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Abstract

How should small states formulate a countercyclical fiscal policy to achieve economic stability and fiscal sustainability when prone to natural disasters, climate change, commodity price changes, and uncertain donor grants? We study how natural disasters and climate change affect long-term debt dynamics and propose cutting-edge fiscal policy rules. We find the advantages of a recurrent expenditure rule based on non-resource and non-grant revenue, interdependently determined by government debt and budget balance targets with expected disaster shocks. Our rule-based fiscal policy framework is practically applicable for many developing countries facing increasing frequency and impact of devastating natural hazards and climatic change.

1. Introduction

How should small, fragile islands formulate fiscal policy when vulnerable to various shocks such as natural disasters, climate change, commodity price fluctuations or uncertain donor grants? Fiscal rules help mitigate the effects of such shocks on the economy. We develop an analytical framework for a rule-based fiscal policy to ensure fiscal sustainability and economic stability in countries most prone to natural disasters, with a focus on Pacific Islands. Our contributions are: (1) to show how permanent natural disaster shocks or climate change affect the sustainable, steady-state debt-to-GDP ratio; (2) to propose a recurrent expenditure rule interdependently determined by government debt and budget balance targets, incorporating probabilistic disaster shocks; and (3) to define a recurrent expenditure rule robust to natural disasters, commodity price fluctuations, and uncertain grant revenues.

Fiscal policy in the Pacific needs to address region-specific factors in addition to basic objectives. In principle, fiscal policy has three functional objectives: first, stabilize economic cycles via countercyclical policy; second, redistribute national wealth across sectors and reduce poverty; third, support sustainable economy via public goods. The Pacific Islands have large infrastructure gaps, and infrastructure needs to be made more climate/disaster resilient because natural disasters and climate change, including storms, earthquakes, volcanic activity, floods, droughts, and landslides, affect the Pacific island economies (Nakatani 2019a). The economic impacts of frequent natural disasters are intense; The cyclones in 2015-16 caused economic damage equivalent to 25 percent of GDP in Fiji and 64 percent in Vanuatu. A severe drought and commodity price declines in Papua New Guinea (PNG) reduced agricultural and mining productions and fiscal and foreign exchange revenues (Nakatani 2017, 2018). The biggest earthquake in 100 years hit PNG in 2018, suspending LNG, oil, and gold mining operations, lowering economic growth sharply.

Another relevant factor for the Pacific Islands is uncertain donor grants. Remittances are equally important financial flows to mitigate the impact of natural disasters.

The Pacific Islands experience higher macroeconomic volatility because of less economic diversification, which increases their vulnerability to terms-of-trade or commodity price shocks. Moreover, the default fiscal framework in many disaster-prone states is procyclical since they have de-facto balanced budget rule under limited borrowing capacity (i.e. revenue volatility leads to expenditure volatility). The fiscal authorities face difficulty in adjusting to macroeconomic shocks due to the lack of timely macroeconomic data, which weakens the scope for countercyclical measures. The fiscal balance positively correlates with output in developing countries (Nakatani 2019b) and 65 percent of them show a procyclical fiscal policy

(Frankel et al. 2013). Hence, they need to frame rules that insulate spending from revenue volatility.

This paper analyzes fiscal rules in small islands prone to natural disasters. First, we observe the debt-to-GDP ratio maximizing the primary balance from data. Second, we show how to calibrate a debt-to-GDP target in the event of natural disasters. Third, the impact of unexpected climate change shocks on debt sustainability is studied. Fourth, the debt target with probabilistic natural disaster shocks is connected to fiscal balance, expenditure, and revenues. Finally, we recommend a recurrent expenditure rule, which has several advantages: it allows government expenditure required for recovery of damages by disasters; it does not require potential GDP growth rates difficult to estimate for small islands; and it is free from a prerequisite for expenditure growth rule (initial fiscal position is in the steady state). We provide an application of these rules to PNG.

Figure 1: Sovereign Default Episodes in Selected Pacific Island Countries
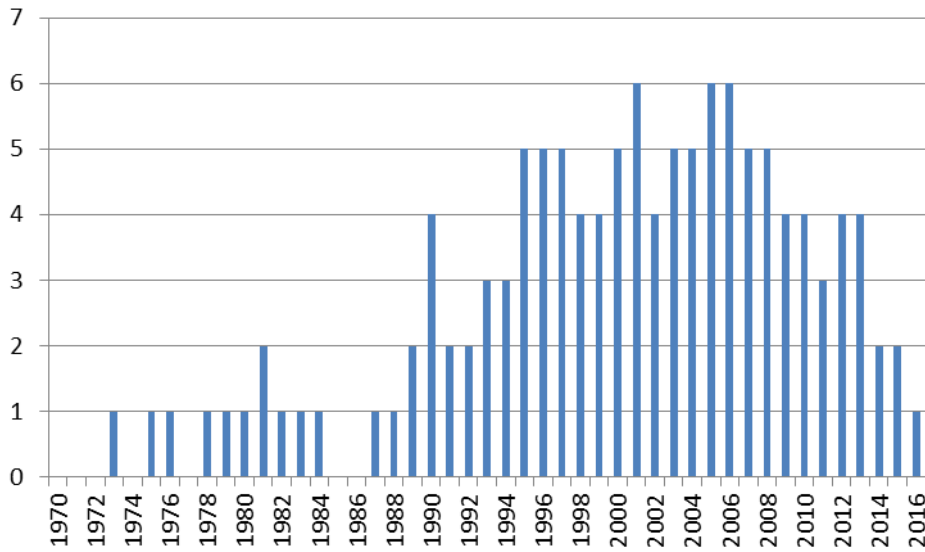
Note: Sample countries are Fiji, Nauru, PNG, Samoa, Solomon Islands, Tonga, and Vanuatu. Data on the other Pacific island countries are not available.

Source: Bank of Canada Sovereign Default Database.

Fiscal rules reduce procyclicality of economy and maintain fiscal sustainability while meeting infrastructure needs. They also control the pressure to overspend during good times and ensure fiscal responsibility, prudence, and debt sustainability. A debt rule critically maintains long-run fiscal sustainability. This is important because the Pacific island countries have experienced frequent sovereign defaults in history (Figure 1). To keep the debt-to-GDP

ratio under certain limits, a budget balance rule should constrain the size of the budget deficit as an operational guide, backed by expenditure or revenue rules. Since revenue has automatic stabilizer effects on the economy, the expenditure policy is desirable to achieve a budget balance rule. Furthermore, investment-friendly rules are important for the Pacific Islands because of large infrastructure needs amplified by natural disasters/climate change. On the revenue side, it may be important to set a floor for revenue, so that the government can secure adequate revenues for policy objectives, and to determine the use of windfall revenues, especially for commodity exporters.

External and internal constraints and economic shocks affect the design and application of fiscal rules. Pacific Islands face binding external borrowing constraints and cannot issue sovereign bonds internationally to prepare for future natural disasters. Most islands have inadequate reserves to cover catastrophic disasters. Not only permanent shocks (e.g. climate change) but also changes in the long-term interest rates or in the fiscal regimes (e.g. new resource projects, fishing agreements) affect fiscal sustainability. Thus, we should consider how they change the implications of fiscal rules and the ability to cope with substantial shocks. Lastly, operational simplicity is preferable when designing the fiscal rules for the Pacific Islands, given their institutional capacity.

2. Literature Review

Fiscal rules are of four types: (1) debt rules, (2) budget balance rules, (3) expenditure rules, and (4) revenue rules. Key objectives as well as pros and cons of each fiscal rule are discussed below.

The key objective of debt rules is fiscal sustainability. Debt rules set the limits or targets for public debt in percent of GDP to ensure debt sustainability. Despite their easiness to communicate, debt rules do not provide clear short-run operational guidance.

Budget balance rules give operational guidance to achieve the debt target/rule, and they are also easy to communicate with public. Asatryan et al. (2018) find that the introduction of a balanced budget rule is associated with lower government debt-to-GDP ratios and lower probability of a sovereign debt crisis. This is achieved by decreasing government expenditure.

Expenditure rules are effective for macroeconomic stabilization. Expenditure rules are more effective than revenue rules because government revenue is more difficult to target or effectively control. Expenditure rules are easy to understand, monitor and enforce, as the government directly controls the expenditure. Caps on expenditure growth (in line with potential growth) is an operational target well under control of policy-makers, being more

transparent and more resilient to measurement errors. Cons of expenditure rules are that they may reduce incentives to mobilize revenues.

However, capping expenditure growth is not suitable for the Pacific Islands. An expenditure growth rule related to potential GDP should be applied only when the initial fiscal position is deemed appropriate. Potential GDP is difficult to estimate for Pacific Islands, and it is hard to believe that they are currently close to steady-state revenue-to-GDP ratios because the increasing frequency and impacts of natural disaster change steady-state parameters. Moreover, capping expenditure growth constrains government expenditure required for recovery of damages caused by disasters. Therefore, we analyze the new type of expenditure rule which is linked to the source of revenue.

The practical way to determine fiscal rules is to begin with a debt ceiling or target. Public expenditure and budget balance should be countercyclical to economic cycles for stabilization. Thus, budget balance can be positive or negative in the short run. However, in the long term, fiscal policy should ensure the debt sustainability. Otherwise, governments face fiscal crises and a debt overhang could constrain government activities.

What is a reasonable level for debt ceiling? Although little literature studied the debt threshold for the Pacific Islands, the empirical literature suggests that the debt limit for other developing countries is broadly between 35 and 55 percent of GDP. Panel threshold analysis by Tran (2018) reveals debt thresholds of 40–55 percent for non-Latin American and 35 percent for Latin American countries. After public debt exceeds a certain threshold level (55 percent of GDP), it is negatively correlated with economic activity in Malaysia (Baharumshah et al. 2017) and in the Caribbean (Greenidge et al. 2012).

Apparently, fiscal rules incorporating natural disasters or climate change have not been analyzed. Instead, natural disaster funds are proposed as the main policy tool. However, this advice may be difficult to implement in the Pacific Islands who face frequent and sizable natural disasters and do not have enough savings in the fund. Thus, we analyze the effects of natural disasters on the fiscal rules.

Is there any literature on fiscal rules for the Pacific Islands? No. This may be partly because only limited information and data are available for these countries. Thus, we examine fiscal rules customized for the Pacific Islands, which can be applicable to other small states in the Caribbean or Africa.

Table 1: Fiscal Rules or Targets in the Pacific Island Countries

Type of Fiscal Rule or Target	Pros	Cons	Countries Using the Rule or Target
Debt Rule	Debt Sustainability; Easy Communication	No Operational Guidance	Fiji; Papua New Guinea (PNG); Samoa; Solomon Islands; Tonga; Vanuatu
Budget Balance Rule	Effective	Procyclicality	Palau; Samoa; Vanuatu
Golden Rule	Link to Debt	Creative Accounting	Solomon Islands
Permanent Income Hypothesis	Intergenerational Equity	Hard to Calculate	PNG
Expenditure Rule	Effective; Monitoring; Countercyclicality	Not Directly Linked to Debt Sustainability	---
Personnel Emolument Rule	Targeted; Simplicity; Operational Guidance	Narrow Coverage; Evasion to Unconstrained Category	PNG; Tonga
Recurrent Spending Rule	Broad Coverage; Development Needs	Not Directly Liked to Debt Sustainability	---
Revenue Rule	Automatic Stabilizer	Procyclicality	Tonga; Timor-Leste
Cash Buffers Rule	Economic Stabilization; Resilience	Opportunity Costs	Solomon Islands; Tonga

Pacific islands have various fiscal rules or targets (Table 1). Fiji has a 40 percent debt-to-GDP ratio as an indicative ceiling. Palau has a non-negative budget balance rule. Some countries have a combination of debt and budget balance rules. Solomon Islands has a public debt limit of 30 percent of GDP and a budget balance rule in which recurrent spending should be financed by revenue (not by debt; golden rule). Samoa has both debt (50 percent of GDP excluding contingent liabilities) and fiscal deficit limit of 2 percent of GDP, while Vanuatu has 40 percent anchor of the present value of government debt-to-GDP ratio and ex ante recurrent budget balance rule. Tonga has several fiscal rules and targets: external public ceiling of 50 percent of GDP; compensation for employees should be below 53 percent of domestic revenue and 45 percent of operating expense; minimum revenue target of 22 percent of GDP; and cash buffers equivalent to three months of recurrent spending. Similarly, PNG also has multiple fiscal rules and targets. First, PNG has a debt target that aims to limit gross central government debt-to-GDP ratio within a range of 30 to 35 percent of GDP. Second, PNG also has a zero average non-resource primary balance target over the medium term. Furthermore, PNG has an expenditure rule that limits personnel emolument costs below 40 percent of non-resource and non-grant revenue. Given the size of the economy and its diversified economic structure

encompassing all characteristics of the Pacific Islands (i.e. commodity exporters, reliance on grants, frequent natural disasters, and climatic shocks) as well as data availability, we choose PNG as an example of a Pacific island country in our analysis of fiscal rules.

3. Analysis of Fiscal Rules and Targets

We analyze five different fiscal rules and targets against natural disasters. We discuss debt, budget balance, expenditure, revenue, and cash buffer rules and targets. Note that fiscal targets are objectives to be achieved by the fiscal policy, while fiscal rules are the means or constraints to achieve the targets. Beginning with a debt target, we first discuss how natural disasters and climate change affect debt dynamics. We should distinguish between temporary shocks – natural disasters – which do not change the steady state, and permanent shocks – climate change – which do. Then, we study the implications of debt for budget balance. Next, we propose expenditure rules and their relationship with revenue structure and disaster funds.

3.1. Long-Run Debt Target

First, we discuss debt targets. We show two approaches for debt targets: an empirical approach and a normative approach. We start our discussion with the empirical approach.

Figure 2: Debt Ceiling with Fiscal Reaction Function
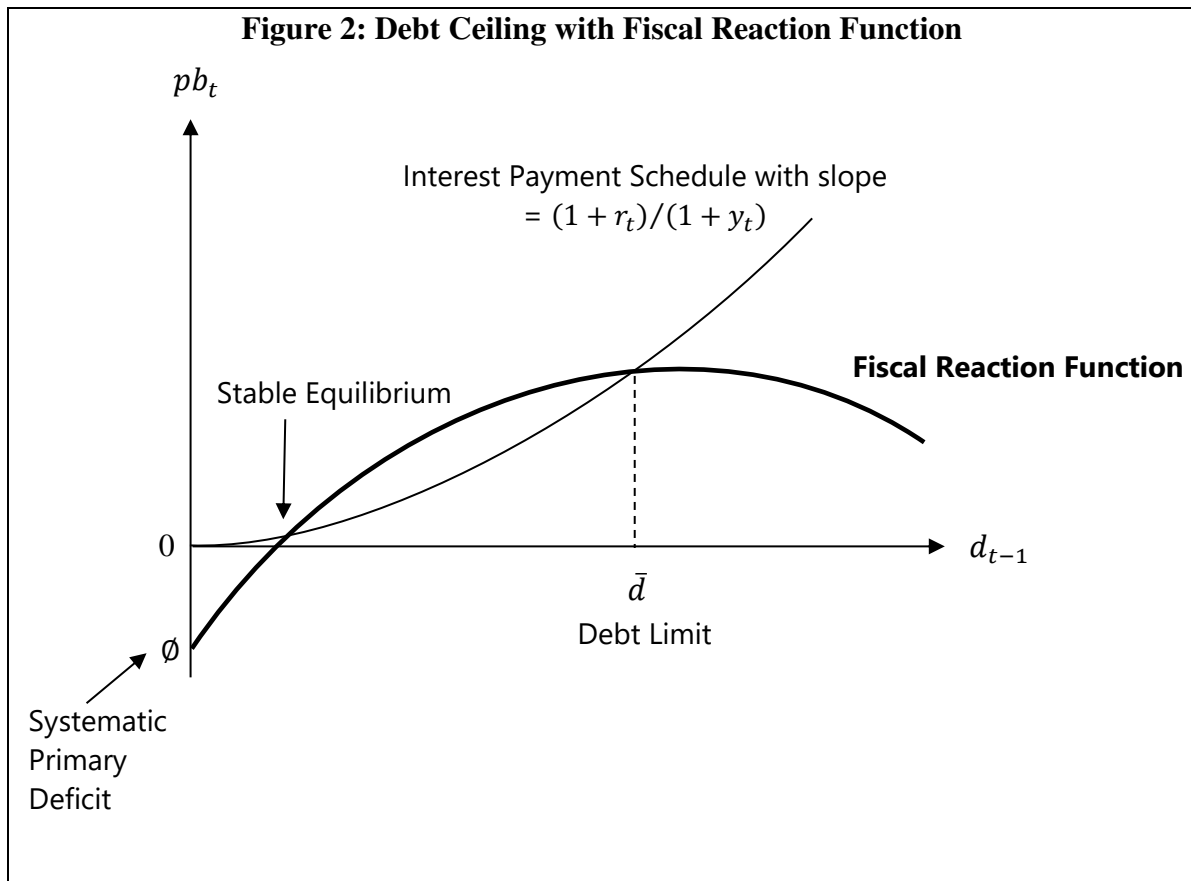
We use country panel data of Pacific Islands to find the debt-to-GDP ratio that maximizes the primary balance. There is a nonlinear relationship between the primary balance and debt ratio if the fiscal reaction function is assumed (Figure 2). As shown in Figure 2, the fiscal authority can respond nonlinearly to the debt level. In this endogenous relationship between primary balance and debt level, the fiscal reaction function can be defined as follows.

$$pb_t = \emptyset + \alpha_1 pb_{t-1} + \beta_1 d_{t-1} + \beta_2 (d_{t-1})^2 + \epsilon_t \tag{1}$$

where pb_t is the primary balance, $\emptyset$ captures all systematic determinants of the primary balance other than lagged debt; β are estimated coefficients on lagged debt level d_{t-1} ($\beta_1 > 0, \beta_2 < 0$), and $\in_t$ is an independent and identically distributed shock to the primary balance. In this case, multiple equilibria emerge to determine the debt level as Figure 2 shows. Note that interest payments are assumed to increase nonlinearly as the debt level goes up. In this setting, the debt limit becomes $\bar{d}$.

If there is a certain point of debt-to-GDP ratio that improves the primary deficit, fiscal sustainability is satisfied. In this context, we plot the Pacific island countries' data on primary balances and gross public debt-to-GDP ratios sourced from the IMF's World Economic Outlook Database. All available data from the Pacific island countries, during the period from 1990 until 2018, are included.[1] The descriptive statistics are shown in Table 2 and regression results are presented in Table 3. The regression equation is (1). Note that our intention here is to show some evidence of nonlinear relationship between debt and primary balance, and maximizing the primary balance is not a goal of fiscal policy.

Table 2: Descriptive Statistics

Variable	Mean	Median	Std. Dev.	Min	Max
Primary Balance	-0.961	-0.333	10.548	-39.522	47.537
Debt-to-GDP Ratio	26.980	25.980	16.557	0.000	76.680
Terms of Trade	94.861	96.650	5.670	74.120	107.870

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[1] Our unbalanced country panel data includes Fiji, Kiribati, Marshall Islands, Micronesia, PNG, Solomon Islands, Timor-Leste, Tuvalu, and Vanuatu. Data for Nauru, Palau, Samoa, and Tonga are not available.

Table 3: Results of Estimated Fiscal Reaction Function for the Pacific Islands

	(1) Baseline Estimation	(2) Robustness Check
Primary Balance (PB)_t-1	0.6570***	0.6485***
	(0.0573)	(0.0655)
[Debt-to-GDP Ratio] × [Debt-to-GDP Ratio]	-0.0056**	-0.0051*
	(0.0024)	(0.0027)
Debt-to-GDP Ratio	0.3108**	0.2941*
	(0.1365)	(0.1560)
Terms of Trade		0.0426
		(0.1256)
Constant	-2.9033	-7.1370
	(1.7842)	(12.3257)
Implied PB Maximizing Debt-to-GDP Ratio	27.611	28.755
Corresponding PB	1.388	1.004
R-squared	0.445	0.436
F-statistic	49.967	27.429
Observations	191	147

*Note*: Standard errors are shown in parentheses.

   *** Statistically significant at the 1 percent level.

   ** Statistically significant at the 5 percent level.

   * Statistically significant at the 10 percent level.

Our baseline estimation results in the first column of Table 3 shows both quadratic and linear terms of debt-to-GDP ratio are statistically significant at the five percent level. Note that we include the lagged dependent variable as a regressor in our estimation because the literature often finds that the primary balance is autocorrelated. We find that the primary balance is maximized at a 28 percent debt-to-GDP ratio in the Pacific Islands. Figure 3 shows the relationship between the public debt-to-GDP ratio and primary balance as a percentage of GDP. There is a slightly nonlinear relationship between these two variables, as the fiscal reaction theory predicts. An economic intuition behind this is that countries can benefit from debt financing by increasing investment and enlarging the economic base with low debt, but the costs of repaying debt increase as the debt reaches a critical level. For robustness checks, we also include a commodity terms of trade index published by the IMF as an independent variable since the literature suggests that low-income countries are dependent on terms-of-trade fluctuations. Our robustness check in the second column of Table 3 indicates that the statistical significance of estimated coefficients, R-squared, and F-statistic become lower than the baseline, partly due to the reduced sample size. Again, the estimated primary balance maximizing debt-to-GDP ratio is around 28 percent. Therefore, we conclude that the primary balance maximizing debt-to-GDP ratio is slightly lower than the 30 percent in the Pacific island countries, which lies at the lower bound of the case for other emerging market economies

explained in the literature review section. This result is not surprising if we take into account the small economic base and the nature of small insular economy, which is vulnerable to natural disasters and climate change.

Figure 3: Debt-Growth Nexus in the Pacific Islands

Source: IMF World Economic Outlook Database, October 2019.
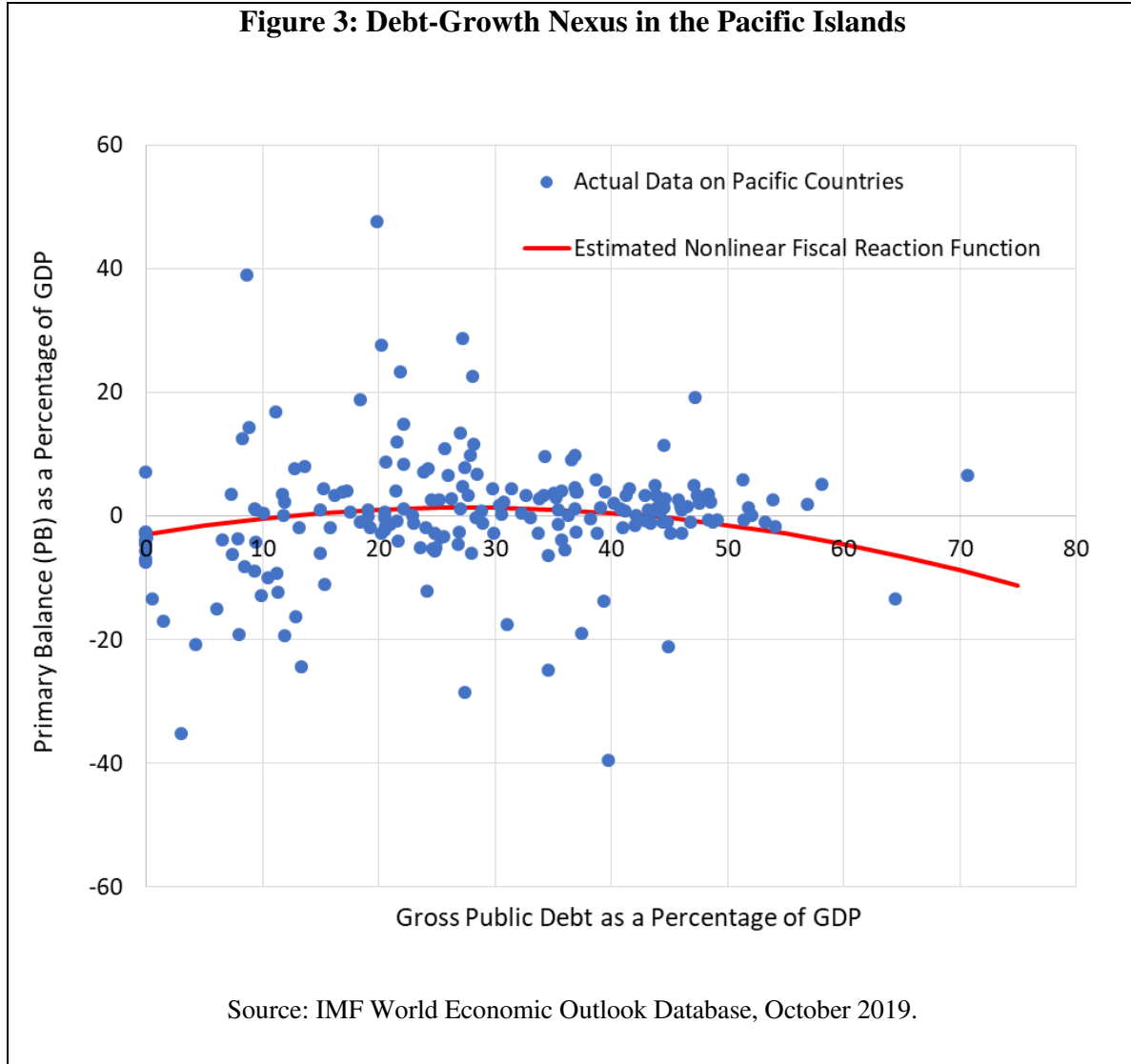
Next, fiscal rules for small islands are discussed from a normative perspective, incorporating a natural disaster shock into the debt sustainability framework. We examine public debt dynamics, starting from the government's cash-flow constraint:

$$T_t + G_t + O_t + D_t + \Delta M_t = E_t + K_t + (1 + i_t)D_{t-1} + S_t N_t \qquad (2)$$

where T_t is tax revenue; G_t is grants from donor countries; O_t is other revenue including dividends from state mineral companies; D_t is government debt; $\Delta M_t = M_t - M_{t-1}$ is money

issuance;[2] E_t is government recurrent expenditure;[3] K_t is capital expenditure (i.e. public investment); $(1 + i_t)D_{t-1}$ is the repayment of debt issued in the previous period; S_t is the share of the net fiscal cost of shock that is picked up by the government; and N_t is the GDP impact of the shock such as a natural disaster. It is to be noted that $S_t N_t$ is the net effect of a disaster shock on the budget balance for analytical convenience, that is, the effect of spending minus revenue.[4] In other words, each component of revenue and expenditure without a natural disaster is expressed in items before this cross-term $(S_t N_t)$ in equation (2).

Equation (2) can be rewritten by dividing it into resource and non-resource revenues. In many Pacific island countries, donor grants G_t are an important source of budget funding. In the case of commodity exporters, mineral taxes in $T_t^{resource}$ and mining and gas dividends in $O_t^{resource}$ are also important revenue sources.

Non-Resource Revenue = $R_t^{non-resource}$

Resource Revenue = $R_t^{resource}$ Stable Revenue = $R_t^{structural}$

$$\underbrace{T_t^{resource} + O_t^{resource}}_{} + \underbrace{T_t^{non-resource} + O_t^{non-resource}}_{} + G_t + \Delta M_t + D_t$$
$$= E_t + K_t + (1 + i_t)D_{t-1} + S_t N_t \tag{3}$$

If we divide equation (2) by nominal $GDP_t = P_t Y_t$, where Y_t is real GDP and P_t is the GDP deflator, all the variables can be expressed as shares of GDP in lower-case letters:

$$t_t + g_t + o_t + d_t + \mu_t = e_t + k_t + (1 + i_t)/\{(1 + y_t)(1 + \pi_t)\} d_{t-1} + s_t n_t \tag{4}$$

where $y_t = Y_t/Y_{t-1} - 1$ is the real growth rate of output; and $\pi_t = P_t/P_{t-1} - 1$ is the inflation rate (for GDP deflator). To simplify the notations, the real interest rate is denoted by $1 + r_t \equiv (1 + i_t)/(1 + \pi_t)$, and the primary balance is expressed as $pb_t = t_t + g_t + o_t - e_t - k_t$. Then, the budget constraint implies the following debt dynamics;

$$d_t = (1 + r_t)/(1 + y_t) d_{t-1} - pb_t - \mu_t + s_t n_t. \tag{5}$$

In the steady state where $d^* \equiv d_t = d_{t-1}$, equation (5) becomes:

$$d^* = (pb + \mu - sn)/\{(1 + r)/(1 + y) - 1\}. \tag{6}$$

The debt dynamics in equation (5) are shown graphically in Figure 4, for the case where the real interest rate is higher than the growth rate.[5] This is a case when debt could diverge from

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[2] Fiscal deficit can be financed by the central bank.
[3] Recurrent expenditure is defined as expense (which is expenditure excluding net acquisition of non-financial assets) minus interest. Put differently, recurrent expenditure is calculated as a sum of compensation of employees, use of goods and services, grants, social benefits, and other expenses.
[4] This framework can be also applied to other types of shock, namely the terms-of-trade shock.
[5] The primary balance is assumed to converge toward a certain point in the steady state.

the steady-state value d^* (Note that we do not analyze the case where the real interest rate is lower than the growth rate because in this case the debt dynamics automatically converges toward the stable steady-state debt level over time and hence there is no need for fiscal policy rule). Thus, it is crucial to have the debt level below the steady-state value to keep debt sustainable (we do not worry about the case where the debt diverges toward zero because it is unrealistic).[6] sn represents the long-term historic average of the impact of disasters. This approach is a straightforward way to include the effects of natural disasters when considering debt sustainability in the long term.[7] An economic intuition is that the amount $sn/\{(1+r)/(1+y) - 1\}$ can be understood as a debt buffer against natural disasters. Note that steady-state parameters can be affected by the governmental activity. For instance, the government can choose the primary balance (pb) in the steady state to change the steady-state debt level (d^*). In this sense, we can think of the primary balance as a choice variable for the government.

Figure 4: Debt Dynamics with Natural Disaster Shocks

$$d_t = \frac{1+r_t}{1+y_t} d_{t-1} - pb_t - \mu_t + s_t n_t$$
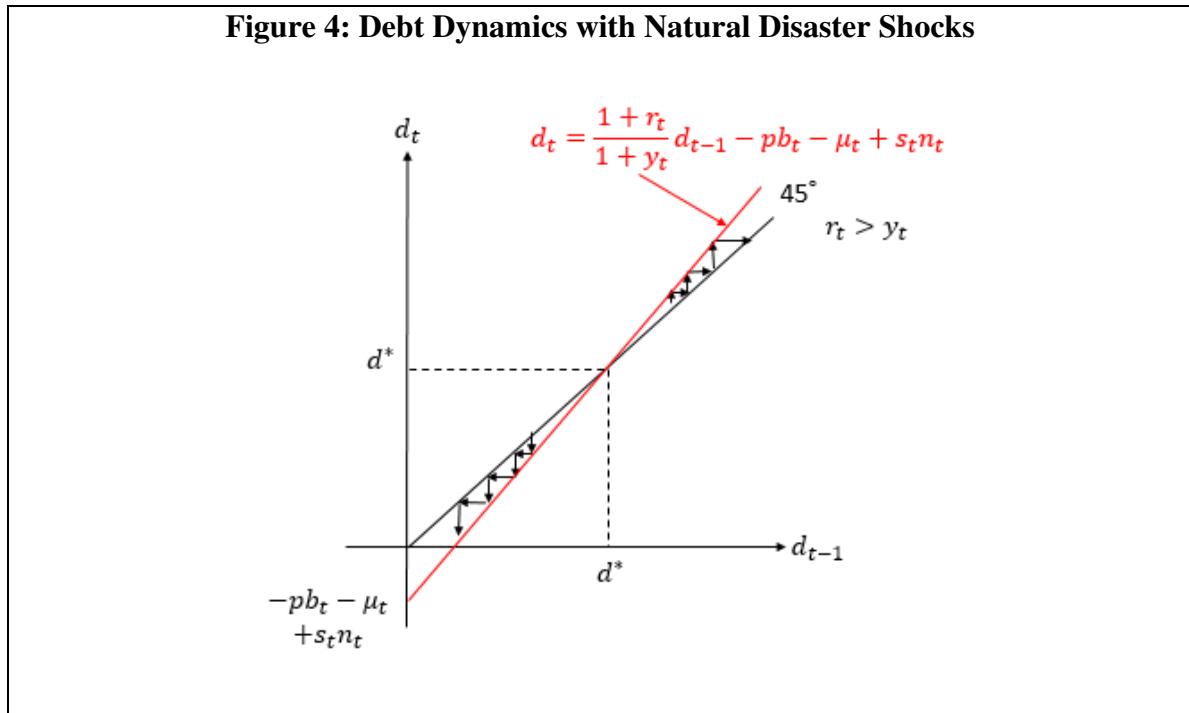
In our example of PNG, simple calculation indicates that the steady-state debt level is around 30 percent. In this exercise, the following steady-state values are assumed: a 0.4 percent

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[6] The sustainability of debt depends on the concessional element of debt in the steady state. Concessional debt is more sustainable than commercial debt, owing to the lower interest rate.

[7] Another approach to calibrate the debt target is by doing stochastic simulations (via e.g. VAR) to know the debt threshold over which the debt becomes unsustainable. However, due to limited availability of economic data in the Pacific island countries, this approach is not practically useful.

of GDP primary budget surplus ($pb = 0.004$)[8]; a money creation rate of 0 percent (i.e. no central bank financing for budget deficit; $\mu = 0$); a real interest rate of 4.5 percent ($r = 0.045$); a real potential growth rate of 3.8 percent ($y = 0.038$); an expected natural disaster shock per year of 0.2 percent of GDP ($n = 0.002, s = 1$), as calculated by Lee et al. (2018).[9] These values are chosen by taking into account various long-term factors and assumptions so that they are consistent with the IMF's debt sustainability analysis and macro framework at the end of the projection period.[10] For example, when we make an assumption about the real interest rate, it is calculated as the nominal interest rate minus the inflation rate. The nominal interest rate assumption reflects the trend and level of interest rate before the country experienced large negative commodity price shocks in 2014, and thereafter, fiscal crunch and foreign exchange shortages. Please note that these parameters are the long-run steady-state values of growth rate and real interest rate, so these are not affected by the countercyclical fiscal policy. However, a drawback of this steady-state analysis is that the result is sensitive to parameters and it is not easy to know true steady-state values. Thus, the exercise presented in this paper should be treated as an illustration rather than true values for PNG.

We also analyze the effects of permanent natural disasters or climate change shocks on debt dynamics. We analyze two cases because the impact of disasters on economic growth and the risk premium is ambiguous. The existing literature finds that the effects of natural disasters on economic growth can be either negative or positive (Kousky 2014). Although it is likely that climate change or natural disasters affect economic growth negatively in the long term, some empirical studies found positive effects. For example, Skidmore and Toya (2002) find that climate disasters are positively correlated with long-run economic growth rates and higher total factor productivity. According to Cavallo et al. (2013), catastrophic natural disasters do not have a significant effect on economic growth in either the short term or the long run. Natural disasters can also affect country risk premiums. Klomp (2015) finds that geophysical and meteorological disasters (e.g. earthquakes, tsunamis, volcanic eruptions, and storms) increase

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[8] If we estimate the primary balance maximizing debt level for PNG using the baseline estimation regression in Table 3, it becomes 22.3 percent of GDP and a corresponding primary balance is maximized at 3.9 percent of GDP.

[9] The magnitude of disaster shocks should be the effect on budget balance ($s_t n_t$). However, it is very difficult to estimate it in the Pacific islands because of limited information. The 0.2 percent shock used here is the effect on GDP assuming that the government can offset the adverse impact on the economy in the steady state ($s = 1$). This is the lower bound of the impact of extreme weather events on budget balance, as Lis and Nickel (2010) find the fiscal impact ranges between 0.2 and 1.4 percent of GDP.

[10] As explained in introduction, PNG economy has been hit by various shocks, so the actual negative primary balance and other economic variables in recent years should not be perceived as long-term steady state values.

the sovereign risk premium, whereas hydrological and climatic disasters (e.g. flood, droughts, and wildfires) do not affect the premium in the long term. Therefore, the effects of natural disasters on growth and interest rates in the steady state are somewhat ambiguous in general. However, it is likely that natural disasters have adverse growth impacts on low-income countries like Pacific Islands, given their limited reconstruction capacity in the aftermath of disasters.

The first case considered is an unexpected permanent natural disaster shock or climate change shock that increases long-term economic growth. For example, imagine the case where a massive earthquake occurs unexpectedly in the rural areas of PNG and one-way wooden bridges are replaced by two-way steel bridges. Then, better-quality infrastructure helps agricultural workers to transport a higher number of coffee bags for export. We can interpret this as a case in which economic disruptions caused by natural disasters trigger positive technological shocks during the recovery process.[11] In such a case, the steady-state debt level could be higher than before the shock because of the improved long-run economic growth, as shown in the left panel of Figure 5.

By contrast, let us consider a second case, in which climate change dampens economic activity permanently. For example, if global warming causes the sea levels to rise in the Pacific Ocean, climate change shocks increase the probability and severity of natural disasters as atoll nations (such as Tuvalu and Kiribati) loses land for economic activities. This is a serious concern for the northern islands in the South Pacific region, and it corresponds to the case shown in the right panel of Figure 5. In this case, the steady-state debt level should be lower than earlier because of lower economic growth relative to the interest rate in the steady state. This exercise implies that if an unexpected permanent shift in the probability of natural disasters is observed, the debt target should be reconsidered or revised.

Note that this argument can be also applied if the government changes the preference of covering the disaster loss. In other words, a shock to variable "$Climate_t = s_t n_t$" does not have to be more destructive or more frequent disasters, but could come from the government covering a larger share of the cost (s_t) of a natural disaster shock to the GDP.[12] This could also be relevant to terms-of-trade shocks if the government tax or subsidy policy provides better for

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[11] Note that this oversimplifies and overestimates the impact because we are comparing to a case in which the poor-quality infrastructure is never replaced. In reality, it would eventually be replaced, so that the disaster really only brings the replacement date forward. Essentially we are treating a temporary total factor productivity shock (which could be quite long) as permanent.

[12] When choosing the value of share (s_t), the government needs to consider the disaster recovery efforts made by the private sector and the local communities.

the private sector.

Figure 5: Impact of Unexpected Permanent Natural Disasters/Climate Change Shocks
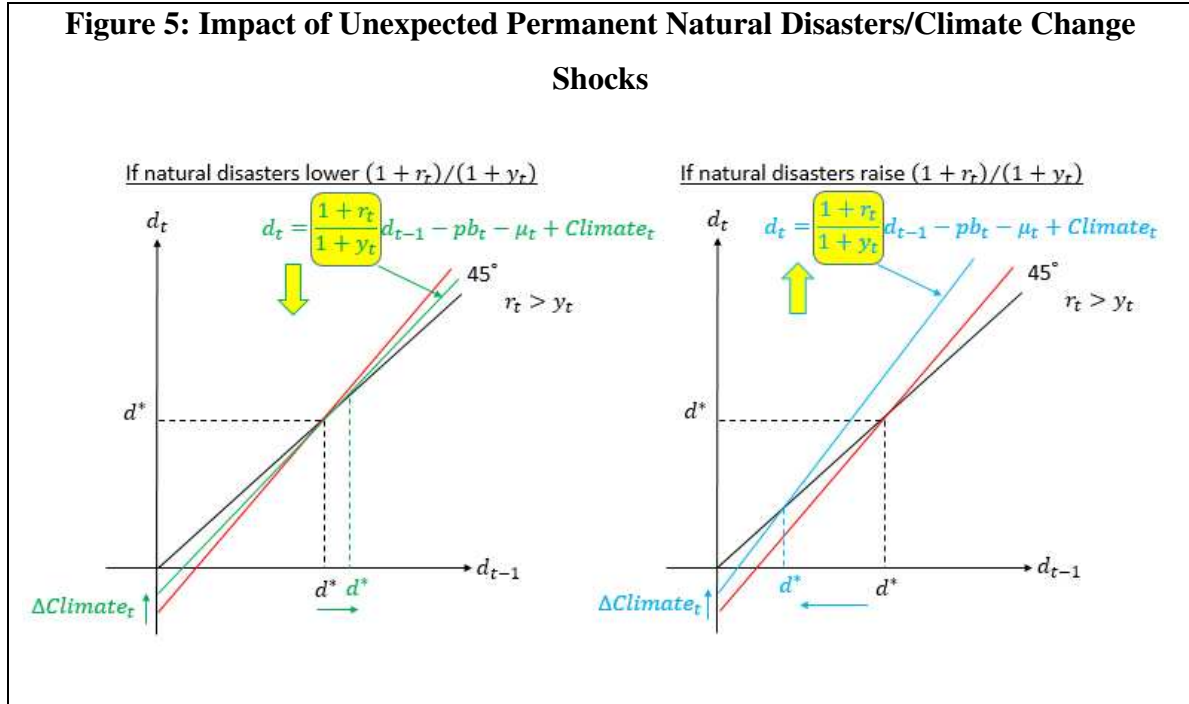
3.2. Budget Balance Target

We have so far analyzed how to adjust the debt target to include the effects of natural disasters. The next step is to derive a budget balance target. Small states typically have no well-defined economic cycles, which make it difficult to define the structural budget balance. Even if we can calculate the structural budget balance by using some filtering techniques, it is well known that the structural balance is very sensitive to calculation methods. Additional complexities of defining the business cycle arise in the case of a resource-rich economy, such as PNG or Solomon Islands. Given these technical problems, we recommend using the headline budget balance as an anchor when formulating budget balance targets in the Pacific Islands.

How can we derive the budget balance target from the debt target?[14] Since the change in debt (ΔD_t) equals the budget deficit ($-B_t$), the debt equation can be written as:

$$D_t = D_{t-1} + \Delta D_t; \Delta D_t = -B_t \tag{7}$$

where $B_t = T_t + G_t + O_t + \Delta M_t - E_t - K_t - i_t D_{t-1} - S_t$ is the budget balance. Dividing this equation by nominal GDP with nominal growth rate γ_t, the debt equation can be expressed as shares of GDP.

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[14] Here we focus on the overall budget balance rather than the primary balance for analytical simplicity.

$$d_t = d_{t-1}/(1 + \gamma_t) - b_t \tag{8}$$

In the steady state, the budget balance as a percentage of GDP is given by[15]

$$b^* = -\gamma/(1 + \gamma)\, d^* \tag{9}$$

For PNG, the implied budget deficit target is 1.4 percent of GDP. Nominal GDP growth is assumed to be 5 percent in PNG ($\gamma = 0.05$).[16] Given the 30 percent debt target derived above ($d^* = 0.3$), budget deficit in the steady state is calculated as 1.4 percent of GDP in PNG ($b^* = -0.014$). Bear in mind that we are talking about the long-run steady-state value of growth rate, which is not affected by the countercyclical fiscal policy. Again, please note that this value is presented as an illustration rather than the recommended value.

If the actual budget balance b_t deviates from the target b^* in practice, the fiscal authority can decide the adjustment period with a time span of λ years. This is because that sticking with a fixed budget deficit target implies that the impact of shocks moving the debt/GDP ratio away from target will only be eliminated asymptotically. The fiscal adjustment (or budget balance rule) to achieve the target each year during the adjustment period (from year $t + 1$ until year $t + \lambda$) is;

$$(b_t - b^*)/\lambda, \forall b_t \neq b^*. \tag{10}$$

This equation (10) is a simple linear adjustment rule. Depending on the preference of the fiscal authorities, other nonlinear adjustment rules are possible, too.

3.3. Expenditure Rule

It is more important to have an expenditure rule than a revenue rule to reduce the procyclicality of the economy. This is because some countercyclical fiscal policies are already embedded in government revenues. For example, if the economy is experiencing a downturn, profits and incomes of corporations and households decline; therefore, the base for direct taxation also diminishes. Sales of goods and services shrink, and indirect tax revenues such as value added tax decrease. In this respect, automatic stabilizer effects prevail as the tax burden decreases during the phase of economic contraction. The opposite effects occur during economic expansion. By contrast, government expenditure does not have the tendency to reduce procyclicality in the absence of fiscal rules.

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[15] The difference between primary balance and the budget balance in the steady state is just an interest expense in the steady state.

[16] Although the historical average of nominal GDP growth rate in PNG is higher, we exclude the impact of construction of massive LNG facility, which happened in recent years, when we calibrate the steady-state nominal growth rate.

An expenditure rule can be derived from the budget balance target or rule, assuming a revenue target. If we assume a 14.8 percent revenue-to-GDP target ratio, consistent with PNG's Medium Term Fiscal Strategy 2018–22, with 5 percent nominal GDP growth, the budget balance target can be interpreted as (1) a constant 16.2 percent of expenditure-to-GDP ratio (=14.8 percent+1.4 percent deficit), or (2) a ceiling of 5 percent nominal expenditure growth if PNG is already in an expenditure position consistent with the budget balance target.

Table 4: Volatility of GDP, Revenue, and Expenditure in the Pacific Island Countries

(Most Volatile Item, Second Most Volatile Item, More Volatile Ratio)

Country	GDP	Revenue	Expenditure	Expenditure/ GDP	Expenditure/ Revenue
Unit	Standard Deviation (SD)			SD divided by average for standardization	
Papua New Guinea	21.5	4.03	4.89	0.12	0.15
Fiji	2.70	0.74	0.85	0.09	0.08
Timor-Leste	1.81	0.33	0.54	0.63	0.24
Solomon Islands	3.34	1.68	1.66	0.37	0.13
Vanuatu	23.8	8.48	8.66	0.24	0.09
Samoa	0.58	0.20	0.21	0.19	0.10
Tonga	0.23	0.12	0.12	0.28	0.10
Micronesia	0.05	0.05	0.03	0.09	0.10
Palau	0.05	0.02	0.01	0.13	0.16
Marshall Islands	0.03	0.02	0.02	0.13	0.11
Kiribati	0.06	0.10	0.08	0.19	0.16
Nauru	0.03	0.06	0.05	0.27	0.11
Tuvalu	0.01	0.02	0.02	0.18	0.21

Source: IMF World Economic Outlook Database, October 2019.

For PNG, an expenditure rule related to non-volatile revenue has advantages in terms of volatility and cyclical stability, operational simplicity, and ease of understanding. Our example above has so far defined expenditure rules as a percentage of GDP for simple analytic purposes. However, GDP is more volatile than revenue in most Pacific island countries (Table 4 calculates the volatility of levels of variables). In such circumstances, defining expenditure

rules as a percentage of GDP may add procyclicality to economic performance.[17] In fact, the normalized volatility in the last two columns of Table 4 show that nine countries among thirteen countries would exhibit higher volatility if an expenditure rule is defined as a percentage of GDP rather than revenue.

Thus, expenditure rules defined as a percentage of stable revenue (non-resource, non-grant revenue) is preferable, for several reasons. First, a release of GDP data takes longer than estimation of revenue, and the impact of GDP revision is relatively large in the Pacific island countries. This is quite an important point in terms of operational feasibility. Second, since income tax revenues are based on the previous year's income of households and companies, expenditure rules based on revenue will be less volatile than if it is based on GDP, as it will not be affected by natural disaster shocks to GDP in the current year due to lags. Third, if the expenditure rule is defined as a percent of revenue, there is a direct link between expenditure and revenue and, as a result, the level of overall balance is uniquely determined and it will be easy to compute the level of spending irrespective of GDP. This is important for small fragile states because it is difficult to estimate the impact of natural disasters on GDP in a timely manner. All three reasons support the recommendation of revenue when formulating fiscal rules for the Pacific island economies.

Expenditure ceilings on certain spending categories (e.g. recurrent spending or personnel emoluments) may be useful in some circumstances. Ceiling on certain expenditure categories, particularly subject to pressure (e.g. wage bills, subsidies), may be considered. This is because the rule can give policy-makers clear operational guidance for enforcement. Operational guidance is a priority for countries with limited public financial management capacity. For instance, compensation for public employees has been an area of over-expenditure or under-budgeting in PNG during the past few years, and personnel costs have more than doubled over the past five years, partly reflecting the new Tuition Fee Free Policy. To address this situation, the Medium-Term Fiscal Strategy introduced an expenditure ceiling to cap personnel emolument costs below 40 percent of non-resource, non-grant revenue as shown in equation (11). Using non-resource, non-grant revenue (stable revenue) as a base is a good strategy, as it can help avoid volatile resource revenue and uncertain grant elements, which have been a common fiscal concern in the Pacific Islands. It would be practical to exclude foreign grants in the revenue as Becerra et al. (2014) find that foreign aid in the aftermath of massive natural

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[17] Another argument for reducing cyclicality of GDP is to use potential GDP like the European Union. However, the Pacific island countries do not have long GDP series time wise, and the presence of frequent natural disasters make it technically difficult to estimate potential GDP.

disasters only covers 3 percent of total economic damages caused by the disasters. Also, there is usually a time lag until the foreign aid arrives in country aftermath of disasters, and foreign aid sometimes does not enter the budget. Designing an expenditure rule to cap personnel emolument costs could be also useful for other Pacific Islands as this category is typically the largest expenditure item and some Pacific island countries (e.g. Kiribati; Vanuatu) have recently experienced a large increase in wages.

$$(Personnel\ Emolument_t)/R_t^{structural} * 100 < 40\% \tag{11}$$

For the Pacific island countries, an investment-friendly expenditure rule, such as recurrent spending as a percentage of stable revenue, is a practically useful rule for stabilization purposes (equation (12)). Put differently, the net acquisition of non-financial assets should be excluded from expenditure rule coverage since the government needs to rebuild infrastructure, such as coastal protection, in the event of natural disasters and there are still larger infrastructure requirements.[19] Recurrent spending rules are more robust than personnel emolument rules because (1) increases in use of goods and services are more serious concerns than personnel emoluments in some countries (e.g. Marshall Islands), and (2) salaries of public employees may be included in grants to local government in some countries (e.g. Fiji). In practice, to implement expenditure controls, public financial management systems need to be strengthened.

$$E_t/R_t^{structural} * 100 = X\% \tag{12}$$

What kind of adjustment is required to satisfy a recurrent spending rule, given that all budget items are interconnected by the government's cash-flow constraint? Assuming that the economy is satisfying the steady-state budget balance target in equation (9) before an actual disaster manifests as a shock, and using the government's cash-flow constraint (3), the recurrent expenditure rule (12) is given as:

$$1 + (R_t^{resource} + G_t + \Delta M_t - K_t - i_t D_{t-1} - S_t N_t - b^* P_t Y_t)/R_t^{structural} = X/100 \tag{13}$$

Note that the budget balance target b^* is a function of steady-state values of nominal and real GDP growth rates (γ and y), real interest rate (r), primary balance (pb), monetary financing (μ), and net fiscal cost of natural disasters (sn). To understand more intuitively, equation (13) can be rewritten as follows:

$$(1 - X/100)R_t^{structural} + B_t^{non-resource,non-recurrent} - B^* = S_t N_t - R_t^{resource} \tag{14}$$

where $B_t^{non-resource,non-recurrent} = G_t + \Delta M_t - K_t - i_t D_{t-1}$ is the budget balance

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[19] In the Pacific, countries usually receive grants and loans from foreign governments or multilateral donors for reconstruction of infrastructure in the event of natural disasters. If public investment is financed by such grants, it will not affect the debt target.

calculated as non-resource revenue excluding stable revenue minus non-recurrent expenditure; and B^* is the budget balance target before scaling by GDP (i.e. $B^* = b^* P_t Y_t$).

We can consider the left-hand side of equation (14) as the policy variable, and the right-hand side as the exogenous shock that small island economies cannot change (although S_t can be a choice variable). The economic intuition is that if there is any surprise in resource revenue or natural disaster shocks, the government can allow the non-resource, non-recurrent budget balance to deviate from the target under the constraint (14). This enables the government to adjust to volatile resource revenues and rebuild infrastructure in the event of natural disasters.

In the case of X = 100, where all non-resource, non-grant revenue can be spent as recurrent expenditure, the coefficient on the stable revenue term becomes zero, and hence it disappears from equation (14). Note that equations (9) and (6) show that the budget balance target, B^*, is higher when the average fiscal cost of a disaster (sn) is higher or nominal GDP growth rate (γ) is lower. Thus, a country satisfies the non-resource, non-recurrent budget balance constraint, which allows some deviation from the target if the actual natural disaster cost is higher or resource revenue is lower than expected. This result is because the recurrent spending rule also constrains other items in the budget due to the government's cash-flow constraint. Further calculation could yield the condition in which other items, mainly public investment, are automatically determined by the fiscal rule, depending on the realized value of natural disaster shocks, which is another essence of the recurrent expenditure rule.

To illustrate the case of the 2018 earthquake in PNG, the natural disaster-resilient fiscal rule would have suggested a 0.4 percent of fiscal stimulus in 2018 at the margin. Let us assume that the impact of the earthquake that occurred in PNG in 2018 is around 3 percent of GDP ($n_{2018} = 0.03$), and the government covers a half of the economic loss ($s_{2018} = 0.5$). Given that our calibrated budget balance target is -1.4 percent of GDP ($b^* = -0.014$), if we assume that resource-revenue is 0.5 percent of GDP and $X = 100$, then equation (14) shows that non-resource, non-recurrent budget balance needs to be smaller than -0.4 percent of GDP in 2018 ($b_{2018}^{non-resource,non-recurrent} < -0.4$). Using the nominal GDP number in the 2018 budget, this is equivalent to 320 million Kina. To simplify the story, let's postulate that non-resource, non-recurrent budget balance is mainly driven by public investment. Under this assumption, approximately 320 million Kina can be spent on public investment or emergency relief. This calibrated amount is close to the actual 450 million Kina emergency relief approved by the PNG government, although other items on the budget are precluded in this argument.

3.4. Relationship with Revenue Structure

How different are the revenue structures among the Pacific island countries? We need to take note of different revenue structures because revenue appropriation strategy depends on specific characteristics of the economy. For example, the permanent income hypothesis is useful for commodity exporters, especially for countries that collect revenue from non-renewable resources (PNG; Timor-Leste). In this case, the non-resource primary balance as a percentage of non-resource GDP can be an option as a fiscal target to smooth resource earnings and promote intergenerational equity. Consumption from resource revenue should be a fixed proportion of the nation's annuity provided by the natural resource wealth, and it should be consistent with the permanent income hypothesis. Our calibration for PNG indicates that the non-resource primary balance should be close to zero (-0.3 percent of non-resource GDP) to be consistent with the permanent income hypothesis. It is important to exclude volatile resource revenue from the fiscal rule to avoid procyclicality. The volatile resource revenues in the Pacific island countries are listed in Table 5.

Table 5: Volatile Resource Revenue Items in the Pacific Island Countries

Country	Resource Revenue Items
Fiji	------
Kiribati	Fishing License Fees
Marshall Islands	Fishing License Fees
Micronesia	Fishing License Fees
Nauru	Fishing License Fees
Palau	------
Papua New Guinea	Mining and Petroleum Taxes; Mining, Petroleum and Gas Dividends
Samoa	------
Solomon Islands	Logging Revenues; Fishing License Fees
Timor-Leste	Petroleum Revenue
Tonga	------
Tuvalu	Fishing License Fees
Vanuatu	------

It would be useful to point out the risks associated with each type of economy's revenue structure below. For countries whose main industries are renewable resources, such as fishing (Kiribati, Micronesia, Marshall Islands, Nauru, and Tuvalu) and logging industries (Solomon Islands), license fees can be an important indicator. If the countries relying on fishing industries increase recurrent spending when fishing revenue is high, it will be difficult to sustain fiscal

policies when climate change adversely affects fishing activity. However, for small island economies like Kiribati, Marshall Islands, and Tuvalu, it may be difficult to exclude fishing revenue as a volatile component from the revenue base because fishing license fees are a major source of revenue as other revenues are small. For countries exporting services such as Fiji, Vanuatu, and Palau, tourism revenues such as airport tax or taxes from service industries are important. The question arising is how to deal with countries relying on remittances, such as Tonga and Samoa? It could be cyclically synchronized with Australia/New Zealand business cycles where emigrant workers from these countries live. Finally, it could be important to set the minimum revenue requirement like Tonga to secure adequate revenues for the fiscal policy.

3.5. Stabilization Fund / Cash Buffers

Fiscal surpluses during good years should be put in a stabilization fund (or natural disaster fund).[20] If an actual fiscal outcome is better than the situation defined by the fiscal rule (expenditure rule), the fiscal surplus should be saved in the fund. These surpluses are needed in non-disaster years to build up reserves in the fund for emergency relief in disaster years. Holding reserves in the stabilization fund is necessary to meet cash outflows, particularly as the country's borrowing ability is constrained. In practice, due to the increased frequency of natural disasters, the targets may be more difficult to achieve.

Pacific island countries can also build cash buffers against natural disasters. For example, Tonga has a cash buffer rule, which requires the government to hold cash deposits equivalent to three months of recurrent spending. Solomon Islands had a similar cash buffer rule when the country implemented an IMF program in recent years. The idea of holding such cash buffers is similar to the stabilization fund discussed above. This type of buffer ensures quick and easy access to funds in the event of economic shocks or natural disasters to reinforce the objective of operational fiscal sustainability. Although the cash buffer rule is defined as holding of cash reserves equivalent to three months of operating expenditure in most cases, it is neither calibrated nor aligned with other fiscal anchors.

3.6. Escape Clauses

Well-defined and predetermined escape clauses may help budget execution in the presence of

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[20] For commodity exporters, stabilization funds can be funded from resource revenue windfalls. For example, the Organic Law on Sovereign Wealth Fund in PNG legislates that 50 percent of all mining and petroleum taxes, 60 percent of the proceeds of sale of mineral or petroleum assets, and 75 percent of all distributions from the State's mining or petroleum projects will be deposited in the stabilization fund.

unexpected massive natural disaster shocks. If the size of a natural disaster shock is too big to be covered by the stabilization fund, the escape clause should be applied. In this situation, the debt target and fiscal rules can be recalculated as we elaborated in Figure 5. The government may breach fiscal rules only in the event of an unexpected disaster or a severe economic shock, which should be clearly defined in the law beforehand. However, we should note that flexibility provisions (such as escape clauses) could complicate the budget process by allowing fiscal targets to change with circumstances. Since triggering an escape clause involves a costly review process in practice, it is generally optimal to have an escape clause if the cost of review is cheap, the volatility of shocks is high, and the government deficit bias is severe (Yared 2019). The existing literature reports mixed results on the impact of escape clauses on fiscal stance. For example, Guerguil et al. (2017) find that escape clauses in fiscal rules do not seem to affect the cyclical stance of fiscal policy and public spending. In contrast, Combes et al. (2017) find that fiscal rules with escape clauses are harmful for stabilization in high-debt countries by making fiscal policy more procyclical. Thus, country authorities should be very careful when applying escape clauses to violate fiscal rules.

A suggested approach to handle escape clauses is to have a forward-looking explanation mechanism similar to inflation targeting regimes in monetary policy. If unexpected and devastating natural disasters happen and trigger the escape clause, fiscal authorities should provide the future fiscal path to explain how fiscal targets will be met over the medium term. This is similar to the inflation targeting approach adopted by central banks worldwide. Namely, if a drought causes inflation to deviate from the inflation target, the monetary authority needs to explain how this effect from climate change or natural disaster dissipates over time and type of policy action required to meet the inflation target in the medium term. The same forward-looking approach is useful for fiscal policy-making. In other words, the fiscal authority needs to analyze and explain how natural disasters affect revenues, expenditures, and debt projections in the medium term and what kind of fiscal consolidation plan is required to meet the target over time. This will increase the credibility of the fiscal policy.

4. Conclusion

Fiscal rules for small islands vulnerable to natural disasters, climate change and commodity price fluctuations as well as foreign aid are discussed in this study, using the Pacific island countries as an example. The Pacific island countries are highly vulnerable to natural disasters and climate change shocks. To handle such shocks, we propose fiscal policy framework that includes the expected impact of shocks on fiscal balances. We provide an analytical framework

to calibrate the debt and budget balance targets and expenditure rules. Our theoretical framework shows that an appropriate level of debt target depends on individual country parameters. We demonstrate that these parameters can be affected by unexpected permanent climate change shocks. Furthermore, alternative fiscal rules for commodity exporters based on permanent income hypothesis are discussed. We also use the example of PNG to demonstrate the practical application of our fiscal rule framework for policy-makers. We chose PNG because it is the largest economy in the Pacific Islands, it has all characteristics of the region (commodity exporters, reliance on grants, frequent natural disasters, and climatic shocks), and we have available data. Our main argument is that a recurrent expenditure rule may be the most useful fiscal rule in the Pacific Islands as a countercyclical policy tool to handle natural disasters, volatile resource revenues, and uncertain foreign grants, together with the debt target, which is linked to the budget balance target. It would be useful to apply similar analytical methods to other Pacific, Caribbean, or Indian Ocean countries.

Disclosure Statement

The views expressed here are those of the author's and do not reflect those of the institution to which the author belongs.

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