Balance	0.120	0.000	I (1) c	0.000	0.000	I (0) c
Exchange Rate	0.186	0.000	I (1) c & t	0.269	0.000	I (1) c & t
Consumer Price Index	0.087	0.000	I (1) c & t	0.913	0.000	I (1) c & t
Policy Rate	0.675	0.000	I (1) c & t	0.490	0.000	I (1) c & t

Source: Author Computations
Note: c=constant; t=time trend

After correlation test analysis, FE and RE regression models were estimated. Using the Hausman (1978) test, it was assessed whether country-specific effects could be captured in the FE model or RE model. The test result reported in table 3 rejects the null hypothesis that RE is the appropriate model, confirming that the FE model is preferred. It is also worth noting that the FE regression estimated after the Hausman test selection failed the robustness test against heteroscedasticity and cross-section dependency, but was robust against serial correlation (Appendix I). This is typical in macro panel data with long time series (i.e. N < T) as reported by Torres-Reyna (2007) and Baltagi (2008). The study, therefore, estimated a FE regression that produces robust standard error estimates for linear panel models as recommended by Torres-Reyna (2007), Baltagi (2008) and Green (2008).[12] The robust FE regression results are reported in table 3.

[12] The standard error estimates are robust to disturbances being heteroscedastic, contemporaneously cross-sectionally correlated and autocorrelated of type AR (1).

Table 3: Fixed Effects Regression Results

	Full Sample				**Pre Shock**				**Post Shock**			
	All	LI	LMI	UMI	All	LI	LMI	UMI	All	LI	LMI	UMI
Domestic Real GDP (-1)	**0.149*** **	**0.425*** **	**0.421*** **	**-0.050**	**0.439*** **	**0.317*** **	**0.495*** **	**0.427*** **	**-0.052**	**0.472*** **	**0.192**	**-0.203**
	(0.034)	(0.052)	(0.059)	(0.056)	(0.038)	(0.067)	(0.070)	(0.065)	(0.074)	(0.104)	(0.120)	(0.121)
US Real GDP	**0.751*** **	**0.494*** **	**0.460*** **	**1.223*** **	**0.259**	**-0.271**	**-0.626**	**0.527***	**0.670*** **	**0.574*** **	**0.535*** **	**0.963** **
	(0.083)	(0.092)	(0.114)	(0.178)	(0.212)	(0.356)	(0.450)	(0.297)	(0.187)	(0.145)	(0.160)	(0.449)
Federal Funds Rate	**0.018**	**-0.113**	**-0.136**	**0.514**	**-0.348***	**-0.165**	**-0.496**	**-0.437**	**0.756**	**0.460**	**0.935**	**1.244**
	(0.226)	(0.251)	(0.311)	(0.485)	(0.197)	(0.331)	(0.420)	(0.272)	(0.782)	(0.602)	(0.674)	(1.855)
Commodity Price Index	**3.792*** **	**1.852** **	**1.669**	**7.381*** **	**2.046*** **	**2.504** **	1.898	**1.922** **	**7.580** **	**0.135**	**0.150**	**16.930***
	(0.831)	(0.919)	(1.131)	(1.793)	(0.688)	(1.153)	(1.454)	(0.968)	(3.690)	(3.004)	(3.116)	(8.865)
Volatility in Temperature	**0.001**	**-0.000**	**-0.019**	**0.004**	**0.001**	**0.013**	**-0.009**	**0.005**	**0.002**	**0.020**	**-0.047**	**-0.006**
	(0.006)	(0.011)	(0.015)	(0.009)	(0.004)	(0.012)	(0.017)	(0.004)	(0.024)	(0.033)	(0.034)	(0.042)
Volatility in Rainfall	**-0.939*** **	**-0.370**	**-0.932***	**-0.780**	**-0.479** **	**-0.249**	**-0.604**	**-0.199**	**-1.451**	**-0.948**	**-1.968***	**-1.261**
	(0.344)	(0.498)	(0.476)	(0.671)	(0.241)	(0.525)	(0.510)	(0.305)	(1.211)	(1.218)	(1.098)	(2.628)
Constant	**-16.705*** **	**-7.489***	**-6.211**	**-35.539*** **	**-7.906** **	**-7.817**	**-8.061**	**-8.358**	**-36.930** **	**0.516**	**1.753**	**-84.692**
	(4.065)	(4.505)	(5.544)	(8.775)	(3.458)	(5.780)	(7.334)	(4.845)	(18.354)	(14.928)	(15.545)	(44.167)

Hausman's Test Result: Chi-square statistic =246.52; P-Value=0.000***

Source: Author Computations

Notes: Numbers in parentheses are robust standard errors. The standard errors are robust to disturbances being heteroscedastic, contemporaneously cross-sectionally correlated and autocorrelated of type AR (1) and the observations are clustered at country or country group level. The asterisk ***, **, and * indicate statistical significance at 1 percent, 5 percent and 10 percent level, respectively.
LI, LMI and UMI denote low income, lower middle-income and upper middle-income economies, respectively. Low-income economies include DRC, Madagascar, Malawi, Mozambique and Zambia; Lower-middle income include Angola, Eswatini, Lesotho, and Tanzania; and Upper-middle income include Botswana, Mauritius, Namibia, Seychelles and South Africa

According to table 3, real GDP growth exhibits persistence: current real GDP growth rate is affected by the previous quarter real GDP growth rate. The result entails that when real GDP growth rate in the previous quarter is 1 percent, on average, the expected GDP growth rate in the current quarter will range between 0.149 percent and 0.425 percent in the full sample and 0.317 percent and 0.495 percent in the pre-shock period, ceteris paribus. However, the coefficient on lagged real GDP growth rate becomes negative and mostly insignificant in the post-shock period except for low-income countries, with a positive and significant coefficient.

Broadly, external shocks affect macroeconomic performance in SADC countries. The results point to evidence of higher global growth being positively related with real GDP growth in SADC in the full sample and across the three income sub-groups consistent with Mato et al. (2011) and Zgambo and Funyina (2022). However, the coefficient for the upper middle-income sub-group is disproportionally larger at 1.22 percent, suggesting that economic activity between this sub-group in SADC and advanced economies tends to be highly correlated through the trade channel.[13] Comparing the results between the pre- and post-shock periods, the impact of global growth on economic activity in SADC countries is positive, but only statistically significant for the upper middle-income sub-group in the pre-shock period. The post-shock results show a positive and significant increase in the coefficient, indicating that economic synchronization is more intense during crisis periods like COVID-19 and geopolitical tensions.

The measure of financial shock (federal funds rate) is positive, albeit statistically insignificant, in the full sample contrary to expectations. This result is also mirrored in the case of UMI economies. However, in the case of LI and LMI sub-groups, the coefficients on the financial shock are correctly signed, but statistically insignificant. In the pre-shock period, the federal funds rate impacted SADC economies negatively, but weakly significant across the sub-groups. As global financial conditions tighten, it slows down external demand, which weighs on economic activity in the SADC region. Tightening financial conditions in advanced economies slowed global demand and further increased borrowing costs in SSA, undermining debt sustainability and triggered capital outflows (IMF, 2022). However, the weakly statistically significant coefficient on the federal funds rate points to evidence of low financial interconnection between the SADC region and advanced economies (Kose and Riezman, 2001; Mato et al., 2011; Zgambo and Funyina, 2022). This also points to the underdevelopment of financial markets in most SADC countries. In contrast, in the post-shock period, the coefficient on the federal funds rate becomes positive across all income sub-groups, but remains statistically insignificant.

The commodity price index is positively related to real GDP as most of the SADC countries are primary commodity-dependent. The result demonstrates that an increase in commodity prices boosts domestic output in the SADC region. This confirms the significance of commodity prices to the region's economic fortunes, particularly mining and agriculture sectors, as well as for foreign exchange markets. Periods of falling or low commodity prices

[13] The upper-middle income economies often engage in significant trade with advanced economies relative to other income sub-groups.

have been associated with low growth rates, and periods of high commodity prices have tended to coincide with high growth rate in the SADC region. These results are in tandem with Roch (2017), Chileshe et al. (2018) and Zgambo and Funyina (2022) who established that a positive shock to commodity prices is associated with higher GDP growth. In the full sample, the results for the commodity price increase show a significant positive relationship with real GDP in SADC countries. This holds across income sub-groups except for the LMI bearing a positive, but statistically insignificant coefficient. On a comparative basis, the pre-shock results seem to mirror those obtained in the full sample while in the post-shock period, the coefficients on all and UMI sub-groups increase and remain significant. For LI and LMI sub-groups, coefficient sizes reduce and are statistically insignificant. More interestingly, the results for the LMI economies, while positive, are statistically insignificant across samples, perhaps suggesting that commodity prices may not be a relevant factor in these economies. Possibly the variation in coefficient size and statistical significance between the pre- and post-shock periods, particularly for all, LI and UMI sub-groups, reflects the disruptive nature of the recent health and geopolitical crises.

Volatility in rainfall (climate change reflecting extreme weather conditions – drought and floods) generally impacts domestic output in SADC countries negatively. It tends to have adverse effects on agricultural production and hydropower generation in the region thereby threatening overall growth and heightens food insecurity (Raddatz 2007; 2009; IMF, 2022). The full sample results show that volatility in rainfall has a negative and statistically significant influence on real GDP in SADC countries. In the income sub-groups, the coefficients are broadly negative, but statistically insignificant except for LMI, perhaps pointing to rainfall variations (Appendix III (A)) from country to country and distribution, which is not captured in the measurement variable used (Khurshid et al., 2022). In contrast, volatility in temperature does not have a significant impact on SADC countries' domestic output. It also has a small and insignificant impact on output across sub-samples and sub-groups given that countries in the SADC region exhibit varying temperature patterns (Appendix III (B)). This demonstrates that the climate change-related risk is likely to impact macroeconomic performance in the SADC region through extreme rainfall (floods and drought) as most economies depend on the agriculture sector. Overall, climate change results corroborate the literature (Raddatz 2009; Lee et al., 2016; Khurshid et al., 2022) that shows that extreme weather, especially volatile rainfall, hurts agricultural yields, worker productivity, risks food security and in turn impacts household welfare and may increase incidences of poverty.

To enhance the understanding of the impact of external shocks on the SADC region, in addition to the FE model, a panel SVAR was estimated. Similar to the exogenous shocks used in the FE regression model, the study utilises global growth (US real GDP), foreign interest rate (federal funds rate), commodity price index and climate change (volatility in rainfall) to assess their impact on domestic SADC macroeconomic variables. However, climate change (volatility in temperature) is dropped in the SVAR due to very low and statistically insignificant coefficient recorded in the FE model signifying very weak or no relationship with domestic macroeconomic indicators in the region. In this regard, impulse response functions (figures 9-12) and variance decompositions (figure13) are used.

The results in figure 9 show the impact of a positive shock to global growth on domestic GDP, fiscal balance, exchange rate, inflation and monetary policy (policy rate). Several studies have identified economic activity in advanced economies as a direct determinant of GDP in emerging markets and developing economies (Sato et al., 2009; Matos et al., 2011; Roch, 2017; Chileshe et al., 2018; Olamide et al., 2022; Zgambo and Funyina, 2022). Accordingly, chart (a) in figure 9 shows that domestic GDP increases following a positive shock to global growth and the impact is significant for all the 20 quarters. The impact is contemporaneous and dissipates over time. Likewise, across income sub-groups, a positive global growth shock is significant and expands economic activity in LMI and UMI economies for the first 16 and 6 quarters, respectively. The shock seemingly persists relatively longer among LMI economies while the highest instant impact is among the UMI. Among the LI economies, the impact is only significant in the first quarter. These findings reflect how domestic SADC growth prospects are aligned to global economic activities. This global synchronicity of economic activity was demonstrated at the height of the COVID-19 pandemic when major economies slid into a recession and the SADC region equally recorded negative growth. However, the variations across income sub-groups in response to the global growth shock demonstrate that relatively higher income economies (UMIs) could be more exposed to such shocks due to higher trade integration with advanced economies. Further, since UMI economies are more resilient than LMI economies, the shock fades more quickly in their case.

Further chart (a) in figure 9 also indicates that global growth shock significantly affects the fiscal balance and exchange rate, but has no impact on inflation and monetary policy (policy rate) in the full sample. A positive shock to foreign GDP translates into a fiscal surplus (significant for 3 quarters, peaking at about 0.3 percent) and appreciates the exchange rate by 0.1 percent. This result is similar to LI and LMI sub-groups (charts b and c). However, for the UMI economies, aside from the fiscal balance and exchange rate, inflation and the policy rate respond positively and are significant during the first two and four quarters, respectively (chart d). Broadly, this result entails that a boost to global activity translates into higher demand for commodities (consistent with the commodity price shock result), improves revenue for most SADC countries and lead to narrower fiscal deficits. Being highly dependent on commodities for foreign exchange earnings, high global demand for commodities tends to support exchange rates in the region.

With regard to the federal funds rate results in figure 10, a positive shock (hike) to the federal funds rate (representative of foreign interest rates) translates into reduced growth, averaging nearly 0.02 percent, among SADC countries (chart a). The impact is gradual and peaks in the second quarter and is only significant up to the third quarter. This result is similar across income sub-groups (charts b-d) and reinforces the fact that tight global financial conditions tend to subdue economic activity in the SADC region, undermine debt sustainability and trigger capital outflows (IMF, 2022). Consistently, the results show that a positive shock to foreign interest rates also depreciates nominal exchange rates for the full sample as well as income sub-groups as depicted in charts (a-d). Overall, a positive shock to the federal funds rate leads to an exchange rate depreciation by about 0.1 percent, on average, for three quarters. Given that the capital account is open in SADC countries, Chileshe et al. (2018) contend that it is expected that changes in foreign interest rates may have a significant impact on domestic economies via the uncovered interest rate parity. With

weaker exchange rates, inflation also increases contemporaneously, inducing lagged monetary policy tightening (policy hike), only for a third quarter. Monetary policy response is stronger among UMI economies where the policy rate is immediately raised and gradually increases before peaking in the seventh quarter (chart d). Central banks' reaction to financial shocks is indicative that there is a tendency for the SADC monetary authorities to adjust policy rates in line with US interest rate setting decisions, a sign of policy contagion (Chileshe et al., 2018). Besides, for the full sample and the UMI economies, a positive federal funds rate shock appears to also result in a fiscal surplus after four quarters and the impact is significant up to the nineth quarter. The seemingly delayed response is counter-intuitive as it shows that tight global financial conditions result in improved fiscal balance in the region. This might be explained by the relatively lower financial interconnection between the SADC region as a whole and advanced economies (Mato et al., 2011; Zgambo and Funyina, 2022).

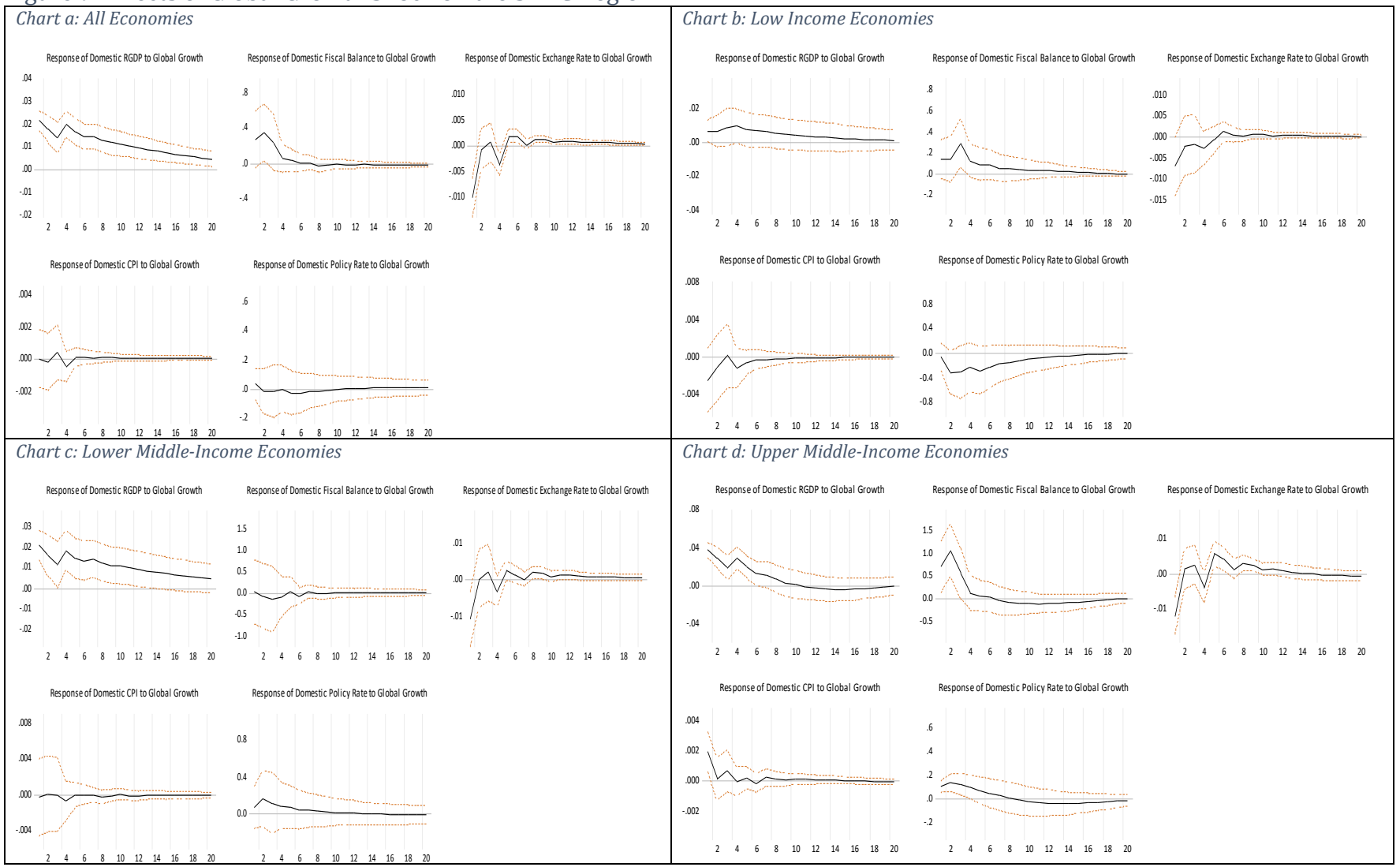
In response to a positive commodity price shock, the model simulations show a significant and positive increase in the SADC region's GDP, peaking in quarter nine (figure 11 chart a). A rise in commodity prices supports the fiscal balance, which is significant from quarter 6 to quarter 12. The shock also has a significant negative relationship with the exchange rate (higher commodity prices favour exchange rate appreciation, but increases inflation). Both exchange rate and inflation response is significant in the first four quarters. Higher commodity prices broadly render support to the foreign exchange market as the region is predominantly commodity export-oriented. In addition, an increase in commodity prices tends to spur economic activity in the region, which seems to trigger inflationary pressures.[14] Consequently, this induces a lagged monetary policy tightening (after two quarters) for the full sample (chart a). This result is similar for the LI economies (chart b). In the case of UMI economies, the policy rate increases and is significant for six quarters (chart d). Consistent with the price stability objective of central banks, the policy rate responds positively to movements in consumer prices. For the LI economies, the response of GDP growth to a commodity price shock is positive as expected, but is only significant between quarters four and eight (chart b). The fiscal balance improves, exchange rate appreciates and consumer prices increase in response to a commodity price shock. For the LMI economies, the commodity price shock is only significant on GDP and exchange rate (chart c).

On the climate change-related shock, given the important role the agriculture and energy sectors play in the SADC economies, a negative shock to rainfall broadly leads to a significant reduction in GDP growth, deterioration in the fiscal balance and depreciation of the exchange rate (figure 12, chart a). Volatility in rainfall outcomes constrain agricultural output and the capacity to generate hydropower (Raddatz, 2007; 2009; IMF, 2022). Low hydropower production reduces productivity as prolonged power cuts may be instituted. Further, volatile rainfall patterns also exert fiscal pressures through more disaster management spending than planned. The exchange rate also tends to come under pressure as government might increase demand for agricultural and electricity imports to cover deficits induced by climate change. An assessment across income sub-groups shows mixed results. For LI economies, macroeconomic variables (except for fiscal balance) respond as expected to a positive shock

[14] The impact of commodity price shock on GDP is relatively higher than on exchange rate, thus triggering demand driven inflationary pressures (chart a).

to climate change, but are broadly insignificant (chart b). Among the LMI economies, inflation and fiscal balance respond positively to the climate change shock. However, the significant response of fiscal balance in this case is counter-intuitive (chart c). For the UMI, GDP seems to contract between quarters 6 and 12 in response to a rainfall volatility shock while the exchange rate depreciates and is significant during the first three quarters (chart d). The delayed response of GDP to a rainfall shock may be associated with the harvest period whose impact on the economy manifests later.

Figure 9: Effects of Global Growth Shock on the SADC Region



Source: Author Computations

Figure 10: Effects of Foreign (US) Interest Rate Shock on the SADC Region

Chart a: All Economies

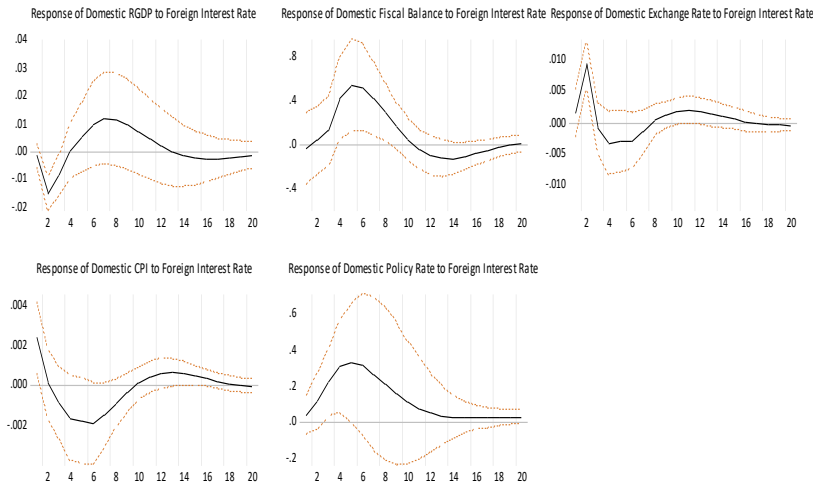


Chart b: Low Income Economies

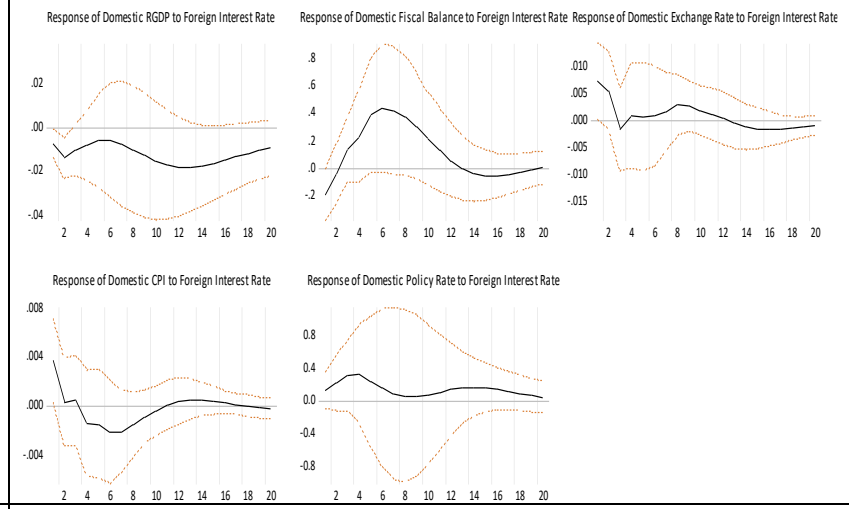


Chart c: Lower Middle-Income Economies

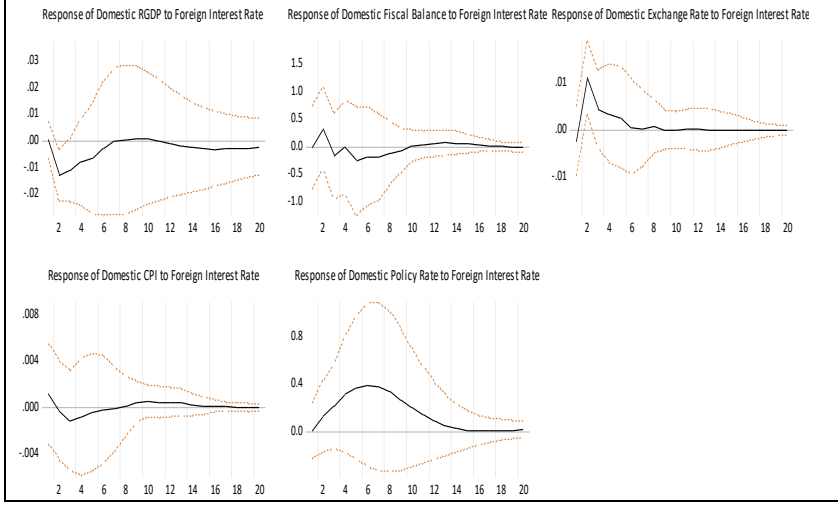
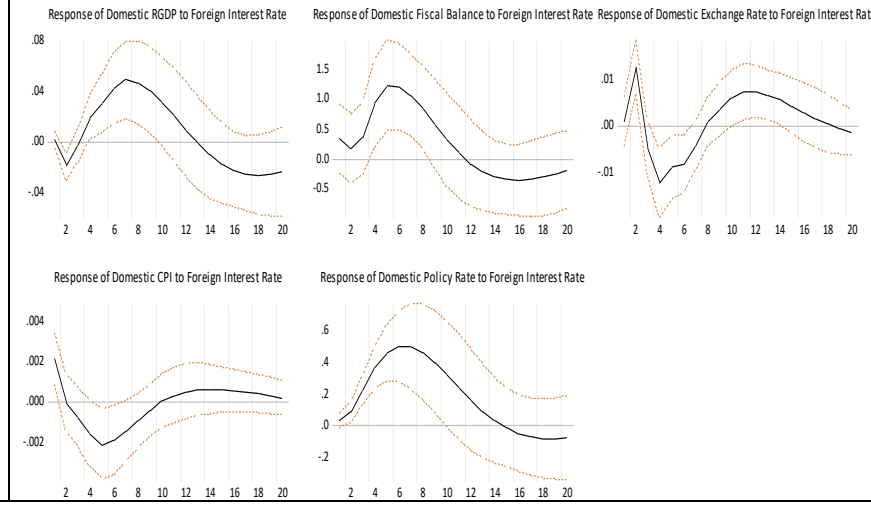
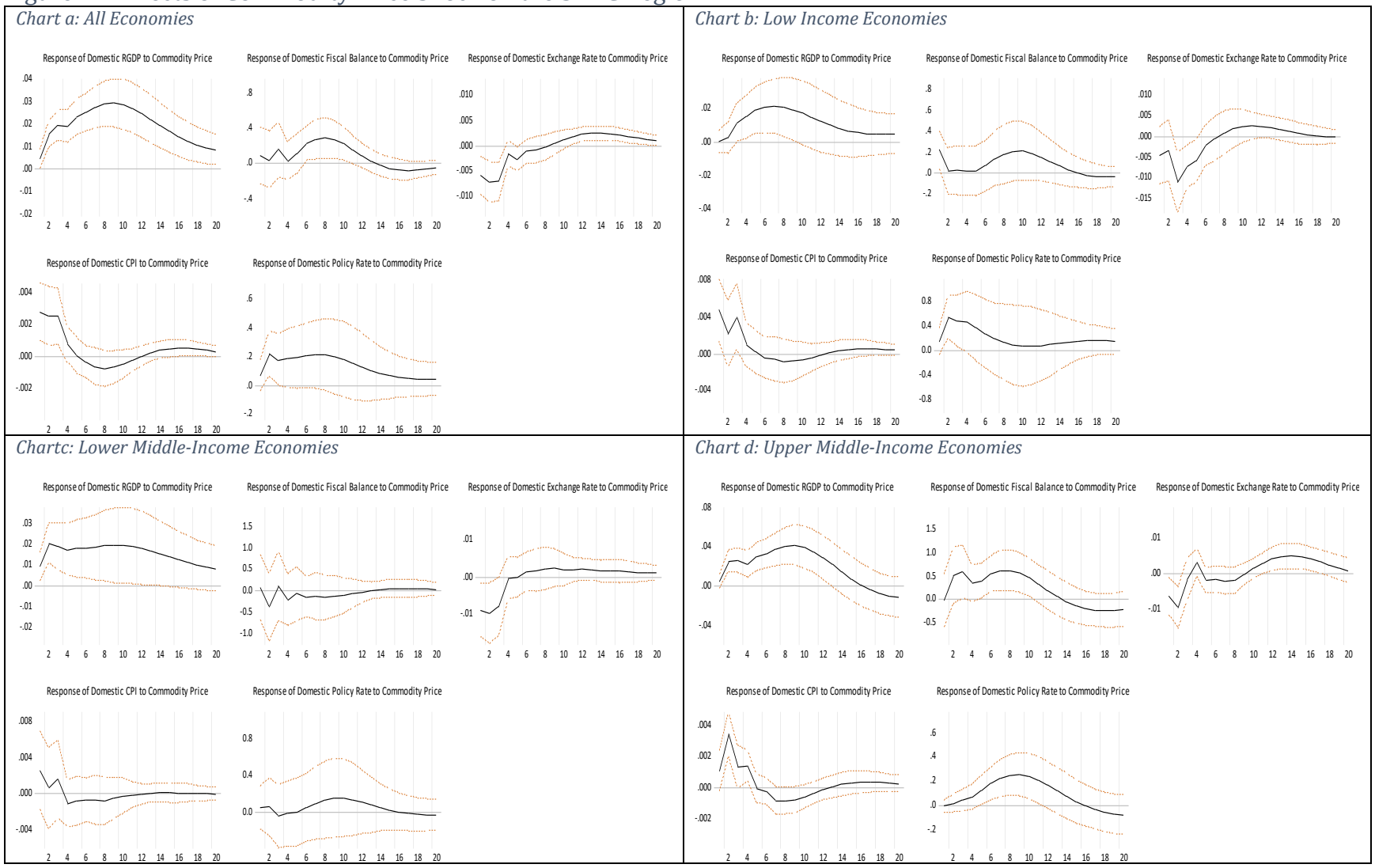


Chart d: Upper Middle-Income Economies



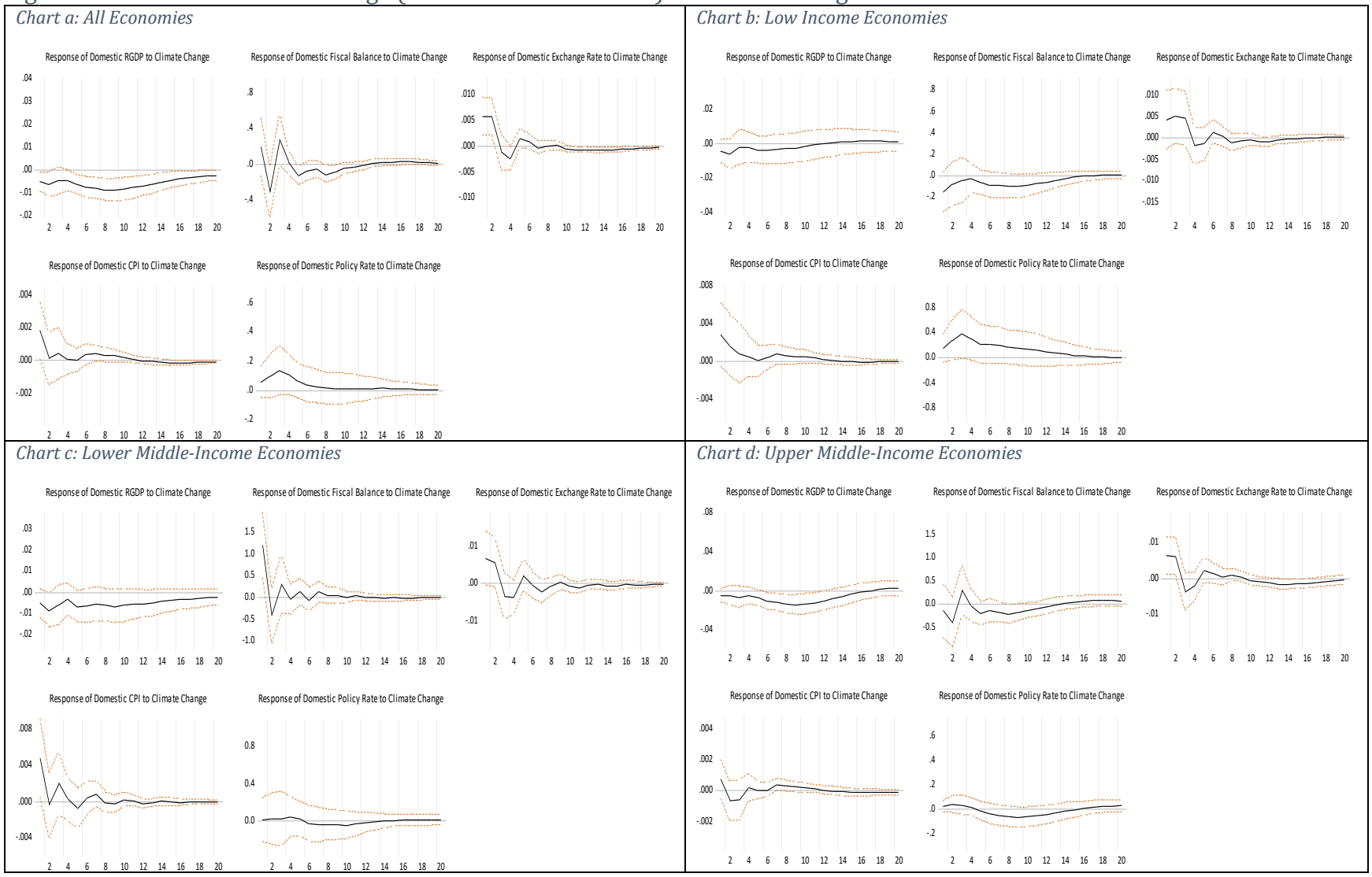
Source: Author Computations

Figure 11: Effects of Commodity Price Shock on the SADC Region



Source: Author Computations

Figure 12: Effects of Climate Change (Extreme Rainfall Shock) on the SADC Region



Source: Author Computations

Variance decomposition analysis is conducted to assess the relative contribution of external shocks to variations in selected macroeconomic indicators in the SADC region. Figure 13 (Tables A-E) reports forecast error variance decomposition for the selected variables up to 10 quarters.

In the initial periods, variations in GDP growth are mainly due to its own shocks and global growth (Table A). However, after seven quarters, commodity prices begin to account for a sizable portion of fluctuations in GDP growth in the region. Changes to the monetary policy stance (policy rate) appear to make the least contribution to variations in domestic GDP growth.

Besides own shocks, variations in the fiscal balance are notably influenced by the federal funds rate (Table B). Commodity price shocks appear to matter the most to the variations in exchange rates in the region working through real domestic GDP (Table C). Over time, inflation tends to respond to variations in the exchange rate, commodity prices and the monetary policy rate (Table D).

To maintain price stability, central banks in the region (proxied by the monetary policy) tend to react countercyclically to commodity price shocks, which induce inflationary pressures by raising aggregate demand and in turn depreciate domestic currencies (Table E). In addition, monetary policy responds to rising foreign interest rates consistent with previous investigations (Chileshe et al., 2018). Rising foreign interest rates induce capital outflows and depreciation of domestic currencies, compelling central banks to intervene in the foreign exchange market to dampen inflationary pressures.

Figure 13: Panel SVAR Results from the Variance Decomposition

Table A: Variance Decomposition of Real GDP Growth

Period	S.E.	USRGDP	FFR	CP	CLIM	RGDP	FD	EXR	CPI	R
1	0.015009	13.09877	0.046289	0.630582	0.738134	85.48623	0.000000	0.000000	0.000000	0.000000
2	0.016675	11.46666	3.219967	3.914224	0.942165	78.77270	0.067050	1.356930	0.193984	0.066317
3	0.017108	10.34086	3.024626	6.821259	0.916223	76.36939	0.532970	1.387770	0.458707	0.148201
4	0.017478	11.58655	2.401689	8.486318	0.892401	73.42868	0.918355	1.416424	0.645309	0.224279
5	0.017629	11.66770	2.215540	10.94402	1.030027	70.39015	1.294135	1.408182	0.756151	0.294091
6	0.017717	11.37826	2.522776	13.40149	1.233034	67.21117	1.633066	1.404564	0.828819	0.386819
7	0.017773	11.18074	3.014541	15.87257	1.440891	63.81296	1.914068	1.403749	0.868906	0.491578
8	0.017805	10.87257	3.344587	18.36689	1.652302	60.68606	2.156053	1.423190	0.890726	0.607616
9	0.017819	10.56877	3.482822	20.62259	1.848837	58.00339	2.379574	1.457029	0.902516	0.734473
10	0.017834	10.34199	3.454359	22.53062	2.003999	55.81060	2.580841	1.503180	0.908321	0.866090

Cholesky ordering: USRGDP FFR CP CLIM RGDP FD EXR CPI PR

Source: Author Computations

Table B: Variance Decomposition of Fiscal Balance

Period	S.E.	USRGDP	FFR	CP	CLIM	RGDP	FD	EXR	CPI	R
1	0.015009	0.420325	0.006295	0.044776	0.211827	0.366745	98.95003	0.000000	0.000000	0.000000
2	0.016675	1.063677	0.014852	0.050583	0.704210	1.356045	96.19834	0.130517	0.239518	0.242253
3	0.017108	1.254636	0.094315	0.176758	1.027479	1.274027	95.22521	0.140733	0.525982	0.280856
4	0.017478	1.261552	0.984587	0.178693	1.017891	1.274039	94.24743	0.151902	0.546041	0.337861
5	0.017629	1.242700	2.387344	0.234866	1.080048	1.264863	92.71656	0.156764	0.551472	0.365387
6	0.017717	1.222383	3.669875	0.481695	1.089622	1.262918	91.18266	0.166706	0.542290	0.381846
7	0.017773	1.207929	4.455865	0.820884	1.089768	1.280073	90.05645	0.166137	0.535629	0.387268
8	0.017805	1.198980	4.825139	1.205786	1.140438	1.301334	89.24339	0.165426	0.531716	0.387792
9	0.017819	1.193051	4.928577	1.539142	1.170268	1.328432	88.75945	0.164630	0.529734	0.386713
10	0.017834	1.189757	4.923957	1.764624	1.176333	1.349934	88.51608	0.164334	0.529081	0.385906

Cholesky ordering: USRGDP FFR CP CLIM RGDP FD EXR CPI PR

Source: Author Computations

Table C: Variance Decomposition of Exchange Rate

Period	S.E.	USRGDP	FFR	CP	CLIM	RGDP	FD	EXR	CPI	R
1	0.015009	3.966568	0.107814	1.360539	1.307683	31.68100	0.033465	61.54293	0.000000	0.000000
2	0.016675	3.511614	3.205732	3.031439	2.332012	28.09909	0.064432	58.68136	0.989972	0.084346
3	0.017108	3.406994	3.117820	4.617630	2.296742	27.47987	0.262258	56.68361	2.035699	0.099381
4	0.017478	3.791197	3.405278	4.616722	2.436694	27.57669	0.295856	55.72917	2.050473	0.097919
5	0.017629	3.863044	3.633381	4.791770	2.482425	27.75493	0.320131	55.03329	2.024224	0.096811
6	0.017717	3.949313	3.870054	4.782880	2.489632	27.95899	0.319213	54.52286	2.007604	0.099459
7	0.017773	3.935260	3.916217	4.784059	2.481970	28.15506	0.318437	54.30429	2.003397	0.101309
8	0.017805	3.985116	3.912706	4.772122	2.474285	28.30442	0.317543	54.13030	2.001072	0.102434
9	0.017819	4.028636	3.947496	4.766400	2.467030	28.41124	0.317416	53.96052	1.998287	0.102977
10	0.017834	4.031917	4.035415	4.799288	2.467787	28.46799	0.319793	53.77992	1.995202	0.102690

Cholesky ordering: USRGDP FFR CP CLIM RGDP FD EXR CPI R

Source: Author Computations

Table D: Variance Decomposition of Consumer Price Index

Period	S.E.	USRGDP	FFR	CP	CLIM	RGDP	FD	EXR	CPI	R
1	0.015009	0.000273	1.032660	1.401540	0.606343	1.661509	0.715885	1.284614	93.29718	0.000000
2	0.016675	0.003754	0.972257	2.380492	0.572462	1.830243	0.756250	3.705223	87.83803	1.941293
3	0.017108	0.036204	1.052844	3.326652	0.585968	2.477937	0.753528	4.748171	84.76356	2.255140
4	0.017478	0.065786	1.465939	3.383313	0.581250	2.500089	0.783913	4.857517	83.89828	2.463912
5	0.017629	0.068409	1.964078	3.360224	0.577479	2.482709	0.785259	4.849947	83.31314	2.598751
6	0.017717	0.071508	2.508976	3.354101	0.594992	2.473532	0.781264	4.820581	82.68962	2.705426
7	0.017773	0.072750	2.839257	3.399472	0.623282	2.474176	0.777167	4.800372	82.21455	2.798972
8	0.017805	0.075478	2.952504	3.480336	0.639684	2.479561	0.774484	4.794913	81.92029	2.882755
9	0.017819	0.077715	2.963661	3.542912	0.652241	2.486758	0.773904	4.799401	81.74816	2.955251
10	0.017834	0.079398	2.961680	3.574551	0.659375	2.493947	0.774309	4.806097	81.63709	3.013550

Cholesky ordering: USRGDP FFR CP CLIM RGDP FD EXR CPI R

Source: Author Computations

Table E: Variance Decomposition of Policy Rate

Period	S.E.	USRGDP	FFR	CP	CLIM	RGDP	FD	EXR	CPI	R
1	0.015009	0.063601	0.088482	0.266629	0.172260	1.108490	0.189506	1.090001	2.149097	94.87193
2	0.016675	0.033223	0.357156	1.264403	0.299184	2.029968	0.268410	3.599136	4.843499	87.30502
3	0.017108	0.025715	1.021071	1.353889	0.493518	3.060063	0.263284	5.932290	5.304975	82.54519
4	0.017478	0.020206	1.983952	1.502927	0.531600	3.707426	0.265262	7.549501	5.149295	79.28983
5	0.017629	0.025710	2.829773	1.687108	0.496881	4.069843	0.271278	8.444895	4.931091	77.24342
6	0.017717	0.029162	3.484477	1.931121	0.462126	4.252042	0.273187	8.940511	4.768847	75.85853
7	0.017773	0.028865	3.872264	2.207071	0.436443	4.341668	0.272247	9.205858	4.668221	74.96736
8	0.017805	0.028733	4.053051	2.486632	0.416898	4.384854	0.268140	9.358778	4.610188	74.39273
9	0.017819	0.027994	4.112511	2.726856	0.403245	4.404382	0.263139	9.454042	4.578689	74.02914
10	0.017834	0.027309	4.107876	2.914896	0.394251	4.409326	0.258318	9.516877	4.562711	73.80844

Cholesky ordering: USRGDP FFR CP CLIM RGDP FD EXR CPI R

Source: Author Computations

7 Conclusion

This study assessed the macroeconomic effects of global shocks on the SADC region. Panel data spanning from 2010Q1 to 2022Q4 for 14 SADC countries was used. Two methodological approaches, FE panel regression and panel structural vector autoregression model, were employed. Using FE regression, the study assessed the impact of global growth (US real GDP), foreign interest rate (federal funds rate), commodity price shock (commodity price index) and climate change (measured using volatility in rainfall and temperature) on real GDP in SADC. This investigation assessed pre-shock (2010Q1-2019Q4) and post-shock (2020Q1-2022Q4) impacts. In addition, the analysis was extended to income sub-groups according to the World Bank classification of SADC countries.

The results show that, broadly, real GDP in SADC is influenced by global growth, commodity prices and volatility in rainfall (climate change). The dominant factors are commodity prices and global growth across all income sub-groups. In the pre-shock era, GDP was mainly determined by its past performance and commodity prices. However, during the post-shock period, domestic economic activity synchronization with the global economy intensified and was driven by global growth. As supply-chains were disrupted, the effect of commodity prices generally reduced. These effects are more intense among the UMI as they are more integrated in global financial markets relative to the rest of the region. However, the federal funds rate has a generally weak impact on domestic GDP growth, pointing to evidence of low financial interconnection between the SADC region and advanced economies.

With regard to the fiscal balance and exchange rate, the results broadly confirm that global growth, commodity price and climate change shocks matter the most. Positive global growth and commodity price shocks tend to stimulate domestic economic activity in the region, improve the fiscal balance and support the exchange rate, especially among the UMI economies through the trade channel. Conversely, a climate shock leads to a deterioration in fiscal balance and depreciation of the exchange rate. Volatility in rainfall affects rainfed

agricultural production and hydropower generation leading to lower output and productivity. This prompts governments to meet shortfalls via imports, resulting in increased demand for foreign currency and in turn pressure on the treasury to cover deficits caused by unforeseen disaster mitigation spending. The variation in the exchange rate is explained by changes in the federal funds rate since tight global financial conditions tend to dampen economic activity in the SADC area, compromising debt sustainability and causing capital outflows.

In the case of inflation and domestic monetary policy stance (policy rate), variations are largely explained by commodity prices, global growth and federal funds rate. Positive global growth and commodity price shocks prompt a positive response on consumer prices and consequently policy rate hikes only among UMI economies as they are more integrated in the global financial system. As earlier stated, a rise in the federal funds rate results in subdued economic activity in the region and depreciates the nominal exchange rate. This is reflected in inflationary pressures that begin to mount causing central banks to hike interest rates. There is also strong evidence of policy contagion in the region, especially among the UMI economies, in response to federal funds rate hikes.

To strengthen regional resilience and make progress on MEC, policy response by the authorities in SADC can be categorized into structural and fiscal reforms as well as monetary policy. Structural and fiscal policy reforms include scaling-up economic policy reforms at country level, as well as deepening and strengthening intra-regional commerce to insulate against future external shocks arising from global supply-chain disruptions. This has the potential to promote regional industrial growth, increase productive capacity and reduce the region's macroeconomic vulnerability to external shocks. In addition, there is need to strive for macroeconomic stability through low and stable inflation, manageable fiscal deficits, low public debt, and equitable current account balance. This stability encourages economic growth by providing a predictable and appealing environment for investment and business resulting in improved regional economic performance and macroeconomic convergence.

Further, to improve the effectiveness of fiscal policy in the region, countries need to build fiscal buffers in times of commodity price booms and strong growth to smooth expenditures when commodity prices slump, and revenue mobilization becomes challenging. This is supported by the fact that commodity exports account for a significant portion of fiscal revenues in SADC economies, which increases in value consistently in boom periods and fall in downturns (Casal et al., 2016). This also entails that strategies and policies aimed at value addition and diversifying the region’s economies away from commodities are pursued. Value addition and export diversification are key for SADC countries to safeguard against vulnerabilities and economic uncertainties associated with commodity price volatility.

There is also need to scale up investments in the agriculture sector to mitigate the impact of adverse climatic shocks. This requires investing in rainwater harvesting and irrigation facilities, planting early maturing varieties and mixed cropping. In addition, agriculture insurance would provide a cushion in the wake of losses from such weather-related natural disasters. Another critical area for consideration will be picking up the pace towards energy

transition. Policies to fast-track green energy transition will yield long-term payoffs for energy security and the costs of ongoing climate change. In this regard, there is need for SADC countries to idiosyncratically transition into clean energy.

On monetary policy reforms, SADC countries need to build foreign exchange reserve buffers during commodity price boom periods, which can be redeployed during economic stress to address exchange rate volatility and facilitate importation of critical imports. There is also a need to maintain an appropriate monetary policy stance in crisis periods. Evidence in this study reveals countercyclical monetary policy in mitigating macroeconomic instability induced by external shocks. In addition, there is a role for central banks in spearheading and implementing green finance incentive programmes. Climate change mitigation is the most fundamental approach to reducing the impact of climate change on financial system stability. Green finance may not only minimise financial risks posed by climate-related natural disasters, but can also ably offset financial risks posed by transitioning to a low-carbon economy. These initiatives have the potential to bridge the climate finance gap while also substantially addressing long-term financial concerns posed by climate change (Liu et al., 2021).

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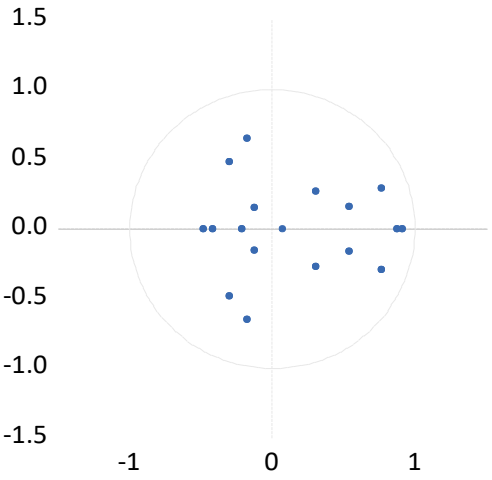
Appendix

Appendix I: Residual Diagnostic Tests

Test	Test Statistic	p-value
Modified Wald test for groupwise heteroskedasticity	chi2 (14) = 1086.10	Prob>chi2 = 0.0000
Pesaran's test of cross-sectional independence	chi2(91) = 5.308	Prob = 0.0000
Woodridge serial correlation	F (1,13) = 0.021	Prob>F = 0.883

Source: Author Computations

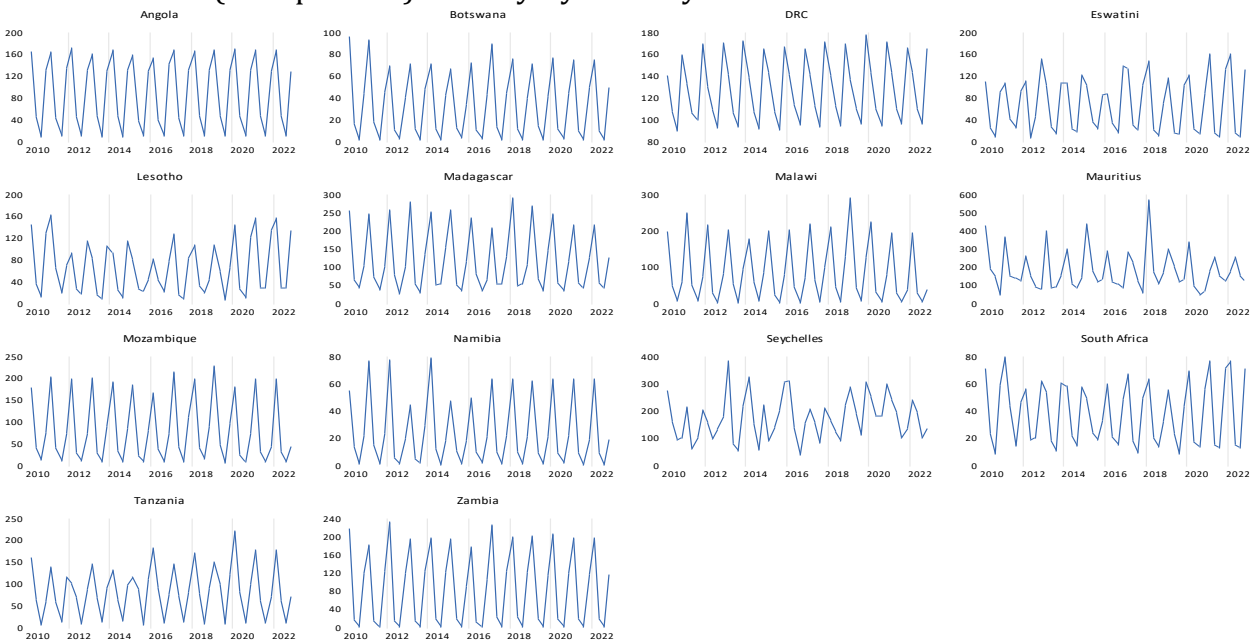
Appendix II: Inverse Roots of AR Characteristic Polynomial



Source: Author Computation

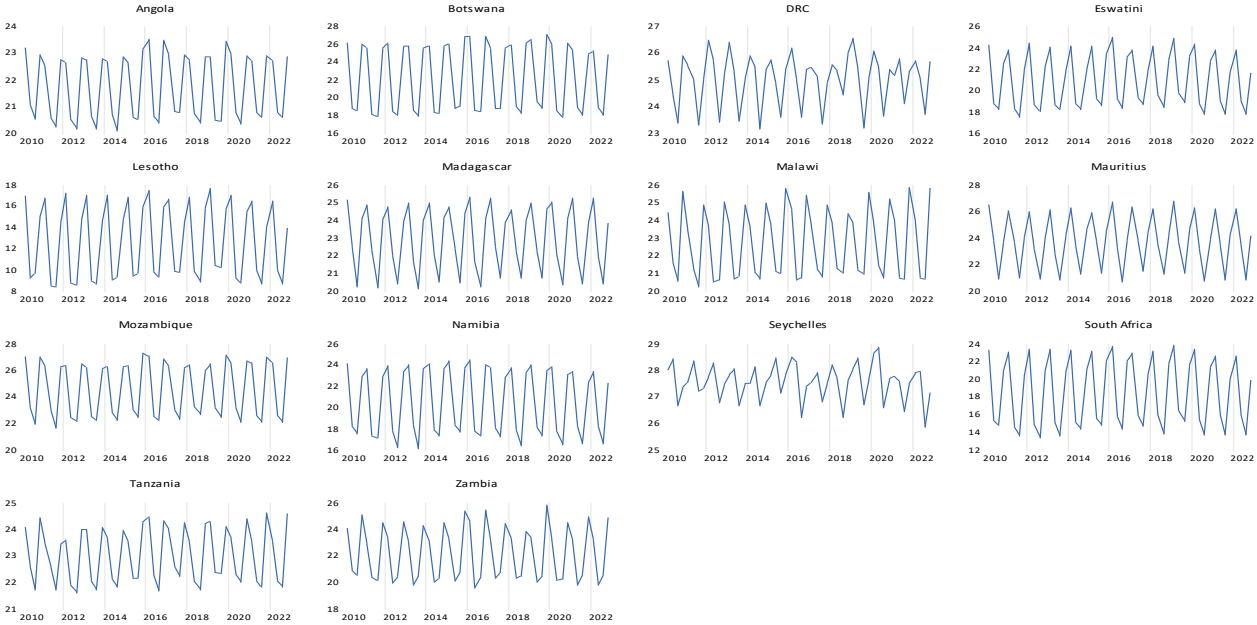
Appendix III: Rainfall and Temperature Distribution

A. Rainfall (Precipitation) Country-by-Country

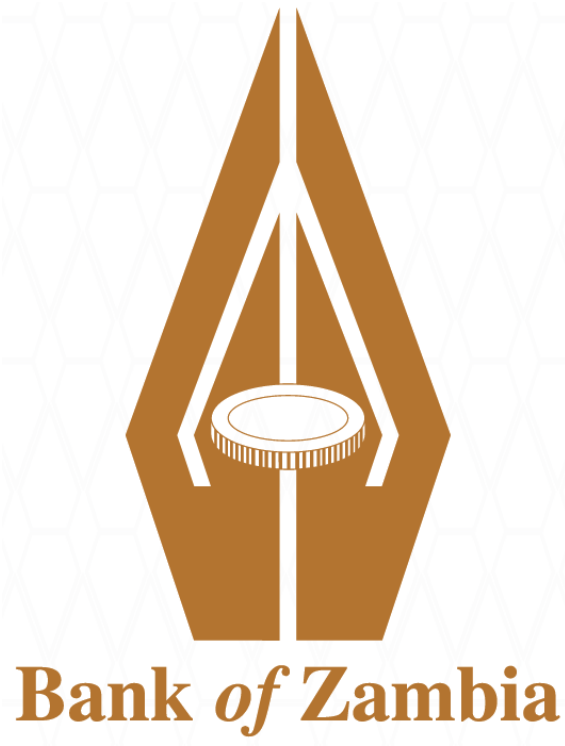


Source: Author Computations

B. Temperature Country-by-Country



Source: Author Computations



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