Understanding Fiscal Limits and Debt in the Developing Economies of Central America and the Caribbean.

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April 2014

Abstract

This study uses simulations of state dependent distributions of fiscal limits for eighteen (18) economies within Central America and the Caribbean to better understand governments' ability to service its 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 distribution of fiscal limits for the open economy model subject to term of trade shocks, indicating that terms of trade volatility impacted the ability of state economies in servicing their debt. It is therefore prudent that policymakers and central bankers consider models that incorporate the use of trade and its volatility, as a robust way of more accurately determining fiscal limits which are a critical component in better understanding governments' ability to service its debt.

Keywords: Fiscal Limits, Laffer Curves, Debt and Developing Economies

JEL Number: C15; E62; H60; O54

1.0: Introduction

The main 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 are able and willing to serve (Bi and Leeper, 2010). Using simulations of state dependent fiscal limits for eighteen (18)[1] economies we produced results that were not previously available for these economies, showing varying and wider distribution limits for the simulations when applying an open economy model subject to term of trade shocks versus the same model without considering this particular shock. The results indicated that terms of trade volatility impacted the ability of these developing economies in servicing their debt.

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

The methodologies used analyzed the fiscal limit, which is defined as the maximum level of debt that governments are able to service given the current underlying macroeconomic fundamentals of the economies; the present value of fiscal surpluses, the state of government transfers and subsidies and the impact of sovereign risk on the economy. (Bi 2011 and Juessen et al 2011). Using an open economy Real Business Cycle (RBC) model for simulating fiscal limits, we derived dynamic Laffer curves, which are obtained endogenously as governments normally raises the tax rate in response to a rising debt level (Leeper 1991)

[1] 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.

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 also have 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 with rising sovereign debt especially after the period of the great recession, and continue to be impacted, sometimes negatively by the state of world trade and the economies of their leading trade partners. The understanding of fiscal limits within these economies is vital as policy makers and central bankers are continually searching for methodologies and tools that can help them better define these limits, provide more robust forecast of the ability of their economies in raising debt and the necessary fiscal policies in containing debt and default risk within the short and long term. (Bi 2011 and Bi et al 2013)

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

The organization of the study is as follows: Section 2 contains a clearer understanding of why the studying fiscal limits are important to developing economies; Section 3 presents the latest literature review on fiscal limits. Section 4 discusses the methodologies used, the data and parameters used in deriving the simulation of the fiscal limits. This is followed by the simulation results, discussions, policy implications and conclusions.

2.0: Why understanding Fiscal Limits is important to developing economies.

Fiscal limit is usually the highest level of debt that the government is able to service and is dependent on the current state of 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 and Bi et al 2013). The simulations of the limits are demonstrated in endogenously derived dynamic Laffer curves. The peak of the distribution curves shows the point at which governments are limited in further raising tax revenues to finance sovereign debt, hence their ability to adequately service sovereign debt. Usually, even before this point 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 sovereign debt. (Uribe, 2006)

The fiscal limit, which is state dependent on existing macroeconomic fundamentals and stochastic in nature as random disturbances affects the future path of fiscal surpluses, are effectively defined at each period and will depend on the macroeconomic circumstances and fiscal policy (Leeper 1991, Juessen et al 2011 and Bi et al 2013). 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 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 stabilizers as counter cyclical fiscal policy within periods of low economic growth will have lower surpluses as income remains depressed and face greater difficulty in servicing sovereign debt. Furthermore, the occurrence of 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. (Leeper 1991, Bi 2011, Bi et al 2013).

A careful analysis of developing economies' fiscal positions show that among the economies studied, economies with specific focus on the past decade (2002-2012) 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 1 below and Figure 5 showing public debt to GDP in appendix).

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 the increasing levels of debt and in most cases low growth or weak macroeconomic fundamentals and declining fiscal surpluses, developing economies of the Central America and the Caribbean are becoming more concerned regarding their ability to adequately service sovereign debt from lower fiscal surpluses with the increase possibility of sovereign default risk (See table 2 below, showing average fiscal surplus or deficit over the period studied).

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 debts, which has resulted in the downgrading of the credit worthiness of these economies. Below is a table which shows the sovereign credit rating of several Central American and Caribbean economies over the past decade (See Table 3 below).

Sovereign 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.

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

3.0: Literature Review

Juessen et al 2011 determine endogenously dynamic Laffer curves, showing the amount of debt that could be accommodated by an average Eurozone country member by predicting its debt capacity baseline. The authors however show that with income volatility and changes in the macroeconomic fundamentals, significant risk premium can emerge. Adjusting the baseline parameters within their closed economy model, Juessen et al 2011 determined that the debt capacity level of the Grecian economy was lower than specified in the scenario, as agents doubted the ability of the Grecian government to raise tax revenues to its maximum to finance rising debt levels. Bi 2011 paper 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 rise from continuing explosive government spending and transfers.

The closed economy model used by Bi 2011 for developed economies in Europe and Oceanic area showed a likely framework to discuss fiscal measures in the short run and policy reform in the long run. This work was extended by Bi et al 2013, in determining the state dependent fiscal limits of two (2) Latin American economies. The authors' findings suggest that expected future income was critical in deriving lower fiscal bounds or limits for developing countries verses developed economies. Using a small open economy model with separation of non-tradable and tradable economy, the authors determined the impact on the distribution of fiscal limits from shocks in macroeconomic uncertainty, fiscal policy and terms of trade.

The Bi et al 2013 results appear similar to the previous work, as government spending and transfers were reduced as the economies approached their fiscal limits and increased tax revenues to finance rising debt, reduced 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, that they referred to as "natural debt limit". However, the analysis held interest rate at a constant level, an exogenously determined risk premium was used by Buffie et al (2012) as economies were not allowed to default on sovereign debt.

Our paper derived endogenously determined fiscal limits from economic fundamentals and fiscal policy, recognizing that sovereign default might occur if existing debt levels exceed fiscal limits, as rising tax rates are unable to covering mounting debt. We incorporate shocks of terms of trade in our open general equilibrium model, in recognition that most developing economies apart from relying heavily on external borrowing also export significant amounts of their domestic production, with changes in terms of trade magnifying sovereign default risk (Bi et al 2013). We produced results for developing economies that were not previously available to better aid policy makers and central bankers formulate fiscal consolidations and reform in both the short and long term.

4.0: Models, Data and Parameters

4.1: Model

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

4.1.1 Households

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

$$c_t = \omega\ c_t^{\frac{\upsilon-1}{\upsilon}} + (1-\omega)\ g_t^{\frac{\upsilon-1}{\upsilon}}{}^{\frac{\upsilon}{\upsilon-1}}$$

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 good, labor, and investment and capital in the tradable and nontradable sectors:

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

Where $U_t = \log(c_t) + \phi \frac{(1-l_t)^{1-\sigma}}{1-\sigma}$. 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 the budget constraint,

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

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 depreciation of capital, that is assume is 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 deliver the following intertemporal equilibrium condition for the households:

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

$$\begin{aligned}
1+\kappa\left(\frac{i_t^N}{k_{t-1}^N}-\delta\right) &= \beta E_t \left(\frac{c_{t+1}}{c_t}\right)^{\frac{-1}{\upsilon}} \left(\frac{c_{t+1}}{c_t}\right)^{\frac{1}{\upsilon}-1} \\
&= \left(1-\tau_{t+1}\right) r_{t+1}^N - \kappa\left(\frac{i_t^N}{k_{t-1}^N}-\delta\right)^2 + \kappa\left(\frac{i_t^N}{k_{t-1}^N}-\delta\right)\frac{i_{t+1}^N}{k_{t+1}^N} + \left(1-\delta\right)\left(1+\kappa\left(\frac{i_t^N}{k_{t-1}^N}-\delta\right)\right)
\end{aligned}$$

$$\begin{aligned}
1+\kappa\left(\frac{i_t^T}{k_{t-1}^T}-\delta\right) &= \beta E_t \left(\frac{c_{t+1}}{c_t}\right)^{\frac{-1}{\upsilon}} \left(\frac{c_{t+1}}{c_t}\right)^{\frac{1}{\upsilon}-1} \\
&= \left(1-\tau_{t+1}\right) r_{t+1}^T - \kappa\left(\frac{i_t^T}{k_{t-1}^T}-\delta\right)^2 + \kappa\left(\frac{i_t^T}{k_{t-1}^T}-\delta\right)\frac{i_{t+1}^T}{k_{t+1}^T} + \left(1-\delta\right)\left(1+\kappa\left(\frac{i_t^T}{k_{t-1}^T}-\delta\right)\right)
\end{aligned}$$

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.

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

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

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

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

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

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

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 non tradables, and as s_t CPI real exchange rate (assuming the law of one prince holds), then

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

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) processes. ε_t^a is the productivity shock that it is assumed 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:

$$l_t^N = \alpha^N \ \frac{p_t^N}{w_t^N} \ y_t^N$$

$$l_t^T = \alpha^T \ \frac{\xi_t s_t}{w_t^T} \ y_t^T$$

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

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

Where $\xi_t = p_t^x / s_t$ are de term of trade, which is assume that follows an exogenous process

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

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

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 non tradables, so g_t is represented as a CES basket of these types of goods. So the price index for government goods is given by:

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

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:

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

Where q_t is the price of foreign bonds and $q_t s_t b_t^*$ is the number of unit of local goods raised with the selling 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 limit 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:

$$b^*_{t-1} = \sum_{i=0}^{\infty} \beta^i E_t \left[\frac{1}{s_{t+i}} \left(T_{t+i} - p^g_{t+i} g_{t+i} - z_{t+i} \right) \right]$$

i.e. the external debt at the start to period t is the present value of future surpluses.

The evolution of fiscal policy variables are the following. Government expenditure, g_t, is assume to be procyclical, as the evidence suggests[2] for developing countries. Relative to taxes, the policy rule establishes that taxes adjust to maintain sustainability. Thus, the expenditure and taxes rules are,

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

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

Where $\varepsilon^i_t \sim N(0, \sigma^2_i)$ for $i \in \{\tau, g\}$

4.1.4 Market clearing

The market clearing conditions require that factor market clear, so labor and capital supplies equals to their respective demands in each market and in the aggregate, so

$$k_t = k^N_t + k^T_t$$

[2] Gavin and Perotti (1997)

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

The output in local units is

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

Market clearing condition for nontradables is

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

The balance of payment condition is

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

4.1.5 Defining the fiscal limit

As in Bi, et. al. (2013), the fiscal limit is defined *as the maximum level of debt in 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.

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

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

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

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 the 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, that we assumed constant.

As Bi et al (2013) comments, 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 describe by Bi et al (2013), we solve the non-linear model for each country and obtain the decision rules for the state variables of the model.
2. After solving, we simulate the model 1000 periods, randomly drawing the exogenous shocks for TPF, government expenditure and the term 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.
3. We repeat the simulation 10,000 to have $\left\{B^{max}\left(\mathfrak{H}_t\right)\right\}_{j=1}^{10,000}$

4.2: Data

4.3: 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 common across economies, and the rest are obtained from sample data of key model variables for these economies.

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

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 to 0.5 for the countries considered, similar to the value estimated for the Dominican Republic (0.49)[3] and Bi et al (2013) that 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 weigth on c_t in effective consumption is set to 0.8. The elasticity of substitution between tradable and non-tradable goods in both private and public consumption basket is

[3] From Central Bank price surveys classifications.

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

The country specific parameters are calibrated using annual data on percapita GDP, real effective exchange rate, real ex-post interest rates, government expenditures, transfers, revenues and external public debt from 1990 to 2012. Data is obtained from multiple sources such as 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 through average ex-post real interest rate for each country. The average ex-post real rate is around 9%, which implies a discount rate of 0.92. El Salvador is the country with the highest discount (0.96) and Dominica has the minimum (0.86).

Data on the political risk parameter is 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 with developed economies. The index decreases from 0.80 in the case of The Bahamas to 0.46 for Haiti. There is no data on this indicator for Barbados, Belize, Dominica, Grenada, St, Kitts, St. Lucia and St. Vincent and Grenadines, so we calibrate this parameter to 0.64, which is the sample average for Latin-American countries.

In terms of persistence and volatility parameters, these vary in wide ranges across countries. Productivity shocks are more persistent than the average in countries like Trinidad and Tobago, Honduras and Panama. Nevertheless, the volatility of productivity shocks is very similar across countries. Term of trade shocks, approximated by the persistence and volatility of the deviation of real exchange rate from its HP trend, displays heterogeneity in the set of countries with an average persistence of 0.38 and volatility of 3.8%.

In relation to fiscal parameters, the ratio of government expenditure over GDP on average is 25%, with countries with traditional low levels like Guatemala (14%), Dominican Republic (16%) and Costa Rica (17%). Despite The Bahamas, countries in the Small Antilles have the highest average of government expenditure in the sample, with Barbados at the top with 37% of GDP.

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

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

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

Table 4.2. Parameters 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

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

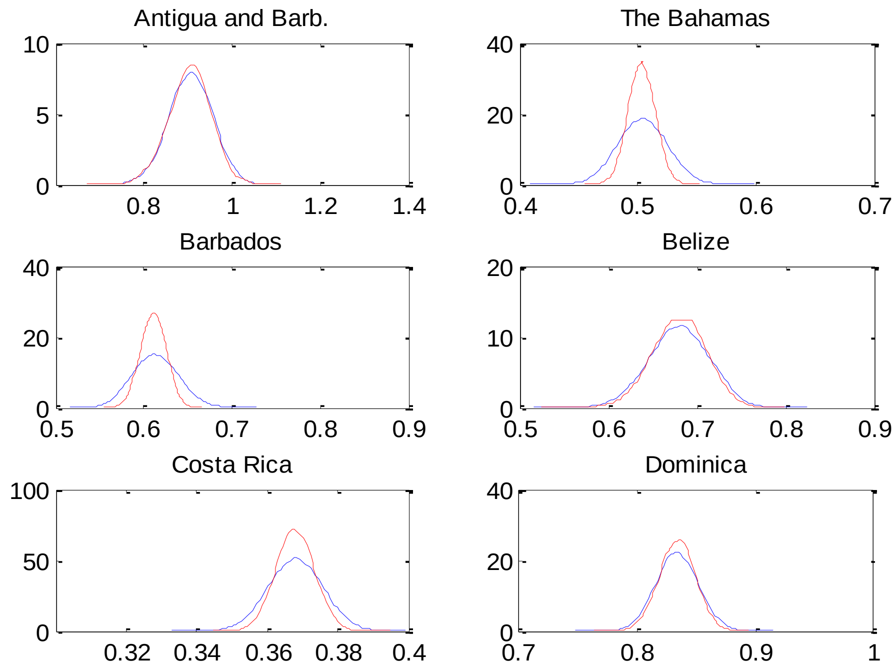
5.0: Simulation Results of Fiscal Limits and Discussion

Using a small open economy model to simulate fiscal limits for eighteen (18) Central American and Caribbean economies, we draw the distribution of limits that show 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 1, 2 and 3 below). 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 exceeds 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 shocks, as these economies are heavily reliant on external borrowing and export earnings, with increased volatility in terms of trade elevating sovereign default risk through their balance sheets. (Bi et al 2013). Our results are outline below for each of the eighteen (18) economies and provide policy makers and centrals bankers with results not previously available for these economies.

Figure 1. Fiscal Limit Distribution (Debt to GDP %)

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

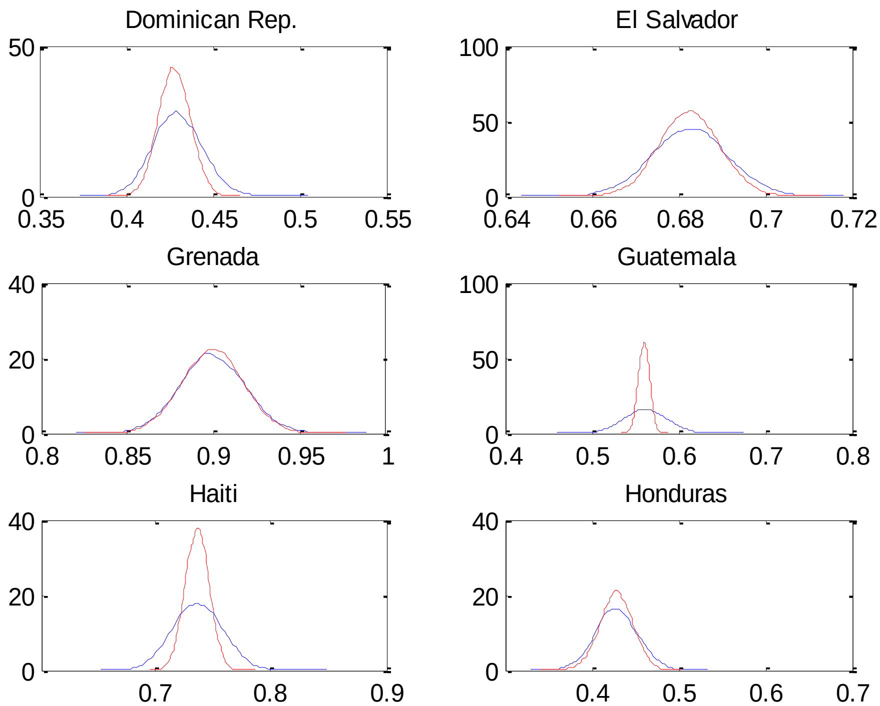


For most of the economies studied, the fiscal limit using the open economy model lies at a lower bound than the economy without terms of trade shock simulated Laffer curve. The economies with the greatest ability to service debt given economic fundamentals and fiscal policy and derived from the dynamic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

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

Figure 2. Fiscal Limit Distribution (Debt to GDP %)

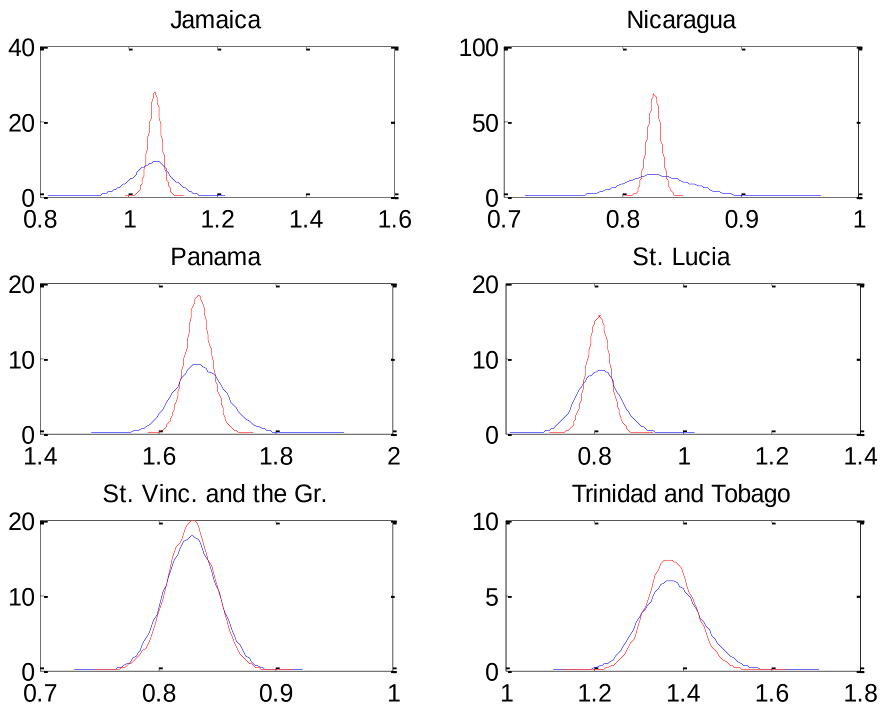
(Blue line: considering open economy model term of trade shocks)



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, indicating the openness of these developing economies and the impact, terms of trade shocks generally have on their balance sheet and the elevated default risk as existing debt exceeds the fiscal limit.

Figure 3. Fiscal Limit Distribution (Debt to GDP %)

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



6.0: Policy Implications

From the simulations of the fiscal limits for the developing economies of Central America and the Caribbean, policy makers and central bankers are able to clearly see the maximum level of debt these economies can service given macroeconomic fundamentals and fiscal policy. The results not previously available show in comparison to actual public debt to GDP percent (see Figure 4 and Figure 5 in the Appendix) several economies within the study are rapidly expanding public debt and appear to lie above the endogenously determined Laffer curves bound. These economies need to urgently engage in fiscal consolidation, reform and debt relief or restructuring strategies to improve both the short and long term outcomes.

Figure 4 Observe Debt-to-GDP Ratio (2012) and Average of the Simulated Fiscal Limit

Countries	Observed (2012)	Simulated
Antigua and Barbuda	89.1	90.7
The Bahamas	51.2	50.4
Barbados	85.9	61.3
Belize	77.7	68
Costa Rica	35.3	36.8
Dominica	74.8	83.3
Dominican Republic	33.5	42.9
El Salvador	55.4	68.3
Grenada	109.5	89.9
Guatemala	24.4	56.2
Haiti	15.4	73.6
Honduras	34.4	42.9
Jamaica	146.1	104.9
Nicaragua	42.7	83
Panama	42.2	167.1
St. Lucia	70.9	81.1
St. Vincent and the Grenadines	70.1	82.8
Trinidad and Tobago	38.7	137.7

7.0: Conclusions

Using macroeconomic fundamentals and fiscal policy variables, we are able to derive the fiscal limits for eighteen (18) Central American and Caribbean economies. The results show the maximum debt these economies could reasonable service given the fundamentals. Within Central America, Panana had the highest derived Laffer curve, while Costa Rica and Honduras were simulated among the lowest. For Caribbean economies, the Dominican Republic was considered among the lowest while Trinidad and Tobago among the highest. The open economy model with terms of trade shocks produced lower distribution fiscal limits than the model without terms of trade, showing that trade volatility in these small open developing economies was significant in impacting their ability to service sovereign debt.

Some economies that currently lie below the simulated fiscal limits (Haiti, Nicaragua, Dominica and Antigua and Barbuda) have engaged in significant debt restructuring and forgiveness programs from 2003 while Trinidad and Tobago rapid growth in GDP have contributed to the fall in their debt to GDP ratios.

Continuously weak macroeconomic fundamentals have contributed to accelerating debt levels in (Jamaica, Barbados and Grenada) that lie above their limits, while Belize even after restructuring their debt after 2003, continues to show higher limits.

8.0 References

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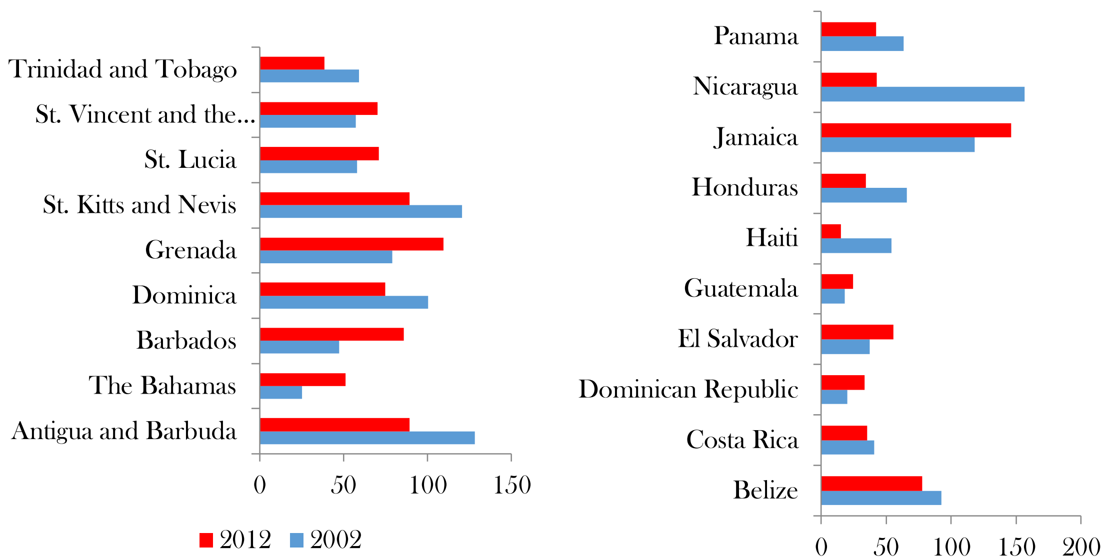
Appendix: Figure 5: Public Debt to GDP (Percent) among studied economies



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 characterize 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 rise their tax rates until the top of their dynamic Laffer Curve, due to political restrictions). Computing the fiscal limit require, conditional to a initial state, the simulation of T_t^{max} .

1. Assume the following decision rules for the relative price in non-tradable $p_t^{N,max}$, labor in non-tradable sector , $l_t^{N,max}$, the capital in non-tradable 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, in consequence, 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 a non-linearity 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 guesses for $\mathrm{m}_0^{\mathrm{p}}$, $\mathrm{m}_0^{\mathrm{l}}$ and $\mathrm{m}_0^{\mathrm{k}}$ over the discretized state space.
2. At each grid point solve the nonlinear model under the assumption that the tax rate is always at $\tau^{\max}$ using the given rules $\mathrm{m}_{\mathrm{t-1}}^{\mathrm{p}}$, $\mathrm{m}_{\mathrm{t-1}}^{\mathrm{l}}$ and $\mathrm{m}_{\mathrm{t-1}}^{\mathrm{k}}$ to update to $\mathrm{m}_{\mathrm{t}}^{\mathrm{p}}$, $\mathrm{m}_{\mathrm{t}}^{\mathrm{l}}$ and $\mathrm{m}_{\mathrm{t}}^{\mathrm{k}}$
3. Check convergence of the decision rules. If $\mathrm{m}_{\mathrm{i}}^{\mathrm{p}} - \mathrm{m}_{\mathrm{i-1}}^{\mathrm{p}}$, $\mathrm{m}_{\mathrm{i}}^{\mathrm{l}} - \mathrm{m}_{\mathrm{i-1}}^{\mathrm{l}}$, or $|\mathrm{m}_{\mathrm{i}}^{\mathrm{k}} - \mathrm{m}_{\mathrm{i-1}}^{\mathrm{k}}|$ is above the desired tolerance (set to 1e-7), go back to step (2). Otherwise, $\mathrm{m}_{\mathrm{i}}^{\mathrm{p}}$, $\mathrm{m}_{\mathrm{i}}^{\mathrm{l}}$, and $\mathrm{m}_{\mathrm{i}}^{\mathrm{k}}$ are the decision rules.
4. With the converged rules, compute the decision rules for $\mathrm{m}_{\mathrm{t}}^{\mathrm{T}}$ and $\mathrm{m}_{\mathrm{t}}^{\mathrm{s}}$.

Once the decision rules for maximum tax revenue $\mathrm{m}_{\mathrm{t}}^{\mathrm{T}}$ and $\mathrm{m}_{\mathrm{t}}^{\mathrm{s}}$ 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 1000 periods, randomly drawing the exogenous shocks for TPF, government expenditure and the term 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

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