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The Path Not Taken: Could State Contingent Debt Instruments Have Prevented Zambia's 2020 Debt Default?

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Abstract

This dissertation investigates whether State-Contingent Debt Instruments (SCDIs) could have prevented Zambia's 2020 sovereign default and reduced the adjustment costs from delayed debt restructuring. Using a calibrated dynamic general equilibrium (DGE) model of a small open economy calibrated to Zambia, the study compares the welfare outcomes of standard debt arrangements against SCDI alternatives under adverse climate shocks proxied by Total Factor Productivity (TFP) shocks. Results highlight the potential of SCDIs to preserve fiscal space, mitigate debt distress, and improve economic resilience in the face of external climate shocks.

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1. Introduction

Climate shocks are threatening Zambia's debt sustainability. Zambia is not unique in this regard. Small open economies, particularly climate-vulnerable, developing economies, are disproportionately affected by the ongoing climate crisis.[1] In a particularly recent era of rapidly declining foreign aid and reduced global liquidity, there is mounting pressure on the domestic budgets of these economies to close fiscal gaps and do so as climate risks grow. Climate shocks impose significant challenges for public finance to stabilise the economy and protect firms and households' consumption.

In traditional economic theory, debt is a tool used by agents to smooth consumption across time. For a government, this intertemporal 'trading' of consumption is achieved by borrowing from and lending to the rest of the world using debt and the current account of the balance of payments. In this way, the open economy can 'de-link' current consumption from current production which is going to be particularly important when production suffers an adverse shock. Crucially, consumption need not decline with it.

The issue is that conventional debt contracts are unattractive in the sense that they pass all debt service risk onto the debtor. This leads us to a broader public discussion: are there ways to provide borrowing countries with greater financing flexibility when subject to an adverse shock? An increasingly popular instrument being considered in the global financial architecture is state-contingent debt instruments (SCDIs), which are discussed more in Section 2. These instruments tie debt service payment obligations to the prevailing state of the world. In effect, the debt service burden falls during a 'bad' state, allowing for countercyclical policy space when a country is most likely to struggle to meet its obligatory spending, and rises again during a 'good' state.

This paper considers the use of SCDIs, using a counterfactual analysis, to investigate whether Zambia might have avoided sovereign debt default in 2020 had it had access to them during the 2019 drought. The model used throughout the analysis (an adaptation of Buffie et al., 2012) is designed to provide an integrated assessment of the welfare gains available under various government borrowing practices, while considering the downsides of conventional borrowing practices. It is to support debt sustainability analysis in the context of systematically incorporated TFP shocks. The justification for this line of enquiry is that as climate risks intensify in severity and frequency, their impact on output and the economy's productive capacity could translate into lower government revenue and/or the need for higher spending. It is also likely that climate change will affect the structure of economic systems in ways that are difficult to incorporate into standard debt sustainability analysis (DSA) scenarios.[2] Hence, for a climate-vulnerable, small open economy such as Zambia, it remains pertinent to explore how the design and availability of SCDIs might promote much-needed stabilisation and debt sustainability.

As of March 2025, 9 of the poorest countries in the world were considered to be in external 'debt distress' currently, 26 are at 'high risk' according to the IMF's (2015) DSA. This is defined by the International Monetary Fund (2025) as 'facing severe difficulties in servicing their debt obligations'. Many of these countries' external debt has been deemed unsustainable: they can no longer meet all their current and future financial obligations without recourse to exceptional financing, adjustment measures, and/or

[1] Center for Global Development, "The Socioeconomic Impact of Climate Change in Developing Countries in the Next Decades: A Review," Working Paper 681, 2024.

[2] European Central Bank, "The Climate Change Challenge and Fiscal Instruments and Policies in the EU," Occasional Paper 315, 2022.

default. The World Bank (2024a) reported that in 2023, developing countries spent an unprecedented $1.4 trillion on external debt servicing due to steep interest costs. In 2025, interest payments for 56 developing countries exceeded 10% of government revenue on, and for 17 countries, more than 20% of revenue.[3] Prior to default, high debt service payments constituted a large share of Zambia's statutory expenditure as it aimed to reduce its debt overhang. This eventually exceeded spending on critical public services.[4]

External sovereign debt, however, can be and remains a powerful instrument for economic policy. It allows governments to smooth intertemporal consumption by decoupling current expenditures from current revenues, thereby enabling countercyclical fiscal policy and long-term investment planning. By altering the feasible trajectory of public spending, debt issuance can enhance aggregate welfare when risks are appropriately shared between debtor and creditor. However, this relies critically on the expectation that debt will be serviced fully and punctually. The risk of debt distress arises when these expectations falter.

For many developing economies, debt distress arises more as a consequence of illiquidity than insolvency.[5] This is exacerbated by the so-called 'original sin' problem: much of their debt is denominated in foreign currencies, limiting the ability to respond via monetary expansion. Unlike advanced economies, they cannot simply print domestic currency to finance short-term gaps. The result is that debt crises in these contexts are frequently liquidity-driven, with implications for how creditors respond and how governments formulate appropriate policy responses.

The aim of this paper is thus to explore the economic outcomes of alternative debt structures on Zambia's debt sustainability compared to conventional borrowing practices by employing a counterfactual analysis. Following a brief review of where this paper fits in the literature, Section 3 provides context on the Zambian economy and its path to default. Section 4 lays out the modelling approach before Section 5 provides context for the policy simulations and Section 6 details specific scenarios. Discussion of the results and policy relevance are found in Section 7. The final section concludes. Details of the model and the baseline calibration, as well as the various policy simulations, are described in a set of appendices.

2. Related Literature

This paper builds on three primary strands of literature. First, it draws from the class of structural macroeconomic models used to analyse public investment, fiscal constraints, and debt sustainability in low-income countries (LICs). Buffie et al. (2012) present a dynamic general equilibrium (DGE) model tailored for fiscal policy analysis in small open economies with limited access to capital markets.[6] This framework was further refined by Adam et al. (2016) to address the specific institutional and economic constraints facing LICs, incorporating public capital accumulation, concessional and non-concessional borrowing, and fiscal adjustment mechanisms.[7] These models underpin the calibration and structure of the model used in this dissertation.

Second, the analysis contributes to the growing body of literature on SCDIs, which aim to improve external sovereign debt sustainability by linking debt service to the prevailing state of the world. Hatchondo et al. (2016) argue that SCDIs can reduce default probabilities by aligning payment obligations with the borrower's capacity to pay.[8] The IMF (2017) has provided practical proposals for sovereign SCDI design, highlighting instruments indexed to GDP, commodity prices, or disaster-related events.[9] The core premise is that such instruments provide automatic fiscal relief during economic downturns or exogenous shocks, facilitating countercyclical fiscal policy and reducing costs borne of delayed adjustment.

The case of Barbados provides early evidence of the feasibility and potential of SCDIs in practice. Following its 2018–2019 debt restructuring, Barbados included natural disaster clauses in most of its newly issued debt, both domestic and external. The IMF's analysis of these clauses highlighted that amortisation could be deferred for up to two years after a climate event, and triggers were tied to the Caribbean Catastrophe Risk Insurance Facility (CCRIF) payouts. Such arrangements created automatic liquidity support during periods of fiscal stress and demonstrate how SCDIs can be operationalised within the global financial architecture.[10]

SCDIs offer several benefits. They might preserve debt stock accounting by reprofiling rather than reducing principal, maintain investor confidence through pre-defined, rule-based mechanisms, and offer a form of climate justice by giving risk-sharing to countries disproportionately affected by exogenous climate shocks that they contributed minimally to. As argued in this paper, SCDIs can also reduce the likelihood and cost of sovereign default by mitigating the "debt overhang" effect—where expected future debt burdens discourage investment and consumption. This echoes early work on sovereign default incentives, including Cohen and Sachs (1985), who explore the dynamics of debt sustainability and risk premia for sovereign borrowing.[11]

Despite their promise, SCDIs face implementation challenges. First-mover moral hazard concerns by the creditor arise under the belief that debtor countries have reduced incentives to invest in resilience-building. Similarly, it is contended that the complexity of contract design, pricing, and the lack of established legal frameworks remain barriers to broader adoption. Nevertheless, proposals such as the G20 Common Framework for Debt Treatments highlight growing international interest in more flexible and adaptive debt instruments, particularly for climate-vulnerable countries like Zambia.

Finally, this research aligns with a third strand of literature that examines macro-fiscal risks from climate change. Recent studies such as UNEP and NIESR (2022) model the effects of climate-induced volatility—such as droughts, floods, and commodity price shocks—through sector-specific TFP shocks.[12]

This paper lies at the intersection of these three strands of research. By interacting climate vulnerability with sovereign debt dynamics, the following analysis contributes to the literature by conducting a structured assessment of adverse TFP shocks (as

[3] UNCTAD, "A World of Debt: A Growing Burden to Global Prosperity," 2024.

[4] Finance for Development Lab and ZIPAR, "The Road to Zambia's 2020 Sovereign Debt Default," 2023.

[5] O. Bjerkholt, "New Approaches to Debt Relief and Debt Sustainability in LDCs," CDP Background Paper No. 5, United Nations Department of Economic and Social Affairs, 2004.

[6] E. F. Buffie, A. Berg, C. Pattillo, R. Portillo, and L.-F. Zanna, "Public Investment, Growth, and Debt Sustainability: Putting Together the Pieces," *IMF Working Paper No. 12/144*, 2012.

[7] C. Adam, D. Bevan, and T. Ohlenburg, "Public Investment, Fiscal Rules, and Growth in Low-Income Countries," IGC Working Paper S-43302-UGA-1, 2016.

[8] J. C. Hatchondo, L. Martinez, and C. Sosa-Padilla, "Sovereign Defaults and Debt Sustainability: The Role of State-Contingent Debt," *IMF Economic Review* 64, no. 4 (2016): 641–664.

[9] International Monetary Fund, "State-Contingent Debt Instruments for Sovereigns," IMF Policy Paper PP/17/10, 2017.

[10] M. Anthony, G. Impavido, and B. van Selm, "Barbados' 2018–19 Sovereign Debt Restructuring—A Sea Change?" *IMF Working Paper WP/20/34*, 2020.

[11] D. Cohen and J. D. Sachs, "Growth and External Debt under Risk of Debt Repudiation," NBER Working Paper w1703, 1985.

[12] UNEP and NIESR, "Economic Impacts of Climate Change: Exploring Short-Term Climate-Related Shocks for Financial Actors with Macroeconomic Models," 2022.

proxies for climate shocks), under different debt arrangements.

3. Stylised Facts: Zambia's Debt Dynamics

Zambia's sovereign debt trajectory has been shaped by episodes of debt relief, rapid market re-entry, external shocks, and structural vulnerabilities. In 2005, Zambia received significant debt relief under the Highly Indebted Poor Countries Initiative (HIPC) and Multilateral Debt Relief Initiative (MDRI), launched by the IMF & World Bank, that reduced their debt stock by around $4.5 billion, from $6.9 billion to $2.3 billion.[13] These initiatives, as stated, aimed to 'bring poor countries' debt burden to a sustainable level', thereby eliminating "debt overhang" and reducing their external debt stocks. This engendered a significant improvement in Zambia's credit rating, stimulating five years of macroeconomic stability, fiscal discipline, and high GDP growth. In 2011, this strong macroeconomic performance prompted the World Bank to upgrade its classification of Zambia from a low-income country (LIC) to a lower-middle-income country (LMIC).[14]

Between 2010 and 2015, Zambia's new administration capitalised on favourable external conditions. It issued its first Eurobond in global capital markets in 2012—a 10-year note worth $750 million at a 5.65% coupon rate, with the intent to invest in public infrastructure.[15] This was quickly followed by further issuances: $1 billion in 2014 at 8.5%, and $1.25 billion in 2015 at 8.97%, bringing Zambia's Eurobond exposure to $3 billion within three years.[16] Investor appetite reflected optimism that Zambia's 8% growth trend since 2004 would continue. Zambia's 2014 return to the Eurobond market coincided with the slowing of the commodity 'supercycle',[17] and they faced a credit rating downgrade (B+ to B) and thus a higher coupon rate of 8.5% on their latest loan. Fiscal policy loosened, and increasing reliance on non-concessional debt from private creditors weakened the country's economic resilience.

Since 2015, Zambia's economic vulnerabilities have become more pronounced. The 2015 and 2019 El Niño-linked droughts severely affected the country's hydro-dependent electricity sector.[18] Daily power outages hindered industrial activity and triggered the government to increase energy imports and subsidies. As a result, GDP growth slowed to 3.4% in 2015, and inflationary pressures surged. A large portion of Zambia's external sovereign debt was US dollar-denominated. Hence, the depreciation of the Kwacha by 40% contributed 10 percentage points to the GDP to the debt stock.

By 2016, Zambia's economic outlook had deteriorated. Public debt doubled from 60.6% to 120% of GDP between 2016 and 2019, driven by a combination of sustained non-concessional borrowing, weak copper export revenues, and rising interest costs, which had risen to 6% of GDP by 2019. This reduced fiscal space hampered social spending: by 2019, Zambia was allocating 1/3 of GDP to obligatory debt service payments compared to 8.8% to essential public services like health and education.[19]

A joint IMF–World Bank Debt Sustainability Analysis (DSA) in 2019 formally assessed Zambia's external debt as unsustainable and Zambia's credit rating was downgraded to CCC, signalling high default risk. The debt burden had quadrupled since 2014, and Zambia began to fall into arrears. In 2020, it defaulted on a $42.5 million Eurobond coupon payment, becoming the first African country to default on commercial debt during the COVID-19 era.

Zambia's 2020 sovereign default triggered a prolonged and uncertain debt restructuring process under the G20 Common Framework (CF). President Hichilema, elected in 2021 on a mandate of fiscal prudence and growth, in 2022 began the process of debt restructuring with its creditors under the CF, supported by the IMF. Despite the urgency of relief, negotiations persisted for over three years, creating economic uncertainty and fiscal paralysis. According to the World Bank (2023), Zambia's external sovereign debt is increasingly fragmented: 49% is held by private creditors, 27% by China, 10% by the World Bank, 9% by other multilateral institutions, and 5% by other bilateral lenders. This diversification of creditor types, particularly of private and non-Paris Club actors, complicated restructuring efforts. These delays have imposed high adjustment costs: capital inflows have slowed, borrowing costs have risen, and pressure to implement fiscal consolidation has intensified. These challenges have coincided with climate volatility and weaker commodity prices, further straining Zambia's macroeconomic stability.

Zambia is currently in a post-default phase where it is continuing to negotiate and restructure its debt with creditors.

4. The Modelling Approach

The model employed in this paper is an adaptation of the frameworks originally developed by Buffie et al. (2012) and subsequently utilised by Adam, Bevan, and Ohlenburg (2016). Buffie et al. (2012) create a macroeconomic model to evaluate the impact of public investment surges in developing economies. Adam, Bevan, and Ohlenburg (2016) extend this framework to explicitly address public investment efficiency and macroeconomic management in low-income countries. The adaptation used herein maintains the essential structure:[20] it is a standard two-sector model comprising exportable and non-tradeable goods in a real, small open economy setting. Production within each sector depends on inputs of public capital, private capital, and labour, undertaken by competitive, price-taking firms. The model exhibits constant returns to private factors individually and increasing returns when considering all three inputs collectively. Additionally, it assumes steady, uniform trend growth in productivity across both sectors.

To model Zambia, it is extended to include a copper sector that is majority-owned by foreign investors, and employs domestic labour but remits profits net of royalty. It is assumed that all copper production is exported, and therefore, there is no domestic consumption. Instead, it is a major source of export revenues and hence foreign currency, and the government receives royalty payments. Public debt may be domestic, external concessional, or external non-concessional. Interest payable on the latter may include a risk premium that rises with the government's indebtedness. Some households have access to financial markets,

[13] IMF, "Zambia: Enhanced Initiative for Heavily Indebted Poor Countries—Completion Point Document," IMF Country Report 05/137, 2005.

[14] United Nations, "UN Common Country Analysis Update 2024: Zambia," 2024.

[15] M. Kessler, M. Mbewe, T. Humann, M. Kalikeka, I. Masilokwa, and S. Mwamba, "The Road to Zambia's 2020 Default," ZIPAR-FDL, 2023.

[16] C. Adam and A. Musonda, "Copper Mining in Zambia: From Collapse to Recovery," in *Plundered Nations? Successes and Failures in Natural Resource Extraction*, ed. P. Collier and A. J. Venables (Palgrave Macmillan, 2011), 89–114.

[17] A period, often more than 5 years, during which commodity prices trend above their long-term averages.

[18] F. Alfani, A. Arslan, N. McCarthy, R. Cavatassi, and N. Sitko, "Climate-Change Vulnerability in Rural Zambia: The Impact of an El Niño-Induced Shock on Income and Productivity," FAO Agricultural Development Economics Working Paper 19-02, 2019.

[19] Debt Justice, "Zambia Country Profile—Debt Data Portal," 2020.

[20] See Buffie et al. (2012) for a full set of model equations.

while others are credit-constrained and consume their current income. The former maximise an additive intertemporal utility function; for all households, instantaneous utility is a function of both consumption and leisure.

Instead of explicitly modelling an energy sector, climate-induced TFP shocks are differentiated across sectors to approximate the effect of climate-induced productivity declines. The copper sector faces severe TFP reductions due to its reliance on electricity (e.g., hydropower disruptions). Higher energy costs and supply chain disruptions affect the exportables sector indirectly. Finally, the tradable sector is least affected but still experiences spillovers. The copper sector is unique in the sense that it can be a source—or amplifier—of supply shocks. Mining production in Zambia is highly dependent on the reliable availability of electricity. The mining sector alone accounts for approximately 50% of national electricity consumption, and over 80% of Zambia's electricity generation comes from hydropower.[21] This makes the sector particularly vulnerable to climate-related disruptions such as droughts. This vulnerability was clearly demonstrated in 2015, when a severe El Niño-induced drought led to a 7% reduction in national power generation, contributing to a 17% fall in copper and cobalt output. While efforts have since been made to diversify the energy mix (including investments in solar), droughts continue to represent a risk to mining operations.

Concerning the output effects, climate change can affect both supply and demand. For the former, extreme weather events, the intensity and frequency of which are positively correlated with global warming, can reduce the endowments of some input factors (such as land) and destroy physical capital. Hours worked and labour productivity may also decrease in outdoor industries (such as construction) as a result of rising temperatures.[22]

The model enforces budget balance by design; therefore, sovereign default is defined operationally as a situation where the government faces either prohibitively high borrowing costs, a loss of market access, or the need to implement economically infeasible fiscal adjustments. This dynamic approach draws on the theoretical, two-period framework developed by Sachs and Cohen (1986), in which debt default risk arises under uncertainty in second-period income. The key condition governing repayment is the so-called no-default condition, shown in equation 1:

$$y_2 - (1+r)d_1 \geq y_2(1-\phi) \quad (1)$$

This stipulates that the borrower will repay if and only if consumption with repayment is at least as high as consumption under default, where ϕ represents the cost of defaulting. Default occurs when second-period income falls below a critical threshold: $y_2 \leq y_2^*$, where $y_2^* = \frac{(1+r_s)d_1}{\phi}$. Hence, the country defaults in 'bad times' and repays in 'good times'. The probability of default is given by:

$$\pi = \Pr(y_2 \leq y_2^*) = F\left(\frac{(1+r_s)d_1}{\phi}\right) \quad (2)$$

where $F(\cdot)$ denotes the cumulative distribution function of y_2 and is rising in the borrowing cost, r_s.

Rising interest rates, surging debt ratios, or unsustainable tax hikes capture these dynamics, which align with real-world episodes of sovereign distress as defined by the IMF. Within this framework, the role of SCDIs is assessed by their ability to mitigate these indicators of default risk and improve welfare outcomes relative to the baseline scenario of standard borrowing.

4.1. Scope of the model

Saving and investment are fundamentally inter-temporal concepts about shifting consumption and output through time. So, the correct way to analyse the current account is using dynamic (multi-period) models. The model is a real small open economy model, with three sectors: exportables, non-tradeables, and copper. Production in the first two sectors are a function of public and private capital and of labour, and is carried out by domestic firms that are competitive and price-taking. The majority (80%) of copper production is conducted by foreign private ownership of capital and land share so the sector uses minimal domestic factors. Public debt is disaggregated into domestic, external concessional, and external non-concessional. Interest costs payable on non-concessional debt may include a risk premium that rises with government indebtedness or following periods of debt restructuring to reflect a penalty on future borrowing. Households are characterised as 'Saving households' that have access to financial markets and are able to smooth consumption intertemporally, and 'Rationed households' that are credit constrained and consume income hand-to-mouth.

Taxes are levied on capital and labour incomes and on consumption, with rates adjusting dynamically to finance domestic debt and government spending. As a result, they serve as a proxy for fiscal burden on the population—if they rise under a given debt scenario, it signals fiscal strain or adjustment as the model attempts to plug the fiscal gap. Thus, comparing tax trajectories across different debt scenarios (e.g. standard borrowing vs. SCDI) gives a direct measure of the fiscal cost of each financing structure.

4.2. Limitations

The model is a calibrated policy simulation framework designed to explore the properties of alternative scenarios and so cannot be used for forecasting. It is not a monetary model, so it does not examine inflation or nominal exchange rate dynamics. It is a value-added model, meaning that it cannot examine intermediate input linkages, and it is an aggregated macroeconomic model, so it cannot be used to examine the sectoral composition of public investment. Valid concerns of issues such as tax leakage and congestion effects are assumed away in favour of the assumption of full efficiency of public spending. Though less tractable in reality, this is well-justified in order to isolate the effects of various debt arrangements in the presence of shocks. Apart from aggregate public investment, other public expenditure is not modelled other than as a transfer to private consumers.

Despite the model's ability to examine the effects of changes in the world price of copper on public finances, this paper chooses not to pursue this enquiry. Zambia is a small open economy and hence a price-taker in global commodity markets. This research is focused on welfare outcomes under different debt and financing structures during a negative TFP shock and isolates these changes. It is therefore less concerned with the impact of terms of trade shocks. Further study could explore welfare outcomes and economic gains in the instance of expected rises in international copper prices.

[21] International Energy Agency, "Zambia: Energy Mix," 2024.

[22] M. Dell, B. F. Jones, and B. A. Olken, "What Do We Learn from the Weather? The New Climate-Economy Literature," *Journal of Economic Literature* 52, no. 3 (2014): 740–798.

5. Calibration and the Context for Policy Simulations

To utilise this model for debt policy analysis and simulation necessitates calibrating the initial baseline solution and each policy simulation. The aim of the calibration is twofold: to ensure that the initial numerical solution of the model replicates the broad macroeconomic contours of contemporary Zambia, and to ensure that the values of key behavioural parameters and elasticities governing the model behaviour generate plausible responses to the simulated policy experiments. For the policy simulations, the paper seeks to characterise a suite of SCDI options that participating governments might plausibly consider in light of an exogenous climate shock to the lending government's economy. These are summarised in Table 1 below. The baseline calibration parameters are reported in Appendix A.

5.1. Baseline model calibration

The baseline scenario captures Zambia's macro-fiscal conditions during much of the 2000s, a period characterised by relatively prudent borrowing practices, limited exposure to commercial debt markets, and only mild exogenous shocks. It assumes a modest TFP shock and access to a concessional sovereign bond with a 20-year maturity, reflecting the long-term concessional financing Zambia primarily relied on before issuing Eurobonds.

The baseline calibration, described in Table 1, is calibrated to reflect how the Zambian economy in equilibrium at Period 0 handles a mild negative TFP shock beginning in Period 1 that serves as a proxy for an exogenous climate shock, namely drought in the case of Zambia. At the onset of the shock, domestic debt is 27% of GDP, while external concessional borrowing is 11% and non-concessional borrowing accounts for 33%. Revenue is raised principally from import taxes (which reflects the relative ease with which these are collected in small open economies as compared to labour income tax) as well as other taxes on expenditure such as excise and VAT/sales tax. Government expenditures are allocated between necessary public investment spending, transfers to households, and recurrent expenditures including debt service costs. The equilibrium state is reflected in tax smoothing and a modest (single-digit) current account surplus. The calibration sets the initial GDP to 100 and normalises all initial prices and wage vectors to 1. It also defines a set of parameters defining production. Moreover, whereas the private sector is assumed to optimise its consumption and production behaviour by construction in the model, the government is not an optimising agent. Instead, it is assumed to operate by making simple exogenous policy choices over borrowing, expenditure and taxation in the presence of adverse TFP shocks. This construction allows for positive analysis of alternative debt financing structures and fiscal management following climate-induced productivity shocks.

5.2. Debt structure simulations

The debt structure simulations outlined in Table 1 and analysed throughout this paper, share a common thread in which policymakers aim to plug the fiscal gap created by the productivity shocks, and output by issuing external debt. This is with exception to Scenario 3, which explores the fiscal response required when Zambia loses complete access to global external credit markets. Following the increase of external debt, authorities increase expenditure of public investment and transfers. Borrowing is undertaken in the present to fund public investment that is expected to yield greater returns than the initial cost of borrowing. Debt sustainability of this borrowing requires the country's external debt (inclusive of interest obligations) be no greater than the discounted present value of future trade surpluses. As a share of GDP, over continuous time, this is given by the fundamental equation of motion for the debt ratio in equation 3:

$$\dot{d}_t = (r - g)d_t - b_t \tag{3}$$

External debt over time, $\dot{d}_t$, is an increasing function of the interest costs of debt r, and the debt stock, d_t, and decreasing in growth and the trade balance.

5.2.1. SCDIs

For the purposes of this model, SCDIs have been designed/configured such that in the instance of an exogenous climate shock, a 'bad' state, the interest rate on non-concessional debt is automatically reprofiled and adjusted downwards towards the concessional interest rate. This aids debt sustainability by reducing r in equation 3. This rate is kept lowered for the duration of the shock but increases to a premium rate of 10% once the climate (TFP) shock has dissipated and the 'good' state returns.

Table 1. Summary of TFP Shock and Response Scenarios

No.	Name	Details
1	Pre-Eurobond	Baseline case before Zambia issued Eurobonds. Low external debt, mild TFP shock.
2	Standard borrowing	10-year non-concessional borrowing under a severe TFP shock. No SCDI or external support.
3	No external debt	Same as Scenario 2 but with no external borrowing allowed. All adjustment done through taxes and domestic debt.
4	SCDI full + premium	SCDI reduces interest rates during the shock, then rises to premium rate. Matches Scenario 2 in all other respects.
5	SCDI full, no premium	Same as Scenario 4 but no interest rate increase after the shock.
6	SCDI full + grant	Same as Scenario 4 but includes extra support from donors.
7	SCDI partial reprofiling	Same as Scenario 4 but interest rate falls by less. Tests whether partial relief is enough to avoid default.
8	High-risk borrowing	Short, large borrowing over 5 years. Tests outcomes when Zambia borrows aggressively and front-loads debt.
9	Consecutive shocks (10-year)	TFP shock occurs twice, using a 10-year bond structure. Tests resilience to repeated external shocks.
10	Consecutive shocks (20-year)	Same as Scenario 9, but with 20-year bond maturities. Tests whether longer debt helps smooth adjustment.

This reflects the novelty premia demanded on new instruments by creditors. The degree to which interest rates are cut will depend on the pre-arranged terms of the debt agreement. It is this pre-shock agreement that allows for automatic reprofiling and thus reduces the time and steep cost of adjustment for the economy.

5.2.2. Grants

The interest cost savings generated during each period of automatic debt re-profiling are treated as equivalent to implicit grants, credited directly to the fiscal balance. This effectively expands fiscal space, providing the government with crucial 'breathing room' to preserve essential public investment and transfers during economic strain. The model also incorporates explicit grants from multilateral institutions such as the IMF and World Bank, which reflect crisis support to Zambia during the 2024 drought.[23] In light of recent reductions in foreign aid budgets—including substantial cuts to programmes like USAID[24]—this interpretation of SCDIs as implicit, rule-based grant equivalents provides a policy-relevant lens through which to assess debt management strategies in developing countries like Zambia.

5.3. Severity of shocks

With the exception of the baseline, all other scenarios are treated with a 'severe' shock. Productivity in the copper, exportable and non-tradeable sectors fall at their lowest by 15%, 10% and 5%, respectively. In comparison, the baseline TFP shocks 10%, 7% and 3% to the three sectors are defined as 'mild'. The classification of the shocks considered reflect the ongoing intensification of climate events as global warming is projected to breach the 1.5-degree limit, beyond which both the frequency and severity of climate shocks will increase. The model attempts to capture this in the design of the scenarios and hence future-proof key results and insights. Drought is endemic to Zambia, partly due to below-average precipitation, particularly during the seasonal rains. The country has a long history of drought years: 1987/88, 1991/92, 1994/95, 1997/98, 2001/03, 2004/05, 2011/12, 2015/16, 2018/2019 and 2024, which was declared a state of disaster by President Hichilema (2024).[25] This sequence implies that the country experiences drought every 4 to 5 years, and the frequency is projected to increase in the future due to climate change.[26]

6. Debt Structure Scenarios, Climate Shocks, and Sensitivity Analysis

6.1. Introduction

The following exercise aims to investigate which debt structures, in the presence of climate-induced productivity shocks, best preserve fiscal space, minimise welfare losses, and ultimately promote long-term debt sustainability by helping Zambia avoid default. The intention is to explore how the design, specifically the magnitude of reprofiling, of SCDIs might protect this economy when triggered by adverse climate shocks. To assess how they might mitigate the uncertainties such shocks pose to medium and long-term external debt sustainability.

Default can be defined as, at its simplest, a broken promise, or a breach of contract. For sovereign debt, this might be a missed payment or a series of them. This is illustrated operationally in the model where sharp tax hikes, which serve as proxies for fiscal adjustment, are required to plug the fiscal gap. A feature of DGE models is that they enforce budget balance across the economy so sudden tax rate increases demonstrate the model struggling to finance the imbalance of default. In this framework, the use of SCDIs is assessed by their ability to mitigate these indicators of default risk.

6.2. The 10 simulations

Baseline Scenario 1: Pre-Eurobond Zambia

The baseline simulation is designed to reasonably reflect Zambia's economy in the years before it began much more aggressive borrowing practices by issuing 10-year Eurobonds. The TFP shock occurs immediately, reducing output disproportionately across the three sectors, as shown in Table 2. The exportable sector, which only recovers in period 7, does so particularly slowly due to the direct effects of the shock and diminished business confidence and investment necessary to recover output.

Table 2. Macroeconomic Indicators Over Time – Baseline

Indicator	t = 0	t = 5	t = 11	t = 20
Output (level rel. to initial)	100	98.06	102.93	102.52
Consumption (level rel. to initial)	100	100.40	101.24	97.16
Tax Rate	5	9.92	10.24	14.03
Debt Stock (% of GDP)	71	107.61	121.79	93.74

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

In order to support households and protect consumption, authorities introduce transfer payments equivalent to 5% GDP for the first 5 years of the shock when impacts are largest. Payments are then tapered down to 2.5% GDP for the next 5 years as the economy recovers and eventually phased out to their initial pre-shock level. This is helped financed by a 20-year sovereign bond that Zambia has already issued, with a straight-line amortisation rate of 10% at a constant interest rate of 8%. This can be interpreted as classic bilateral borrowing, reflective of Zambia's emerging access to global financial markets, non-urgent external borrowing, and continued reliance on concessional finance.

The government also undertakes what is assumed to be critical public investment across the economy (e.g. health, education), which is financed by a combination of domestic resources and concessional and non-concessional finance. The allocation of fiscal resources between public investment and direct transfers is influenced by several factors, including the government's pre-existing policy priorities, the political cycle[27] (particularly proximity to an election year), and the perceived nature of the shock[28]—whether it is temporary or permanent, or rooted in demand- versus supply-side pressures.

As the bond continues to be paid down and no additional borrowing is undertaken, required total tax revenue must increase to plug the fiscal gap since grants remain constant. The interest cost of non-concessional debt does not breach 5% of GDP, so crucially, this occurs smoothly with no sharp tax hikes. The economy returns to its pre-shock state in period 25 without defaulting.

[23] See World Bank (2024b).
[24] In January of 2025, USAID cut 85% of their programmes; see Si (2025).
[25] H. Hichilema, "Statement on the Drought Situation in Zambia," Republic of Zambia, Office of the President, 2024.
[26] European Commission, "Drought Resilience Profile: Zambia," 2021.
[27] See for example Alesina et al. (1997).
[28] See for example Blanchard and Leigh (2013).

Scenario 2: Severe drought with standard borrowing

This scenario illustrates the impact of an unpredictable, exogenous climate event to Zambia's path to default in 2020. Therefore, it serves as the effective point of comparison for subsequent analysis. The severity of the TFP shock increases from 'mild' to 'severe', causing copper production, which relies heavily on climate-vulnerable hydroelectric power, to plummet. Table 3 shows the initial fall in output and consumption. Production of exportables falls, pulling down GDP by around 10% of its initial value. Non-tradeable output rises in period 3 due to a brief real exchange rate appreciation (the price of non-tradeables increases relative to the price of exportables) and continues to rise until period 7 as labour moves out of the other two sectors.

Table 3. Macroeconomic Indicators Over Time – Scenario 2

Indicator	t = 0	t = 5	t = 11	t = 20
Output (level rel. to initial)	100	94.36	103.36	102.63
Consumption (level rel. to initial)	100	98.89	88.38	99.72
Tax Rate	5	9.31	19.84	16.04
Debt Stock (% of GDP)	71	115.5	127.94	60.87

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

Since the shock is correctly assumed to be temporary,[29] this prompts authorities to issue a more aggressive 10-year sovereign bond in an effort to stabilise the economy in the short run and fund increased transfers and critical public investment. Given the severity of the shock, it is reasonable to assume that the government would prioritise and allocate relatively more than in the previous scenario to transfer payments (6% then tapered to 3%). The amortisation rates of 10% for the first 9 years plus a 50% payment reflect Zambia's 'bullet'-style Eurobond borrowing terms explained in the previous section. The total debt stock rises between period 1 and 11 as depicted in Table 3.

To afford the principal payment in period 10, the required total tax revenue would need to more than double from 10 to 25% of non-copper GDP—a far too steep adjustment for an economy. Default can be said to occur at period 11 as interest costs of non-concessional debt rise quickly before the TFP shock has fully passed through causing Zambia to miss the payment, indicating the difficulty of making such a payment. Much of this adjustment would have come from increasing import taxes (tariffs) by more than the increase in taxes on non-tradeables and exportables. This is broadly reflective of the relative ease with which developing economies are able to raise revenues from tariffs as opposed to other formal taxes.

Scenario 3: No external debt

All of the assumptions of the severity of the TFP shock in the first scenario remain, except now the financing structure differs: Zambia, in this instance, does not issue any external debt. This scenario may be interpreted either as a 'no action' policy by the government or as Zambia losing some form of access to the global capital markets.

In response, the government must continue to make necessary public investments into key sectors such as healthcare and education, whilst protecting the most vulnerable households in the economy with transfer payments. Except, in the absence of external debt, significant domestic revenue mobilisation is

Table 4. Macroeconomic Indicators Over Time – Scenario 3

Indicator	t = 0	t = 5	t = 10	t = 20
Output (level rel. to initial)	100	94.26	102.30	102.97
Consumption (level rel. to initial)	100	92.72	98.95	102.44
Tax Rate	5	15.62	16.34	6.80
Debt Stock (% of GDP)	71	109.52	100.51	71.89

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

needed immediately in order to plug this fiscal gap. Table 4 reports that tax rates would need to increase threefold by period 5 when consumption and output are unrecovered, to raise the required revenue. Adjustment of this scale and severity places a tremendous burden on firms and households alike. So whilst Zambia incurs no external debt default on its books, welfare across the economy falls as discussed in greater detail in Section 7. This gives insights into the potential benefits of issuing debt, particularly during an exogenous shock.

Scenario 4: SCDI with full reprofiling

We now consider the hypothetical: a world in which Zambia can issue state-contingent debt instruments as earlier defined. The profile of the TFP shock and all other assumptions of Scenario 2 remain unchanged.

As before, external debt finances increased public investment and transfers, and artificially bolsters the economy until period 10, when the principal payment must be paid in full. Under the standard borrowing scenario, drastic and rather unfeasible tax hikes were needed to cover this payment, hence it could be concluded that default occurred in the following period 11.

However, in this scenario, the SCDI is triggered at the onset of the shock and instantaneously reduces the non-concessional interest rate from 9.5% to 2.5%. This rate is upheld until period 8 when production recovers to at least its initial values. These interest cost savings on the external debt are treated as an implicit grant in the fiscal budget, which gives the government sufficient fiscal space to make key investments and transfers, and meet its obligatory debt servicing payments. Once this grace period lapses, Zambia faces a premium on its future borrowing for 8 periods during the 'good' state of the world, signifying lender compensation.

Table 5. Macroeconomic Indicators Over Time – Scenario 4

Indicator	t = 0	t = 5	t = 11	t = 20
Output (level rel. to initial)	100	94.28	103.73	102.58
Consumption (level rel. to initial)	100	101.99	89.01	99.71
Tax Rate	5	7.10	17.68	15.68
Debt Stock (% of GDP)	71	108.05	121.24	58.96

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

Scenario 5: SCDI with full reprofiling, premium-free

A natural extension is to simulate an identical SCDI structure but without the imposition of a premium. In this case, the interest rate simply returns to its baseline level of 9.5% in period 8. Interestingly, the macroeconomic dynamics are very similar to those in Scenario 4 (Table 5), suggesting that the timing of debt service relief, rather than the exact cost of future borrowing, is the dominant driver of improved outcomes. This strengthens the

[29] If permanent, consumption adjusts downwards by the full amount of the shock, the current account is rebalanced to 0, and no smoothing occurs.

theoretical case that SCDIs operate primarily through liquidity channels.

Scenario 6: SCDI with full reprofiling and grant support

This scenario extends the full SCDI arrangement (Scenario 4) by introducing additional donor-financed crisis support. It simulates a stylised real-world response in which the climate-induced shock triggers not only an automatic market-based reprofiling via the SCDI mechanism, but also draws in multilateral (such as from the IMF or World Bank) or bilateral donor assistance.

The TFP shock remains unchanged, with productivity falling across all sectors. However, in response, Zambia receives an explicit external grant equivalent to 3% of GDP, injected directly into the current account. As a result, consumption is partially de-linked from output: it rises above baseline levels in period 5 despite the contraction in GDP. This reflects the combined effect of automatic payment relief (via the SCDI) and additional liquidity from the grant.

Tax rates remain moderate throughout—peaking below 15%—allowing the government to finance transfers and investment without resorting to sharp fiscal consolidation or defaulting. Notably, the debt trajectory is markedly improved: the debt-to-GDP ratio falls from 71% initially to just 52.7% by period 20. This outcome reflects both the automatic interest relief embedded in the SCDI and the external liquidity provided by the grant. Among all scenarios considered, this design yields the clearest evidence of improved debt sustainability in the aftermath of a climate-induced productivity shock.

Table 6. Macroeconomic Indicators Over Time – Scenario 6

Indicator	t = 0	t = 5	t = 11	t = 20
Output (level rel. to initial)	100	98.6	102.1	106.8
Consumption (level rel. to initial)	100	105.56	91.20	100.50
Tax Rate	5	4.19	14.3	12.88
Debt Stock (% of GDP)	71	98.31	111.63	52.73

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

Scenario 7: SCDI with partial reprofiling

To determine whether full reprofiling is a necessary condition for debt sustainability, this scenario simulates a partial cut in non-concessional rates from 9.5% to 4% (instead of 2.5%) during the shock. The movements in the economy track the same path; however, the government's response necessitates that total tax revenue required exceeds 20% since the implicit grant is diminished. This pushes authorities closer to the trade-off between incurring the cost of default versus enacting steep adjustment to meet repayment costs.

Table 7. Macroeconomic Indicators Over Time – Scenario 7

Indicator	t = 0	t = 5	t = 11	t = 20
Output (level rel. to initial)	100	94.33	103.57	102.61
Consumption (level rel. to initial)	100	100.64	88.49	99.64
Tax Rate	5	8.03	18.83	16.10
Debt Stock (% of GDP)	71	111.21	124.71	60.24

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

Scenario 8: High-risk borrowing

This scenario simulates a high-risk financing strategy wherein Zambia issues a short-term, 5-year commercial bond in the wake of a negative TFP shock. This aggressive borrowing approach is indicative of weak fiscal discipline or myopic policymaking. While government transfers initially shield consumption from the shock, the benefits are short-lived: by period 5, the debt stock has surged to 125% of GDP—up from 71% in Table 8—and the country must begin repaying principal under non-concessional terms.

Table 8. Macroeconomic Indicators Over Time – Scenario 8

Indicator	t = 0	t = 5	t = 11	t = 20
Output (level rel. to initial)	100	94.33	101.65	103.58
Consumption (level rel. to initial)	100	102.89	86.95	103.70
Tax Rate	5	1.05	34.15	8.53
Debt Stock (% of GDP)	71	125.01	118.98	33.80

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

The truncated borrowing period means that interest costs of debt spike to 9% of GDP well before the economy recovers from the shock. Critically, although consumption rises briefly in period 5, it plummets in period 11 due to an abrupt fiscal tightening. Required tax revenue jumps to 34.15%—a level that would be politically and economically unfeasible in a real-world context. Without access to external grants, Zambia defaults in period 6 when the amortisation schedule outpaces fiscal capacity. Despite a recovery in consumption and output by period 20, the cost of front-loaded debt service produces a sharp welfare penalty as discussed in Section 7, confirming the unsustainability of this high-risk strategy.

Scenario 9: Consecutive shocks with 10-year bond

This exercise simulates a world of increasingly frequent climate or TFP shocks in the model. The economy is hit immediately with the first severe shock putting downward pressure on output and consumption. Critically, before the economy can fully recover to its initial values, it is subject to another TFP shock of similar magnitude in period 10.

Authorities again issue a 10-year sovereign bond at the onset of the first shock. The overlap between repayment obligations and the second shock results in acute fiscal pressure. By period 11, consumption drops to 84.4—the lowest across all scenarios—and the debt stock reaches 137.1% of GDP. The government would be forced to raise taxes dramatically, from 5 to 20.7% over the first half of the horizon, with tax rates remaining high through period 20. Although output and consumption recover toward the end of the simulation, the short maturity amplifies adjustment costs in the interim. These results illustrate the dangers of "debt bunching," where principal repayments coincide with adverse economic conditions, triggering inefficient fiscal tightening and deep welfare losses.

Scenario 10: Consecutive shocks with 20-year bond

Finally, to test how sensitive outcomes are in a system of consecutive shocks to a given financing structure, a longer, 20-year bond maturity is considered. The extended repayment window delays the fiscal burden, allowing more space to absorb the shocks. Debt still rises sharply—to 131.7% of GDP by period 11—but tax rates increase more gradually, peaking at 21.6% only by period 20. Crucially, the consumption drop is smaller and

Table 9. Macroeconomic Indicators Over Time – Scenario 9

Indicator	t = 0	t = 5	t = 11	t = 20
Output (level rel. to initial)	100	94.64	97.84	105.19
Consumption (level rel. to initial)	100	98.99	84.38	99.94
Tax Rate	5	9.31	20.70	24.87
Debt Stock (% of GDP)	71	114.86	137.14	73.15

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

more contained, reaching a low of 91.1 before recovering to 97.5. These outcomes show that while long-term bonds cannot prevent debt accumulation under repeated shocks, they meaningfully reduce the pace and severity of fiscal adjustment. The simulation underscores the value of longer maturities in improving short-run resilience—not by averting default outright, but by softening its economic and welfare costs.

Table 10. Macroeconomic Indicators Over Time – Scenario 10

Indicator	t = 0	t = 5	t = 11	t = 20
Output (level rel. to initial)	100	94.63	97.29	104.62
Consumption (level rel. to initial)	100	98.20	91.07	97.51
Tax Rate	5	9.93	10.68	21.59
Debt Stock (% of GDP)	71	113.92	131.71	107.98

Note: $t = 0$ denotes the initial period before the shock. Tax rates reflect the average across exportables, non-tradeables, and imports.

7. Discussion

7.1. Summary of key findings

The scenario analysis above indicates that when severe shocks occur under an SCDI debt arrangement with full reprofiling plus an explicit grant, Zambia indeed averts default in the model. It is therefore argued that SCDIs could have preserved fiscal space and eased adjustment pressures in 2020. The only other instance that this is true is in the baseline scenario, when the TFP shock is mild and therefore borrowing is less aggressive. The key mechanism at work is that a generous SCDI offers immediate relief on debt interest payments when capacity in the economy is at its lowest as a result of an adverse climate shock. This implicit grant allows for smaller or slower tax rate increases relative to standard borrowing practices, where grants are assumed to be unchanging.

To assess the welfare consequences of alternative debt arrangements, this section evaluates outcomes across three lenses: intertemporal utility, consumption-equivalent variation (CEV), and two social welfare functions (SWF_1 and SWF_2). The analysis provides a comprehensive account of both average welfare improvements and distributional effects, offering a policy-relevant interpretation of how state-contingent debt instruments (SCDIs) compare to conventional borrowing structures. It is assumed that around a third of the population are saving households, s, who are able to allocate consumption across time through borrowing and saving and hence, smooth consumption over their lifetimes. Two-thirds of households are modelled as rationed, h, who consume hand-to-mouth. This distinction drives a wedge in their respective utility outcomes, U_s and U_h.

Table 11 reports welfare outcomes under each scenario. Scenario 2, standard borrowing, is treated as the effective baseline against which the outcomes of the counterfactuals are compared.

In the event of a shock, government transfers are non-discriminantly channelled to both sets of households. The consumption equivalent variation (CEV),

$$\text{CEV} = \frac{PV\ c_{\text{policy}}}{PV\ c_{\text{baseline}}} - 1 \tag{4}$$

is the present value (PV) of consumption under the specified policy, relative to the present value of consumption under the baseline, where PV is discounted at the subjective discount rate, β. CEV is expressed as percentage gains which offers an intuitive measure of policy desirability. It asks: "What is the equivalent amount of lifetime consumption that households would be willing to forgo to access a particular financing structure compared to the standard borrowing case?" Essentially, it is the willingness to pay in terms of consumption.

The SCDI arrangement with full reprofiling plus an explicit grant offers the highest welfare gains, with an aggregate CEV of 3.26%. This means that households would be willing to forgo more than 3% of the present value of their lifetime consumption to access this policy. Even in the absence of grants, SCDI Full, SCDI Full + Premium and SCDI Partial + Premium yield significant welfare improvements, suggesting that automatic re-profiling alone offers substantial insurance value. In contrast, high-risk borrowing and repeated shock scenarios result in negative CEVs.

Utility is defined as:

$$U_i = \sum_{t=0}^{\infty} \beta^t \frac{(c_t^i)^{1-1/\tau_i}}{1-1/\tau_i}, \quad i = s, h \tag{5}$$

where β is the subjective discount factor, c_t^i is consumption by household type i at time t, and τ_i governs the intertemporal elasticity of substitution.

Disaggregating by household type reveals the extent to which policy impacts are unevenly distributed. Column 4 of Table 11 shows that saving households exhibit modest variation in utility across scenarios compared to rationed households who experience pronounced changes and depend more heavily on transfers and public services. This is explained by the ability to borrow/save offering protection during an adverse shock since it de-links the fall in income from consumption. For rationed households, the SCDI with full reprofiling plus a grant improves their utility by 3.7% over standard borrowing. Conversely, the high-risk scenario is most damaging for credit-constrained households. This difference in utility indicates that rigid debt structures exacerbate vulnerability among credit-constrained groups, and that SCDIs offer both macroeconomic resilience and a pro-poor distributional tilt.

The social welfare functions (SWF) are the weighted aggregate of utility across both sets of households in the economy. The first welfare function, SWF_1, is defined as a utilitarian linear combination:

$$\text{SWF}_1 = \omega_s \cdot U_s + \omega_h \cdot U_h \tag{6}$$

where ω_i is the population weight of household type i. In this model, $\omega_s = \frac{1}{3}$ and $\omega_h = \frac{2}{3}$, reflecting a larger share of liquidity-constrained (rationed) households. This function aggregates household utilities using fixed population weights, thereby giving a population-weighted average welfare level. This makes it sensitive to total welfare but less sensitive to inequality than SWF_2 which introduces inequality aversion as follows:

Table 11. Welfare metrics under different debt arrangements and shocks. Utilities and SWFs are expressed as percentages of baseline saving utility = 0.

Debt Arrangement/Shock	CEV(%)	SWF_1 / SWF_2 (%)	U_s / U_h (%)
Standard borrowing	0.0	0 / 0	0 / 0
Pre-Eurobond	0.93	0.21 / 0.44	0.16 / 1.71
No Debt	−0.03	0.022 / 0.47	0.00 / 0.57
SCDI Full + premium	1.43	0.30 / 0.38	0.26 / 1.62
SCDI Full	1.57	0.34 / 0.5	0.29 / 1.83
SCDI Partial + premium	0.83	0.18 / 0.2	−0.16 / 0.96
SCDI Full + Grant	3.26	0.68 / 1.26	0.59 / 3.71
High-Risk	−0.25	−0.08 / −0.16	−0.06 / −0.55
Consecutive Shocks ($T = 10$)	−0.55	−0.19 / 0.3	−0.15 / −1.3
Consecutive Shocks ($T = 20$)	−0.09	−0.02 / 0.04	−0.04 / −0.4

$$SWF_2 = \left(\omega_s U_s^{1-\phi} + \omega_h U_h^{1-\phi}\right)^{\frac{1}{1-\phi}} \quad (7)$$

Here, ϕ is the Atkinson inequality aversion parameter. A higher ϕ implies that the social planner places greater weight on improving the utility of worse-off groups. This study sets $\phi = 2$, a commonly used benchmark in the development economics literature (e.g. Deaton, 1997) to reflect moderate to strong aversion to inequality.[30] $\phi = 2$ has become standard in applied welfare analysis involving poor and vulnerable populations. Table 11 reports that while both functions identify SCDI Full plus Grant as the socially optimal outcome, the parameterisation of ϕ in SWF_2 magnifies the welfare losses under regressive policies and the gains under equitable ones. For example, SWF_2 assigns a 1.26% improvement to SCDI Full plus Grant, compared to only 0.68% under SWF_1.

Inequality is penalised by assigning greater weight to utility gains accruing to poorer households (here, the rationed group), and discounts equivalent utility gains accruing to already better-off households (the savers). Crucially, SWF_2 reveals improvements in equity that SWF_1 understates and that the greatest social welfare gains under SCDIs come from increasing the welfare of those with the least flexibility under rigid, high-risk debt structures.

The choice between SWF_1 and SWF_2 reflects a trade-off between efficiency and equity, depending on the policymaker's objectives—for example, ϕ might be chosen if it is politically gainful to protect rationed households that comprise most of the economy and hence the voting base. An insightful extension of this welfare analysis would be to introduce overlapping generations (OLG), enabling welfare evaluation across both those who experience the shock and those who bear its long-run fiscal cost.

7.2. SCDIs: Political Feasibility and Implementation

The protracted and uncertain restructuring process under the G20 Common Framework (CF) has exposed critical weaknesses in the global sovereign debt resolution architecture—particularly its lack of timeliness, transparency, and predictability.[31] In contrast, state-contingent debt instruments (SCDIs) offer a rule-based alternative: pre-agreed clauses for temporary payment relief means that they can reduce the costs and uncertainty associated with conventional restructurings.

SCDIs also provide a structural solution to the classic external transfer problem. In cases where governments face external debt obligations but limited access to foreign currency, they may respond by taxing the export sector heavily to appropriate export earnings. This creates a distortionary disincentive for firms to produce for export, worsening balance-of-payments pressures and deepening economic contraction. SCDIs alleviate this by aligning repayment with capacity to pay and preserving incentives for export-oriented production.

From a policy reform standpoint, sovereign debt restructurings present a strategic window to introduce SCDIs at scale. Unlike new issuances, which face market resistance due to the "first-mover" disadvantage, restructurings allow retrofitting of these instruments across the entire renegotiated debt stock. With creditor consent, this can help resolve legacy contract fragmentation and enhance the consistency of debt treatment.[32]

Moreover, SCDIs represent a form of embedded climate justice. They acknowledge the disproportionate exposure of low-income countries to climate shocks—events they did not cause—and offer relief in those countries when fiscal space is most constrained. From the creditor's perspective, SCDIs reduce the likelihood of outright default by allowing payments to adjust in response to negative shocks, thus preserving long-term repayment capacity.

Political feasibility, however, remains contingent on key design features: coordination across diverse creditor groups, credible and transparent trigger mechanisms, and deeper integration into sovereign debt markets. Yet these challenges are not insurmountable. Rising climate risk and the IMF's Global Sovereign Debt Roundtable have renewed calls for innovation in sovereign debt instruments. SCDIs offering contingent interest rate reductions or maturity extensions are increasingly seen as viable tools to prevent adverse shocks from escalating into debt crises—benefiting borrowers, creditors, and the international financial system alike.

Multilateral institutions, particularly the IMF and World Bank, have a critical role to play in normalising SCDIs within the sovereign debt architecture. Their endorsement, combined with technical support and coordinated creditor engagement, can help mainstream the adoption of SCDIs as part of a broader effort to climate-proof public finances and enhance debt sustainability in small open economies such as Zambia.

8. Conclusion

This dissertation set out to explore whether Zambia's 2020 sovereign default could have been avoided had it adopted

[30] A. Deaton, *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*, World Bank, 1997.

[31] D. Grigorian and A. Bhayana, "Zambia: A Case Study of Sovereign Debt Restructuring under the G20 Common Framework," Center for Global Development, 2024.

[32] C. Cohen, S. A. Abbas, M. Anthony, et al., "The Role of State-Contingent Debt Instruments in Sovereign Debt Restructurings," IMF Staff Discussion Note, 2022.

state-contingent debt instruments (SCDIs), and whether such instruments can promote long-run debt sustainability in the presence of adverse climate shocks. Using a dynamic general equilibrium model calibrated to Zambia's macroeconomic and sectoral realities, the analysis simulated the macro-fiscal consequences of various debt arrangements in response to severe, climate-induced productivity shocks. The results provide compelling evidence that well-designed SCDIs—especially when combined with donor support—can offer a powerful, rules-based framework for maintaining debt sustainability and preserving welfare.

Three central findings emerge. First, in contrast to standard borrowing arrangements, SCDIs that automatically reprofile interest rates during economic downturns reduce fiscal strain, prevent abrupt tax hikes, and maintain public investment flows. This timing of relief is critical: liquidity support during "bad states" mitigates the compounding effects of output loss, rising debt service costs, and procyclical austerity. Second, the addition of grants—either explicit or treated as equivalent to interest savings—amplifies the stabilising effects of SCDIs, enabling governments to smooth transfers and investment without jeopardising long-run fiscal sustainability. Third, the welfare gains from such arrangements are not only economically significant but also socially progressive. The strongest improvements in lifetime utility accrue to the most vulnerable households, underlining the distributional advantages of embedding contingency and solidarity into sovereign debt contracts.

The study also highlights that not all alternative debt strategies yield equal benefits. High-risk, short-term commercial borrowing was shown to amplify default risk and reduce welfare—particularly for liquidity-constrained households. Similarly, strategies that forgo external borrowing entirely impose severe adjustment costs and undermine macroeconomic stability, even if they avoid external arrears. Conversely, maturity extension alone cannot prevent crisis, but it can cushion its most acute impacts when shocks are repeated or prolonged.

From a policy standpoint, the findings strengthen the case for the incorporation of SCDIs into the debt architecture of climate-vulnerable developing countries. Their countercyclical features offer a sound path to enhance resilience in an era of intensifying climate volatility and declining grant finance. Future challenges will lie more in their implementation rather than their theoretical desirability. As the global community rethinks sovereign debt governance in the wake of Covid-19 and mounting climate stress, Zambia's experience stands as a timely reminder that how countries borrow can matter just as much as how much.

Ultimately, this dissertation argues that SCDIs are not simply a financial innovation, but a necessary evolution in global debt architecture—one that better aligns the instruments of development finance with the lived realities of an increasingly shock-prone world. For countries like Zambia, whose fiscal futures are closely tied to climate dynamics, adopting such instruments may be the path not taken—but perhaps the path that must be built.

References

[1] Adam, C., Bevan, D. and Ohlenburg, T. (2016). Public investment, fiscal rules, and growth in low-income countries. IGC Working Paper S-43302-UGA-1.

[2] Adam, C. and Musonda, A. (2011). Copper mining in Zambia: From collapse to recovery. In P. Collier and A. J. Venables (eds.), *Plundered Nations? Successes and Failures in Natural Resource Extraction*, Palgrave Macmillan, pp. 89–114.

[3] Alesina, A., Roubini, N. and Cohen, G. D. (1997). *Political Cycles and the Macroeconomy*. MIT Press.

[4] Alfani, F., Arslan, A., McCarthy, N., Cavatassi, R. and Sitko, N. (2019). Climate-change vulnerability in rural Zambia: The impact of an El Niño-induced shock on income and productivity. FAO Agricultural Development Economics Working Paper 19-02.

[5] Anthony, M., Impavido, G. and van Selm, B. (2020). Barbados' 2018–19 sovereign debt restructuring—A sea change? *IMF Working Paper WP/20/34.*

[6] Bjerkholt, O. (2004). New approaches to debt relief and debt sustainability in LDCs. CDP Background Paper No. 5, United Nations.

[7] Blanchard, O. and Leigh, D. (2013). Growth forecast errors and fiscal multipliers. *American Economic Review* 103(3), 117–120.

[8] Buffie, E. F., Berg, A., Pattillo, C., Portillo, R. and Zanna, L.-F. (2012). Public investment, growth, and debt sustainability: Putting together the pieces. *IMF Working Paper No. 12/144.*

[9] Center for Global Development (2024). The socioeconomic impact of climate change in developing countries in the next decades: A review. Working Paper 681.

[10] Cohen, C., Abbas, S. A., Anthony, M., Best, T., Breuer, P., Miao, H., Myrvoda, A. and Togo, E. (2022). The role of state-contingent debt instruments in sovereign debt restructurings. IMF Staff Discussion Note.

[11] Cohen, D. and Sachs, J. D. (1985). Growth and external debt under risk of debt repudiation. NBER Working Paper w1703.

[12] Deaton, A. (1997). *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*. World Bank.

[13] Debt Justice (2020). Zambia country profile—Debt data portal.

[14] Dell, M., Jones, B. F. and Olken, B. A. (2014). What do we learn from the weather? The new climate-economy literature. *Journal of Economic Literature* 52(3), 740–798.

[15] European Central Bank (2022). The climate change challenge and fiscal instruments and policies in the EU. Occasional Paper 315.

[16] European Commission (2021). Drought resilience profile: Zambia.

[17] Finance for Development Lab and ZIPAR (2023). The road to Zambia's 2020 sovereign debt default.

[18] Grigorian, D. and Bhayana, A. (2024). Zambia: A case study of sovereign debt restructuring under the G20 Common Framework. Center for Global Development.

[19] Hatchondo, J. C., Martinez, L. and Sosa-Padilla, C. (2016). Sovereign defaults and debt sustainability: The role of state-contingent debt. *IMF Economic Review* 64(4), 641–664.

[20] Hichilema, H. (2024). Statement on the drought situation in Zambia. Republic of Zambia, Office of the President.

[21] IMF (2005). Zambia: Enhanced initiative for heavily indebted poor countries—Completion point document. IMF Country Report 05/137.

[22] IMF (2017). State-contingent debt instruments for sovereigns. IMF Policy Paper PP/17/10.

[23] IMF (2025). World economic outlook database, April 2025: Zambia.

[24] IMF and World Bank (2019). Zambia: Joint World Bank-IMF

debt sustainability analysis.
[25] International Monetary Fund (2025). List of LIC DSAs for PRGT-eligible countries as of March 31, 2025.
[26] International Energy Agency (2024). Zambia: Energy mix.
[27] Kessler, M., Mbewe, M., Humann, T., Kalikeka, M., Masilokwa, I. and Mwamba, S. (2023). The road to Zambia's 2020 default. ZIPAR-FDL.
[28] Si, A. K. (2025). Which countries could be most affected by US aid cuts? *Devex*.
[29] UNCTAD (2024). A world of debt: A growing burden to global prosperity.
[30] UNEP and NIESR (2022). Economic impacts of climate change: Exploring short-term climate-related shocks for financial actors with macroeconomic models.
[31] United Nations (2024). UN common country analysis update 2024: Zambia.
[32] World Bank (2023). Zambia's external debt composition, 2023.
[33] World Bank (2024a). International debt report 2024.
[34] World Bank (2024b). World Bank steps up support to increase Zambia's resilience to natural disasters. Press Release, December 18, 2024.

Appendix A: Baseline Calibration Parameters

Parameter	Value	Definition
g	3.0	Trend per capita growth rate (% p.a)
a_{ratio}	1.75	Ratio rationed/non-rationed households
i_{zy}	0.10	Public investment rate (% GDP)
h_{xo}, h_{mo}, h_{no}	1.5, 10, 3.5	Consumption tax rate (% consumption)
θ_{lo}	5%	Labour tax rate (% wage bill)
θ_{no}, θ_{xo}	10, 9	Profit tax rates (% sector-specific profits)
θ_{ro}	7.5	Royalty tax rate (% copper profits)
$\lambda_{hx}, \lambda_{hm}, \lambda_{hn}$	0.2, 0.4, 0.4	Long-run tax financing shares (x, m, n sectors)
η_g	1.0	External risk premium parameter
ω	2.00	Adjustment cost scaling parameter
τ_s, τ_h	0.80, 0.50	Inter-temporal elasticity of substitution
ϵ	0.7	Elasticity of substitution in consumption
ι_s, ι_h	0.4, 0.4	Frisch elasticity (saving, rationed households)
η	0.01	Interest elasticity of foreign bonds
$\alpha_x, \alpha_n, \alpha_{cu}$	0.45, 0.3, 0.76	Capital shares (exportables, non-tradables, copper)
$\delta_x, \delta_n, \delta_z$	0.05	Depreciation rates (x, m, n sectors)
ρ_x, ρ_m	0.25, 0.35	Consumption shares (exportables, imports)
prem	0.01	Premium for future borrowing
R_{zo}	0.35	Initial return to public capital
$r_o, r_{do}, r_{dco}, r^*$	0.09, 0.0075, 0.09, 0.015	Initial interest rates
f_{div_o}	0.24	Return to capital/land in copper
$\text{share}_b, \text{share}_d, \text{share}_{dc}$	0.27, 0.11, 0.33	Initial debt (dom., concess., non-concess.)
$\text{share}_{\text{remit}}, \text{share}_{\text{grants}}$	0.05, 0.015	Init. private remittances, grants (% GDP)
y_o, q_{cu_o}, w_o	100, 14, 1.0	Initial GDP, copper share in GDP, nominal wage

Note: Data used in calibration sourced from Bank of Zambia reports, Ministry of Finance Zambia, IMF Article IV reports, and World Bank reports.