

Full Length Research Paper

Stochastic simulation analysis of sustainable public debt in Zimbabwe

Nebson Mupunga¹ and Pierre Le Roux²

¹Reserve Bank of Zimbabwe

²Nelson Mandela Metropolitan University, Department of Economics, Port Elizabeth, South Africa

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This paper applies dynamic stochastic simulation methods to assess sustainable public debt management policies in Zimbabwe. The methodology applied involves estimating a fiscal reaction function and using it to simulate public debt path using a stochastic approach and historical information on drivers of public debt accumulation and their volatility. The results from the baseline scenario show that Zimbabwe's public debt would not deviate much from the desired regional indicative target in the SADC region of 60 percent in the medium to long-term. The policy implication is the need for policy makers to proactively respond to the changing macroeconomic environment and to implement countercyclical fiscal policies to limit the probability of debt from exploding.

Key words: Public debt dynamics, debt sustainability, stochastic simulation, fiscal reaction function.

INTRODUCTION

The sustainability of public debt cannot be determined with certainty. What matters is the risk caused by significant public debt accumulation, instead of the expected evolution of the public debt. A key determinant of the risk indicator is the quality of government policies in controlling public debt in the event of adverse shocks (Casper van Ewijk et al., 2013). Insight into the risk caused by significant rise in public debt and policy responses is critical as it informs decisions concerning the need for reform. As such the need for a dynamic, forward-looking framework to assess the stability of public debt under uncertainty is of critical importance.

Analysis of public debt under uncertainty is particularly crucial to Zimbabwe given the existence of a public debt overhang in an uncertain macroeconomic environment.

The country's susceptibility to exogenous shocks increased following the adoption of the multi-currency regime in 2009, where the United States dollar, the South African rand, Botswana pula, United Kingdom pound and the euro were accorded legal tender status for transaction purposes in the country. The adoption of the multiple-currency regime implies that Zimbabwe ceased to have a currency of its own. As a result, the dollarisation phenomenon curtailed the country's ability to generate seignorage revenue as well as its ability to influence policy through traditional demand management tools, such as the discount window and open market operations.

In the absence of seignorage revenue, the only policy instrument available to government to stimulate economic activity and to respond to macroeconomic shocks is

*Corresponding author. E-mail: nmupunga@rbz.co.zw.

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external borrowing. Excessive reliance exacerbates the economy's vulnerability to external shocks. The current account deficit, which is a major driver of external debt dynamics has also been widening over the period 2000 to 2013, averaging more than 20 percent of GDP. The current account deficit has key being financed by debt creating flows, thus, worsening the already precarious debt overhang with adverse effects on debt sustainability.

Unlike, in the past where the country could retire domestic debt through seignorage revenue, under the multicurrency regime, Zimbabwe has to boost its revenue collections to be able to service both domestic and external debt. This paper is, therefore, motivated by the need to identify how the government has been responding to public debt developments with a view to determining sustainable public debt management policies in the medium to long-term. In doing so, the paper seeks to provide insights into the following key questions:

1. What should be the medium to long-term public debt path given the nature of shocks facing the country and its fiscal policy stance?
2. What should be the government's fiscal response to ensure medium to long term sustainability of public debt levels?

Answers to these questions will enable government to come up with public debt management policies that are consistent with maintaining public debt at sustainable levels. However, since future borrowing involves uncertainty, this requires stochastic simulation of public debt to obtain the distributions of public debt as well as the median public debt path and the probability of debt deviating from the optimal steady state.

Although the International Monetary Fund (IMF) regularly conducts debt sustainability analysis to assess the future path of public debt in Zimbabwe, the analysis has mainly been deterministic and does not take into consideration uncertainty in the public debt portfolio. The debt sustainability analysis, as typically carried out by the IMF has focused instead on debt dynamics. Under this approach, the government can be considered to be operating within its budget constraint as long as the expected fiscal policy stance keeps the debt-to-GDP ratio on a stable (or declining) path.

As pointed out by Celasun et al. (2006), there are serious shortcomings to this approach. First, the conditions under which the debt-to-GDP ratio behaves over time are not deterministic but stochastic. The government may have control over its policy setting, but the debt path also depends on macroeconomic conditions that are outside of its control, i.e. GDP growth, interest rates and the exchange rate. Second, even if debt is declining, a high level of debt and its rollover create a risk that liquidity (or other) shocks will unravel into a debt crisis. Without a handle on the probability distribution of shocks, it is impossible to assign a probability to this risk. This paper

derives fan charts to depict the probability distribution of the public debt to GDP ratio under a medium-term adjustment scenario, as a result of shocks to GDP growth and interest rates. The distribution of shocks is derived from the past shocks to these variables and the related variance covariance.

The high dependence of Zimbabwe on primary commodities and exposure to terms of trade shocks underscore the need for a stochastic analysis of the dynamics of government primary balance and its response to public debt. Since borrowing decisions are mainly determined by fiscal policy, an understanding of the determinants of fiscal performance is also critical to the formulation of sustainable public debt management policies. Insight into the sustainability of public debt is also essential to policymakers as it creates the need for speedy fiscal consolidation, the need for reform and the determination of the appropriate risk premium on public debt.

The analysis generates a distribution of simulated public debt paths, which shows the effect of fiscal responses and interest and growth rate volatility on public debt to GDP ratios. The results from the stochastic simulations would indicate the ability of government to control its finances in the medium to long-term, thereby allowing government to craft sustainable public debt management policies. If the simulated public debt is large, the government would be considered incapable of controlling its finances and the risk of medium to long-term default would be high. The projected median public debt levels from the simulation analysis, thus, offer a dynamic, forward-looking assessment of the sustainability of public debt.

The rest of the paper is structured as follows. Section two provides a review of Zimbabwe's public debt dynamics. Section three reviews the theoretical literature on stochastic public debt, fiscal response function and public debt dynamics. Section four describes in detail the methodology for stochastic public debt projections based on the estimated fiscal reaction function and debt dynamics. Section five provides analysis of results while section six concludes and provides policy implications and recommendations.

SECTION TWO: EVOLUTION OF ZIMBABWE'S PUBLIC DEBT

Historically, from 1980 until 2012, the public debt to GDP ratio for Zimbabwe averaged 80.1 percent reaching an all-time high of 105.9 percent in December 2008, and a record low of 16 percent in December 1980. The slowdown in the debt to GDP ratio from 2008 onwards reflects an improvement in capacity to repay, as measured by increases in GDP, exports and government revenue, as opposed to actual debt service payments. The country has not been servicing its debt which has culminated in accumulation of external payment arrears estimated at

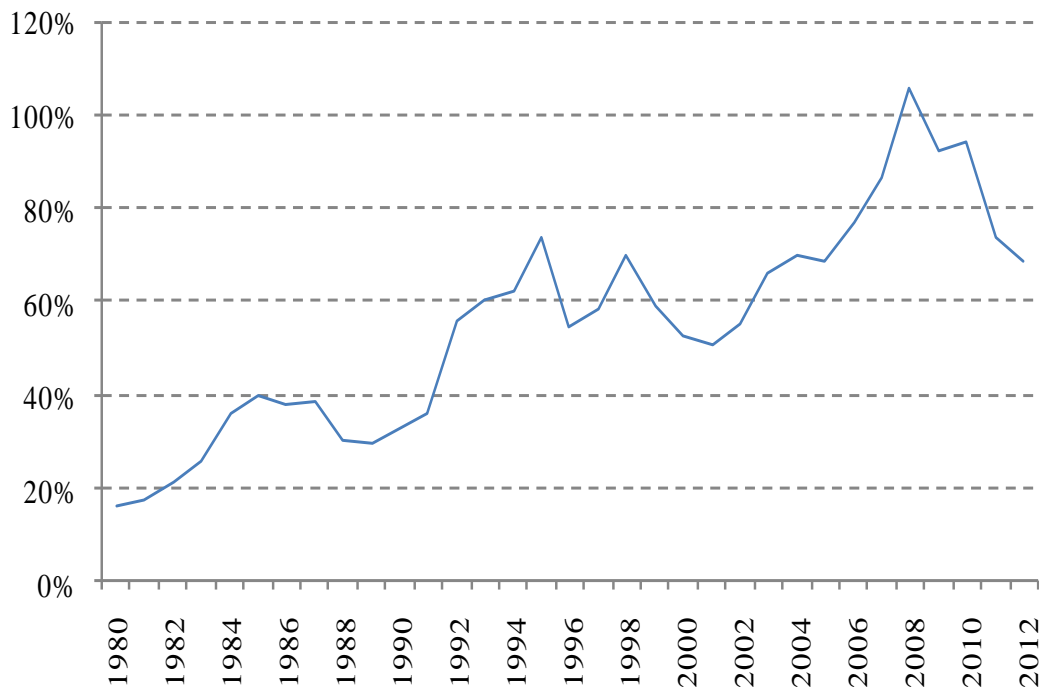


Figure 1. Trends in Zimbabwe's public debt to GDP ratio (1980-2012). Source: IMF World Economic Outlook 2012.

over 60 percent of GDP in 2012. Generally, public debt as a percentage of GDP is used by investors to measure a country's ability to make future payments on its debt, thus affecting the country's borrowing costs and government bond yields. As highlighted by Reinhart et al. (2010), the country's historical fiscal performance helps inform the assessment of what constitutes an optimal public debt policy. The arguments put forth by Reinhart et al. (2003) was based on the fact that a country's record at meeting its public debt obligations and managing its macro economy in the past, is relevant to simulating its ability to sustain moderate to high levels of indebtedness in the medium to long-term. Figure 1 shows the trend in Zimbabwe's public debt to GDP ratio.

From Figure 1, it can be shown that, Zimbabwe's public debt maintained an upward trajectory before stabilising somewhat between 1995 and 2000, when the economy was still recording fair growth rates. However, from 2000 onwards, the debt level spiraled due to more domestic borrowing in the absence of adequate external support. The growth in total debt was also a reflection of penalty charges for accumulating external payment arrears as well as new short-term loan facilities contracted by the central bank for Government in the absence of official development assistance.

At independence in 1980, Zimbabwe adopted a socialist ideology in which expenditure on human and social needs were given prominence. The new government was under immense pressure to finance post war reconstruction

projects as well as fulfilling the post-independence development agenda that included free education, health and higher wages. This culminated in increased expenditure which was not commensurate with the country's revenues. Consequently, the country began to experience high fiscal deficits and rising public debt.

The country's fiscal position was further exacerbated by the severe drought which hit the country between 1983 and 1985. The Government had to commit its limited resources towards drought mitigation programmes, thus, adding more pressure on the fiscal. As the country's public debt grew, the proportion of interest payments in total expenditure also increased significantly. On average, Government was spending 8.2% on interest payments in the 1980s. By 1990, interest payments accounted for about 16% of the Government's total budget, or an equivalence of 6% of GDP.

Government expenditure continued to rise in 1998 and 1999 due to Government's need to fulfill regional peace and security commitments in Democratic Republic of Congo (DRC). Consequently, the economy began to experience negative GDP growth rates of -0.8 and -2.1% in 1998 and 1999, respectively. Resultantly, the fiscal deficit as a percentage of GDP increased from 5.4% in 1997 to 24.6% in 1999. Shrinking tax revenue collection triggered by reduced economic activities, expenditure overruns from unbudgeted wage increases and huge domestic interest outlays all contributed to the weakening of the country's fiscal position. Figure 2 shows the trend in

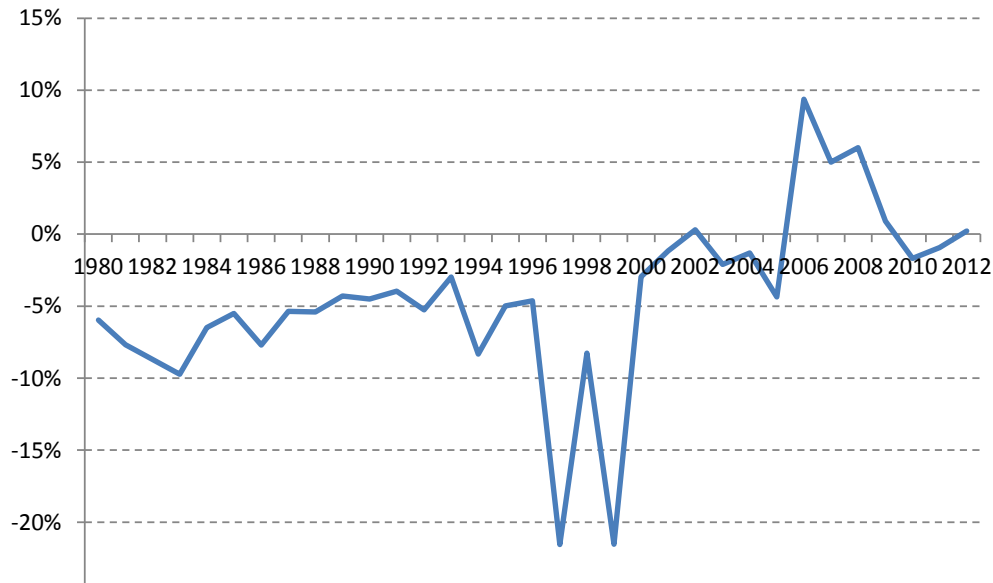


Figure 2. Trend in Government Primary Balance. Source: Government of Zimbabwe (2012).

the government primary balance from 1980 to 2012.

In 1999, the Government failed to honor its external payment obligations and was suspended from further accessing any financial support from the IMF, World Bank and other international lending institutions. Since then, the country has not been able to pay its external obligations for nearly a decade (2000- 2010) against the backdrop of progressive decline in export performance and the depletion of the foreign currency reserves, due to restrictive measures imposed on the country. The meager foreign currency resources available to the country have been allocated towards critical social needs such as education and health delivery systems.

Failure to service the loans and persistent breach of economic conditionality's caused the withdrawal or suspension of new credit by a number of international financial institutions (IFIs) including the IMF. This was, however, before the public debt level had soared to unsustainable levels. The US Government passed the Zimbabwe Democracy and Economic recovery Act (ZIDERA), which directed US representatives at major International Financial Institutions boards to block any extension of credit or cancellation of debt to Zimbabwe. This international isolation further constrained Zimbabwe's ability to access any future donor funding and meet its debt obligations and made it difficult to carry out investments in infrastructure. The public debt situation was aggravated further by a period of economic crisis and an unsustainable borrowing on the domestic front post 2000, negative economic growth, a disruptive political environment and macroeconomic fragilities.

The prevalence of high inflation rates which reached 231 million percent levels by July 2008 resulted in investors resisting long term Government paper in preference to

short term but high rewarding treasury bills, exposing Government to refinancing risk. By 2006, the portfolio was 99 percent short term and 1 percent long term, compared to 96 percent long term recorded in 1990.

The debt burden has been a stumbling block towards economic recovery initiatives of the country and has impacted negatively on the country's international credit rating, a development which has been a major deterrent to potential foreign investment and credit inflows. The accumulation of external payment arrears has to some instances, resulted in litigations against the Government of Zimbabwe by creditors as well as the placement of the country on lending restrictions by the international financial institutions. This resulted in difficulties in accessing financial support for key developmental projects, from the global financial markets. The country has, therefore, been relying mainly on domestic sources of finance for its operations. However, following the adoption of the multicurrency system in February 2009, with the US dollar as the principal currency, the Government has not been in a position to significantly borrow domestically due to attended liquidity challenges that have characterized Zimbabwe's multicurrency regime.

Composition of public debt

The composition of public debt has important implications on public debt dynamics. Analysis of the currency composition of the public debt and its maturity structure are relevant to assess the vulnerability of a country to a debt crisis (World Bank, 2005). This in turn determines the optimal public debt policy given the cost and risk trade characteristics of the public debt portfolio. Hence,

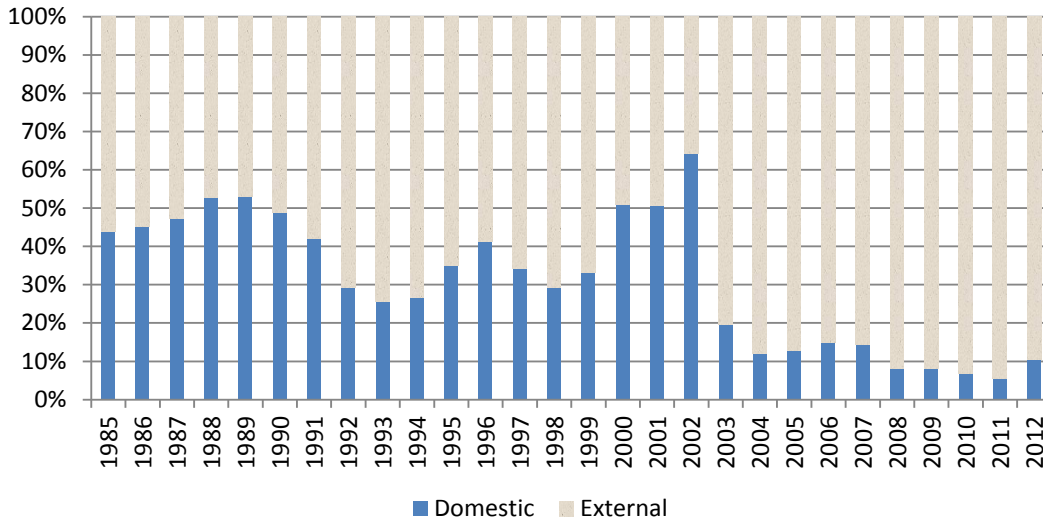


Figure 3. Composition of Zimbabwe's Public Debt (1985-2012). Source: Government of Zimbabwe (2012).

alongside the level of public debt ratio, analysis of the composition of public debt in terms is warranted.

Since the year 2000, there has been a general shift in the composition of public debt in Zimbabwe from external to domestic debt. This move was necessitated by the drying up of external sources of financing following the placement of Zimbabwe on restrictive measures by traditional creditors, notably the IMF and the World Bank. This trend has, however, been consistent with developments in other developing and emerging market economies where domestic debt is increasingly becoming more pronounced (Panizza, 2008). According to Panizza (2008), developing economies traditionally used the domestic debt market as a residual only when they did not have access to external resources or to sterilize aid flows. Recent developments have, however, seen an increasing number of countries switching from external to domestic debts, thus, posing the risk of trading a currency mismatch for a maturity mismatch since few of them are able to issue long-term domestic debts at reasonable interest rates (Panizza, 2008).

As at end of 2012, external debt constituted about 90 percent of Zimbabwe's public debt stock, while domestic debt accounted for the balance of 10 percent. The significant proportion of external debt implies a low cost public debt portfolio as most of the external debts were to a large extent contracted at concessional rates while the presence of captive investors, and practice of forced placements, has kept the cost of domestic debt below a true market rate. Furthermore, the IMF (2012) also noted the unidentified domestic contingent liabilities within some public entities as another source of potential debt. Figure 3 shows the trend in the composition of public debt since the year 1985 to 2012.

Figure 3 shows that the composition of domestic debt increased sharply in 2000 as the government tried to steer

the economy through more domestic borrowing against the imposition of economic sanctions on the country. The proportion of domestic debt in total public debt, however, declined progressively due to erosion of the value of the Zimbabwean dollar as a result of spiraling inflation.

REVIEW OF LITERATURE

An extensive literature that analyses and proposes different measures of public debt sustainability exists. Most of this literature, however, relies on unit root and co integration tests often in combination with the inter-temporal budget constraint to analyze the sustainability of public debt. Bohn (2007), however, shows that the consistency with the inter-temporal budget constraint is not a sufficient condition for public debt sustainability. According to Bohn, it is possible to satisfy the inter-temporal budget constraint, while simultaneously having a mildly explosive path of public debt to GDP ratios. The theoretical framework, motivated by Bohn (1998, 2008), also advocates for the existence of a fiscal reaction function, which implies that the primary balance is positively correlated with lagged public debt levels.

Ghosh et al. (2011), however, suggest that the size of primary balance response may vary with the level of the public debt ratio, reacting more strongly when the debt ratio exceeds a given threshold, but then the responsiveness eventually begins to weaken, and then actually decreases at very high public debt levels. Burger (2012) extended the model and calculated stable public debt positions based on the premise that a sustainable public debt policy is the one which stabilizes public debt at whatever level. Recent studies have also illustrated the existence of fiscal fatigue, whereby the government's ability to increase primary balances cannot keep pace with

rising public debt. As a result, the government faces an endogenous public debt limit beyond which public debt cannot be rolled over (Ghosh et al., 2013).

Bohn (2008) approach applied the inter-temporal budget constraint for government debt and a behavioral equation for the government's primary balance to analyze the behaviour of public debt. Bohn's approach equates fiscal sustainability with the stationarity of the public debt-to-GDP ratio and suggests that when the public debt-to-GDP ratio is stationary over time without a trend, one can consider public debt to be sustainable. The starting point of Bohn's analysis is, therefore, the inter-temporal budget constraint, which states that debt is a function of past debt and interest payments on previous debt outstanding. This is algebraically illustrated as follows:

$$D_t = (1 + i_t)D_{t-1} - PB_t + SF_t \quad (1)$$

Where D_t is the outstanding debt at time t , PB_t is the primary balance at time t , i_t is the nominal interest rate at time t , and SF_t is the stock-flow adjustment that ensures consistency between net indebtedness and variation in the observed public debt stock. The stock-flow adjustment includes a number of variables, such as the recognition of contingent liabilities, extra budgetary expenditures and other statistical discrepancies. Dividing equation 1 by nominal GDP gives the following:

$$\frac{D_t}{P_t Y_t} = \frac{(1+i_t)}{(1+\pi_t)(1+g_t)} * \frac{D_{t-1}}{P_{t-1} Y_{t-1}} - \frac{PB_t}{P_t Y_t} + \frac{SF}{P_t Y_t} \quad (2)$$

Where the nominal GDP is algebraically defined as: $P_t Y_t = (1 + \pi_t)(1 + r_t)P_{t-1} Y_{t-1}$, where Y_t is the nominal GDP at time t , P_t is the GDP deflator at time t , π_t is the inflation rate at time t , r_t is the real interest rate at time t and g_t is the real growth rate of the economy at time t . Assuming that $\pi_t = 0$ the equation can translate to:

$$d_t = \frac{(1+i_t)}{(1+\pi_t)(1+g_t)} d_{t-1} - pb_t = d_t = \frac{(1+r_t)}{(1+g_t)} d_{t-1} - pb_t \quad (3)$$

Where, the nominal interest rate is given by $i_t = (1 + r_t)(1 + \pi_t) - 1$. Defining equation 3 in lower cases results in the following equation:

$$d_t = \phi_t d_{t-1} - pb_t \quad (4)$$

Where $\phi_t = \frac{(1+i_t)}{(1+\pi_t)(1+g_t)} = \frac{(1+r_t)}{(1+g_t)}$, $d_t = \frac{D_t}{P_t Y_t}$ and $pb_t = \frac{PB_t}{P_t Y_t}$

The parameter in equation 4 is known as the automatic debt dynamics, and it can result in the accumulation of public debt without the government contracting any new debt. As shown in the equation, changes to automatic public debt dynamics are explained by the real interest rate and growth rate of the economy. The other determinants of the change in the public debt ratio as shown in equation 2 are the primary balance and the stock

flow adjustment, which is a residual. The primary balance is controlled by fiscal policy makers, while interest rates largely depend on actions of monetary authorities. The growth rate enters into this equation because a higher growth rate tends to reduce the public debt ratio, by raising the denominator of the public debt to GDP ratio.

The key reason for analyzing the public debt dynamics is to determine whether public debt is stable or explosive. Accordingly, from equation 4 it can be deduced that the ratio of the debt to GDP converges to a predetermined optimal level, or however, the public debt portfolio would explode from the predetermined optimal path. This condition has increasingly become known as the Aaron condition (Aaron, 1996). This implies that if the interest rate being paid on debt is greater than the growth rate of the economy, the interest burden on existing debt increases, while the debt to GDP ratio also increases. Subtracting from both sides of equation 3 results in the following equation:

$$\Delta d_t = (r_t - g_t)d_{t-1} - pb_t \quad (5)$$

Equation 5 shows that changes in the public debt ratio can be decomposed into three factors and their underlying processes that determine the evolution of public debt-to-GDP ratio. Equation 5 shows that for public debt to remain stable, the primary balance needs to at least cover the interest payments due. However, if past debts are very large or if interest rates are very high, the government would either be required to raise the primary balance or the public debt will increase every year in a snowballing effect because the portion of the payments that cannot be covered by the primary balance will be covered by issuing new loans, thereby increasing the debt stock.

The second part of Bohn's methodology involves estimating the fiscal reaction function, which indicates whether the government increases its primary balance in response to changes in the public debt-to-GDP ratio. Bohn's assumption is based on the fact that government budget is subject to changing circumstances and that governments usually react to increases in public debt instead of passively waiting to see their public debt evolving without putting some effort to control the debt level. This action is reflected in the policy response function, which has increasingly come to be known as the fiscal reaction function. A positive fiscal response means that the government takes action to reduce the deficit (or increase the surplus) when the public debt ratio rises. The fiscal reaction according to Bohn is specified as follows:

$$pb_t = \alpha + \rho d_{t-1} + z_t + \varepsilon_t \quad (6)$$

Where ρ is the fiscal reaction parameter and measures the response of the primary balance to the lagged public debt ratio, α is the constant variable, z_t is a set of other determinants of the primary balance and ε_t is an i.i.d. error term shock to the primary balance. This specification

shows how governments react to public debt accumulation given the structure of macroeconomic shocks facing the economy. Substituting equation (6) into (5) and assuming that the non-fiscal determinants are zero result in the following equation.

$$\Delta d_t = (r_t - g_t - \rho)d_{t-1} - \alpha \quad (7)$$

Equation (7) summarizes the determinants of public debt dynamics for the government, with the crucial factor being the sign of the term in front of the lagged public debt variable. If, implying that the interest rate exceeds the sum of the growth rate and the fiscal response coefficient, then public debt is intrinsically unstable. A rise in the public debt level leads to a further acceleration of the growth of public debt, which means that debt is on a potentially explosive path. However, if, implying that the interest rate does not exceed the sum of the growth rate and the fiscal response coefficient, then the time path of debt is intrinsically stable.

The condition for stability is referred to as the modified version of the Aaron condition, which is usually stated as the condition that the growth rate should exceed the interest rate, for government to have a sustainable public debt path. According to the modified Aaron condition, higher interest rates increase the growth of debt levels, whereas higher growth rates and a stronger responsiveness of the budgetary policy to debt tend to reduce debt growth.

Following Bohn's literature, several authors have investigated the potential relationship between the primary balance and the public debt ratio. For instance, Hamilton and Flavin (1986) analyzed the budget inter-temporal relation and No Ponzi game condition. This approach has been criticized by Bohn (2008) who proposed a sustainability test based on whether the primary balance to GDP ratio is a positive linear function of the debt to GDP ratio. Roubini (2001) showed that a stable debt to GDP in the medium to long term is considered as sustainable regardless of its level. According to him a debt to GDP ratio of 150% is as sustainable as a debt to GDP ratio of 50%. Ghosh et al. (2013) affirm that the sustainability indicator introduced by Bohn is too weak, and advocated for a new framework for assessing debt sustainability in the advanced economies by determining a debt limit beyond which fiscal solvency is in doubt. There is also a general empirical premise that governments usually behave responsibly, increasing primary surpluses in response to rising debt service so as to stabilize the public debt-to-GDP ratio at a reasonable level. This empirical finding is consistent with the findings of Bohn (2008) for the US, and Mendoza and Ostry (2008) for subsets of industrial and emerging economies. Despite the existence of this vast theoretical and empirical literature on public debt sustainability, literature is far from being settled. There is no consensus on the optimal (stable) debt limit and corresponding fiscal space, which provide early warning guide to exploding public debt levels. This paper,

thus applies the dynamic stochastic framework to simulate the public debt path for Zimbabwe given the nature of shocks facing the economy and its fiscal stance. This is particularly important to avoid the previous costly mistakes of accumulating public debt to unsustainable levels.

RESEARCH METHODOLOGY

The paper applies the methodological approach of Bohn (1998, 2008) to analyze Zimbabwe's debt sustainability using historical information. The methodology also draws from the method proposed by Celasun et al. (2006) which simulates interest rates and growth rates, taking account of the uncertain nature of these variables. The method combines the simulated interest rates and growth rates with the estimated fiscal response in order to determine the evolution in the public debt to GDP ratio. The analysis yields a distribution of possible time paths for future public debt to GDP ratios. This distribution can be characterized by the median for the public debt to GDP ratio and the confidence interval around this value.

First, the methodology consists of estimating the fiscal reaction function in line with Bohn's specification. Accordingly, the primary fiscal balance, which is considered the key operational target of the fiscal authorities, was estimated as follows:

$$pb_t = \alpha_0 + \rho d_{t-1} + \gamma ygap_t + X_t \beta + \varepsilon_t \quad (8)$$

where pb_t is the primary balance at time t , α_t is the intercept d_{t-1} is the public debt level at the end of the previous period, $ygap_t$ is the output gap, ε_t is an error term, and $X_t \beta$ is a vector of macroeconomic variables explaining changes in the primary balance unrelated to the solvency requirement.

With respect to the expected coefficients from the fiscal reaction function, a zero or negative coefficient of debt to GDP indicates that governments fail to respond effectively, or even have a perverse reaction of increasing the deficit when debt increases. This is referred to as fiscal fatigue by Ghosh et al. (2013). The specification includes a range of other explanatory variables suggested by Celasun et al. (2006), Mendoza and Ostry (2008), Burger et al. (2011) and Ghosh et al. (2013). These variables are the output gap to control cyclical fluctuations, and political and institutional variables. The output gap for Zimbabwe was computed using the Hodrick Prescott Filter (Hodrick, 1996) and the output gap results are depicted in Figure 4

The graph shows a negative output gap over the period 1999-2008, reflective of the downturn in economic performance during this period. During this period, the debt level was also on an increasing trajectory. The model specification is, however, not intended at predicting the fiscal behaviour but instead serve as a reference for simulating the public debt path for Zimbabwe in the medium to long term. It addresses the question of what would be the predicted public debt path if government balance were debt stabilizing and interest rates and output exhibit similar historical behaviour.

Estimation technique

The paper applies the method of ordinary least squares (OLS) to undertake the joint estimation of the primary fiscal reaction function and regression equations of other variables such as interest rates and economic growth that enter the law of motion of public debt dynamics. However, estimation of the fiscal reaction function raises some econometric issues stemming from the dependence of primary balance on past values of the debt to GDP ratio. A country able to generate higher primary balances on average would also tend to

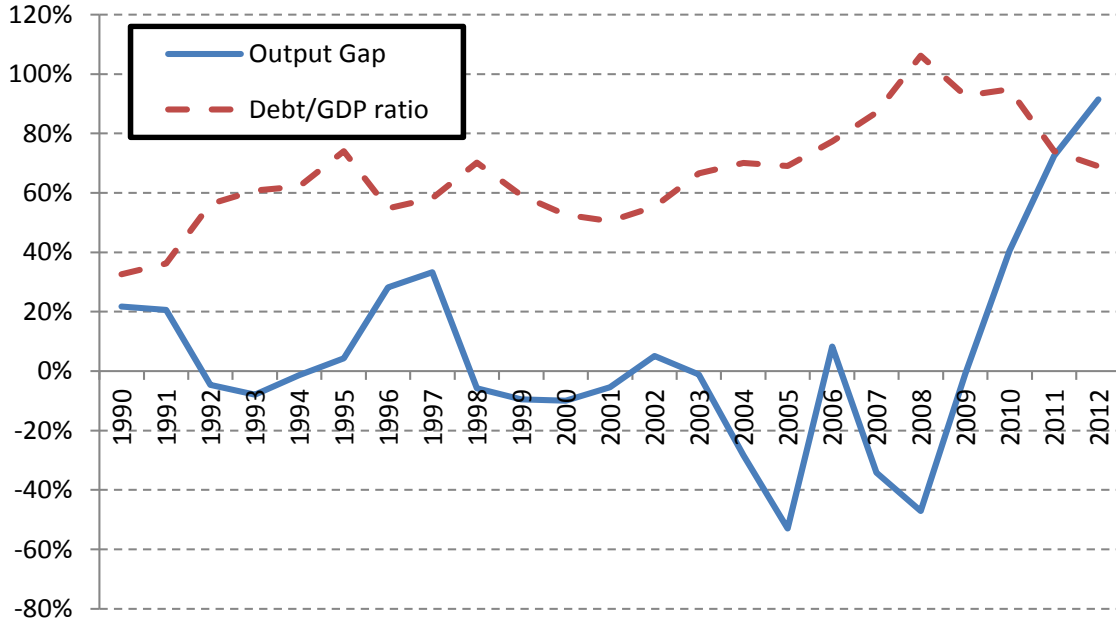


Figure 4. Trend in Public Debt to GDP and Output Gap for Zimbabwe. Source Researchers Own Computations.

have lower levels of public debt. This negative association between debt and time invariant country specific features, if not properly accounted for, could generate a downward bias in the estimated response of primary balance to lagged debt. As such, the Hausman endogeneity test was applied to test for potential endogeneity between the primary balance and the output gap.

For robustness check, the model was also estimated using panel data for Low Income Countries (LICs), given the structural breaks that Zimbabwe went through, which may affect the credibility of the estimated parameters. The estimated coefficients from the fiscal reaction function were then used to project the public debt path for Zimbabwe given its macroeconomic outlook as specified in the IMF World Economic Outlook (WEO), and the country's macroeconomic Framework (IMF, 2012).

Stochastic Simulation approach

The stochastic simulation was done in three stages, namely, estimating the fiscal reaction function, projecting the primary balance, using the variance of the residuals from the estimated fiscal reaction function and a standard normal distribution to generate the public debt path. The estimated fiscal reaction function from equation (8) above will be as follows:

$$\widehat{pb}_t = \widehat{\alpha}_t + \widehat{\rho}d_{t-1} + \widehat{\beta}_t gap_t \quad (9)$$

The error term is computed from the estimated fiscal response function in equation (9) as follows:

$$\varepsilon_t = pb_t - \widehat{\alpha}_t - \widehat{\rho} * d_{t-1} - \widehat{\beta}_t gap_t \quad (10)$$

The error term is then specified as follows:

$$\varepsilon_t = \varnothing \varepsilon_{t-1} + \mu_t \quad (11)$$

Where $\mu_t \sim N(0, \sqrt{(1 - \varnothing^2) * \sigma_\varepsilon})$ and σ_ε is the estimated standard

error of the regression. The effective interest on public debt was computed as a weighted average of domestic and foreign rates and exchange-rate movements as follows:

$$r_t = i_t^d d_{t-1}^d + i_t^f d_{t-1}^f \quad (12)$$

The weights of public debt denominated in foreign currency and domestic debt followed the historical pattern and varied to reflect the government's thrust to develop the domestic debt market in the medium to long-term. Projections of the underlying public debt dynamics are obtained through a fiscal reaction function and growth forecasts obtained from Zimbabwe's macroeconomic policy framework (IMF, 2012).

Baseline public debt to GDP simulation

The estimated fiscal response function was used to simulate the public debt path together with assumed growth rate of the economy and simulated interest rate structure from the macroeconomic framework. However, to account for the considerable share of public debt denominated in foreign currency, the simulation of the baseline public debt to GDP ratio was conducted using the debt dynamics equation illustrated below:

$$d_t = \left[\frac{(1+i_t^f)(1+\Delta\varepsilon_t)d_{t-1}^f + (1+i_t^d)d_{t-1}^d}{(1+\pi_t)(1+g_t)} \right] - pb_t \quad (13)$$

Where ε_t is the exchange rate. In the Zimbabwean case $\Delta\varepsilon_t$ is zero

since the country is dollarised and does not have an exchange rate of its own. Equation (13) can be summarized as:

$$d_t = \varnothing d_{t-1} - pb_t \quad (14)$$

$$\text{Where } \emptyset = \left[\frac{(1+i_t^f)d_{t-1}^f + (1+i_t^d)d_{t-1}^d}{(1+\pi_t)(1+g_t)} \right]$$

Replacing the primary balance with the estimated primary balance reaction function in equation (9) results in the following simulated public debt position:

$$d_t = \emptyset d_{t-1} - (\hat{\alpha}_t + \hat{\rho}d_{t-1} + \hat{\beta}_t \text{gap}_t) \quad (15)$$

This translates to the following equation after collecting the like tiers.

$$d_t = (\emptyset - \hat{\rho})d_{t-1} - (\hat{\alpha}_t + \hat{\beta}_t \text{gap}_t) \quad (16)$$

Equation (16) implies that the future public debt path is determined by automatic debt dynamics and the estimated fiscal response parameter and non-fiscal determinants of public debt policy which in this case is the output gap. The simulations are conducted under various scenarios on growth rate given the simulated interest rate path and the estimated fiscal policy response. As previously stated the simulated public debt path can only be sustainable if the modified Aaron condition is satisfied, implying that the effective interest rates on public debt do not exceed the sum of growth rate and the fiscal response on average. This implies that the public debt ratio will revert to an equilibrium steady state after a macroeconomic shock.

Bounds on the public debt limit

In order to derive the range of the sustainable public debt path, the upper and lower bounds of public debt dynamics were also established. These bounds provide an insight into the range within which the optimal public debt target would lie. As such, in line with the approach taken by Ghosh et al. (2013), the upper bound was computed as the largest root of the following equation:

$$\alpha + \rho(\bar{d}_2) + \bar{\varepsilon} = (r^* - g_t)\bar{d}_2 \quad (17)$$

The left-hand-side of equation 17 shows the best primary surplus that the government can achieve at a debt ratio under the best realization of macroeconomic shocks. The right-hand-side shows the lowest effective interest payment required by government to reduce or mitigate the risk of default. As public debt increases beyond, the primary surplus would increase at a slower rate. As a result, if the debt ratio exceeds, the primary balance would not suffice even under the best of circumstances to cover the interest payment, and debt dynamics would become explosive, thus, violating the modified Aaron condition and triggering default. Similarly, the lower bound was obtained as the largest root of the following equation:

$$\alpha + \rho(\bar{d}_1) - \bar{\varepsilon} = (r^* - g_t)\bar{d}_1 \quad (18)$$

The left side of equation 18 shows the smallest primary surplus required to cover the effective interest payment to ensure sustainability. In this case, since debt is non-increasing for all possible realizations of macroeconomic shocks, and there is no risk of default, the lower limit thus corresponds to the so called natural debt limit, defined in the macroeconomic literature on savings under incomplete markets as the largest debt that the government could take if it wants to ensure that it will never default in the next period or at any point in the future, even if the primary balance remains at its worst realization forever.

RESULTS AND ANALYSIS

This section provides the results of the fiscal reaction

function together with the simulated public debt to GDP ratio for Zimbabwe in the medium term. The results are then used to estimate the probability that public debt will exceed the desired target of 60% in the medium to long term. The analysis also facilitates the determination of the upper and lower limit of the public debt level, which are critical in establishing the natural public debt limit and the point at which public debt becomes highly unsustainable.

Estimated fiscal response

The results from the estimated fiscal reaction function are shown in Table 1. The regression only considered the fiscal determinants of public debt and omitted other variables that may affect fiscal policy such as institutional factors. These factors were omitted to avoid determining their out of sample trajectories required to simulate public debt paths until 2020. All the variables were integrated of order 1 and the signs of the main explanatory variables are as expected.

A strong response of the primary increases in public debt implies that the mean reversion of public debt is always sustainable. On the other hand, a weak response implies a public debt limit which explosive paths occur beyond a certain threshold, implying that public debt is unsustainable. A sufficiently strong response of the primary balance is essential to guarantee sustainability, whereas a weak response, although technically sufficient for solvency, cannot rule out explosive public debt paths.

The Hausman endogeneity test accepts the null hypothesis of weak instruments and as a result the OLS methodology was applied to estimate the fiscal reaction function for Zimbabwe. For the panel data for low income countries, the Hausman Specification test was used to select between the fixed effects and random effects model. The test chose the random effects as a perfect fit. As a result, the results of a random effects model which can jointly capture cross-country and within country determinants of primary balance was used.

The results in Table 1 show that the primary balances respond positively to increase in the public debt to GDP ratio, suggesting that the inter-temporal budget constraint exists. The output gap has a negative sign indicating that the primary balance response negatively to increases in the output gap. A positive response of the primary balance to lagged debt can be expected if buoyant public debt dynamics are corrected and a positive response to output gap imply that favourable economic developments would improve the budgetary position of a country via boom-induced revenue windfalls. This would indicate that the government follows counter-cyclical fiscal response. On the contrary, a negative coefficient would indicate a pro-cyclical fiscal policy, and an insignificant coefficient of output gap a cyclical fiscal response. The results show that if the primary balance-to-GDP ratio improves by 1% of GDP in year t , the primary balance would improve by 0.7% of GDP in year $t+1$. The negative and insignificant

Table 1. Primary balance reaction function.

	ZIM Model 1	LIC Panel: Model 2
Constant	-0.08*** (-0.00)	-0.04*** (0.01)
Lagged Debt/GDP Ratio	0.07*** (0.01)	0.06*** (0.01)
Output Gap	-0.08* (0.07)	-0.02** (0.05)
Diagnostic Test		
Adjusted R-Squared	0.41	0.48
Durbin-Watson Stat	1.62	2.37
Hausman Test	Prob<chi2=0.74	

Source: Researchers' Own Computations. Note: ***, significance at 1%, **, significance at 5%, *, significance at 10% and figures in parenthesis are p-values.

coefficient of the contemporaneous output gap indicates that the primary budget has a counter-cyclical effect in the year the business cycle position changes, probably due to a predominant impact of the built-in automatic stabilizers. The insignificant coefficient of the output gap in model 1 shows that Zimbabwe's fiscal policy stance has been cyclical during the past three decades, from 1980 to 2012. Nevertheless, the coefficient for the output gap for low income countries in LIC Panel Model 2 is negative and significant indicating pro-cyclical fiscal policy stance. This result is consistent with a large empirical literature that finds fiscal policy in low income countries to be pro-cyclical, in contrast to high-income countries where it is usually found to be countercyclical (Ilzetzki and Vegh, 2008). Burger et al. (2011) found a positive and statistically significant coefficient for South Africa indicating that the country follows a counter cyclical fiscal stance.

Implications of the estimated fiscal response for debt sustainability

Combining the information on interest rate and growth rate together with the estimated coefficients from the fiscal reaction function shows the following graph for testing Aaron condition (Figure 5).

A look at the evolution of interest rates and growth rates shows that Zimbabwe only satisfied the Aaron condition (< 0) from 2009 onwards, wherein the growth rates exceeded interest rates on average. This reflects the dominance of concessional external loans in the public debt portfolio, in the absence of significant domestic debt borrowing. Since the introduction of the multiple-currency system, Zimbabwe has not been able to borrow significant amounts from the domestic debt market due to attendant liquidity risk. During the crisis period, Zimbabwe experienced a significant

decline in real growth rates and a steady rise in real interest rates, on the external front, factors which resulted in explosion of public debt. The violation of the Aaron condition over the last 25 years, imply that solid fiscal responses was critical for government to ensure sustainable public debt. The introduction of the cash budgeting system by the Zimbabwean government in 2009 was, therefore, a positive response and partly helped in alleviating the public debt burden.

Simulated baseline of public debt dynamics

The stochastic simulations facilitated a derivation of a comprehensive indicator for assessment of a sustainable public debt policy. The simulations were undertaken by assessing the 'at risk' indicator, which measures the degree to which governments are in control of their public finances. The indicators were constructed as the median debt path in the simulation and the expected probable upper and lower bound for the debt level in the medium term. In the literature on stochastic public debt, the distribution of public debt is summarized using fan-charts (Medeiros, 2012). The fan chart provides a probabilistic view of the uncertainty around the baseline by showing a spectrum of possible outcomes. It also facilitates the computation of the stochastic properties of the data that incorporates the interaction between macroeconomic variables (Celasun et al., 2006). Accordingly, the results were summarized in a fan-chart type of analysis, which provided the frequency distribution of the calibrated public debt paths and served to illustrate the overall range of risks to the public debt dynamics. Fan-charts also provide a probabilistic view of the uncertainty around the baseline (IMF, 2013). The results are shown in Figure 6.

The results from the baseline stochastic simulation in

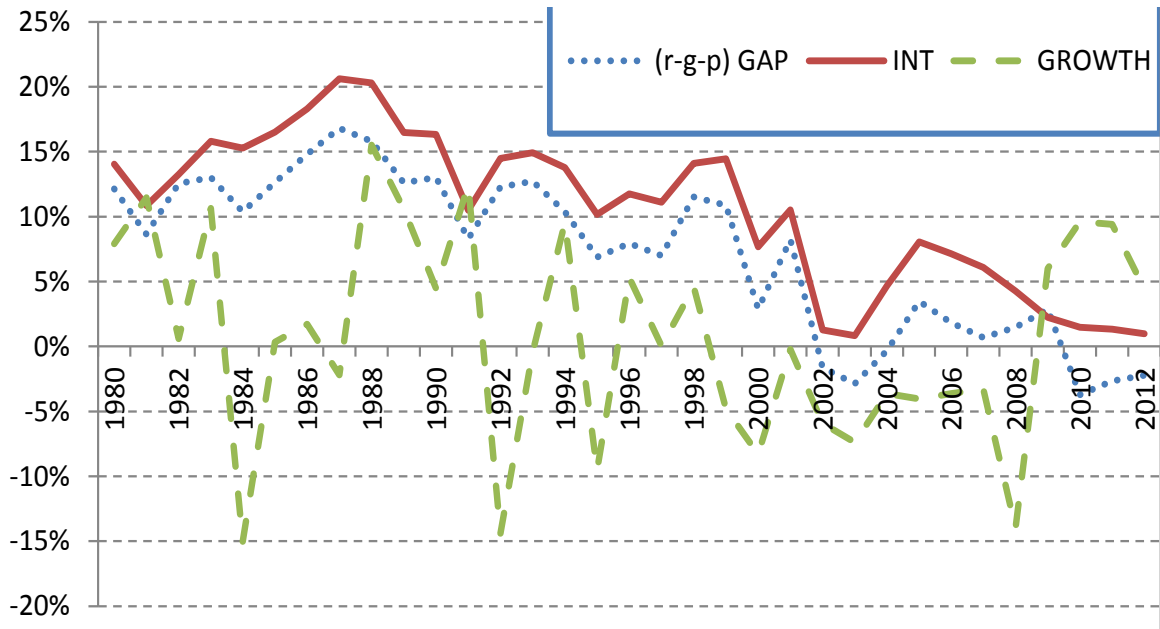


Figure 5. Graph historical movements in $(\phi - \rho^*)$ gap. Source Researchers' Own Computations.

Figure 6 show a general decline in public debt-to-GDP ratio for Zimbabwe in the medium to long-term. The results indicate that Zimbabwe's public debt would be slightly below the 60 per cent mark by 2020. The results, however, show a great deal of uncertainty in the projected debt-to-GDP ratio. The stochastic distribution shows the public debt-to-GDP ratio for Zimbabwe to be around 60 per cent for all the scenarios, with a lower bound of approximately 40 per cent of GDP. The lower bound can be regarded as the natural debt limit which is the debt level that the country can accommodate without fearing the risk of default, even under extreme macroeconomic shocks (Ghosh et al., 2013). Furthermore, the results show the 'at-risk' indicator of about 30 per cent of GDP. The at-risk indicator measures the deviation of the upward dispersion in the simulation. It is computed as the expected probable upper bound minus the expected debt level in the medium term projection. The median projections show that Zimbabwe's public debt would not get out of control until the end of the forecasting horizon. As a result, Zimbabwe's public debt can thus be regarded to be sustainable from an inter-temporal solvency condition over the period from 2013 to 2020.

Distribution of the simulated public debt-to-GDP ratio

The theoretical distributions shown in Figure 7 confirm that Zimbabwe's public debt follows a normal distribution. A skewed distribution would imply more risk to future debt sustainability. Hall (2013) shows that if the distribution of the simulated debt paths is properly defined in the

long-run, the debt-to-GDP ratio is stationary and follows a near unit root instead of a unit root process.

The distributions in Figure 7 capture interactions among the macroeconomic and fiscal variables being shocked, and informs about the plausible range of risks associated with the projected public debt paths. This in turn, prepares policy makers for a better-informed policy reaction should such risks materialize. The distributions are also informative of public debt sustainability. A narrower distribution indicates greater certainty on future debt dynamics and characterizes a country that is more in control of its finances. The distributions show that the debt level is skewed towards high debt ratios despite the shocks being normal. This implies that the snowball effect grows with the level of public debt. The distribution for the baseline scenario mean shows a slightly wider debt-to-GDP from as low as 40 to 160 per cent. The lower bound, however, shows a narrow distribution of up to 50 per cent. This implies that Zimbabwe would require a debt-to-GDP within this range to guarantee medium to long-term to ensure sustainability.

Robustness checks/ evaluating forecasting accuracy

The stochastic model's forecasting ability was also confirmed by the Q-Q plots shown in Figure 8 which confirms a normal distribution in the data.

The results from the normal Q-Q plots in Figure 8 strongly support the idea that the public debt distributions are normally distributed.

Overall, the results show that Zimbabwe public debt is

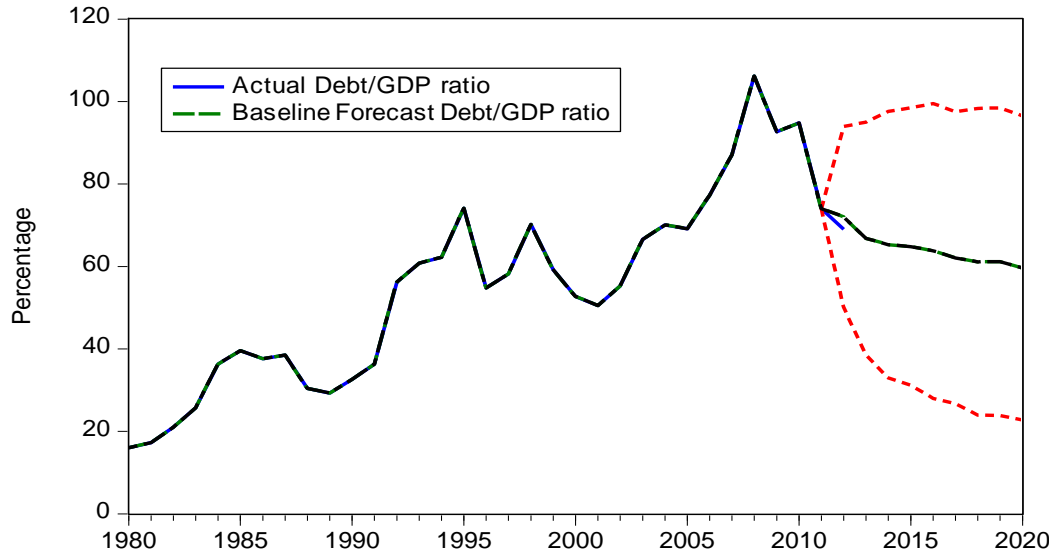


Figure 6. Stochastic Simulated Baseline public Debt Trajectory. Source: Researchers Own Computations.

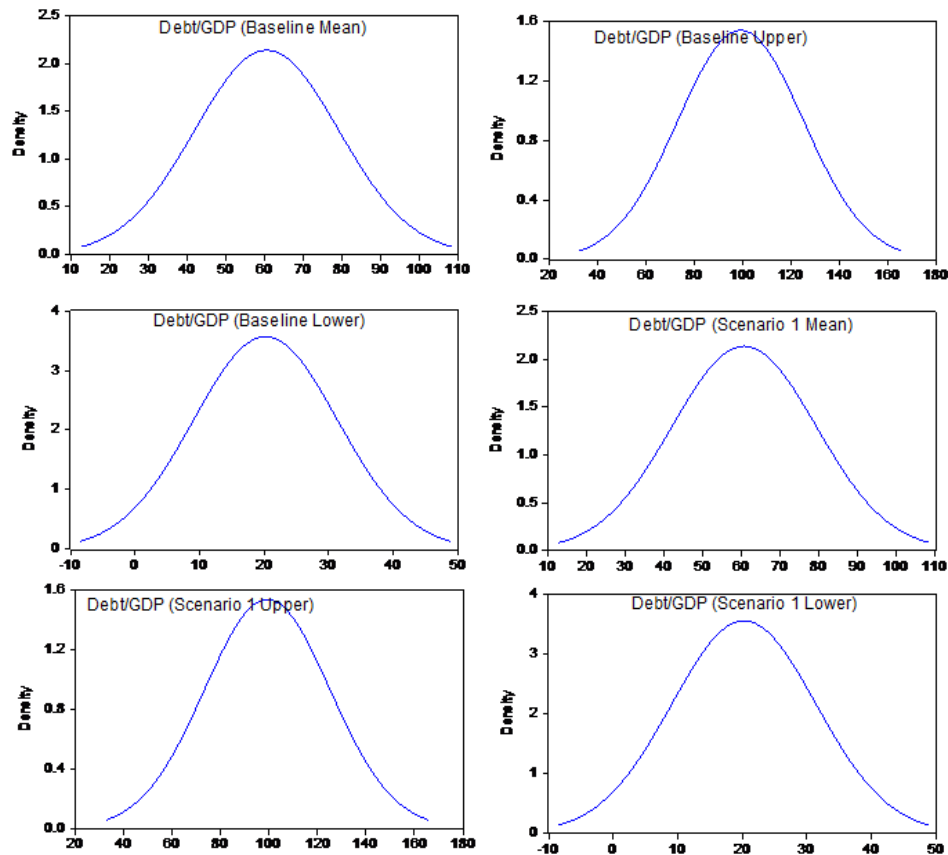


Figure 7. Distributions of the simulated public debt to GDP ratio path. Source: Researchers' own computations based on E-views.

sustainable from a solvency perspective and unsustainable from a liquidity perspective, given the

existence of external payment arrears in Zimbabwe's public debt stock. The country does not have resources to

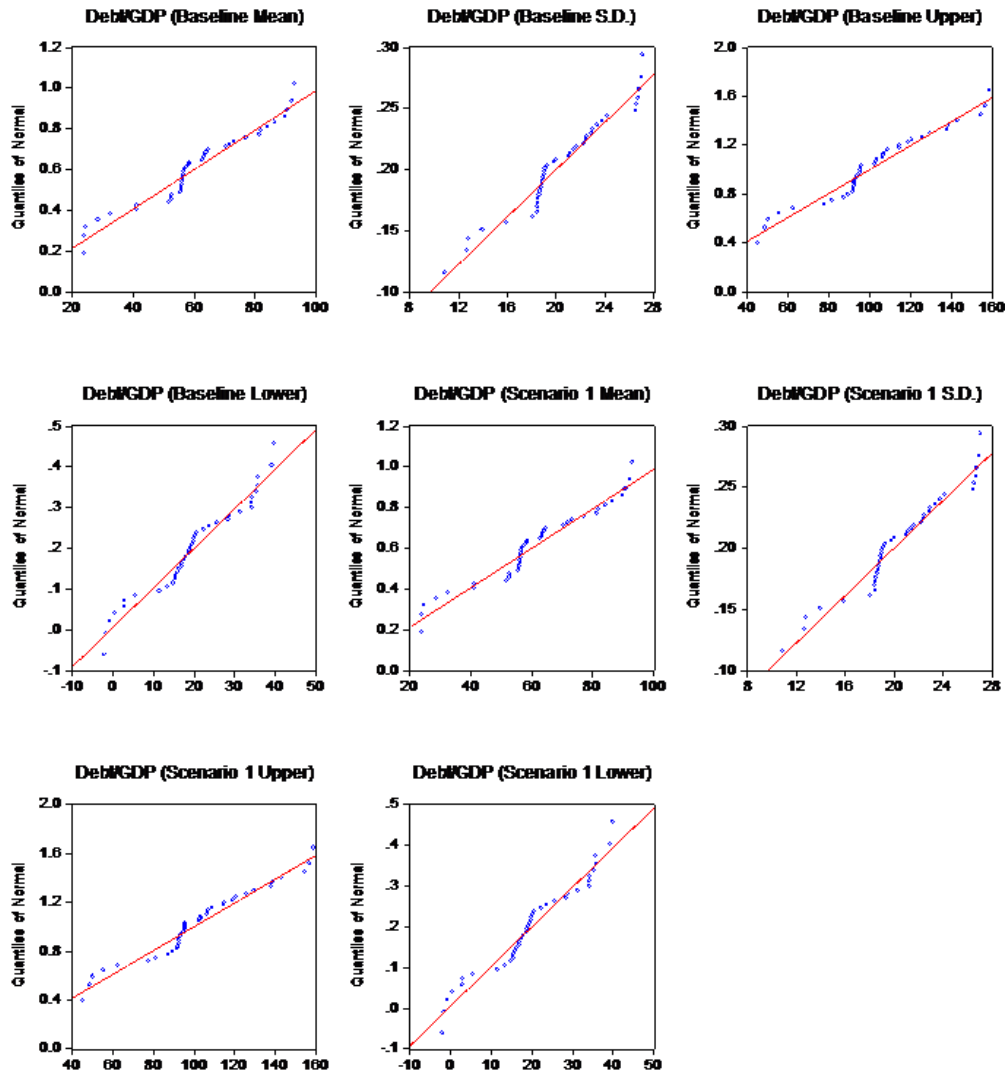


Figure 8. QQ Plots Baseline Scenario. Source: Researchers' Own Computations.

meets its maturing short term obligations which might require a debt resolution strategy. The simulations, however, suggest that Zimbabwe has the capacity to meet its obligations given the nature of shocks affecting the country, its fiscal stance and other macroeconomic fundamentals.

The results, therefore, underscore the need for prudent debt management to guard against the high risk of default as shown by large uncertainty within the projected public debt path. These results suggest that there is a higher chance that Zimbabwe would be able to reduce and maintain its public debt within sustainable limits in the medium to long term, given the macroeconomic shocks facing the economy and its current growth trajectory and fiscal stance.

From a policy perspective, the results from the stochastic simulation approach can be used to flag cases where fiscal consolidation may be urgently needed in

order to ensure that public debt remains on a sustainable path and that macroeconomic shocks do not derail public debt sustainability.

Conclusion

This paper applied the methodology of dynamic stochastic debt simulation to analyze the medium term public debt path for Zimbabwe. The paper followed the methodological approach of Bohn (2008) and distinguishes three channels that contribute to sustainable public debt. These channels are the economic growth, real interest rates and fiscal responses. The methodology combined the estimated fiscal response with a stochastic public debt simulation to project the median public debt path and the probability of public debt-to-GDP exceeding the desired SADC macroeconomic convergence threshold of 60 percent in

the medium to long-term.

Results from the fiscal reaction function show that Zimbabwe fiscal policy reacts positively to lagged public debt and negatively to the contemporaneous lagged output gap. The positive fiscal response to public debt suggests that the inter-temporal budget constraint exist and the negative response to output gap indicates that the fiscal policy stance has been pro-cyclical. The median public debt projections showed a declining path indicating that Zimbabwe's public debt would not get out of control until the end of the forecasting horizon and can, thus, be qualified to be sustainable over the medium to long term. The probabilistic sustainability indicator shows a moderate probability of 53 percent for a sustainable debt path in the medium term. Further the public debt simulations shows a lower bound distribution of between 20-50 percent which provide a reasonable range within which public debt sustainability would be guaranteed.

The stochastic simulation presented in this paper does not take into account liquidity or rollover risks or the possible realization of contingent liabilities. As such, the existence of arrears in Zimbabwe's public debt portfolio implies that the sustainability analysis presented in the paper mainly relates to government solvency which shows that the country has the capacity to service its public debt given its fiscal stance and the nature of shocks affecting it in the medium to long term. Nevertheless, exploring the implications of liquidity and rollover risk on the medium to long term debt sustainability presents possible avenues for future research.

From a policy perspective, the dynamic stochastic simulation provided in this paper can be used to flag cases where fiscal consolidation may be needed to ensure that public debt maintains a sustainable path. The implication from this analysis is the need for government to swiftly respond to increases in public debt to control the swings in public debt caused by macroeconomic shocks and to pursue counter-cyclical fiscal policies. Inappropriate response to increases in public debt in a timely and continuous fashion can quickly lead to a larger probability of the public debt paths getting out of control.

Disclaimer

The views expressed in this paper are those of the authors and do not necessarily coincide with those of the Reserve Bank of Zimbabwe or Nelson Mandela Metropolitan University, Port Elizabeth, South Africa.

Conflict of Interests

The author has not declared any conflict of interests.

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