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Abstract[1]

This study uses simulations of state-dependent distributions of fiscal limits for 18 economies in Central America and the Caribbean to better understand governments' ability to service their debt, arising from endogenously determined dynamic Laffer curves. Using a small, open economy model to simulate macroeconomic fundamentals and fiscal policy interactions, the empirical findings produced results not previous available for these economies, showing varying and wider distributions of fiscal limits for the open economy model subject to terms-of-trade and flexible exchange rate shocks. This indicates that terms-of-trade and exchange rate volatility impacted the ability of national economies to service their debt. It is therefore prudent that policymakers and central bankers consider models that incorporate the use of trade and exchange rate volatility as a robust way of more accurately determining fiscal limits, which are a critical component in understanding governments' ability to service their debt.

JEL Codes: C15; E62; H60; O54
Keywords: fiscal limits, Laffer curves, debt and developing economies

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(e-mail: f.ramirez@bancentral.gov.do). This paper presents preliminary findings and is being distributed to economists and other institutions solely to stimulate discussion and comments. The views expressed in this paper are those of the authors and are not necessarily reflective of views at the Central Bank of the Dominican Republic.

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1. Introduction

The objective of this study is to better understand Central American and Caribbean governments' ability to service their debt, derived from the estimation of their fiscal limits, defined as the maximum level of debt that they are able and willing to service (Bi and Leeper, 2010). Using simulations of state-dependent fiscal limits for 18 economies,[2] we produced results that were not previously available for these economies. These results show varying and wider distribution limits for the simulations when applying an open economy model subject to terms-of-trade shocks versus the same model without considering these shocks. The results indicate that terms-of-trade volatility impacted the ability of these developing economies to service their debt.

The paper provides another critical tool to policymakers and central bankers to help determine the best way to understand fiscal limits derived from simulating macroeconomic uncertainty and fiscal policy interactions in the developing economies of Central America and the Caribbean.

The methodologies used analyses the fiscal limit. Fiscal limit is defined the maximum level of debt that governments can service given the current underlying macroeconomic fundamentals, the present value of fiscal surpluses, the state of government transfers and subsidies, and the impact of sovereign risk on the economy. (Bi 2011; Juessen et al., 2011). Using an open economy real business cycle (RBC) model for simulating fiscal limits, we derive dynamic Laffer curves, which are obtained endogenously as governments normally raise the tax rate in response to rising debt levels (Leeper 1991).

This understanding of the fiscal limit, or the maximum level of debt that Central American and Caribbean economies can service, is critical for these small developing economies, some of which currently have high spending levels due to transfers and subsidies and a history of high political risk that thwarts tax and spending adjustment across the business cycle. These economies commonly experience low and declining fiscal surpluses, accompanied by rising sovereign debt, especially following the great recession. They continue to be impacted, sometimes negatively, by the state of world trade and the economies of their leading trade partners. An understanding of fiscal limits

[2] Antigua and Barbuda, The Bahamas, Barbados, Belize, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago.

within these economies is vital, as policymakers and central bankers are continually searching for methodologies and tools that can help them better define these limits, provide more robust forecasts of the ability of their economies to raise debt, and develop the fiscal policies necessary for containing debt and default risk in the short and long term (Bi 2011; Bi et al., 2013).

Our paper provides evidence of fiscal limits for all the economies studied. It shows, through simulation of fiscal limits in an open economy model, that terms-of-trade shocks play an important role in shaping fiscal limit distribution for most of the economies included in the study.

The study is organized as follows: Section 2 discusses the reasons why studying fiscal limits is important to developing economies. Section 3 reviews the latest literature on fiscal limits. Section 4 discusses the methodologies, the data, and the parameters used in deriving the simulation of the fiscal limits. Section 5 discusses the results of the simulation, Section 6 discusses the policy implications, and Section 7 concludes.

2. Why Understanding Fiscal Limits is Important to Developing Economies

The fiscal limit is usually the highest level of debt that the government can service. It is dependent on the current state of the macroeconomic fundamentals, the present value of fiscal surpluses, the state of government transfers and subsidies, and the impact of sovereign risk on the economy (Bi 2011; Bi et al., 2013). The simulations of the limits are demonstrated in endogenously derived dynamic Laffer curves. The peak of the distribution curve shows the point at which governments are limited in further raising tax revenues to finance sovereign debt, indicating their ability to adequately service sovereign debt. Usually, even before this point is reached, and with the increasing possibility of reaching the peak of the Laffer curve, householders or agents will require a higher risk premium on sovereign debt, which could also limit financing of sovereign debt (Uribe, 2006).

The fiscal limit, which is state-dependent on existing macroeconomic fundamentals and stochastic in nature as random disturbances affect the future path of fiscal surpluses, is effectively defined at each period and depends on macroeconomic circumstances and fiscal policy (Bi et al., 2013; Juessen et al., 2011; Leeper, 1991). Depending on current macroeconomic circumstances and fiscal policy, several results can emerge that define the state of fiscal limits and the ability of the government to service its debts. First, a government with a high burden of transfers and government spending will most likely experience lower fiscal surplus for an extended period, lower-bound fiscal limits, and a diminished ability to service its debt. Additionally, governments that use strong automatic stabilisers as countercyclical fiscal policy in periods of low economic growth will have lower surpluses as income remains depressed and will face greater difficulty in servicing sovereign debt. Furthermore, random exogenous shocks to economies can negatively impact the future path of fiscal surpluses, making it increasing difficult for governments to service their debt and maintain their current sovereign credit rating. (Bi, 2011; Bi et al., 2013; Leeper, 1991).

A careful analysis of developing economies' fiscal positions shows that among the economies studied in the past decade (2002–2012) they have seen nominal gross public debt stock almost doubling to end December 2012 at approximately US$119 billion from a level of US$60 billion in 2002, for a sample of Central American and Caribbean economies (See Table 2.1 and Figure 5 in the Appendix showing public debt to GDP).

Table 2.1: Nominal Public Debt in Selected Central American and Caribbean Countries by IMF World Economic Outlook Report

Nominal Public Debt (US$ billion)	2002	2012
Antigua and Barbuda	1.0	1.1
The Bahamas	1.7	4.2
Barbados	2.0	4.7
Belize	0.8	1.2
Costa Rica	6.5	14.9
Dominica	0.3	0.4
Dominican Republic	0.1	18.7
El Salvador	5.4	12.4
Grenada	0.4	0.9
Guatemala	3.9	12.4
Haiti	1.4	1.3
Honduras	5.0	5.6
Jamaica	10.3	19.0
Nicaragua*	7.5	4.9
Panama	8.5	12.6
St. Kitts and Nevis	0.4	0.7
St. Lucia	0.3	0.7
St. Vincent and the Grenadines	0.2	0.5
Trinidad and Tobago	4.6	2.9
Total	60.3	119.0
Caribbean	22.7	55.1
Central America	37.6	64.0

*Public debt data was only available for 2003.
Source: IMF WEO.

With increasing levels of debt and, in most cases, low growth or weak macroeconomic fundamentals and declining fiscal surpluses, the developing economies of Central America and the Caribbean are becoming more concerned about their ability to adequately service sovereign debt from lower fiscal surpluses with the increasing possibility of sovereign default risk (See Table 2.2, showing average fiscal surplus or deficit over the period studied).

Table 2.2: Average Government Surplus or Deficit of Caribbean Countries (2002–2012), Authors Estimates

Government Surplus or Deficit % of GDP	Spending	Transfers	Tax revenue	Fiscal deficit
Antigua and Barbuda	0.29	0.03	0.20	-0.12
The Bahamas	0.18	0.01	0.16	-0.04
Barbados	0.37	0.05	0.33	-0.09
Belize	0.29	0.02	0.25	-0.07
Costa Rica	0.17	0.06	0.14	-0.09
Dominica	0.32	0.03	0.30	-0.06
Dominican Republic	0.16	0.04	0.14	-0.06
El Salvador	0.19	0.03	0.16	-0.06
Grenada	0.27	0.02	0.23	-0.06
Guatemala	0.14	0.03	0.12	-0.05
Haiti	0.16	0.01	0.14	-0.02
Honduras	0.27	0.04	0.23	-0.07
Jamaica	0.28	0.05	0.25	-0.08
Nicaragua	0.25	0.03	0.24	-0.04
Panama	0.25	0.05	0.24	-0.05
St. Kitts and Nevis	0.30	0.02	0.26	-0.05
St. Lucia	0.26	0.02	0.24	-0.04
St. Vincent and the Grenadines	0.28	0.03	0.25	-0.05
Trinidad and Tobago	0.31	0.05	0.31	-0.04
Total	4.8	0.59	4.2	-1.15
Caribbean	3.2	0.3	2.8	-0.72
Central America	1.6	0.3	1.4	-0.43

Over the past decade, the fiscal limits of several developing economies have signalled to credit markets more riskiness in their sovereign debt, which has resulted in the downgrading of the creditworthiness of these economies. Table 2.3 shows the sovereign credit rating of several Central American and Caribbean economies over the past decade.

Table 2.3: Sovereign Credit Ratings of Long-Term Foreign Currency Bonds

Sovereign Credit Ratings Long-Term Foreign Currency Bonds	2002	2012	Change
The Bahamas	A-*	BBB	-
Barbados	A-	BB+	-
Belize	B+	SD	-
Costa Rica	BB	BB	
Dominican Republic	BB-	B+	-
El Salvador	BB+	BB-	-
Grenada	BB-	CCC+	-
Guatemala	BB	BB	
Honduras	B+	B+	
Jamaica	B+	B-	-
Panama	BB	BBB	+
Trinidad and Tobago	BBB-	A	+

SD = Selective Default. *2003.

Source: Standard and Poors 2012

Studying their fiscal limits is vital for Central American and Caribbean economies to understand how much debt they can accumulate given macroeconomic uncertainty and fiscal policies, and the point at which sovereign default risk increases as existing debt exceeds the fiscal limit.

3. Literature Review

Juessen et al. (2011) determine endogenously dynamic Laffer curves, showing the amount of debt that could be accommodated by an average Eurozone member by predicting its debt capacity baseline. The authors, however, show that with income volatility and changes in the macroeconomic fundamentals, a significant risk premium can emerge. Adjusting the baseline parameters within their closed economy model, Juessen et al. (2011) determined that the debt capacity of the Greek economy was lower than specified in the scenario, as agents doubted the ability of the Greek government to raise tax revenues to the maximum to finance rising debt levels. Bi (2011) attempts to build on the results derived by Juessen et al. (2011) by allowing the tax rate to rise in response to accumulating debt, even as sovereign default risk rises from continuing explosive government spending and transfers.

The closed economy model used by Bi (2011) for developed economies in Europe and the Oceanic area (Australia, New Zealand and the archipelago of Indonesia) showed a likely framework to discuss fiscal measures in the short run and policy reform in the long run. Bi et al. (2013) extended this work, determining the state-dependent fiscal limits of two Latin American economies. The authors' findings suggest that expected future income was critical in deriving lower fiscal bounds or limits for developing countries versus developed economies. Using a small, open economy model with separation of the nontradable from the tradable economy, the authors determined the impact on the distribution of fiscal limits of macroeconomic uncertainty, fiscal policy, and terms-of-trade shocks.

Bi et al. (2013)'s results appear similar to the previous work. Government spending and transfers were reduced as economies approached their fiscal limits and increased tax revenues to finance rising debt, reducing the fiscal multiplier as the cost of consumption rose.

Mendoza and Oviedo (2004) also used a general equilibrium model to determine the maximum amount a government could borrow, which they termed a "natural debt limit." However, the analysis held interest rates constant. Buffie et al. (2012) used an exogenously determined risk premium, as economies were not allowed to default on sovereign debt.

Our paper derives endogenously determined fiscal limits from economic fundamentals and fiscal policy, recognizing that sovereign default may occur if existing debt levels exceed fiscal limits because rising tax rates are unable to cover mounting debt. We incorporate terms-of-trade shocks in our open general equilibrium model, recognizing that most developing economies, in addition to relying heavily on external borrowing, export significant amounts of their domestic production, with changes in terms of trade magnifying sovereign default risk (Bi et al., 2013). We produce results for developing economies that were not previously available to aid policymakers and central bankers in formulating fiscal consolidation and reform in both the short and long term.

4. Models, Data, and Parameters

4.1: Model

Since the main objective of this study is to approximate the fiscal limit for a set of small, open developing economies, we use the approach employed by Bi et al. (2013) to analyse this topic in three developing economies. The model consists of a small, open economy with tradable and nontradable goods to consider the role of terms-of-trade and exchange rate shocks in the distribution of fiscal limits. We provide a brief description of the model, and we refer readers to the Bi et al. (2013) paper for details.

4.1.1 Households

Households derive utility from the consumption of a bundle containing a private and public, $\tilde{c}$, and leisure $1-l$. The composite is a CES index of both types of goods

$$\tilde{c}_t = \left[\omega(c_t)^{\frac{\upsilon-1}{\upsilon}} + (1-\omega)(g_t)^{\frac{\upsilon-1}{\upsilon}}\right]^{\frac{\upsilon}{\upsilon-1}}$$

where ω and υ are the participation of the consumption of private good in the basket, and the degree of substitutability, respectively.

Preferences are characterized by the following utility function, that households maximize over an infinite horizon choosing optimal paths for composite goods, labor, investment, and capital in the tradable and nontradable sectors:

$$E_t \sum_{t=0}^{\infty} \beta^t U_t$$

where $U_t = \left(log(\tilde{c}_t) + \phi \frac{(1-l_t)^{1-\sigma}}{1-\sigma}\right)$, where $\beta \in (0,1)$ is the discount factor, σ is the inverse of the Frisch elasticity of labor supply, and ϕ is the weight of leisure in the utility function.

Subject to budget constraints,

$$c_t + i_t^N + i_t^T + \frac{\kappa}{2}\left(\frac{i_t^N}{k_{t-1}^N} - \delta\right)^2 k_{t-1}^N + \frac{\kappa}{2}\left(\frac{i_t^T}{k_{t-1}^T} - \delta\right)^2 k_{t-1}^T$$
$$= (1-\tau_t)(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T) + z_t$$

where $i_t^N, i_t^T, k_t^N,\ k_t^T$ represent sector-specific investment expenditure and capital. The spending in investment goods is subject to adjustment cost with the parameter κ, where this feature is necessary to close the model in the terminology of Schmith-Grohe and Uribe (2003). Finally, δ is the rate of capital depreciation, assumed to be the same in both sectors.

The law of motion of sectoral capital is:

$$k_t^N = (1-\delta)k_{t-1}^N + i_t^N$$
$$k_t^T = (1-\delta)k_{t-1}^T + i_t^T$$

and the aggregate investment is:

$$i_t = i_t^N + i_t^T$$

The first-order condition of this optimization program delivers the following intertemporal equilibrium condition for households:

$$\phi(1-l_t)^{-\sigma} = (1-\tau_t)w_t\omega c_t^{\frac{-1}{\upsilon}}\tilde{c}_t^{\left(\frac{1}{\upsilon}-1\right)}$$

$$1+\kappa\left(\frac{i_t^N}{k_{t-1}^N}-\delta\right) = \beta E_t\left(\frac{c_{t+1}}{c_t}\right)^{\frac{-1}{\upsilon}}\left(\frac{\tilde{c}_{t+1}}{\tilde{c}_t}\right)^{\left(\frac{1}{\upsilon}-1\right)}$$
$$= \left[(1-\tau_{t+1})r_{t+1}^N - \kappa\left(\frac{i_t^N}{k_{t-1}^N}-\delta\right)^2 + \kappa\left(\frac{i_t^N}{k_{t-1}^N}-\delta\right)\left(\frac{i_{t+1}^N}{k_{t+1}^N}\right)\right.$$
$$\left. + (1-\delta)\left(1+\kappa\left(\frac{i_t^N}{k_{t-1}^N}-\delta\right)\right)\right]$$

$$1+\kappa\left(\frac{i_t^T}{k_{t-1}^T}-\delta\right) = \beta E_t\left(\frac{c_{t+1}}{c_t}\right)^{\frac{-1}{\upsilon}}\left(\frac{\tilde{c}_{t+1}}{\tilde{c}_t}\right)^{\left(\frac{1}{\upsilon}-1\right)}$$
$$= \left[(1-\tau_{t+1})r_{t+1}^T - \kappa\left(\frac{i_t^T}{k_{t-1}^T}-\delta\right)^2 + \kappa\left(\frac{i_t^T}{k_{t-1}^T}-\delta\right)\left(\frac{i_{t+1}^T}{k_{t+1}^T}\right)\right.$$
$$\left. + (1-\delta)\left(1+\kappa\left(\frac{i_t^T}{k_{t-1}^T}-\delta\right)\right)\right]$$

Aggregate private consumption and investment are split between tradables and nontradables in an imperfect substitutability way, through a CES aggregate function with intratemporal elasticity of substitution of χ and home bias degree of φ.

$$c_t = \left[\varphi^{\frac{1}{\chi}}(c_t^N)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}}(c_t^T)^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}$$

$$i_t = \left[\varphi^{\frac{1}{\chi}}(i_t^N)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}}(i_t^T)^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}$$

In terms of the distribution of labor between sectors, the CES aggregator is

$$l_t = \left[{\varphi^l}^{-\frac{1}{\chi^l}}(l_t^N)^{\frac{1+\chi^l}{\chi^l}} + (1-\varphi^l)^{-\frac{1}{\chi^l}}(l_t^T)^{\frac{1+\chi^l}{\chi^l}}\right]^{\frac{\chi^l}{1+\chi^l}}$$

where φ^l is the steady-state share of labor in the nontradable sector and χ^l is the elasticity of substitution between sectors. The household chooses the optimal amount of labor for each sector, solving the intratemporal problem:

$$\min w_t^N l_t^N + w_t^T l_t^T$$

subject to

$$l_t = \left[{\varphi^l}^{-\frac{1}{\chi^l}}(l_t^N)^{\frac{1+\chi^l}{\chi^l}} + (1-\varphi^l)^{-\frac{1}{\chi^l}}(l_t^T)^{\frac{1+\chi^l}{\chi^l}}\right]^{\frac{\chi^l}{1+\chi^l}}$$

From the first-order condition we obtain the labor supply for each sector:

$$l_t^N = \varphi^l \left(\frac{w_t^N}{w_t}\right)^{\chi^l} l_t$$

$$l_t^T = (1-\varphi^l) \left(\frac{w_t^T}{w_t}\right)^{\chi^l} l_t$$

From the last cost minimization problem, the aggregate wage index can be derived as:

$$w_t = \left[\varphi^l (w_t^N)^{1+\chi^l} + \left(1-\varphi^l\right)(w_t^T)^{1+\chi^l}\right]^{\frac{1}{1+\chi^l}}$$

In this model, prices are presented as relative prices respect to the price of the composite private consumption good, which is set to 1. Defining as p_t^N the relative price of nontradables, and as s_t CPI real exchange rate (assuming the law of one price holds), then

$$1 = [\varphi(p_t^N)^{1-\chi} + (1-\varphi)(s_t)^{1-\chi}]^{\frac{1}{\chi-1}}$$

4.1.2 Firms

Bi et al. (2013) assume that firms in both sectors are perfectly competitive, and the technology of production is a Cobb-Douglas production function in both sectors:

$$y_t^N = a_t (k_t^N)^{1-\alpha^N} (l_t^N)^{\alpha^N}$$

$$y_t^T = a_t (k_t^T)^{1-\alpha^T} (l_t)^{\alpha^T}$$

and

$$\ln \frac{a_t}{a} = \rho_a \ln \frac{a_{t-1}}{a} + \varepsilon_t^a$$

$$\varepsilon_t^a \sim N(0, \sigma_a^2)$$

where y_t^N and y_t^T are the levels of production, and a_t and at are the total factor of productivity that follows an AR(1) process. ε_t^a is the productivity shock that is assumed to be the same for both sectors.

Each firm in both sectors takes the prices of production factors as given and maximizes their profit functions and obtains the demand of labor and capital for each sector. That is,

$$\max \Pi_t^{\mathrm{N}} = p_t^N y_t^N - w_t^N l_t^N - r_t^N k_{t-1}^N$$

$$\max \Pi_t^T = p_t^x y_t^T - w_t^T l_t^T - r_t^T k_{t-1}^T$$

subject to their respective production functions. From the first-order conditions, the demand for each factor of production is derived:

$$l_t^N = \alpha^N \left(\frac{p_t^N}{w_t^N}\right) y_t^N$$

$$l_t^T = \alpha^T \left(\frac{\xi_t s_t}{w_t^T}\right) y_t^T$$

$$k_{t-1}^N = (1-\alpha^N) \left(\frac{p_t^N}{r_t^N}\right) y_t^N$$

$$k_{t-1}^T = (1-\alpha^T) \left(\frac{\xi_t s_t}{r_t^T}\right) y_t^T$$

where $\xi_t = p_t^x / s_t$ are the term of trade, which is assumed follow an exogenous process

$$\ln \frac{\xi_t}{\xi} = \rho_\xi \ln \frac{\xi_{t-1}}{\xi} + \varepsilon_t^\xi$$

$$\varepsilon_t^\xi \sim N(0, \sigma_\xi^2)$$

4.1.3 Government

In this model, the government collects taxes and issues an external debt bond (b_t^*) to finance public expenditure (g_t), transfers (z_t), and the external debt service. In terms of public expenditure, the government consumes both tradables and nontradables, so g_t is represented as a CES basket of these types of goods. Thus, the price index for government goods is given by:

$$p_t^g = [\varphi^g (p_t^N)^{1-\chi} + (1-\varphi^g)(s_t)^{1-\chi}]^{\frac{1}{1-\chi}}$$

where φ^g is the degree of home bias and χ is the intratemporal elasticity of substitution. The government flow budget constraint is given by:

$$\tau_t(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T) + q_t s_t b_t^* = s_t b_{t-1}^{d*} + p_t^g g_t + z_t$$

where q_t is the price of foreign bonds and $q_t s_t b_t^*$ is the number of units of local goods raised through the sale of b_t^*. In Bi et al. (2013), $b_t^{d*} = (1-\Delta_t) b_{t-1}^*$ are the post-default liabilities introduced to study the dynamic of fiscal limits when the government randomly defaults. In our research, we do not study that case, so $\Delta_t = 0$.

We assume that foreign creditors are risk-neutral, so the demand for domestic bond is

$$q_t = \beta.$$

Iterating forward, and using the transversality condition for government, $\lim_{i\to\infty} E_t \beta^i b_{t+i}^* = 0$, the government budget constraints is can be rewritten as:

$$b_{t-1}^* = \sum_{i=0}^{\infty} \beta^i E_t \left(\frac{1}{s_{t+i}}\right) \left(T_{t+i} - p_{t+i}^g g_{t+i} - z_{t+i}\right)$$

that is, the external debt at the start to period t is the present value of future surpluses.

The evolution of fiscal policy variables is the following: government expenditure, g_t, is assume to be procyclical, as the evidence suggests for developing countries (Gavin and Perotti, 1997). Relative to taxes, the policy rule establishes that taxes adjust to maintain sustainability. Thus, the expenditure and taxes rules are

$$\ln\left(\frac{\tau_t}{\tau}\right) = \rho_{tau} \ln\left(\frac{\tau_{t-1}}{\tau}\right) + \gamma \ln\left(\frac{b_t^*}{b^*}\right) + \varepsilon_t^\tau, \text{ with } \gamma > 0$$

$$\ln\left(\frac{g_t}{g}\right) = \rho_g \ln\left(\frac{g_{t-1}}{g}\right) + \eta_g \ln\left(\frac{y_{t-1}}{y}\right) + \varepsilon_t^g$$

where $\varepsilon_t^i \sim N(0, \sigma_i^2)$ for $i \in \{\tau, g\}$

4.1.4 Market Clearing

The market-clearing conditions require that factor markets clear, so labor and capital supplies are equal to their respective demands in each market and at the aggregate, so

$$k_t = k_t^N + k_t^T$$
$$l_t = l_t^N + l_t^T$$

The output in local units is:

$$y_t = p_t^N y_t^N + \xi_t s_t y_t^T$$

The market-clearing condition for nontradables is:

$$y_t^N = (p_t^N)^{-\chi} \left\{ \varphi \left[c_t + i_t + \frac{\kappa}{2} \left(\frac{i_t^N}{k_{t-1}^N} - \delta \right)^2 k_{t-1}^N + \frac{\kappa}{2} \left(\frac{i_t^T}{k_{t-1}^T} - \delta \right)^2 k_{t-1}^T \right] + \varphi^g \left(p_t^g \right)^{\chi} g_t \right\}$$

The balance of payment condition is:

$$c_t + i_t + \frac{\kappa}{2} \left(\frac{i_t^N}{k_{t-1}^N} - \delta \right)^2 k_{t-1}^N + \frac{\kappa}{2} \left(\frac{i_t^T}{k_{t-1}^T} - \delta \right)^2 k_{t-1}^T + p_t^g g_t - y_t = s_t [q_t b_t^* - b_{t-1}^*]$$

4.1.5 Defining the Fiscal Limit

As in Bi et al. (2013), the fiscal limit is defined as the maximum level of debt per unit of local goods that a government is able and willing to serve. Based on the definition of government budget constraint, the fiscal limit can be described as the present value of future surpluses evaluated at the top of the Laffer curve.

Willingness to pay is approached by a political risk factor bounded by the range 0 and 1, so that low levels of these parameters reflect high levels of political risk, and consequently, lower levels of fiscal limits. In other words, countries with high levels of political risk are more prone to default at lower debt-to-GDP ratios.

One of the characteristics of fiscal limits is its state-dependent nature. This implies that fiscal limits are random variables, as the state of the economy at each moment is determined by random shocks. In this model, these shocks are productivity, term of trade processes, and the evolution of fiscal policy, each of which has a random component. Formally, from the intertemporal budget constraint evaluated at τ_{max} the distribution of fiscal limit is:

$$B^{max}(\mathfrak{H}_t) \sim \left[\sum_{i=0}^{\infty} \beta^t \, \theta \, \frac{1}{s_{t+i}^{max}} (T_{t+i}^{max} - p_{t+i}^{g} g_{t+i} - z_t) \right]$$

where the state of the economy is $\mathfrak{H}_t = (a_t, g_t, \xi_t, k_{t-1}^N, k_{t-1}^T)$. T_t^{max} and s_t^{max} are government revenue and the real exchange rate associated with τ^{max}. θ is the government willingness to pay the public debt or the level of political risk, which we assumed constant.

As Bi et al. (2013) note, the computation of the maximum tax, consistent with dynamic Laffer curves, delivers values slightly above those observed in the sample, so that fiscal limits are evaluated at the maximum tax rate observe in the sample.

The simulation of the fiscal limit distribution involves the following steps:

1. Using the procedure described by Bi et al, (2013), we solve the nonlinear model for each country and obtain the decision rules for the state variables of the model.
2. After solving, we simulate the model 1,000 periods, randomly drawing the exogenous shocks for TPF, government expenditure, and term of trade, and compute T_{t+i}^{max} and s_t^{max}. Then, we compute the definition of fiscal limit for this sequence of shocks.
3. We repeat the simulation 10,000 to have $\{B^{max}(\mathfrak{H}_t)\}_{j=1}^{10,000}$

4.2 Data

4.2.1 Parameters and Calibration of the Model

The model is calibrated for 18 Caribbean and Central America economies to simulate the distribution of fiscal limits. To accomplish this task, our calibration strategy assumes that some parameters are common across economies, and the rest are obtained from sample data of key model variables for these economies.

Because of the lack of previous studies or empirical evidence, we rely on Bi et al. (2013)'s calibration and other studies for common parameters. Table 4.1 summarizes these common calibrated parameters.

Table 4.1 Common Calibrated Parameters

	Parameters	
φ	Tradable share in the consumption price index	0.5
σ	Inverse of the Frisch labor supply elasticity	2

υ	Elasticity of substitution between c_t and g_t	0.49
ω	Preference weight on c_t in effective consumption	0.8
χ^l	Substitution elasticity between l_t^N and l_t^T for l	1
φ^l	Steady state labor income share of the nontradable sector in labor income	0.5
κ	Investment adjustment cost	1.7
α^N	Labor income share of the nontradable sector	0.5
α^T	Labor income share of the tradable sector	0.5
δ	Capital depreciation rate	0.1

Source: Bi et al. (2013).

The tradable share in the consumption price index (φ) is set at 0.5 for the countries considered, similar to the value estimated for the Dominican Republic (0.49)[3] and Bi et al. (2013), which set this parameter to 0.53 for Ecuador and Argentina.

From the parameterization of Bi, et al. (2013) we take: σ, the inverse of the Frisch elasticity of supply, which is set to 2, a common assumption in the literature. The elasticity of substitution between the private good and the public good in the composite consumption basket of the household (υ) calibrated to 0.49 and ω, the preference weight on c_t in effective consumption is set to 0.8. The elasticity of substitution between tradable and nontradable goods in both private and public consumption basket is calibrated to 0.44. The sectoral mobility of labor,χ^l, is set to 1. In addition, φ^l, the steady-state labor income share of nontradable sector in labor income, is equal to 0.5. Finally, the investment adjustment parameter is set to 1.7.

Other common parameters across countries are the labor income shares of national income (α^N) which are calibrated to 0.5. We assume that both sectors have the same labor intensive technology, so $\alpha^T = 0.5$. Steady-state labor share is set to 0.25, which means that households spend 25 percent of their day at work. Finally, as our model is calibrated on annual data, the depreciation rate of capital is 10 percent per year in both sectors.

The country-specific parameters are calibrated using annual data on per capita GDP, real effective exchange rates, real ex-post interest rates, government expenditures, transfers, revenues, and external public debt from 1990 to 2016. Data are obtained from

[3] From Central Bank price surveys classifications.

multiple sources, such as the IMF International Financial Statistics Database, Economic Commission for Latin America and the Caribbean (ECLAC) statistics, and country-specific government agencies (central banks and finance ministries).

After detrending, using the Hodrick-Prescott filter, we estimate the persistence and volatility parameters for the exogenous processes (productivity, terms of trade, and fiscal policy variables). To obtain reliable parameters, we include dummy variables to control outliers in years of financial or important crisis. Finally, data for the political risk parameter is taken from the International Country Risk Guide's Index of Political Risk. Table 4.2 shows calculated parameters for each economy.

The discount factor, β, was computed using average ex-post real interest rates for each country. The average ex-post real rate is around 9 percent, which implies a discount rate of 0.92. El Salvador has the highest discount (0.96), and Dominica has the lowest (0.86).

Data on the political risk parameter are only available for 2012. For the current sample, this parameter is in a range of 0.46–0.80 with an average of 0.65 and standard deviation of 0.07. The OCDE average is 0.83, denoting the high level of political risk of our set of countries compared to developed economies. The index decreases from 0.80 for The Bahamas to 0.46 for Haiti. Since there are no data on this indicator for Barbados, Belize, Dominica, Grenada, St, Kitts, St. Lucia, and St. Vincent and Grenadines, we calibrate this parameter to 0.64, which is the sample average for Latin American countries.

Persistence and volatility parameters vary widely across countries. Productivity shocks are more persistent than the average in countries like Honduras, Panama, and Trinidad and Tobago. Nevertheless, the volatility of productivity shocks is similar across countries. Terms-of-trade shocks, approximated by the persistence and volatility of the deviation of real exchange rate from its HP trend, display heterogeneity in the set of countries, with an average persistence of 0.38 and volatility of 3.8 percent.

With respect to fiscal parameters, the ratio of government expenditure to GDP on average is 25 percent, with countries with traditionally low levels like Guatemala (14 percent), the Dominican Republic (16 percent), and Costa Rica (17 percent). Except for The Bahamas, countries in the Lesser Antilles have the highest average government expenditure in the sample, with Barbados at the top, at 37 percent of GDP.

Similar to the distribution of the ratio of public expenditure to GDP, government revenues over GDP are smaller in the Central America countries mentioned. The sample average for these economies is 14 percent versus the average of the full sample of 22 percent.

Finally, average public debt to GDP is 63 percent with a standard deviation of 33 percent. The Lesser Antilles countries and Jamaica all have debt-to-GDP ratios greater than 50 percent, with countries like Antigua and Barbuda, Jamaica, and St. Kitts standing out with ratios over 100 percent. Central America and the Greater Antilles countries (excluding Jamaica and Nicaragua) exhibit ratios under 50 percent.

In terms of parameters characterizing the assumed behavior of fiscal policy, government spending behaves in a procyclical manner with respect to GDP, meaning that government spending is reduced when economic growth slows down. Of the sample countries, only Belize and St. Lucia display countercyclical behavior. The tax-to-debt adjustment elasticity suggests that these countries tend to raise taxes when debt rises.

Table 4.2. Parameter Calibration by Country

Countries	θ	ρ_a	ρ_g	ρ_ξ	σ_a	σ_g	σ_ξ	$\frac{g}{y}$	$\frac{z}{y}$	τ	τ_{max}	ρ_τ	β	$\frac{b}{y}$	η_g	γ	φ^g
Antigua and Barbuda	0.64	0.68	0.62	0.31	0.02	0.05	0.04	0.29	0.03	0.20	0.23	0.37	0.93	1.01	0.45	0.65	0.42
The Bahamas	0.80	0.61	0.38	0.57	0.01	0.01	0.03	0.18	0.01	0.16	0.18	0.28	0.91	0.33	0.16	0.39	0.38
Barbados	0.64	0.58	0.16	0.31	0.01	0.01	0.04	0.37	0.05	0.33	0.37	0.14	0.92	0.55	0.48	0.32	0.38
Belize	0.64	0.62	0.73	0.09	0.01	0.02	0.02	0.29	0.02	0.25	0.29	0.32	0.89	0.88	-0.54	0.69	0.38
Costa Rica	0.73	0.26	0.68	0.62	0.01	0.01	0.03	0.17	0.06	0.14	0.16	0.38	0.90	0.34	0.54	0.51	0.31
Dominica	0.64	0.46	0.24	0.47	0.01	0.04	0.02	0.32	0.03	0.30	0.38	0.31	0.86	0.80	1.33	0.53	0.46
Dominican Republic	0.65	0.53	0.53	0.29	0.01	0.02	0.07	0.16	0.04	0.14	0.18	0.48	0.92	0.25	0.68	0.65	0.25
El Salvador	0.67	0.63	0.26	0.18	0.01	0.01	0.02	0.19	0.03	0.16	0.18	0.23	0.96	0.41	0.49	0.40	0.36
Grenada	0.64	0.56	0.33	0.43	0.02	0.02	0.02	0.27	0.02	0.23	0.27	0.07	0.93	0.85	0.68	0.46	0.48
Guatemala	0.61	0.54	0.47	0.45	0.01	0.01	0.05	0.14	0.03	0.12	0.13	0.31	0.92	0.21	0.01	0.26	0.27
Haiti	0.46	0.46	-0.45	0.31	0.02	0.00	0.04	0.16	0.01	0.14	0.30	0.38	0.88	0.39	1.28	0.34	0.38
Honduras	0.59	0.72	0.40	0.54	0.01	0.03	0.03	0.27	0.04	0.23	0.26	0.49	0.90	0.46	0.20	0.52	0.43
Jamaica	0.74	0.40	0.37	0.27	0.01	0.03	0.08	0.28	0.05	0.25	0.28	0.31	0.90	1.24	1.79	0.45	0.38

Nicaragua	0.63	0.40	0.23	0.13	0.01	0.01	0.08	0.25	0.03	0.24	0.28	0.77	0.91	0.92	0.71	0.30	0.26
Panama	0.71	0.70	0.47	0.31	0.01	0.01	0.04	0.25	0.05	0.24	0.35	0.30	0.94	0.55	0.46	0.64	0.25
St. Kitts and Nevis	0.64	0.68	-0.27	0.53	0.01	0.02	0.03	0.30	0.02	0.26	0.41	0.36	0.95	1.34	0.79	0.37	0.41
St. Lucia	0.64	0.42	0.23	0.61	0.01	0.01	0.02	0.26	0.02	0.24	0.28	0.19	0.94	0.58	-0.33	0.56	0.49
St. Vincent and the Grenadines	0.64	0.60	0.40	0.30	0.01	0.03	0.03	0.28	0.03	0.25	0.30	0.64	0.94	0.62	0.83	0.39	0.49
Trinidad and Tobago	0.72	0.84	0.37	0.60	0.02	0.01	0.03	0.31	0.05	0.31	0.39	0.53	0.95	0.40	0.46	0.50	0.38

Sources: International Financial Statistics, ECLAC Statistics Database, Central Banks, and Ministries of Finance of selected economies.

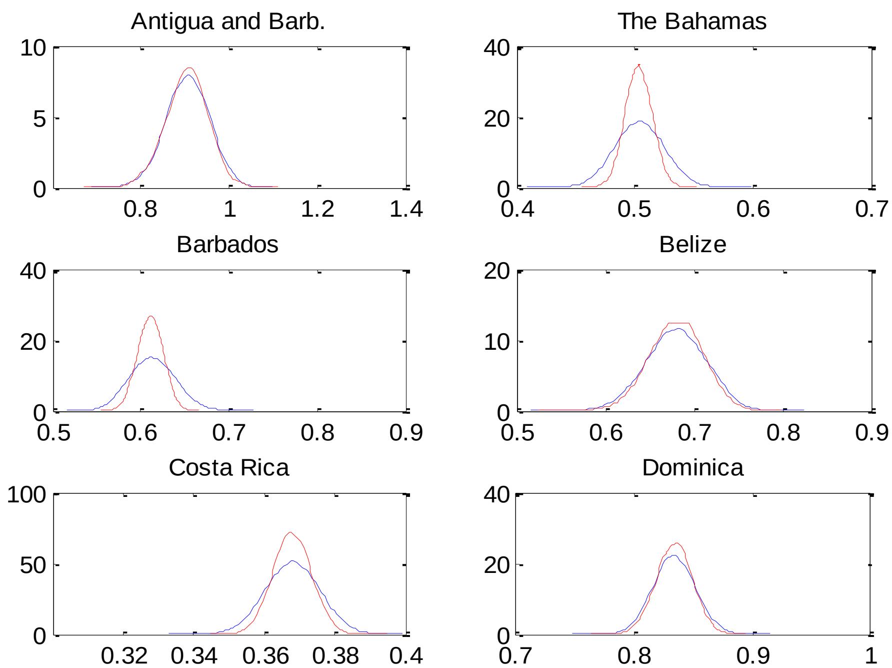
5. Simulation Results of Fiscal Limits and Discussion

Using a small, open economy model to simulate fiscal limits for 18 Central American and Caribbean economies, we draw the distribution of limits that shows the highest level of debt these economies can service given macroeconomic fundamentals and fiscal policy, comparing the case with term of trade shocks (blue line) related to the simulations without this type of shock (See Figures 5.1, 5.2, 5.3 and 5.4). The results are shown below in endogenously dynamic Laffer curves.

By determining the fiscal limits, we recognized that economies' sovereign default risk increases as existing debt levels exceed the endogenously determined Laffer curves, as rising tax revenues will be increasing unable to cover the mounting debt. Our paper studies the developing economies of Central America and the Caribbean, including terms-of-trade and flexible exchange rate regime shocks, as these economies are heavily reliant on external borrowing and export earnings, with increased volatility in terms of trade and exchange rate changes elevating sovereign default risk through their balance sheets. (Bi et al., 2013). Our results, outlined below, provide policymakers and central bankers with results not previously available for these 18 economies.

Figure 5.1. Fiscal Limit Distribution (Debt to GDP %)

(Blue line: considering open economy model term of trade shocks)

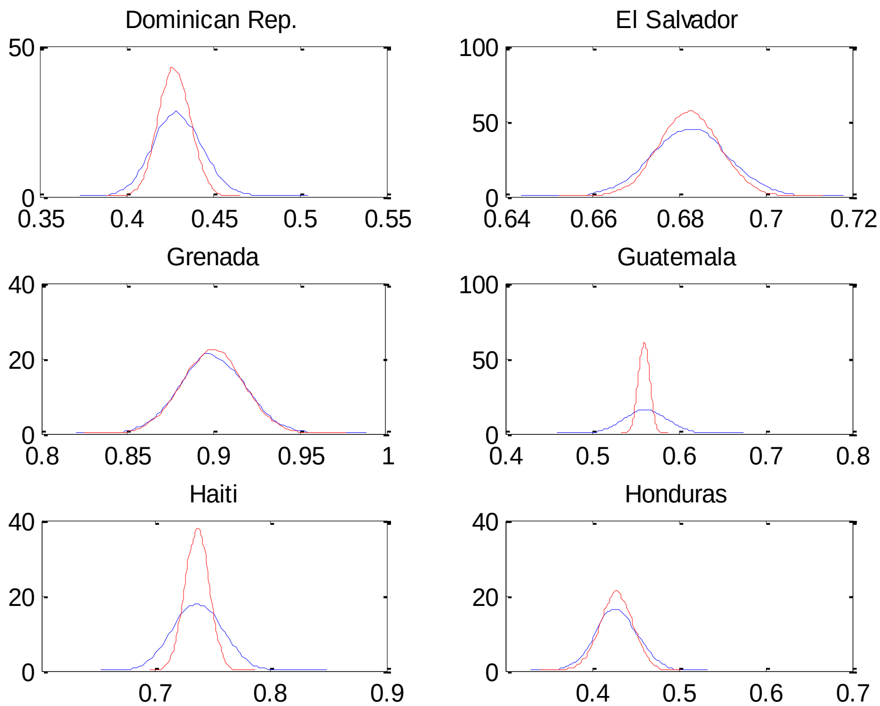


For most of the economies studied, the fiscal limit using the open economy model lies at a lower bound than the economy without the terms-of-trade shock simulated Laffer curve. The economies with the greatest ability to service debt given economic fundamentals and fiscal policy and derived from the dynamic Laffer curve within Central America were Panama (167 percent), Nicaragua (83 percent) and El Salvador and Belize, respectively (68 percent), and the lowest were Costa Rica (37 percent) and Honduras (43 percent).

Among the Caribbean economies, Trinidad and Tobago (138 percent), Jamaica (105 percent) and Antigua and Barbuda (91 percent) were listed among the economies showing the highest endogenously determined Laffer curves, while the Dominican Republic (43 percent), The Bahamas (50 percent), and Barbados (61 percent) were lower.

Figure 5.2. Fiscal Limit Distribution (Debt to GDP %)

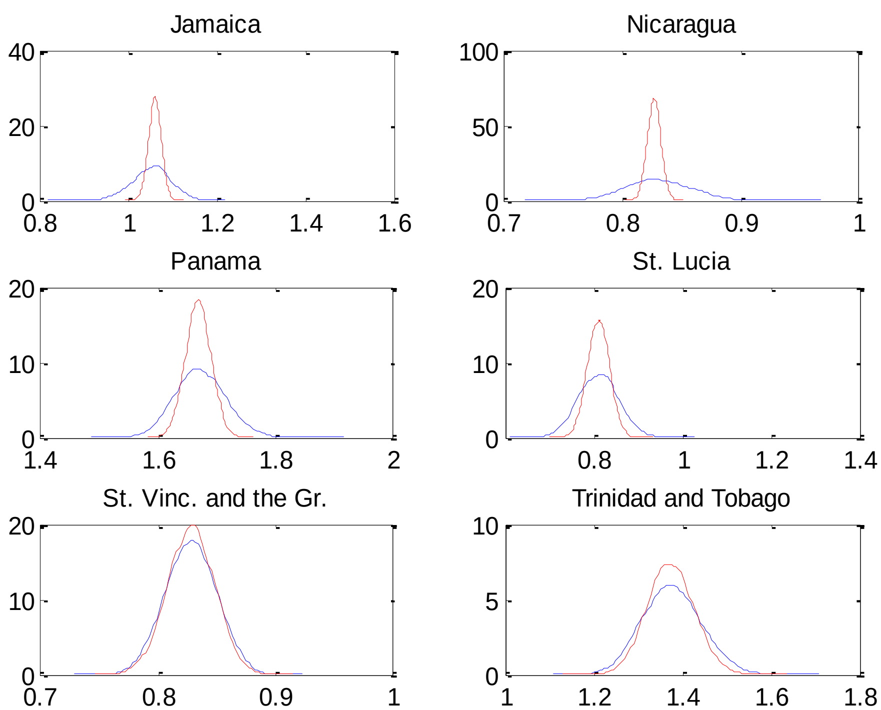
(Blue line: considering open economy model term of trade shocks)



The endogenously derived Laffer curves using the open economy model with terms-of-trade shocks is at a lower bound than those derived without shocks. Thus indicates the openness of these developing economies and the impact of terms-of-trade shocks on their balance sheets and the elevated default risk as existing debt exceeds the fiscal limit.

Figure 5.3. Fiscal Limit Distribution (Debt to GDP %)

(Blue line: considering open economy model term of trade shocks)

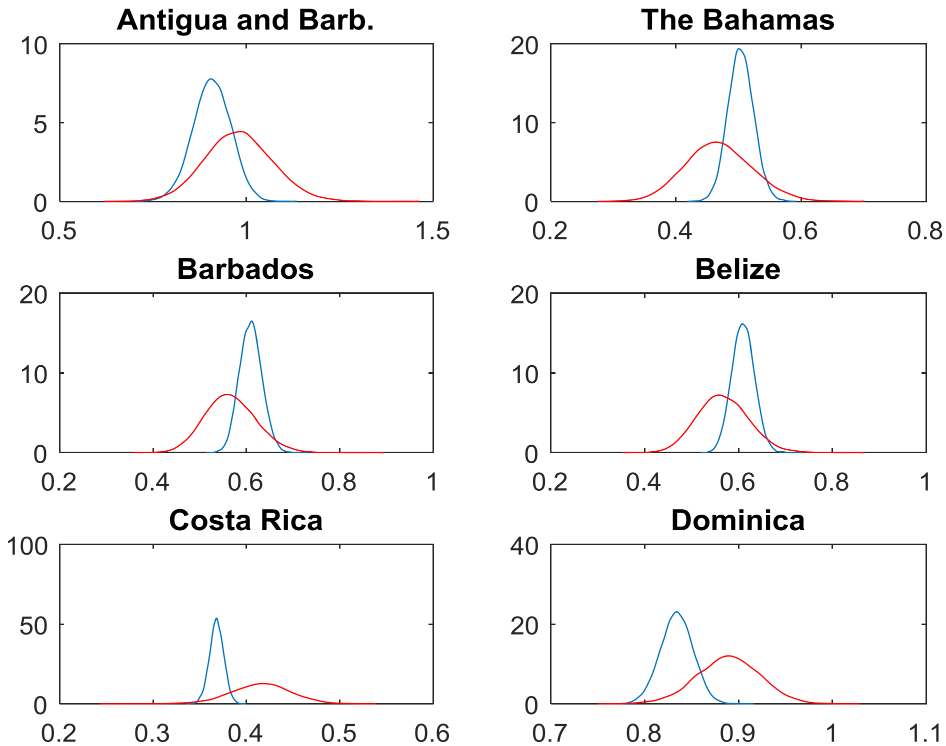


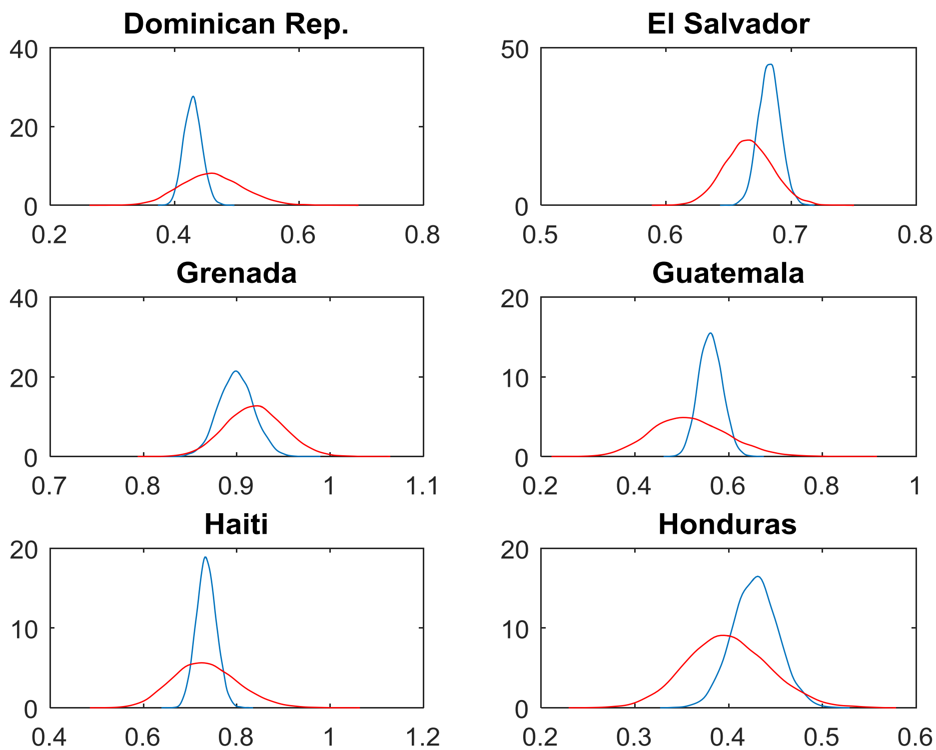
The impact of exchange rate shocks

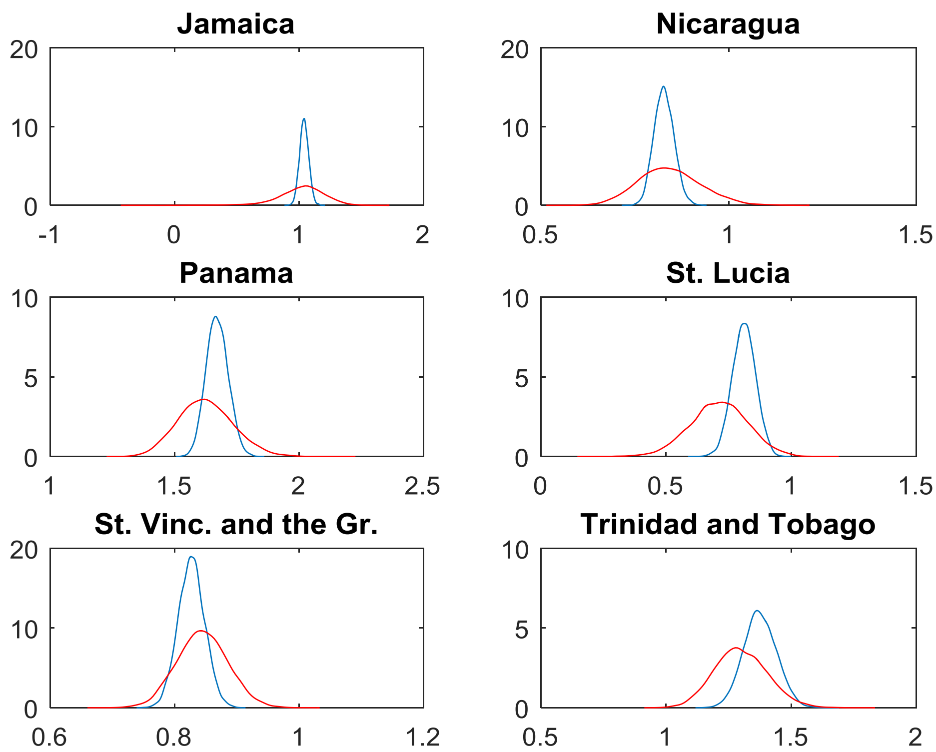
Results are similar to terms of trade shocks where the endogenously derived Laffer curves using the open economy model with flexible exchange rate shocks is at a lower bound than those derived without shocks. This indicates the openness of these developing economies and the impact of exchange rate shocks on their balance sheets and the elevated default risk as existing debt exceeds the fiscal limit.

Figure 5.4. Fiscal Limit Distribution (Debt to GDP %)

(Red line: considering open economy model with flexible exchange rates)



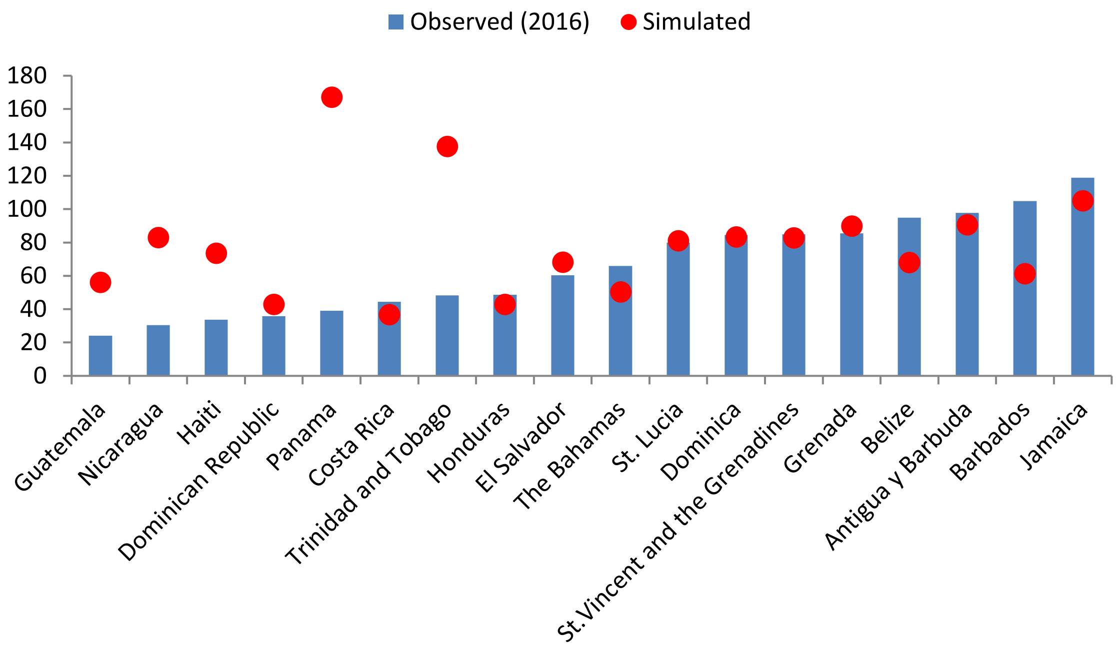

Dominican Rep.
40
20
0
0.2
0.4
0.6
0.8
El Salvador
50
0
0.5
0.6
0.7
0.8
Grenada
40
20
0
0.7
0.8
0.9
1
1.1
Guatemala
20
10
0
0.2
0.4
0.6
0.8
1
Haiti
20
10
0
0.4
0.6
0.8
1
1.2
Honduras
20
10
0
0.2
0.3
0.4
0.5
0.6



6. Policy Implications

From the simulations of the fiscal limits for the developing economies of Central America and the Caribbean, policymakers and central bankers can clearly see the maximum level of debt that these economies can service given macroeconomic fundamentals and fiscal policy. The results not previously available show, in comparison to actual public debt to GDP ratios (see Figures 4 and 5 in the Appendix), that several economies within the study are rapidly expanding public debt and appear to lie above the endogenously determined bound of the Laffer curves. These economies should promptly consider deepening their fiscal consolidation efforts, including potential fiscal reforms, to improve both short- and long-term outcomes.

Figure 6.1 Observed Debt-to-GDP Ratio (2016) and Average of the Simulated Fiscal Limit



7. Conclusions

Using macroeconomic fundamentals and fiscal policy variables, we derive the fiscal limits for 18 Central American and Caribbean economies. The results show the maximum amount of debt that these economies could reasonable service given the fundamentals. Within Central America, Panama had the highest derived Laffer curve, while Costa Rica and Honduras were simulated among the lowest. Among Caribbean economies, the Dominican Republic was among the lowest, while Trinidad and Tobago was among the highest. The open economy model with terms-of-trade and flexible exchange rate shocks produced lower distribution fiscal limits than the model without terms of trade. This shows that trade volatility in these small, open developing economies significantly impacted their ability to service sovereign debt.

Some economies that currently lie below the simulated fiscal limits (Haiti and Nicaragua) have engaged in significant debt restructuring and forgiveness programs since 2003, while Trinidad and Tobago's previous rapid GDP growth has contributed to the current position. Weak macroeconomic fundamentals have contributed, over the last decade or so, to rising debt levels above their limits, while debt in Belize, even after restructuring its debt in 2003, continues to climb.

References

Bi, H. 2011. “Sovereign Default Risk Premia, Fiscal Limits, and Fiscal Policy.” International Economic Analysis Department Working Paper 2011–10. Ottawa, Canada: Bank of Canada.

Bi, H. and E. Leeper. 2010. “Sovereign Debt Risk Premia and Fiscal Policy in Sweden.” *Swedish Economic Policy Review, Volume 3, pages 1-48*

Bi, H., W. Shen, and S.-C. Yang. 2013. “Fiscal Limits, External Debt, and Fiscal Policy in Developing Countries. International Economic Analysis Department. Ottawa, Canada: Bank of Canada.

Buffie, E., et al. 2012. “Public Investment, Growth, and Debt Sustainability: Putting Together the Pieces.” IMF Working Paper 12/144. Washington, DC: International Monetary Fund.

Gavin, M. and R. Perotti. 1997. Fiscal Policy in Latin America. NBER Macroeconomics Annual Vol. 12. Cambridge, MA: National Bureau of Economic Research.

International Monetary Fund. 2012. World Economic Outlook Database [Data File]. Available at http://imf.org/external/pubs/ft/weo/2012/update/02/.

Juessen, F., L. Linnemann, and A. Schabert. 2011. “Default Risk Premia on Government Bonds in a Quantitative Macroeconomic Model.” Unpublished manuscript.

Leeper, E. 1991. “Equilibria under ‘Active’ and ‘Passive’ Monetary and Fiscal Policies.” *Journal of Monetary Economics* 27(1): 129–47.

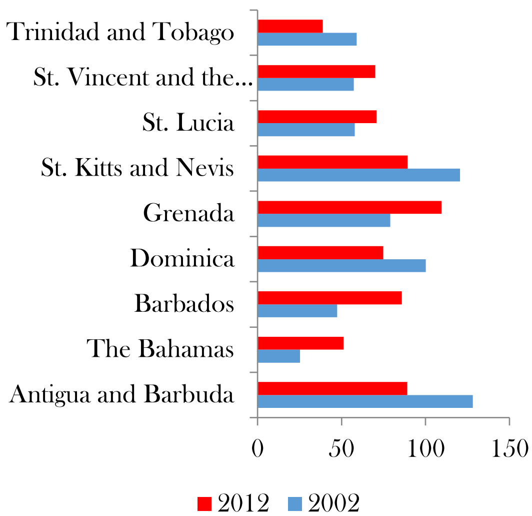
Mendoza, E. and M. Oviedo. 2004. “Fiscal Solvency and Macroeconomic Uncertainty in Emerging Markets: The Tale of the Tormented Issuer.” Working Paper, Iowa State University.

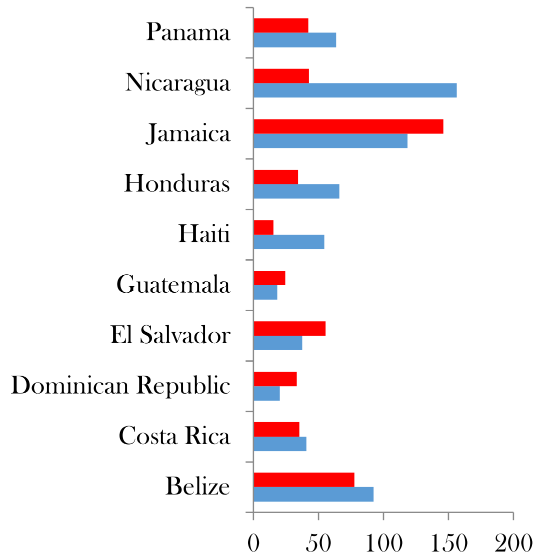
Uribe, M. 2006. “A Fiscal Theory of Sovereign Risk.” *Journal of Monetary Economics* 53: 1857–75.

Uribe, M., and S. Schmitt-Grohe. 2003. “Closing Small Open Economy Models.” *Journal of International Economics* 61(1): 163–85.

Appendix

Figure A1: Public Debt to GDP in the Economies Studied (percent) by authors' estimates





TECHNICAL APPENDIX

Following Bi et al. (2013), this appendix describes the procedure to solve the nonlinear model and obtain the simulations required for the fiscal limit.

At each point, the state of the economy is characterized by the state variables $S_t = \{a_t, g_t, \xi_t, k_{t-1}^N, k_{t-1}^T\}$, conditional to the high-in-sample tax rate (as we assume, that developing countries cannot raise their tax rates until they reach the top of their dynamic Laffer Curve, due to political restrictions). Computing the fiscal limit required, conditional to an initial state, the simulation of T_t^{max} .

1. Assume the following decision rules for the relative price in nontradable $p_t^{N,max}$, labor in the nontradable sector, $l_t^{N,max}$, capital in the nontradable sector, $k_t^{N,max}$:
   a. $p_t^{N,max} = m^p(S_t)$
   b. $l_t^{N,max} = m^l(S_t)$
   c. $k_t^{N,max} = m^k(S_t)$
2. Given the convergence rules for $m^p(S_t)$, $m^l(S_t)$ and $m^k(S_t)$ and the assumption of $\tau_t^{max} = \tau$, derive the rule for $T_t^{max} = m^T(S_t)$ and, consequently, compute $s_t^{max} = m^s(S_t)$, which is the primary balance in the state S_t and consistent with the optimization conditions from the household's and firm's problem.

Given the existence of nonlinearity in the model that is a maximum tax rate, the model is solved using the algorithm suggested by Bi et al. (2013):

1. Discretize the state space defining a set of grid points and make an initial guess for m_0^p, m_0^l and m_0^k over the discretized state space.
2. At each grid point, solve the nonlinear model under the assumption that the tax rate is always at τ^{max} using the given rules m_{t-1}^p, m_{t-1}^l and m_{t-1}^k to update to m_t^p, m_t^l and m_t^k
3. Check convergence of the decision rules. If $|m_i^p - m_{i-1}^p|$,$|m_i^l - m_{i-1}^l|$, or $|m_i^k - m_{i-1}^k|$ is above the desired tolerance (set to 1e-7), go back to step (2). Otherwise, m_i^p, m_i^l, and m_i^k are the decision rules.
4. With the converged rules, compute the decision rules for m_t^T and m_t^s.

Once the decision rules for maximum tax revenue $\mathrm{m_t^T}$ and $\mathrm{m_t^s}$ are obtained, the distribution of fiscal limit is computed using Markov Chain Monte Carlo simulations in two steps:

1. After solving, we simulate the model 10,000 periods, randomly drawing the exogenous shocks for TPF, government expenditure and the terms of trade, and compute T_{t+i}^{max} and s_t^{max}. Then, we compute the definition of fiscal limit for this particular sequence of shocks.
2. We repeat the simulation 10,000 to have $\{B^{max}\,(\mathfrak{H}_t)\}_{j=1}^{10,000}$

where

$$B^{max}(\mathfrak{H}_t)\sim\left[\sum_{i=0}^{\infty}\beta^t\,\theta\,\frac{1}{s_{t+i}^{max}}\left(T_{t+i}^{max}-p_{t+i}^{g}g_{t+i}-z_t\right)\right]$$