TECHNICAL

NOTES & MANUALS

Calibrating Fiscal Rules

A Consideration of Natural Disaster Risks

Olusegun Akanbi, William Gbohoui, and W. Raphael Lam

TNM/2023/02

TECHNICAL NOTES AND MANUALS

Calibrating Fiscal Rules

A Consideration of Natural Disaster Risks

Olusegun Akanbi, William Gbohoui, and W. Raphael Lam

Authorized for distribution by Ruud de Mooij

This technical note illustrates a methodology to integrate natural disaster risks when calibrating fiscal rules. It complements Eyraud and others (2018), which provides a primer guidance on how to calibrate fiscal rules. This technical note is accompanied by a set of toolkits that provides instructions on calibrating a medium-term debt anchor and corresponding operational rules in the presence of natural disaster risks, accounting for climate investment and other mitigation mechanisms.

The template is available at (http://workspaces.imf.org/departments/FAD/FiscalRules/Pages/default.aspx).

The technical note and accompanied toolkits benefited from comments from Virginia Alonso, Teresa Curristine, Nikolay Gueorguiev, Paulo Medas, Paolo Mauro, and Claude Wendling (Fiscal Affairs Department); inputs from Rui Mano, Marie Kim, and Weicheng Lin (Western Hemisphere Department); and comments from departmental reviews.

Cover Design: IMF Creative Solutions

Cataloging-in-Publication Data
IMF Library

Names: Akanbi, Olusegun, author. | Gbohoui, William, author. | Lam, W. Raphael, author. | International Monetary Fund, publisher.
Title: Calibrating fiscal rules : a consideration of natural disaster risks / Olusegun Akanbi, William Gbohoui, and W. Raphael Lam.
Other titles: A consideration of natural disaster risks. | Technical note and manual.
Description: Washington, DC : International Monetary Fund, 2023. | July 2023. | TNM/2023/02. | Includes bibliographical references.
Identifiers:
ISBN:
9798400237508 (paper)
9798400238710 (ePub)
9798400238666 (web PDF)
ISSN:
2075-8669 (print)
2522-7882 (online)
Subjects: LCSH: Fiscal Policy. | Natural disasters.
Classification: LCC HJ192.5.A33 2023

Recommended citation:
Akanbi, Olusegun, William Gbohoui, and W. Raphael Lam. 2023. “Calibrating Fiscal Rules: A Consideration of Natural Disaster Risks.” IMF Technical Notes and Manuals 2023/02, International Monetary Fund, Washington, DC.

Please send orders to:
International Monetary Fund, Publication Services
PO Box 92780, Washington, DC 20090, USA
Tel: (202) 623–7430 | Fax: (202) 623–7201
publications@imf.org
www.elibrary.imf.org
www.bookstore.imf.org

Contents

I. Introduction 1

II. Calibrating the Medium-Term Fiscal Anchor 2
Flexibility in the Horizon of Simulations 2
Accounting for Natural Disaster Risks 2
Incorporating Mitigating Measures of Natural Disaster Shocks 3

III. Calibrating the Operational (Deficit) Rules 7
Flexibility of the Pace of Fiscal Adjustments 7
Incorporating Climate Investment 9
Introducing Natural Disaster Shocks 10
Translating the Calibrated Deficit Path to Different Types of Rules 13

References 14

I. Introduction

Large shocks from natural disasters remain a significant challenge for countries and are a key source of vulnerabilities for public finances in disaster-prone countries. Beyond the direct costs of damages, natural disasters can weaken a country's fiscal position because the eventual contraction in activity may reduce the government's ability to mobilize revenues while increase the need for more priority expenditures (ranging from short-term emergency relief to reconstruction efforts over the medium term), resulting in an increase in borrowing that could undermine debt sustainability.[1] Large natural disaster shocks also pose persistent deviation of GDP from its underlying trend in the medium term, despite reconstruction activities, especially in small developing countries (Cavallo and Noy 2009; Acevedo 2014; Banholzer, Kossin, and Donner 2014; IMF 2016; Lian, Moran, and Vishvesh 2022), and their incidence is expected to increase.[2]

The increasing severity and frequency of extreme weather events caused by climate change call for a holistic way to address the associated effect on public finances. This requires building structural, financial, and postdisaster resilience (IMF 2019, 2022). Elements may include enhancing macro-resilience against natural disasters, improving the capacity to adapt to climate change, participating in regional insurance schemes, accessing external grants and financing, and building fiscal buffers (Cevik and Huang 2018; IMF 2022). It also involves rethinking the rules-based frameworks. For example, the framework can allow governments to meet long-term adaptation investment needs and build or maintain some buffers in normal times that can be quickly deployed in emergencies. In the postdisaster recovery phase, the fiscal framework may allow a gradual transition to provide scope for reconstruction efforts. In that context, disaster-related fiscal risks can be incorporated in the design and calibration of rules-based fiscal frameworks.

This note is an extension of the 2018 Fiscal Affairs Department calibration toolkit (Eyraud and others 2018). This note develops a methodology to calibrate fiscal rules in the event of natural disaster shocks and the possibility of implementing additional investment for climate adaptation. It also provides some important features that allow for (1) inputs to parameterize the frequency and intensity of natural disaster risks; (2) modeling of asymmetric growth shocks to reflect the effect of natural disasters; (3) other mitigating mechanisms such as disbursements from regional insurance schemes or external financing when natural disasters occur; and (4) inputs for adaptation investment needs when countries set an expenditure or budget balance rule. These features are incorporated in a revised toolkit to calibrate a medium-term fiscal anchor as well as annual budgetary limits. The revised toolkit seeks to find a prudent medium-term fiscal anchor and a deficit or expenditure path that would facilitate public finance positions to reach the anchor within a user-specified horizon. It extends the 2018 toolkit to capture different profiles of climate investment, the occurrence of severe natural disasters, and other mechanisms to mitigate disaster shocks. The note is accompanied by two templates that allow users to parameterize these dimensions when calibrating fiscal rules.[3]

1 Empirical estimates suggest that large natural disasters could raise government expenditure by an average of 15 percent and reduce revenue by about 10 percent over five years, leading to a substantial increase in the overall budget deficit (Melecky and Raddatz 2011). The associated rise in public debt has led to higher borrowing costs and default risks and dampened long-term growth (Noy 2009; Lis and Nickel 2010; Cabezonand others 2015; Klomp 2015, 2017; Melecky and Raddatz 2015; Standard & Poor's 2015; Koetsier 2017).

2 The frequency and intensity of disasters are trending upward, consistent with Intergovernmental Panel on Climate Change predictions of more frequent severe climate events (Nishizawa, Roger, and Zhang 2019; Lian, Moran, and Vishvesh 2022).

3 Recent applications of the toolkits include the Article IV Consultations in several countries, including East Caribbean Currency Union countries, The Bahamas, and Grenada, as well as Technical Assitance mission to Cambodia.

II. Calibrating the Medium-Term Fiscal Anchor

In calibrating the medium-term fiscal anchor, the 2018 toolkit seeks to determine a prudent fiscal buffer such that there would be high probability that debt would not exceed a certain limit over the medium term, in line with stochastic macroeconomic shocks. The extensions in this note introduce several new elements.

Flexibility in the Horizon of Simulations

The 2018 toolkit has a default horizon of six years, which is typically appropriate to assess the medium term. However, assessing natural disaster risks may require a longer horizon, particularly as severe natural disasters occur less frequently but have significant consequences beyond the medium term. The extension now accommodates up to a 10-year forecast horizon. Table 1 portrays the simulation of a hypothetical small open emerging market economy. A longer time horizon tends to imply a lower debt anchor level (Table 1, columns A1 and A2), reflecting the prudence needed in the calibration to ensure debt is below a certain exogenous limit given the risk tolerance. In some cases, the simulated debt anchor could be sensitive to the choice of horizon, particularly if the dispersion of the shocks is large (that is, a wide fan in the simulation).

Accounting for Natural Disaster Risks

This note incorporates natural disaster risks in determining the debt anchor. Natural disaster shocks pose an adverse effect on growth with severe downside risks. The damage caused by natural disasters tends to be large relative to GDP, especially in small states, thereby suggesting a need to consider an asymmetric distribution with higher density at the adverse end (that is, thicker left tail in the growth distribution). For example, a quarter of severe natural disasters caused damage at 10 percent of GDP or higher in the Caribbean region between 1970 and 2020 (Lian, Moran, and Vishvesh 2022). Large natural disaster shocks are also found to have persistent deviation of GDP from its underlying trend over the medium term, especially in small countries (Acevedo 2014; Lian, Moran, and Vishvesh 2022). Several options are used to model the asymmetric feature of natural disaster risks on growth. First, the toolkit allows the user to directly specify the growth effect after a disaster shock (that is, assumed to be –5 percent of GDP when a natural disaster occurs in column B of Table 1). Second, it introduces a stochastic approach in modeling natural disaster risks. Equation (1) illustrates how the overall growth shock, Y_t at time t, would combine the typical historical growth shock, Y_t^* with a second component drawn from a Pareto distribution.[4]

$$Y_t = Y_t^* - \prod_{D_{t=1}} Z_t, \qquad \text{(Eq. 1)}$$

where $\prod$ is the indicator function, D_t is drawn from a Bernoulli distribution and takes the value 1 with probability p, and 0 with probability $q = 1 - p$. The probability of occurrence of natural disaster, p, is set exogenously by the user. Z_t is drawn from a Pareto distribution where parameters are to be jointly calibrated by the users to match the average marginal growth effects of natural disaster shocks and the skewness of growth shocks distribution.

4 The choice of the distribution type is mainly driven by its skewness property. The Pareto distribution is one of the most common asymmetric distributions used in the literature. Its cumulative distribution function is as follows:

$F(x) = 0 \text{ if } x < y, \text{ and } F(x) = 1 - \left(\frac{y}{x}\right)^a \text{ otherwise},$

where y and a are parameters, inputs reflecting the scale and shape parameters of the Pareto distribution.

Given multiple underlying shocks, it is sometimes difficult to fully match the overall growth distribution. One option would be a two-step approach used in some Eastern Caribbean Currency Union country cases. First, the natural disaster shocks are differentiated according to small and large shocks—the former would be captured by standard growth shocks. Second, the calibration captures the large natural disaster shocks using a Pareto distribution that has features of a skewed asymmetric growth distribution. The parameters of the Pareto distribution can draw on historical realizations or expected dynamics of extreme weather events based on empirical studies in the literature. In the case of the Eastern Caribbean Currency Union, large natural disaster shocks can be estimated in the sample (for example, pecuniary damage exceeding 1 percent of GDP) based on a reduced-form relationship between the cost damage (available in the Emergency Events [EM-DAT] database) and growth effect (Lian, Moran, and Vishvesh 2022). For illustrative purposes, the parameters of the Pareto distribution are calibrated so that the average growth effects after a natural disaster are equal to the quantitative growth effect under the user-specified scenario (Table 1, column C1).

The introduction of natural disaster risks would affect prudent debt anchor levels (Figure 1). The baseline shows the scenario without natural disaster risks, and the debt anchor is determined by considering typical growth shocks, which follow a normal distribution. The inclusion of natural disaster shocks would imply the growth shocks are asymmetric with more downside effects. As a result, the simulated debt anchor would be smaller at 32.4 percent of GDP relative to the baseline at 42.9 percent of GDP (Table 1, columns A2 and C1; Figure 1).

Natural disaster risks tend to have an important role in the calibration of prudent debt anchor levels. Sensitivity analysis shows that different parameters on the probability and severity of natural disaster shocks would affect the levels of the debt anchor, holding other things constant. A higher frequency of natural disaster shocks measured by a rise in the probability of the occurrence of natural disasters in a year from 10 percent to 25 percent would reduce the debt anchor level by around 10 percentage points of GDP (Table 1, column C2). Moreover, the more severe the natural disaster shock—characterized by a more skewed Pareto distribution with a higher mean—the lower the debt anchor (Table 1, column C3). For example, if the negative growth effects of a natural disaster rise by 3.75 percentage points of GDP, the debt anchor would decline by 8.40 percentage points to 24 percent of GDP, reflecting the need to keep debt farther from its limit when experiencing more severe natural disaster shocks. If policymakers are willing to face a greater risk tolerance that debt could exceed the limit levels, the simulated debt anchor would be higher. For example, a doubling of risk tolerance from 10 to 20 percent would imply an increase in the prudent debt anchor from 24 to 40 percent of GDP (Table 1, column C4). If policymakers are willing to face a higher risk of debt distress, the safety buffers needed would be smaller. However, a higher risk tolerance implies a readiness to face a higher risk of debt distress or to undertake more abrupt fiscal adjustment to lower debt to a sustainable path. Such a strategy could be politically difficult to adopt, given the potential social cost for the population. Moreover, a nonprudent risk-management strategy could face resistance from international partners, including the IMF, that provide a large share of the financing of postdisaster recovery.

Incorporating Mitigating Measures of Natural Disaster Shocks

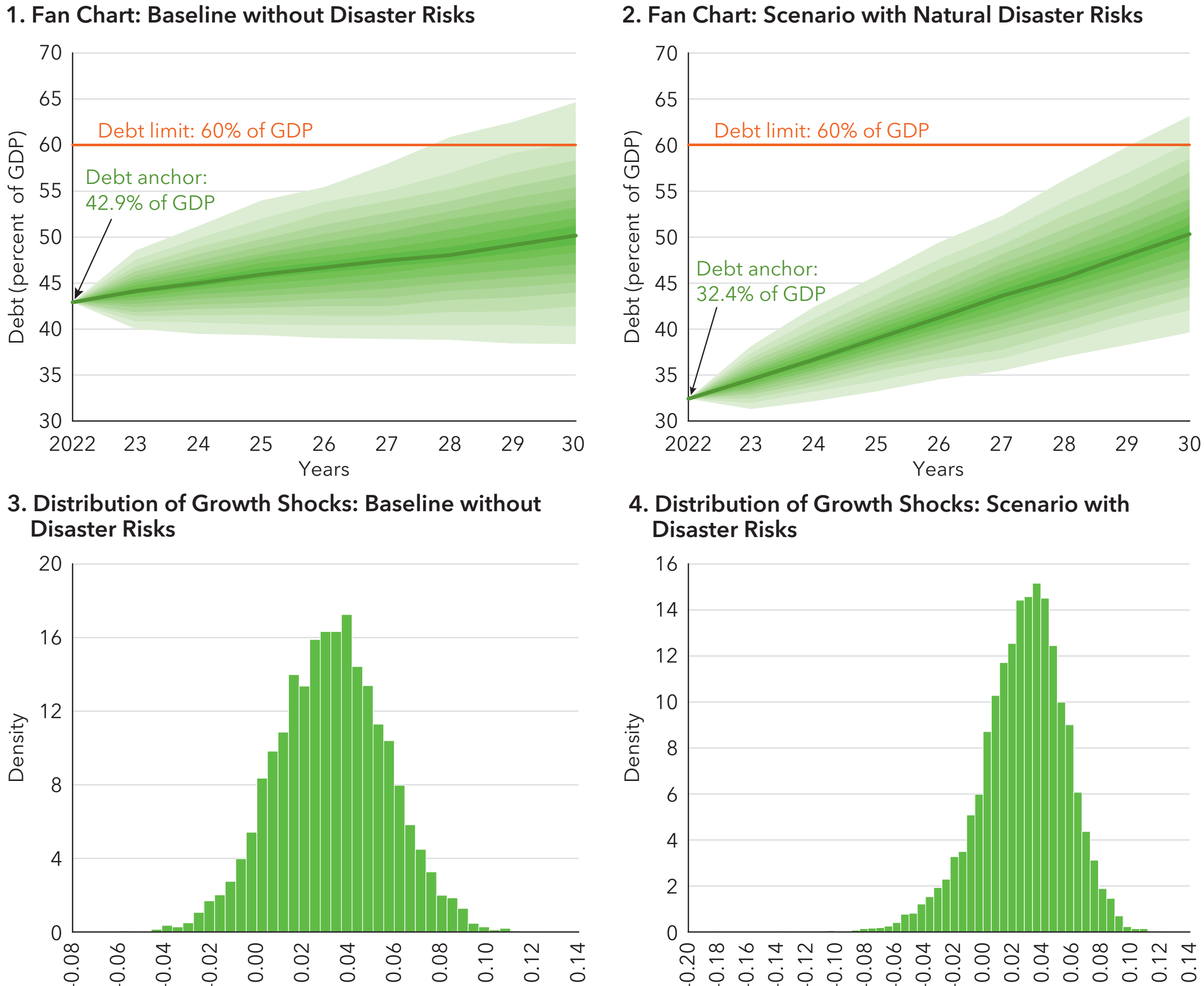
This note also extends to incorporate mechanisms that could mitigate the effects of natural disaster shocks. Maintaining a sufficiently large fiscal buffer from the debt limit (that is, setting a low debt anchor) is one of the options to account for adverse effects from natural disasters. But the simulations suggest that the level of fiscal buffers needed is often sizable, and it would be unrealistic for a small open economy to rely solely on this option. Those economies subject to severe damages from natural disaster shocks or frequent occurrences are often small developing states. Maintaining certain buffers is necessary, so countries can respond by providing quick and timely fiscal support, which will be extremely important when facing a severe disaster. Countries use a combination of other risk-transfer or -sharing instruments—such as climate

Table 1. Summary of Simulations

	Baseline: No Natural Disaster			Random Shock–Stochastic Growth Impact				
	Six-Year Horizon	Eight-Year Horizon	Pre-determined Shock	Baseline	Frequent	Severe	Higher Tolerance	High
Parameters	**A1**	**A2**	**B**	**C1**	**C2**	**A1**	**C4**	**D**
Last year debt-to-GDP	48.3	48.3	48.3	48.3	48.3	48.3	48.3	48.3
Debt limit	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Forecast horizon	6	8	8	8	8	8	8	8
Risk tolerance	10.0	10.0	10.0	10.0	10.0	10.0	20.0	10.0
Average historical growth rate	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Average historical primary balance	−1.2	−1.2	−1.2	−1.2	−1.2	−1.2	−1.2	−1.2
Natural disaster	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Probability of occurrence	NA	NA	NA	10	25	10	10	10
Average growth impact	NA	NA	5	5	5	8.75	8.75	8.75
Pareto: scale parameter	NA	NA	NA	0.042	0.042	0.070	0.070	0.070
Pareto: tail index	NA	NA	NA	6	6	5	5	5
Climate fund	No	No	No	No	No	No	No	Yes
Climate fund disbursement	NA	NA	NA	NA	NA	NA	NA	5
Mean growth shocks[1]	3.29	3.25	2.63	2.73	1.98	2.34	2.34	2.34
Median growth shocks[1]	3.31	3.26	2.85	2.91	2.23	2.86	2.86	2.86
Skewness growth shocks[1]	−0.01	0.01	−0.32	−0.22	−0.26	−0.52	−0.52	−0.52
Mean primary balance[1]	0.28	−0.09	−1.11	−1.19	−2.18	−2.05	−0.43	−0.48
Debt anchor	46.5	42.9	33.0	32.4	22.5	24.0	39.6	39.9

Source: Authors' estimates.
Note: NA = not applicable.
[1]Average across simulations.

Figure 1. Calibrating the Debt Anchor with Natural Disaster Shocks



Source: Authors' simulations.
Note: The scenario assumes a debt limit set at 60 percent of GDP. The simulation seeks the prudent level of debt, such that debt will only exceed the limit levels at a given risk tolerance (assumed to be 10 percent), given typical macroeconomic and natural disaster shocks. In the baseline, the simulation only includes typical macroeconomic shocks, and the simulated debt anchor is 42.9 percent of GDP at an eight-year horizon. In the scenario with natural disasters, the probability of an occurrence of a natural disaster is 10 percent, with the adverse effect of –5 percentage points reduction on growth from the baseline. The simulated debt anchor is lower at 32.4 percent of GDP at an eight-year horizon.

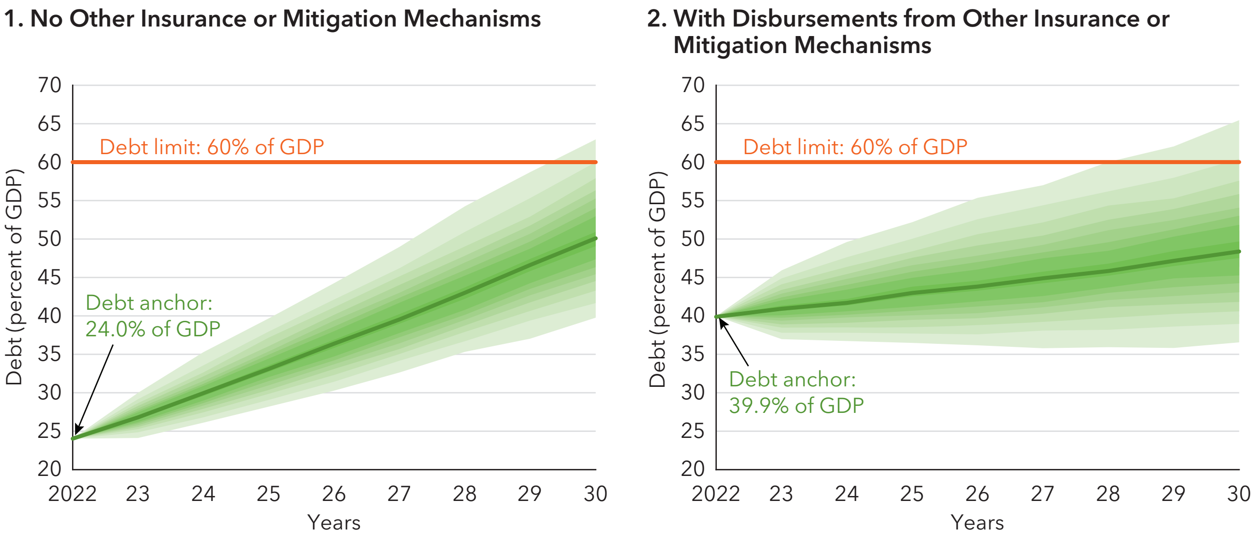
or natural disaster funds (such as in Fiji, Grenada, the Philippines, and Tuvalu); regional insurance (Eastern Caribbean Currency Union); catastrophe bonds (Barbados and Mexico); the African Risk Capacity;[5] or the Catastrophe Containment and Relief Trust of the IMF and the Catastrophe Deferred Drawdown Option (Cat DDO) of the World Bank—to cover immediate needs and longer-term postdisaster development needs. For example, Grenada has multiple layers of buffers to account for natural disaster risks, including a contingency

5 The African Risk Capacity offers risk-pooling and risk-transfer services to African Union members to build resilience against natural disasters, such as droughts and tropical cyclones. For further information, please see http://www.arc.Int/.

fund (that can be used for relief, reconstruction, and recovery from a natural disaster); regional insurance policies; and several self-insuring policies aimed to build resilience.[6,7]

The toolkit integrates these mitigating channels through an exogenous parameter on the size, in terms of GDP, which would be activated during natural disaster shocks. Assuming that the size of the total disbursement is set to X percent of GDP by the user, the climate or natural disaster fund will disburse (X/N) percent annually per year, if at least one event of natural disaster occurs during the forecast horizon (N). The effect of the lower primary balance after the disaster on debt accumulation is then mitigated each year by the fund disbursed amount, limiting debt increase through the occurrence of natural disaster. This, in turn, alleviates the pressure for building buffers through lower debt anchors. For example, for a disbursement of 5 percent of GDP by other mechanisms, the simulated debt anchor would be 40 percent of GDP, relative to 24 percent of GDP in the absence of other insurance mechanisms (Figure 2; Table 1, columns C3 and D).

Figure 2. Effect of Alternative Insurance or Mitigation Schemes on the Debt Anchor under Severe Natural Disaster Shocks



Source: Authors' simulations.

[6] Grenada is putting in place a comprehensive Disaster Resilience Strategy in cooperation with the IMF and other development partners (IMF 2022). It maintains buffers in the contingency fund, including freely available cash reserves (about 2.5 percent of GDP) that could be used in the event of natural disasters, and contingent coverage in the event of natural disasters of up to 3.5 percent of GDP. The buffers were boosted with the approval of the Cat-DDO of 1.7 percent of GDP by the World Bank. The country also maintains some budgetary contingency (about 2 percent of revenues each year or $15 million Eastern Caribbean dollars) and a sinking fund with the Eastern Caribbean Central Bank. Grenada has been operationalizing the use of some of the National Transformation Fund's Contingency Fund resources for natural disasters. In 2019, the government amended the National Transformation Fund's regulations to (1) define the objectives of the fund, focusing on the use of financial resources for relief, reconstruction, and recovery from a natural disaster; (2) set the rules of accumulation of fund resources; and (3) flesh out governance and accountability arrangements. In addition, it has two parametric insurance policies (the Tropical Cyclones and Earthquakes and Excess Rainfall policies from the Catastrophe Risk Insurance Facility and the Caribbean Oceans and Aquaculture Sustainability Facility) and has negotiated a debt service reduction clause in the event of a natural disaster.

[7] The country is assumed to have contributed to the risk-transfer or sharing mechanisms through payments that have been accounted for in its expenditure.

III. Calibrating the Operational (Deficit) Rules

After determining the debt anchor, this section shows how to calibrate its operational rules. Following the 2018 toolkit, the analysis illustrates different approaches for the deficit paths in reaching the debt anchor from the current debt level. It would require inputs on key macroeconomic parameters such as growth, interest rates, and the current levels of deficit and debt. The standard debt dynamic equation is used to determine the deficit paths that would allow debt to converge from the current level to the anchor level. We illustrate a hypothetical scenario for a small open economy with government debt at 80 percent of GDP and a prudent debt anchor calibrated to be 50 percent of GDP, using the approach outlined in the previous section. The illustration shows a deficit path to lower debt to the anchor level in 15 years, assuming the current overall deficit is 5 percent of GDP. Other macroeconomic variables are assumed at levels listed in Table 2, which can be calibrated or tailored to specific country circumstances in the toolkit.[8]

The compilation is based on a set of parameters for illustrative purpose. The analyses assume that a country has set a medium-term debt anchor considering the macroeconomic circumstances to be achieved within the next 15 years (a parameter that can be specified by users). The table illustrates the flexibility in the toolkit that users can tailor to their applications if a natural disaster occurs during the adjustment period. Users have the option to extend the adjustment period instead of recalibrating the debt anchor level. The toolkit allows for an adjustment with and without mitigation mechanisms. The toolkit can also be adapted to countries vulnerable to other macro and external shocks. However, the calibrated parameters without other shocks would provide the minimum effects on the parameters in Table 2, "D. Parameters on the Natural Disaster Shocks."

Flexibility of the Pace of Fiscal Adjustments

Greater flexibility is introduced to allow a gradual pace of adjustments. The 2018 toolkit allowed a convergence toward the debt anchor over the long term (approach 1) or at a given date (approach 2), but countries were assumed to undertake an immediate adjustment to lower debt from the current level to the anchor.

The extension in this note introduces the flexibility to model a gradual adjustment in which users can decide the duration of fiscal adjustments. However, the pace of adjustment chosen will also depend on the nature of financing. For debt with a large private component, the need to maintain market access could heavily influence the speed of adjustment. For illustrative purposes, the initial fiscal adjustment period is assumed to be five years, which could be tailored to country circumstances by users (Table 2, "B. Parameters on the Pace of Adjustments"). Given the initial macroeconomic parameters in Table 2, the convergence toward the debt anchor over the long term would require the overall deficit to adjust by 0.7 percent of GDP (or primary deficit at 0.5 percent of GDP) annually over the first four years and then maintain the deficit at that level for the remaining periods to lower debt from the current level at 80 percent of GDP to the debt anchor level (Figure 3). If the adjustments were taken in a year, as assumed in the 2018 toolkit, it would have led to a sharp tightening of 2.6 percent of GDP in the overall deficit or 2.0 percent of GDP in the primary deficit in the first year. In another scenario, if convergence to the debt anchor is achieved at a given date (assumed to be 15 years), the implied adjustment paths would be tighter. The annual reduction of overall deficit would be about 1 percentage point of GDP in the first four years to reduce debt to its target level of 50 percent of GDP by the end of 15 years (Figure 3).

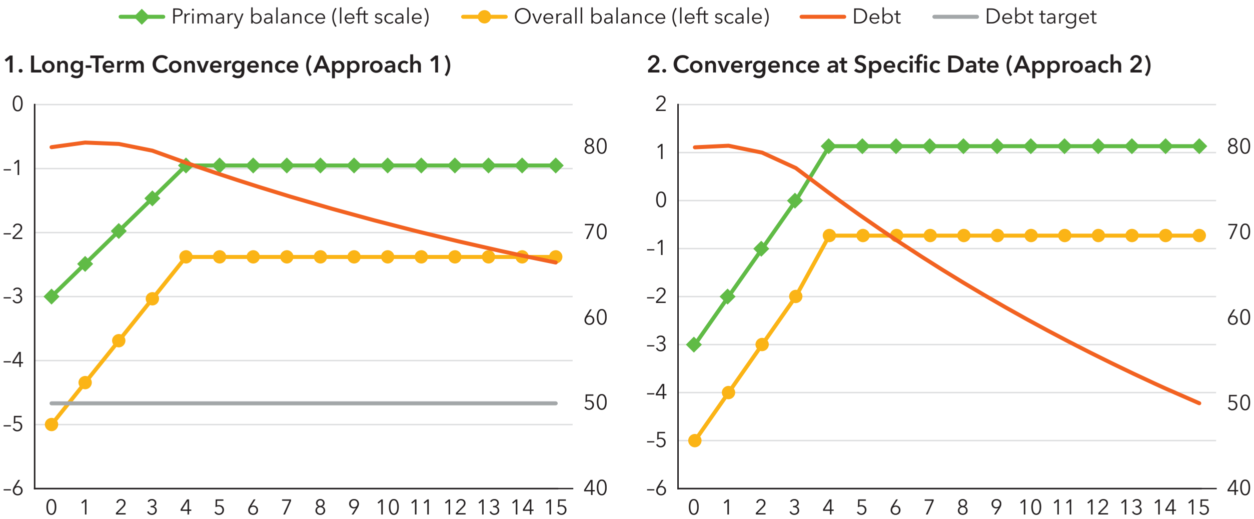
[8] In the event that the interest rate and growth differential (r–g) is positive, a larger adjustment path may be required to lower debt to its target.

Table 2. Illustrative Macroeconomic Parameters

	Baseline: without Natural Disaster Shocks	Scenario 1: Natural Disaster Shocks	Scenario 2: Natural Disaster Shocks with Mitigating External Grants or Climate Funds
A. Macroeconomic Parameters			
Current debt ratio (% GDP)	80	80	80
Target debt ratio (% GDP)	50	50	50
Long-term nominal interest rate (%)	3	3	3
Long-term nominal growth rate (%)	5	5	5
Current fiscal balance (% GDP)			
Primary balance	−3	−3	−3
Overall balance	−5	−5	−5
B. Parameters on the Pace of Adjustments			
Convergence period for debt (years)	15	20	20
No shock gradual adjustment period	4	–	–
Yearly primary and overall balance adjustment (% GDP)	1	–	–
Initial fiscal adjustment period (years)	5	5	5
C. Parameters on Climate Investment			
Period until climate investment spending rise (years)	6	6	6
Long-term incremental climate investment spending (% GDP)	0.2	0.2	0.2
Long-term early or constant climate investment spending (% GDP)	1	1	1
Climate investment spending in the initial adjustment period (% GDP)	1	1	1
D. Parameters on the Natural Disaster Shocks			
Years of natural disaster	–	3	3
After shock gradual adjustment period	–	5	5
Yearly primary and overall balance adjustment (% GDP)	–	2	2
Effect of natural disasters on fiscal balance (% GDP)	–	-7	-7
Climate fund	–	0	1
E. Parameters on Mitigation Measures for Natural Disaster Shocks			
Multiyear grants for natural disaster mitigation (% GDP)			
Year 1	–	0	2
Year 2	–	0	0
Year 3	–	0	0

Source: Authors' compilation.

Figure 3. Debt and Deficit Paths under Different Pace of Adjustments
(Percent of GDP)



Source: Authors' estimates.

Incorporating Climate Investment

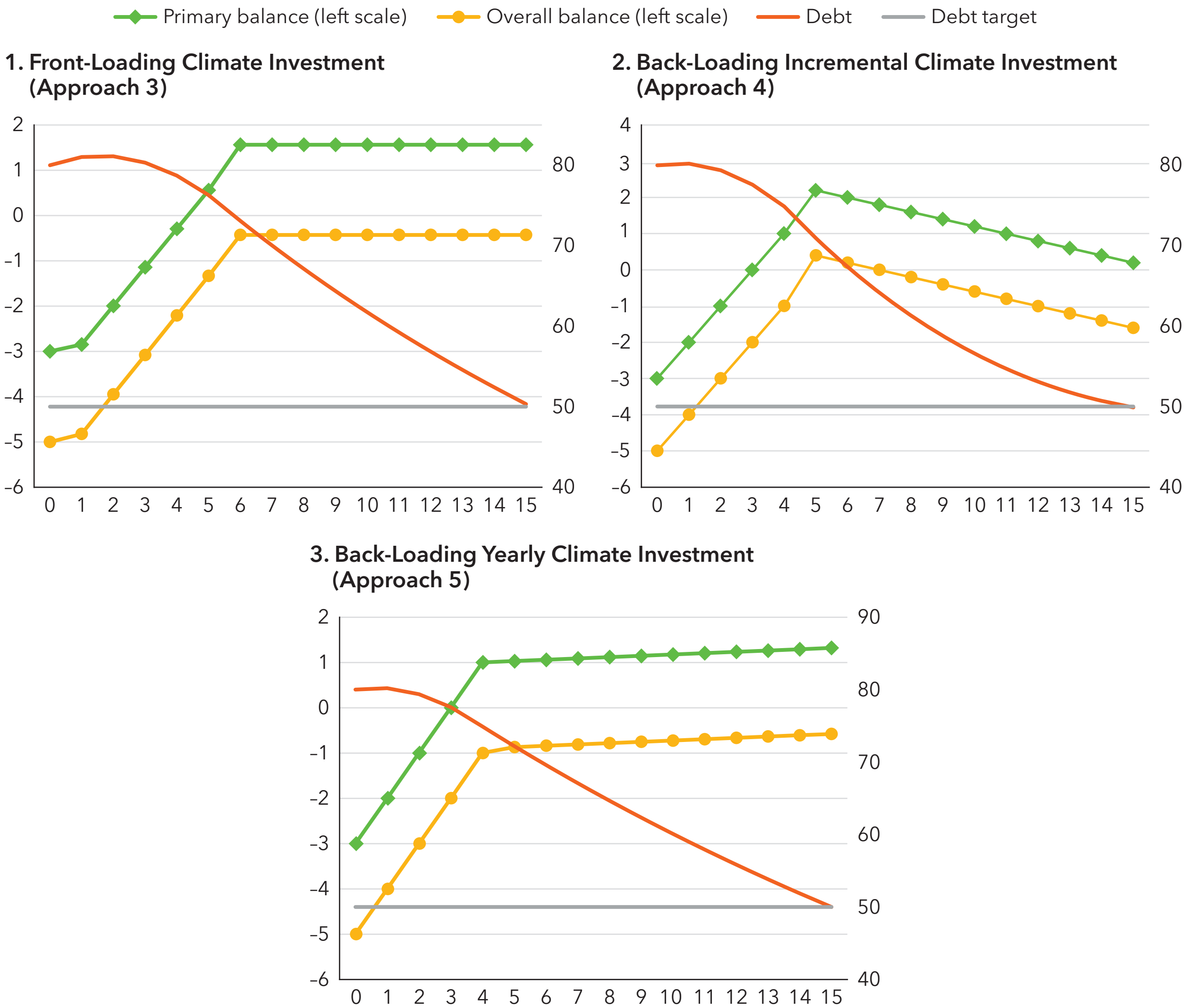
The revised toolkit introduces an analysis on how different climate investment profiles affect the calibration of the deficit rules in the rules-based fiscal framework.[9] It allows users to specify a strategy of climate investment with the anticipated cost over time in the toolkit to see how the climate investment would affect the debt path toward the anchor level. The analysis models an upfront investment (approach 3) and an anticipated investment in the future, either as an increment per year (approach 4) or as a constant annual outlay (approach 5). Higher upfront spending on climate investment would raise deficits and debt unless it is financed by additional revenue. It would behave similar to a more back-loaded adjustment in which the pace of fiscal adjustment in the initial periods would be more gradual but compensated by tighter adjustments in subsequent periods to lower debt to the same level within the same horizon. For illustrative purpose, we assume the government undertakes additional climate investment for six years, front-loading at initial periods at about 1 percent of GDP per year (Table 2, "C. Parameters on Climate Investment"). The calibrated results show that the pace of adjustment in the initial periods is more gradual at an average of 0.7 percent per year relative to 1 percent in approach 2, where there is no additional public investment, but it would require a higher budget balance (at an overall deficit of 0.4 percent of GDP or primary surplus of 1.6 percent of GDP) in subsequent periods to achieve the debt anchor in 15 years (higher than results in approaches 1 and 2). Debt declines more modestly during the investment phase but then falls faster when budget balances are maintained at higher levels (Figure 4, approach 3).

Alternatively, in the scenarios of an anticipated climate investment in the future (that is, a back-loading investment), the incremental investment is set at 0.2 percent per year in approach 4 or an annual constant share at 1 percent of GDP in approach 5 that starts from year 6 (Table 2, "C. Parameters on Climate Investment").[10] The results show that in the initial years, fiscal savings built up with more front-loading of

[9] The toolkit is not limited to climate investment and can adapt to other types of public investment. However, incorporating climate investment could be done through adaptation and mitigation so that the cost is anticipated over time and a country can enter its own strategy to reach the debt anchor. The analysis in this section is in partial equilibrium and does not consider the potential effects of the climate investment on growth.

[10] The number of years for the initial fiscal adjustment and period until climate investment rises are not limited to five and six years, respectively. The template allows for as many years but is not greater than *N*.

Figure 4. Calibration of Deficit Rules under Different Profiles on Climate Investment
(Percent of GDP)



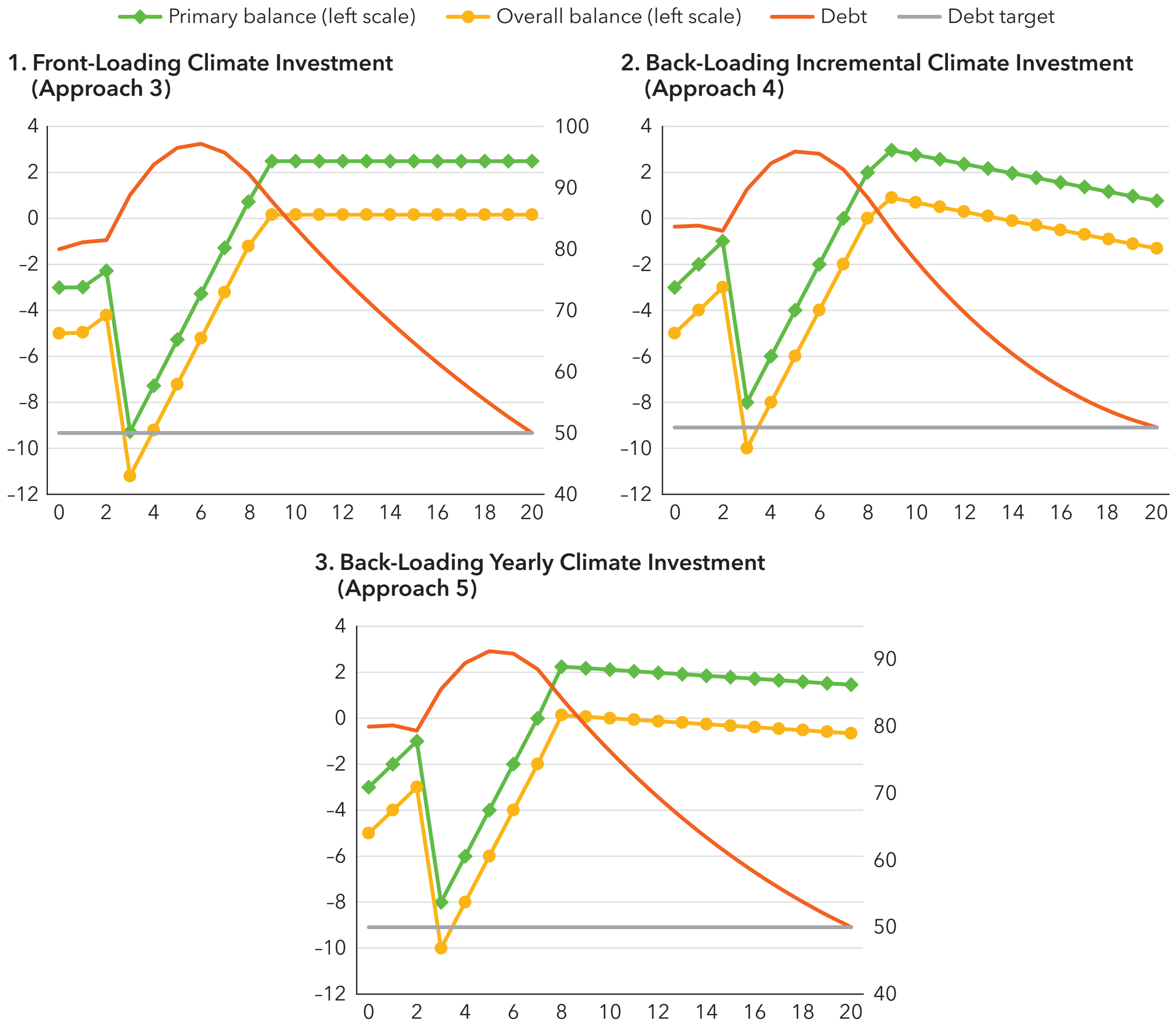
Source: Authors' estimates.

fiscal adjustments would help smooth the burden of adjustments in the future, when climate investment starts to kick in (Figure 4, approaches 4 and 5). Debt initially falls faster as fiscal adjustments take place but then declines more modestly relative to the scenario of a front-loading investment in approach 3. For example, an annual overall and primary balance adjustment of 1 percent of GDP each is required in approach 4. A similar adjustment path is observed in approach 5, except it would need additional savings to finance the larger investment.

Introducing Natural Disaster Shocks

The revised toolkit also allows an occurrence of severe natural disasters in the transition period, with the flexibility for users to set the timing and severity of the shock. The analysis examines how the introduction of natural disaster shocks affects the calibration of deficit rules as well as the transition dynamics toward the deficit limits.

Figure 5. Calibration of Deficit Rules with Natural Disaster Shocks
(Percent of GDP)



Source: Authors' estimates.

The natural disaster scenario considers that a severe natural disaster occurs in year 3 and leads to a deterioration of fiscal balance by 7 percent of GDP, which takes five years to recover (Table 2, "D. Parameters on the Natural Disaster Shocks"). After a natural disaster shock, the country activates the escape clause within the rules-based fiscal framework to provide fiscal support. Without other arrangements or extending the horizon to reach the debt anchor, this would imply a much more ambitious and sustained postshock fiscal adjustment as the economy recovers from the natural disaster, which could prove economically and politically unviable. The size of additional fiscal efforts would depend on the distance of the deficits relative to rule limits as well as the remaining horizon to reach the debt anchor.

The revised toolkit therefore allows a plausible scenario to extend the horizon to reach the debt anchor that accommodates a more gradual fiscal adjustment. Figure 5 illustrates this extension from 15 to 20 years after the occurrence of the natural disaster. When the natural disaster hits in year 3, ongoing climate investment is suspended. The results show that deficits initially deteriorate because of the shock as fiscal measures

Table 3. Sensitivity Analysis on Deficit Rules

	Convergence Period n = 15				Convergence Period n = 20			
	No Disaster Shock		With Disaster Shock		No Disaster Shock		With Disaster Shock	
	Primary Balance	Overall Balance	Primary Balance	Overall Balance	Primary Balance	Overall Balance	Primary Balance	Overall Balance
Long-term convergence (approach 1)	−1.0	−2.4	−1.0	−2.4	−1.0	−2.4	−1.0	−2.4
Convergence at specified date (approach 2)	1.1	−0.7	4.0	1.6	0.4	−1.4	1.8	−0.3
Front-loading climate investment (approach 3)	1.6	−0.4	4.9	2.4	0.8	−1.1	2.5	0.2
Back-loading incremental climate investment (approach 4)	0.0	−1.9	3.8	1.5	0.0	−1.9	1.9	−0.2
Back-loading yearly climate investment (approach 5)	−0.2	−2.2	3.7	1.4	−0.2	−2.2	1.8	−0.3

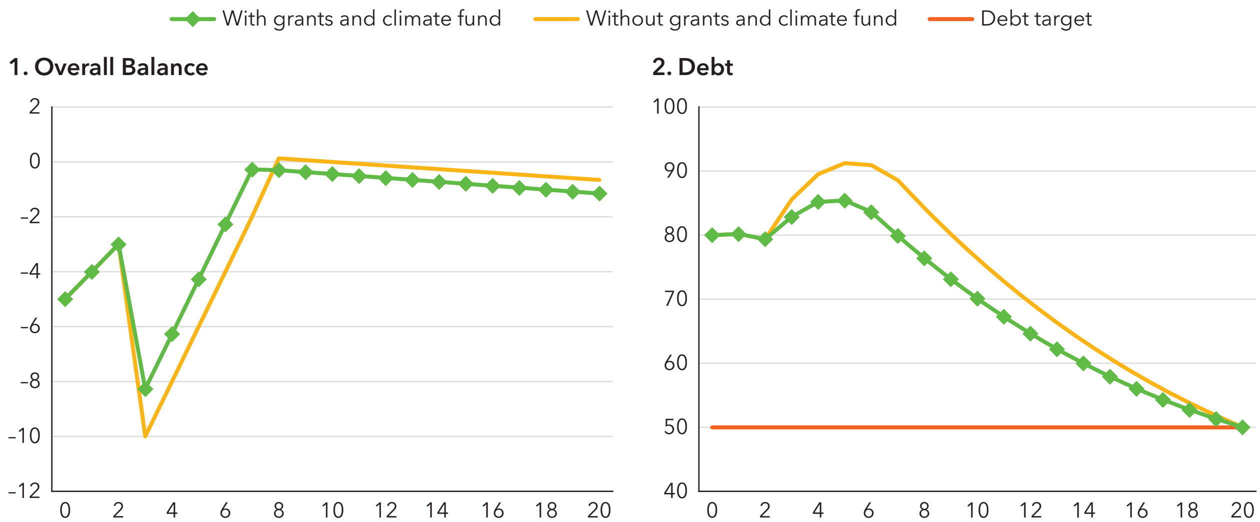
Source: Authors' estimation.

(activating the escape clause) are introduced, and debt rises as a result of weaker growth and higher deficits (Figure 5). The postshock pace of adjustment is assumed to be gradual until it reaches a constant overall surplus of 0.2 percent of GDP or primary surplus of 2.5 percent of GDP (in approach 3) to reach the debt anchor. However, the adjustment path and the eventual deficit limits vary across different profiles of climate investment.

Sensitivity analysis shows how the deficit rules, in terms of constant fiscal balances, would vary according to different horizons to reach the debt anchor, climate investment profiles, and the occurrence of natural disaster shocks (Table 3). Except for approach 1, larger calibrated budget balance limits are required (after the natural disaster shock) to lower debt to the anchor level. In approach 1, because convergence is not necessarily determined at a given date, similar constant fiscal balances can be adopted, but at a cost of a much longer horizon in terms of convergence. The extension of the convergence period from 15 to 20 years shows that it would affect the deficit rule limits and the transition path.

Besides extending the horizon, the country facing natural disasters often has other mechanisms, such as external grants or reinsurance, to mitigate the adverse effect from the shock. Donor support from external entities or disbursements from some contingency funds will cushion the natural disaster shock and reduce fiscal pressures. The revised toolkit allows for external resources to be used when a natural disaster occurs (Table 2, "E. Parameters on mitigation measures for natural disaster shocks"). Assuming 2 percent of GDP of grants in the first year and another 1 percent of GDP disbursed from the climate fund, Figure 6 compares how the deficit and debt paths would vary depending on the availability of mitigating resources. The results show that public finances recover sooner and faster in the event of other mitigating measures in place. The rise in debt is also more modest.

Figure 6. Deficit and Debt Paths with and without Mitigating Mechanisms
(Percent of GDP)



Source: Authors' calculations.

Translating the Calibrated Deficit Path to Different Types of Rules

The calibration of the operational deficit ceilings derived from various approaches above could be interpreted as limits in the deficit rule in the rules-based fiscal framework. The deficit paths can also be translated to other types of fiscal rules, such as expenditure rules or cyclically adjusted budget balance rules. This note can be useful to derive a corresponding threshold for the expenditure ratio to GDP or cyclically adjusted primary balance. For a given deficit target, the cyclically adjusted primary balance ceiling should be sufficiently high to allow automatic stabilizers to fully operate during a typical economic downturn. For the calibration of expenditure rules, which are often expressed in terms of expenditure growth or ratio to GDP, the calibrated deficit paths could be turned to expenditure ceilings with the assumption of the corresponding revenue-to-GDP ratios.

REFERENCES

Acevedo, Sebastian. 2014. "Debt, Growth and Natural Disasters: A Caribbean Trilogy." IMF Working Paper 14/125, International Monetary Fund, Washington, DC.

Banholzer, Sandra, James Kossin, and Simon Donner. 2014. "The Impact of Climate Change on Natural Disasters." In *Reducing Disaster: Early Warning Systems for Climate Change*, edited by Ashbindu Singh and Zinta Zommers, 21–49. Berlin: Springer Publishers.

Cabezon, Ezequiel, Leni Hunter, Patrizia Tumbarello, Kazuaki Washimi, and Yiqun Wu. 2015. "Enhancing Macroeconomic Resilience to Natural Disasters and Climate Change in the Small States of the Pacific." IMF Working Paper 15/125, International Monetary Fund, Washington, DC.

Cavallo, Eduardo A., and Ilan Noy. 2009. "The Economics of Natural Disasters: A Survey." IDB Working Paper IDB-WP-124, Inter-American Development Bank, Washington, DC.

Cevik, Serhan, and Guohua Huang. 2018. "How to Manage the Fiscal Costs of Natural Disasters." How-To Note 2018/003, International Monetary Fund, Washington, DC.

Eyraud, Luc, Anja Baum, Andrew Hodge, Mariusz Jamuzek, H. Elif Ture, Samba Mbaye, and Young-Bae Kim. 2018. "How to Calibrate Fiscal Rules: A Primer." How-To Note 2018/002, International Monetary Fund, Washington, DC.

International Monetary Fund (IMF). 2016. *Analyzing and Managing Fiscal Risks—Best Practices*. Washington, DC: IMF.

International Monetary Fund (IMF). 2019. "2019 Article IV Consultation with Grenada: Staff Report." IMF Country Report 19/192, Washington DC.

International Monetary Fund (IMF). 2022. "Grenada: Disaster Resilience Strategy." IMF Country Report 22/80, Washington DC.

Klomp, Jeroen. 2015. "Sovereign Risk and Natural Disasters in Emerging Markets." *Emerging Markets Finance and Trade* 51 (6): 1326–41.

Klomp, Jeroen. 2017. "Flooded with Debt." *Journal of International Money and Finance* 73 (May): 93–103.

Koetsier, Ian. 2017. "The Fiscal Impact of Natural Disasters." Tjalling C. Koopmans Research Institute Discussion Paper Series 17-17, Utrecht School of Economics, The Netherlands.

Lian, Weicheng, Jose Ramon Moran, and Raadhika Vishvesh. 2022. "Natural Hazards, Disasters, and Scarring Effects." IMF Working Paper 22/53, International Monetary Fund, Washington, DC.

Lis, Eliza M., and Christiane Nickel. 2010. "The Impact of Extreme Weather Events on Budget Balances." *International Tax and Public Finance* 17 (4): 378–99.

Melecky, Martin, and Claudio E. Raddatz. 2011. “How Do Governments Respond after Catastrophes? Natural-Disaster Shocks and the Fiscal Stance.” World Bank Policy Research Working Paper 5564 (2011), World Bank, Washington, DC.

Melecky, Martin, and Claudio Raddatz. 2015. "Fiscal Responses after Catastrophes and the Enabling Role of Financial Development." *The World Bank Economic Review* 29 (1): 129–149.

Nishizawa, Hidetaka, Scott Roger, and Huan Zhang. 2019. “Fiscal Buffers for Natural Disaster in Pacific Island Countries.” IMF Working Paper 19/150, International Monetary Fund, Washington, DC.

Noy, Ilan. 2009. “The Macroeconomic Consequences of Disasters.” *Journal of Development Economics* 88 (2): 221–31.

Standard and Poor’s. 2015. “Special Report: Climate Risk: Rising Tides Raise the Stakes.” *Insights*, December.

PUBLICATIONS

Calibrating Fiscal Rules: A Consideration of Natural Disaster Risks

TNM/2023/02

ISBN 979-8-40023-750-8

9 798400 237508