Journal of Macroeconomics 49 (2016) 119–130

Contents lists available at ScienceDirect

Journal of Macroeconomics

journal homepage: www.elsevier.com/locate/jmacro

Fiscal limits in developing countries: A DSGE Approach

Huixin Bi[a], Wenyi Shen[b,*], Shu-Chun S. Yang[c,d]

[a] Economic Research Department, Federal Reserve Bank of Kansas City, United States
[b] Department of Economics and Legal Studies, Oklahoma State University, United States
[c] Institute of Economics, National Sun Yat-Sen University, Taiwan
[d] International Monetary Fund, United States

ARTICLE INFO

Article history:
Received 24 September 2015
Revised 9 May 2016
Accepted 5 June 2016
Available online 8 June 2016

JEL classification:
E62
H30
H60

Keywords:
Fiscal limits
External debt
Developing countries
DSGE models

ABSTRACT

This paper studies fiscal limits in developing countries using a dynamic stochastic general equilibrium (DSGE) approach. Distributions of fiscal limits, which measure a government's capacity to service its debt, are simulated based on macroeconomic uncertainty and fiscal policy. The analysis shows that expected future revenue plays an important role in explaining the low fiscal limits of developing countries, relative to those of developed countries. Large devaluation of real exchange rates can significantly reduce a government's capacity to service its debt and lower the fiscal limits. Temporary disturbances, therefore, can shift the distribution of fiscal limits and suddenly change perceptions about fiscal sustainability.

1. Introduction

Sovereign debt of developing countries generally perceived as riskier than that of developed countries with the excepti on of the recent European debt crisis. Developing countries with low debt-to-GDP ratios can have much lower credit ratings than developed countries with high debt-to-GDP ratios, as documented in Alvarado et al. (2004), Hausmann (2004), and Reinhart et al. (2003). For example, Belgium, the United Kingdom, and the United States all had government debt-to-GDP ratios over 0.85 in 2012 while maintaining sovereign ratings at or above *AA*. At the same time, Argentina and Ecuador had much lower debt-to-GDP ratios at 0.38 and 0.22 in 2012, but with ratings of only *B* and *B*− (Standard & Poor's (2013)).[1] Fiscal limits, defined as the maximum debt level a government is able to service, are generally lower in developing than developed countries.

Using a dynamic stochastic general equilibrium (DSGE) model, this paper studies several factors that shape fiscal limit distributions in developing countries. Fiscal limits are computed as the expected discounted sum of maximum primary surplus that can be generated in the future. The model, incorporating important economic and fiscal policy shocks, is used

* Corresponding author.
E-mail addresses: huixin.w.bi@gmail.com (H. Bi), wenyi.shen@okstate.edu (W. Shen), syang@mail.nsysu.edu.tw (S.S. Yang).

[1] The debt ratios reported here are computed from general government *gross* debt, taken from the database of the World Economic Outlook (International Monetary Fund (2016)). The data of general government *net* debt are not available for Argentina and Ecuador. The net government gross debt-to-GDP ratios for Belgium, the U.K., and the U.S. were 0.62, 0.77, and 0.79 in 2012.

http://dx.doi.org/10.1016/j.jmacro.2016.06.002
0164-0704/

to simulate a distribution of fiscal limits, conditional on an initial state. The fiscal limits simulated are state-dependent and uncertain, depending on the underlying macroeconomic fundamentals and shock processes. To demonstrate how our approach can be applied, we fit the model to the Argentina's post-default data since 2004 and estimate several structural and shock parameters. A simulated fiscal limit distribution can then be used to assess sovereign default probability for a given debt level of a country.

In our framework, whether a government defaults each period depends on if the current debt exceeds a realized effective fiscal limit, drawn from the simulated distribution. This means that fiscal limits or debt thresholds to trigger a default decision are uncertain. In reality, sovereign default is a political decision that may or may not be grounded in economics.[2] In our modeling, while sovereign default is a stochastic event, its probability rises as a government becomes more indebted as observed in reality. Different from the strategic sovereign default approach of Eaton and Gersovitz (1981), in which a utilitarian government accounts for some economic costs in making default decisions (e.g., Aguiar and Gopinath (2006), Arellano (2008), Yue (2010)), the DSGE framework adopted here is convenient for incorporating economic shocks and conducting policy analysis.

Our analysis highlights two factors important for explaining the relatively low fiscal limits in developing countries. Revenue collection, characterized by the maximum effective tax rates that can be implemented, plays an important role in determining fiscal limits. Due to inefficient tax collection systems, tax evasion, and large informal sectors, developing countries on average have much lower effective tax rates than developed countries (International Monetary Fund (2011)). Callen et al. (2003) estimate that the effective tax rate for emerging markets outside eastern Europe is only 10% , much lower than the average of industrial countries, which exceeds 30% . A smaller tax base has been recognized to contribute to higher sovereign default risks in developing countries (e.g., see Hausmann (2004)). Our analysis quantifies the impact revenue collection has on fiscal limits: a one-percentage point increase in the maximum effective tax rate can raise the mean of the distribution of fiscal limits by almost 12% of GDP for Argentina.

Another factor is real exchange rate fluctuations for developing countries that rely heavily on external borrowing. The literature emphasizes the balance-sheet effect, where a substantial devaluation increases government liabilities in terms of domestic goods prices and therefore sovereign default risks. We show that a large devaluation not only changes the state of the economy at the current period, but also spills over into future periods, both of which lower the fiscal limits and constrain a government's capacity to service its debt. Temporary disturbances in the exchange rate can move the distribution of fiscal limits and suddenly change perceptions about fiscal sustainability. This is consistent with the argument made in Calvo et al. (2004b) in explaining Argentina's 2001 default: a steep real depreciation led by sudden stops turned an otherwise sustainable fiscal position into an unsustainable one in an economy with heavily dollarized liabilities.[3] We also show that higher volatility of real exchange rates leads to a more dispersed distribution of fiscal limits, making sovereign default a more likely event.

Our analysis is related to a growing literature on fiscal limits or debt sustainability assessment, accounting for interactions between macroeconomic conditions and fiscal policy. Celasun et al. (2007) propose a "fan-chart" algorithm to simulate debt distributions using an empirical framework that captures debt interactions with macroeconomic shocks. Motivated by Bohn (1998); 2008), Ghosh et al. (2013) estimate fiscal limits by imposing the debt sustainability condition that government debt should be expected to converge to some finite share of GDP under historical fiscal reaction functions. Also, in response to the recent European debt crisis, several recent papers estimate fiscal limits and assess fiscal crisis probabilities in the context of monetary union (e.g., Daniel and Shiamptanis (2012); 2013) and Polito and Wickens (2015)). Lastly, similar to our general equilibrium approach, Buffie et al. (2012) assess fiscal sustainability for developing countries with external debt, but they assume exogenous risk premia and do not allow for sovereign default risks as modeled here.

2. Model

The model is a small open, real economy with two production sectors for nontradables and tradables (denoted by N and T). The two-sector structure is necessary to have the endogenous real exchange rate. To enhance the empirical relevance of simulated fiscal limits, later we resort to Bayesian estimation for some parameter calibration. Thus, certain rigidities, shown to be important in the DSGE literature to match data, are incorporated, including capital adjustment costs and labor mobility friction. Also, four policy and structure shocks—total factor productivity (TFP), spending and tax policy, and terms of trade—are added as they are important in driving economic fluctuations. Appendix A lists the equilibrium conditions of the model.

[2] For example, the gross general debt-to-GDP ratio was only 0.22 in 2008 when Ecuador defaulted in 2008. Ecuador's President Correa called foreign debt immoral and decided to default on its $3.9 billion external sovereign debt while holding $5.7 billion of international cash reserve from oil receipts. This default was generally perceived as driven more by a political motivation and less by an economic one.

[3] Another important factor explains the relatively high risk of sovereign debt in developing countries is "debt intolerance" resulting from poor credibility and a default history, as emphasized in Reinhart et al. (2003). Our analysis does not explore this factor.

2.1. Households

A representative household chooses consumption (c_t), labor (l_t), investment (i_t^N, i_t^T), and capital (k_t^N, k_t^T) to maximize the expected utility over an infinite horizon

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{c_t^{1-\theta}}{1-\theta} - \phi \frac{l_t^{1+\nu}}{1+\nu} \right], \tag{1}$$

subject to the budget constraint

$$c_t + i_t^N + i_t^T + \Omega_t = (1-\tau_t)\left(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T\right) + z, \tag{2}$$

where $\beta \in (0, 1)$ is the discount factor, θ and ν are the inverses of intertemporal elasticity and the Frisch labor elasticity, τ_t is the income tax rate, and z is government transfers to households. Following Mendoza and Uribe (2000), we assume capital is sector specific, where r_t^N and r_t^T are returns to capital in each sector. Capital is subject to adjustment costs, $\Omega_t \equiv \frac{\kappa}{2}(\frac{i_t^N}{k_{t-1}^N} - \delta)^2 k_{t-1}^N + \frac{\kappa}{2}(\frac{i_t^T}{k_{t-1}^T} - \delta)^2 k_{t-1}^T$, with an adjustment parameter κ. The law of motion for capital is $k_t^j = (1-\delta)k_{t-1}^j + i_t^j$, $j \in \{N, T\}$. Aggregate investment is $i_t = i_t^N + i_t^T$.

Private consumption and investment are CES aggregates of nontradables and tradables with the intra-temporal elasticity of substitution χ and the degree of home bias φ. Thus,

$$x_t = \left[\varphi^{\frac{1}{\chi}} \left(x_t^N\right)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}} \left(x_t^T\right)^{\frac{\chi-1}{\chi}} \right]^{\frac{\chi}{\chi-1}}, \quad x \in \left\{c_t, i_t^N, i_t^T\right\}. \tag{3}$$

Households supply labor to both sectors. Aggregate labor is

$$l_t = \left[(\varphi^l)^{-\frac{1}{\chi^l}} \left(l_t^N\right)^{\frac{1+\chi^l}{\chi^l}} + (1-\varphi^l)^{-\frac{1}{\chi^l}} \left(l_t^T\right)^{\frac{1+\chi^l}{\chi^l}} \right]^{\frac{\chi^l}{1+\chi^l}}, \tag{4}$$

where φ^l is the steady-state share of labor in the nontraded good sector. While capital is sector specific, we allow some labor mobility across sectors, where $\chi^l > 0$ is the elasticity of substitution between sectors. A smaller χ^l implies more friction in labor mobility. From the cost minimization problem, the aggregate wage index can be derived as $w_t = [\varphi^l \left(w_t^N\right)^{1+\chi^l} + (1-\varphi^l)\left(w_t^T\right)^{1+\chi^l}]^{\frac{1}{1+\chi^l}}$.

We normalize the price of composite consumption (or local goods) to 1. Let p_t^N be the relative price of nontradables to composite consumption, and s_t be the relative price of tradables. Then, $1 = [\varphi(p_t^N)^{1-\chi} + (1-\varphi)(s_t)^{1-\chi}]^{\frac{1}{1-\chi}}$. s_t is also the real exchange rate in units of c_t that can be exchanged for a unit of tradables consumed domestically.

2.2. Firms

Firms are perfectly competitive, producing with Cobb-Douglas technology,

$$y_t^j = a_t^j \left(k_{t-1}^j\right)^{1-\alpha^j} \left(l_t^j\right)^{\alpha^j}, \quad j \in \{N, T\}, \tag{5}$$

where a_t^j is TFP of each sector, subject to the common technology shock ε_t^a:

$$\ln \frac{a_t^j}{a^j} = \rho_a \ln \frac{a_{t-1}^j}{a^j} + \varepsilon_t^a, \qquad \varepsilon_t^a \sim N(0, \sigma_a^2). \tag{6}$$

Variables without a time subscript are their steady-state values.

At each period, a representative nontradable goods firm chooses labor and capital to maximize profit $p_t^N y_t^N - w_t^N l_t^N - r_t^N k_{t-1}^N$. Similarly, a representative tradable goods firm maximizes profit $p_t^x y_t^T - w_t^T l_t^T - r_t^T k_{t-1}^T$, where p_t^x is the relative price of exports. To introduce terms-of-trade shocks, tradable goods firms only produce for exports, and domestic demand of tradables is solely met by imports, priced at s_t. The terms of trade $\xi_t \equiv \frac{p_t^x}{s_t}$ follows the exogenous process

$$\ln \frac{\xi_t}{\xi} = \rho_\xi \ln \frac{\xi_{t-1}}{\xi} + \varepsilon_t^\xi, \qquad \varepsilon_t^\xi \sim N(0, \sigma_\xi^2). \tag{7}$$

2.3. Government

At each period, the government collects taxes and issues external bonds (b_t^*) to pay for expenditures, including government consumption (g_t), transfers, and debt services.[4] The superscript $*$ denotes a variable is in units of foreign goods. Government consumption is also a CES basket of nontradables and tradables as composite consumption in (3).

[4] In reality, most countries also issue domestic debt. Given our nonlinear solution method, adding one more debt instrument would dramatically increase computational time. Since our focus is on external debt, we assume the government does not issue domestic debt for simplicity.

At time t, the government sells b_t^* units of bond at a price q_t, which raises $q_t s_t b_t^*$ units of local goods. At $t+1$, the government pays one unit of foreign goods for each unit of b_t^* if there is no default. If there is default, it pays a fraction $(1-\Delta_{t+1})$ of the liabilities. Let b_t^{d*} be the post-default liabilities. The government's flow budget constraint is

$$\underbrace{\tau_t\left(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T\right)}_{\equiv T_t,\ \text{revenue}} + q_t s_t b_t^* = s_t \underbrace{(1-\Delta_t) b_{t-1}^*}_{\equiv b_t^{d*}} + g_t + z. \tag{8}$$

We adopt the common assumption in the literature that foreign creditors are risk neutral. Their demand for government bonds is given by $q_t = \beta E_t(1-\Delta_{t+1})$. The government's intertemporal budget constraint is

$$(1-\Delta_t) b_{t-1}^* = \sum_{i=0}^{\infty} \beta^i E_t \frac{1}{s_{t+i}} (T_{t+i} - g_{t+i} - z), \tag{9}$$

which forms the basis for our fiscal limit definition.

Following Bi (2012), default decisions depend on a realized effective fiscal limit, B_t^{max}, drawn from a fiscal limit distribution, $\mathcal{B}^{max}(\mathcal{S}_t)$, conditioned on the state $\mathcal{S}_t$. If the government's liabilities at the end of $t-1$ are less than B_t^{max}, it fully repays its debt ($\Delta_t = 0$); otherwise, it defaults a fixed fraction of its liabilities ($\Delta_t = d$).

Since the fiscal limits are the maximum level of debt that can be supported without default, when simulating fiscal limits, $\Delta_t = 0 \forall t$. Although default does not occur when simulating fiscal limits, it is, however, necessary to specify the default mechanism to make clear the role of fiscal limits in default decisions. Specifically,

$$\Delta_t = \begin{cases} 0, & \text{if } b_{t-1}^* < B_t^{max} \\ d, & \text{if } b_{t-1}^* \geq B_t^{max} \end{cases} \qquad B_t^{max} \sim \mathcal{B}^{max}(\mathcal{S}_t). \tag{10}$$

The simulation of $\mathcal{B}^{max}(\mathcal{S}_t)$ is described in Section 4.

Government spending as a share of output in developing countries is generally low; retiring debt through cutting government spending may be difficult. We assume that income taxes adjust to maintain debt sustainability. To capture procyclical fiscal policy observed in developing countries (e.g., Alesina et al. (2008), Gavin and Perotti (1997), and Kaminski et al. (2004)), government consumption responds to output with a one-quarter delay (y_{t-1}). Specifically, tax and government spending rules are specified as

$$\ln \frac{\tau_t}{\tau} = \rho_\tau \ln \frac{\tau_{t-1}}{\tau} + \gamma \ln \frac{b_t^{d*}}{b^*} + \varepsilon_t^\tau, \quad \gamma > 0, \quad \varepsilon_t^\tau \sim N(0, \sigma_\tau^2), \tag{11}$$

$$\ln \frac{g_t}{g} = \rho_g \ln \frac{g_{t-1}}{g} + \eta \ln \frac{y_{t-1}}{y} + \varepsilon_t^g, \quad \varepsilon_t^g \sim N(0, \sigma_g^2), \tag{12}$$

where $y_{t-1} = p_{t-1}^N y_{t-1}^N + \xi_{t-1} s_{t-1} y_{t-1}^T$ is aggregate output measured in local goods.[5]

2.4. Aggregation and market clearing

The market clearing condition for nontradables is

$$y_t^N = (p_t^N)^{-\chi} \varphi (c_t + i_t + \Omega_t + g_t). \tag{13}$$

Finally, the balance-of-payment condition is

$$c_t + i_t + \Omega_t + g_t - y_t = s_t\left[q_t b_t^* - (1-\Delta_t) b_{t-1}^*\right]. \tag{14}$$

3. Calibration and estimation

To demonstrate how our framework can be used to assess fiscal limits in reality, the model is calibrated to Argentina's recent economic conditions. Argentina has had substantial external public debt and a history of sovereign default. The calibration uses Bayesian techniques to estimate the posterior mode of some parameter values, including those characterizing economic uncertainty and policy rules. The estimation is performed on the log-linearized model without default.[6] Four observables are used: real GDP, government spending, revenues, and the real exchange rate. Appendix B describes data sources and the estimation details of the posterior mode. Table 1 summarizes parameter values.

Consistent with standard practice in Bayesian estimations, some parameters known for being difficult to estimate are calibrated. The model is at a quarterly frequency. In line with the annual calibration for Argentina in García-Cicco et al. (2010),

[5] When simulating a fiscal limit distribution, the future tax rates are set at the maximum tax rates drawn from an empirical distribution. The fiscal reaction function of (11) is, however, necessary when we fit the model to data, because a sufficiently large fiscal adjustment magnitude, γ, is required to yield an equilibrium.

[6] Estimating the nonlinear model presented here is challenging, if at all possible. Bi and Traum (2012, 2014) show how to estimate simple nonlinear DSGE models using the particle filter.

Table 1
Parameter calibration.

	Parameters	Values
β	The discount factor	0.981
θ	Degree of risk aversion	2.68
ν	Inverse of the Frisch labor elasticity	3.54
δ	Capital depreciation rate for capital (non-tradable and tradable sectors)	0.03
χ	Substitution elasticity b/w tradables and nontradables	0.76
χ^l	Substitution elasticity b/w two types of labor	0.69
φ	The degree of home bias in goods	0.53
φ^l	Steady-state labor income share of the nontradable sector in labor income	0.51
α^N, α^T	Labor income share of the two sectors	0.47
κ	Capital adjustment cost (non-tradable and tradable sectors)	1.66
τ	Income tax rate	0.194
η	Government spending response to y_{t-1}	0.12
γ	τ_t response to stabilize debt	0.047
ρ_g	AR(1) coefficient in g_t	0.47
ρ_τ	AR(1) coefficient in τ_t	0.80
ρ_a	AR(1) coefficient in a_t^N and a_t^T	0.84
ρ_ξ	AR(1) coefficient in ξ_t	0.78
σ_g	Standard deviation of ε^g	2.41
σ_τ	Standard deviation of ε^τ	5.55
σ_a	Standard deviation of ε^a	2.54
σ_ξ	Standard deviation of ε^ξ	3.44

the quarterly discount factor β is set to 0.981, and the depreciation rate δ is 0.03. Burstein et al. (2005) estimate that the tradable share in the consumer price index for Argentina is 0.53; hence, $\varphi = 0.53$. Based on the estimate of four Latin American countries in Ostry and Reinhart (1992), the intratemporal elasticity of substitution between tradables and nontradables, χ, is set at 0.76 and the inverse of the intertemporal substitution elasticity σ is 2.68. Following Boz's 2015 calibration for emerging markets, we set $\nu = 3.54$. Also, from the average of six methods used in Guerriero (2012) for Argentina, we set the labor income share in the two sectors at $\alpha^N = \alpha^T = 0.47$. The labor weight ϕ is endogenously determined to have the steady-state fraction of time devoted to work being 0.26, matching the average annual hours worked divided by total hours, based on the OECD's data for Mexico from 2000 to 2014.[7]

Steady-state fiscal policy variables are calibrated to be their average of the sample used in estimation (2004Q1:2015Q2): the government spending share of output is 0.121, the tax rate, measured by the ratio of current revenues to GDP, is 0.194, and the government debt-to-annual output ratio is 0.448. Government transfers are kept constant throughout the analysis and is calibrated to close the government budget in the steady state. Given other fiscal values, the transfers-to-output share is 0.04.

For estimated parameters, the priors are determined as follows. Given little information on the labor sector mobility in developing countries, the prior of χ^l is assumed to have a beta distribution with a mean of 0.5 and a standard deviation of 0.2. A mean value lower than 1 (Horvath's (2000)) estimate for the U.S.) indicates a higher degree of friction in labor mobility in Argentina than in advanced economies, in line with Artuc et al.'s (2013)) observation of higher mobility costs in developing countries. Also, without existing estimates for the capital adjustment parameter (κ) for our specification for emerging markets, we set the prior centered on Gourio's (2012)) calibration at 1.7 with a standard deviation of 0.3.

The prior distributions for other estimated parameters are rather dispersed. All of the AR(1) coefficients (ρ's) are assumed to have a prior of a beta distribution with mean 0.3 and standard deviation 0.2. The priors for the standard deviations (σ's) of all shocks have an inverse gamma distribution with mean 0.1 and standard deviation of infinity. Based on the estimation in Bi et al. (2014) for Argentina, the prior for η is assumed to follow a normal distribution with mean 0.1 and standard deviation 0.05, which imposes more weight on procyclical spending policy, consistent with conventional view that fiscal policy in most developing countries is procyclical (see e.g., Ilzetzki and Vegh (2008) and Frankel et al. (2013)). The fiscal adjustment parameter, γ, has a gamma distribution with mean 0.03 and standard deviation 0.015. Since the income tax rate is the only the fiscal adjustment instrument, restricting $\gamma > 0$ is necessary to yield an equilibrium. The posterior mode, $\eta = 0.12$, suggests that government spending is procyclical in Argentina.

4. Fiscal limit distributions

We first simulate the unconditional baseline distribution for Argentina (i.e., the distribution with an initial state at the steady state) and then show how revenue collection can affect this distribution. To see how current economic shocks can affect a fiscal limit distribution, a state-dependent distribution is also simulated conditional on an initial large terms-of-trade shock.

[7] Since data for Argentina are not available, we use the only South American country in the OECD's data sample, Mexico, to proxy Argentina's average fraction of time to work.

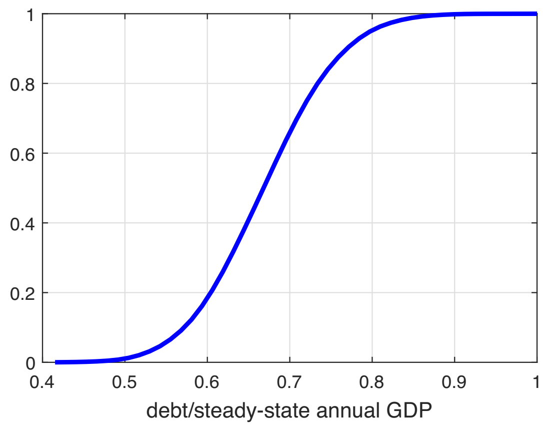

Fig. 1. The estimated CDF of the unconditional fiscal limit distribution for Argentina.

4.1. Simulating fiscal limit distribution

We define fiscal limits as the maximum level of debt in units of foreign goods that a government can service. The maximum debt level equals the sum of all future discounted maximum primary surplus. To compute the maximum surplus of each period that reflects weak revenue collection in developing countries, we draw the maximum tax rate τ_t^{max} from Argentina's truncated empirical tax distribution above the median, ranging from 0.19 to 0.25, with an average 0.22.[8]

State-dependent fiscal limits are computed as

$$\mathcal{B}^{max}(\mathcal{S}_t) \sim \left[\sum_{i=0}^{\infty} \beta^i \frac{1}{s_{t+i}^{max}} \underbrace{\left(T_{t+i}^{max} - g_{t+i} - z\right)}_{\text{primary surplus}} \right], \tag{15}$$

where the state of the economy is $\mathcal{S}_t = \{\varepsilon_t^a, \varepsilon_t^g, \varepsilon_t^\xi, \tau_t^{max}, k_{t-1}^N, k_{t-1}^T\}$, and the superscript *max* indicates variables computed under $\tau_{t+i} = \tau_{t+i}^{max}$.

The expression in (15) is modified from the intertemporal government budget constraint (9) without default. Each draw of a fiscal limit from the distribution is conditional on the current state $\mathcal{S}_t$ and particular sequences of realized shocks in the Markov Chain Monte Carlo simulations. To capture the nonlinearity in the relationship between default probability and the government-debt-output ratio, we use the monotone mapping method to solve for the variables required to compute fiscal limits, as in Davig (2004) and Bi (2012). Appendix C describes the procedure to simulate fiscal limit distributions.

Fig. 1 plots the cumulative density function (CDF) of the baseline unconditional distribution for fiscal limits for Argentina. The x-axis plots fiscal limits in the ratio of government debt to steady-state annual GDP. The default probability is roughly zero when the debt-to-GDP ratio is below 0.45. However, the probability climbs to almost 1 when the debt-to-GDP ratio reaches 0.9. The estimated fiscal limits for Argentina cover the actual debt levels in two recent sovereign default episodes, where the external debt-to-GNP ratios at the year of default were 0.55 in 1982 and 0.53 in 2001 (Table 3 in Reinhart et al. (2003)). As our model assumes all government debt is external, the implied fiscal limit in Fig. 1 should be interpreted as total government debt level. At the time of the default at the end of December 2001, Argentina's general government gross debt as a share of GDP was about 0.6.[9]

4.2. Revenue collection capacity

The simulated fiscal limits in Fig. 1 generally are lower than observed in many developed countries. One important factor driving the difference in fiscal limits between developed and developing countries is revenue collection capacity. This capacity is related to the maximum tax rate a government can implement, subject to institution quality. To simulate fiscal limits under higher revenue collection capacity, we increase the lower bound of the baseline tax rate distribution by one standard deviation of historical tax rates. The maximum tax rate ranges from 0.21 to 0.25, with an average 0.23, 2 percentage points higher compared to the baseline. Fig. 2 displays the baseline distribution for Argentina (solid line) to a higher average

[8] Bi (2012) sets τ_t^{max} to the peak of a Laffer curve, which implies a maximum tax rate around 0.4 or higher. In developing countries, tax rates in this high range are rarely seen, and thus the maximum tax rate implied by the peak of a Laffer curve is less suitable here.

[9] We cannot locate the debt level on the defaulting day, December 26, 2001. Based on the quarterly series of total gross public sector data compiled by Haver Analytics, the average debt level of 2001Q4 and 2002Q1 was 0.61.

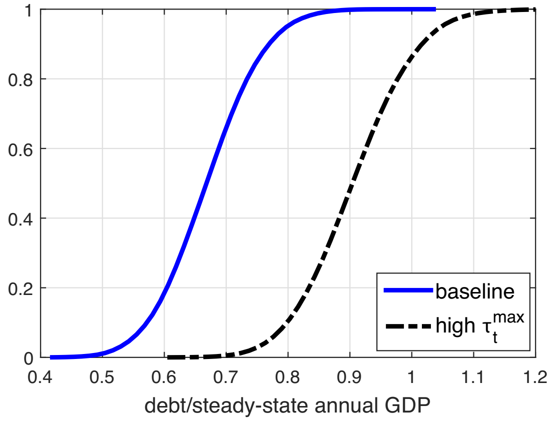

Fig. 2. Estimated CDFs for different revenue collection capacity for Argentina. Solid line—the baseline scenario with the average $\tau_t^{max} = 0.21$; dotted-dashed line—the scenario of higher revenue mobilization capacity with the average $\tau_t^{max} = 0.23$.

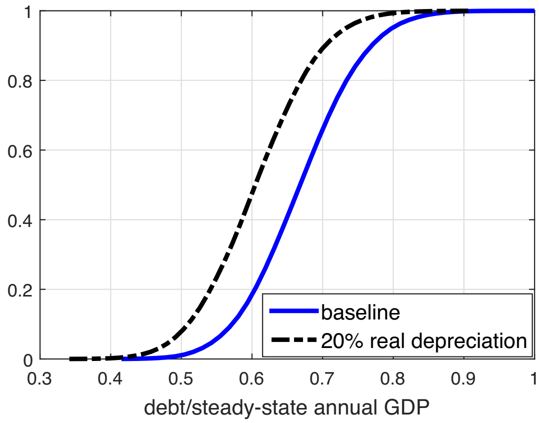

Fig. 3. Estimated CDF of large devaluation of the real exchange rate. Real depreciation is induced by a large negative terms-of-trade shock in the initial state.

effective tax rate (dotted-dashed line). Raising the average maximum tax rate from 0.21 to 0.23 increases the mean of the fiscal limit distribution from 0.67 to 0.90.

Our simulation shows that the maximum tax rate a government can implement has a large impact on fiscal limits: a one-percentage point increase in the tax rate can raise the mean of fiscal limits by almost 12% of GDP for Argentina. The formulation of fiscal limits in (15) indicates that lowering government spending should also be effective in raising fiscal limits. Since government spending as a share of GDP for Argentina (or developing countries in general) is low, the room to increase fiscal limits through cutting government spending may be small. Developed and developing countries differ greatly in revenue receipts. A maximum tax rate of 0.23 is still well below the average effective tax rate in developed countries. The exercise suggests that strengthening revenue collection can effectively raise fiscal limits in developing countries.

4.3. Devaluation

Relative to domestic debt, external government debt carries additional risk due to fluctuations in the real exchange rate. The existing literature has emphasized the balance-sheet effect: devaluation drives up the real exchange rate (s_t) and the government's liability in terms of domestic goods prices. Our paper highlights that large devaluation, in addition to the balance-sheet effect, can significantly lower the fiscal limits. Through the propagation mechanism inherent in the structural model, devaluation not only changes the state of the economy at current period, $\mathcal{S}_t$, but also spills over to future periods, both of which are captured by the fiscal limits as shown in (15).

In order to illustrate the impact of a large devaluation on fiscal limits, we subject the estimated Argentina economy to a negative 35% terms-of-trade shock, which leads to a real depreciation of 20% from its initial steady state. Fig. 3 compares the CDF of the baseline unconditional distribution (solid line) to that of the conditional distribution (dotted-dashed line). It shows that a large external shock substantially shifts the distribution to the left. With a debt-to-GDP ratio of 0.55, the default probability increases from 0.07 to about 0.23, turning a sustainable fiscal path to a risky one. Although a negative

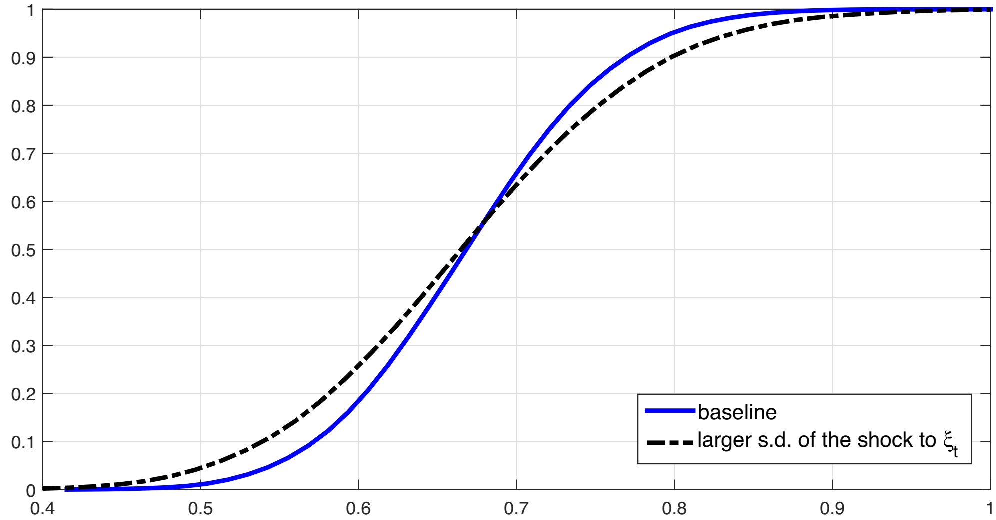

Fig. 4. Estimated CDF of with more fluctuations in the real exchange rate. The dotted-dashed line assumes a larger standard deviation of term-of-trade shocks $\sigma_\xi = 6.88$; the solid line has $\sigma_\xi = 3.44$.

terms-of-trade shock of 35% is rare, a sudden devaluation of the real exchange rate by 20% or more is not uncommon during crisis times. The implication of large negative terms-of-trade shocks can be extended to other shocks. For example, capital flow shocks may also be important in affecting fiscal limits of some developing countries (Calvo et al. (2004a)).

Conditional distributions highlight the impact of an initial state on fiscal limits and default risks. Even though the fundamental economic structure and fiscal policy remain the same, temporary disturbances can move the fiscal limit distribution and suddenly change the perception about fiscal sustainability in the short run.

Another perspective to show additional default risk associated with external debt is to examine how the volatility of real exchange rates affects the fiscal limit distributions. In our estimation, the volatility matches the data, as the real exchange rate is one of the observables. Since the sample only covers the recent, post-default period, it is likely to understate the fluctuation of the real exchange rate for a longer period. Fig. 4 compares the baseline distribution for Argentina to the one with a standard deviation of the terms-of-trade shock that is twice as large ($\sigma_\xi = 6.88$, instead of 3.44). Comparing the two distributions, we notice that a higher volatility of terms-of-trade shocks produce a more dispersed distribution. When the debt-to-GDP ratio is 0.55, the default probability raises from 0.07 under the baseline to 0.14 in the alternative distribution.

5. Conclusion

We use a DSGE approach to study fiscal limits in developing countries with external debt. A DSGE framework with sovereign default risks is constructed to simulate fiscal limit distributions. Simulations for Argentina show that expected future revenue plays an important role in explaining the relatively low fiscal limits observed in developing countries compared to developed countries. State-dependent distributions illustrate how fiscal limits can change when an economy is hit by various types of shocks. In particular, shocks that lead to sharp real depreciation can suddenly raise default probabilities of an economy with large external debt. The state-dependent distribution of fiscal limits implied by our approach illustrates that perception about the fiscal solvency can change suddenly even without changes to economic policies or structures.

While we do not pursue fiscal policy analysis, our framework can be used to study fiscal policy effects in the presence of sovereign default risks, an important policy issue in the era of post-European sovereign crises.

Acknowledgment

We thank Andrew Berg, Valerie Cerra, Fei Han, Eric Leeper, Nicolas Magud, Catherine Pattillo, David Savitski, Mathias Trabandt, Guido Traficante, Andreas Tudyka, Ping Wang (the editor), Todd Walker, an anonymous referee, and participants in various seminars for helpful comments. We acknowledge the support from U.K.'s Department for International Development (DFID); Yang acknowledges the support form the Ministry of Science and Technology, Taiwan. The views expressed here are those of the authors and do not necessarily represent those of DFID, Federal Reserve Bank of Kansas City, the Federal Reserve System, IMF, or IMF policy.

Appendix A. Equilibrium conditions

$$\lambda_t = c_t^{-\theta} \tag{A.1}$$

$$\phi l_t^{\nu} = \lambda_t (1-\tau_t) w_t \tag{A.2}$$

$$Q_t^N = 1 + \kappa\left(\frac{i_t^N}{k_{t-1}^N} - \delta\right) \tag{A.3}$$

$$Q_t^T = 1 + \kappa\left(\frac{i_t^T}{k_{t-1}^T} - \delta\right) \tag{A.4}$$

$$Q_t^N = \beta_t E_t \frac{\lambda_{t+1}}{\lambda_t}\left[(1-\tau_{t+1}) r_{t+1}^N - \frac{\kappa}{2}\left(\frac{i_{t+1}^N}{k_t^N} - \delta\right)^2 + \kappa\left(\frac{i_{t+1}^N}{k_t^N} - \delta\right)\left(\frac{i_{t+1}^N}{k_t^N}\right) + Q_{t+1}^N (1-\delta)\right] \tag{A.5}$$

$$Q_t^T = \beta_t E_t \frac{\lambda_{t+1}}{\lambda_t}\left[(1-\tau_{t+1}) r_{t+1}^T - \frac{\kappa}{2}\left(\frac{i_{t+1}^T}{k_t^T} - \delta\right)^2 + \kappa\left(\frac{i_{t+1}^T}{k_t^T} - \delta\right)\left(\frac{i_{t+1}^T}{k_t^T}\right) + Q_{t+1}^T (1-\delta)\right] \tag{A.6}$$

$$l_t = \left[(\varphi^l)^{-\frac{1}{\chi^l}}\left(l_t^N\right)^{\frac{1+\chi^l}{\chi^l}} + (1-\varphi^l)^{-\frac{1}{\chi^l}}\left(l_t^T\right)^{\frac{1+\chi^l}{\chi^l}}\right]^{\frac{\chi^l}{1+\chi^l}} \tag{A.7}$$

$$l_t^N = \varphi^l \left(\frac{w_t^N}{w_t}\right)^{\chi^l} l_t \tag{A.8}$$

$$l_t^T = (1-\varphi^l)\left(\frac{w_t^T}{w_t}\right)^{\chi^l} l_t \tag{A.9}$$

$$i_t = i_t^N + i_t^T \tag{A.10}$$

$$k_t^N = (1-\delta) k_{t-1}^N + i_t^N \tag{A.11}$$

$$k_t^T = (1-\delta) k_{t-1}^T + i^T \tag{A.12}$$

$$y_t^N = a_t^N \left(k_{t-1}^N\right)^{1-\alpha^N} \left(l_t^N\right)^{\alpha^N} \tag{A.13}$$

$$\alpha^N p_t^N y_t^N = w_t^N l_t^N \tag{A.14}$$

$$(1-\alpha^N) p_t^N y_t^N = r_t^N k_{t-1}^N \tag{A.15}$$

$$(1-\alpha^T) p_t^x y_t^T = r_t^T k_{t-1}^T \tag{A.16}$$

$$y_t^T = a_t^T \left(k_{t-1}^T\right)^{1-\alpha^T} \left(l_t^T\right)^{\alpha^T} \tag{A.17}$$

$$\alpha_T \xi_t s_t y_t^T = w_t^T l_t^T \tag{A.18}$$

$$1 = \left[\varphi (p_t^N)^{1-\chi} + (1-\varphi)(s_t)^{1-\chi}\right]^{\frac{1}{1-\chi}} \tag{A.19}$$

$$D_t^N = \varphi\left[c_t + i_t + \frac{\kappa}{2}\left(\frac{i_t^N}{k_{t-1}^N} - \delta\right)^2 k_{t-1}^N + \frac{\kappa}{2}\left(\frac{i_t^T}{k_{t-1}^T} - \delta\right)^2 k_{t-1}^T + g_t\right] \tag{A.20}$$

$$y_t^N = (p_t^N)^{-\chi} D_t^N \tag{A.21}$$

$$y_t = p_t^N y_t^N + \xi_t s_t y_t^T \tag{A.22}$$

$$c_t + i_t + \frac{\kappa}{2}\left(\frac{i_t^N}{k_{t-1}^N} - \delta\right)^2 k_{t-1}^N + \frac{\kappa}{2}\left(\frac{i_t^T}{k_{t-1}^T} - \delta\right)^2 k_{t-1}^T + g_t - y_t = s_t\left[q_t b_t^* - (1-\Delta_t) b_{t-1}^*\right] \tag{A.23}$$

$$q_t = \beta E_t[(1-\Delta_{t+1})] \tag{A.24}$$

$$\tau_t\left(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T\right) + q_t s_t b_t^* = s_t \underbrace{(1-\Delta_t) b_{t-1}^*}_{b_t^{d*}} + g_t + z_t \tag{A.25}$$

$$\ln \frac{\tau_t}{\tau} = \rho_\tau \ln \frac{\tau_{t-1}}{\tau} + \gamma \ln \frac{b_t^{d*}}{b^*} + \varepsilon_t^\tau \tag{A.26}$$

$$\ln \frac{g_t}{g} = \rho_g \ln \frac{g_{t-1}}{g} + \eta_g \ln \frac{y_{t-1}}{y} + \varepsilon_t^g \tag{A.27}$$

$$\ln \frac{a_t^N}{a^N} = \rho_a \ln \frac{a_{t-1}^N}{a^N} + \varepsilon_t^a \tag{A.28}$$

$$\ln \frac{a_t^T}{a^T} = \rho_a \ln \frac{a_{t-1}^T}{a^T} + \varepsilon_t^a \tag{A.29}$$

$$\ln \frac{\xi_t}{\xi} = \rho_\xi \ln \frac{\xi_{t-1}}{\xi} + \varepsilon_t^\xi \tag{A.30}$$

$$r_t = \frac{1}{q_t} \tag{A.31}$$

Appendix B. Bayesian estimation

The estimation purpose is to calibrate some structural parameters and the process of economic shocks and fiscal policy rules adopted during normal times. The estimation is performed on the log-linearized equilibrium system assuming no default. The post-default sample from 2004Q1 to 2015Q2 is used. The most recent economic crisis in Argentina lasted from 1999 to 2002, and a sovereign default occurred at the end of 2001.

Observables include real GDP, government spending, revenues, and the real exchange rate. Data are collected from the database of Emerging Markets for Latin America complied by Haver Analytics. All data are seasonally adjusted, either at the source or by applying U.S. Census's X13 program. Real GDP is in 2004 millions of pesos. Fiscal data are taken from the consolidated government budget. Government spending is the sum of government consumption and capital expenditures. Revenues include all tax revenues and social security contributions. Capital expenditures and revenues are in current millions of pesos and deflated by the GDP implicit price deflator. Real exchange rate data are taken from the JP Morgan trade-weighted exchange rate index, CPI-based.

Except for real exchange rate, all seasonally adjusted real data (denoted by X_t) are transformed to x_t by

$$x_t = 100 \times \ln\left(\frac{X_t}{\text{population index}}\right). \tag{B.1}$$

Then, x_t and the real exchange rate are detrended to obtain percent deviations from an underlying trend, consistent with the log-linearized model. The population index is constructed such that 2004Q1=1.

The model has no growth; data are detrended with a linear trend, as in Smets and Wouters (2003). The minimization routine `csminwel` by Christopher Sims is used to search for the set of structural parameters that minimize the negative log posterior function. The parameter space of search is restricted to the one in which the model has a unique rational equilibrium. The mode search was initiated from 20 sets of initial values, and 19 of the 20 searches converged to the same mode, reported in Table 1.

Appendix C. Simulating fiscal limit distributions

This appendix describes procedures in simulating fiscal limit distributions, defined as (15) with $\mathcal{S}_t = \left\{\varepsilon_t^a, \varepsilon_t^g, \varepsilon_t^\xi, \tau_t^{max}, k_{t-1}^N, k_{t-1}^T\right\}$ indicates the initial state.

Assume the decision rule for the relative price in the non-tradable sector is $p_t^{N,max} = m^p(\mathcal{S}_t)$, the rule for labor in non-tradable sector is $l_t^{N,max} = m^l(\mathcal{S}_t)$, and the rule for capital in non-tradable sector is $k_t^{N,max} = m^k(\mathcal{S}_t)$. After obtaining the converged rules for $m^p(.)$, $m^l(.)$, and $m^k(.)$, the rules for $T_t^{max} = m^T(\mathcal{S}_t)$ and $s_t^{max} = m^s(\mathcal{S}_t)$ can be derived, which are consistent with the optimization conditions from the household's and the firms' problems.

1. Define the grid points by discretizing the state space. Make initial guesses for m_0^p, m_0^l, and m_0^k over the state space.
2. Under the maximum tax rate (τ_t^{max}), at each grid point, solve the nonlinear model using the given rules m_{i-1}^p, m_{i-1}^l, and m_{i-1}^k, and obtain the updated rules m_i^p, m_i^l, and m_i^k. Specifically,
   (a) Derive s_t in terms of p_t^N using (A.19).
   (b) Given l_t^N, compute y_t^N, w_t^N, and r_t^N using the optimization conditions for non-tradable sector firms, (A.13)-(A.15).

(c) From the labor supply in the tradable and the non-tradable sectors, (A.8) and (A.9), we can derive

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

From the wage equations, (A.14) and (A.18), derive

$$l_t^T = l_t^N (\Gamma)^{\frac{\chi_l}{(\alpha^N-1)\chi_l-1}} \tag{C.2}$$

$$\text{with} \quad \Gamma = \frac{\alpha^N p_t^N a_t^N \left(k_{t-1}^N\right)^{1-\alpha^N}}{\alpha^T \xi_t s_t a_t^T \left(k^T\right)^{1-\alpha^T}}\left(\frac{\chi_l}{1-\chi_l}\right)^{\frac{1}{\chi_l}}. \tag{C.3}$$

Then, we can compute w_t^T, l_t^T, and l_t using (A.7)–(A.9), and the aggregate wage using

$$w_t^{1+\varphi^l} = \chi^l (w_t^N)^{1+\varphi^l} + (1-\chi^l)(w_t^T)^{1+\varphi^l}. \tag{C.4}$$

(d) Next, given w_t, l_t, and τ_t^{max}, compute the marginal utility of consumption λ_t and consumption c_t from (A.2) and (A.1).
(e) Given k_t^N and the initial state k_{t-1}^N, i_t^N can be computed from (A.11). Also, from (A.3), the Tobin's Q in the non-tradable sector Q_t^N can be computed.
(f) Given c_t, g_t, and D_t^N in (A.21), we can solve the variables in the tradable sector: investment i_t^T from (A.20), capital k_t^T from (A.12), return to capital in the tradable sector r_t^T from (A.14), and the Tobin's Q in tradable sector Q_t^T from (A.4).
(g) Use linear interpolation to obtain $m_{i-1}^p(\mathcal{S}_{t+1})$, $m_{i-1}^l(\mathcal{S}_{t+1})$, and $m_{i-1}^k(\mathcal{S}_{t+1})$, where the state vector is $\mathcal{S}_{t+1} = (\varepsilon_{t+1}^a, \varepsilon_{t+1}^g, \varepsilon_{t+1}^\xi, \tau_{t+1}^{max}, k_t^N, k_t^T)$. Then, follow the above steps to solve λ_{t+1}, i_{t+1}^N, i_{t+1}^T, Q_{t+1}^N, Q_{t+1}^T, r_{t+1}^N, and r_{t+1}^T.
(h) Update the decision rules m_i^p, m_i^l, and m_i^k, using (A.5), (A.6), and the combined equation from (A.23) and (A.25), where government debt does not appear explicitly.

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. Use the converged rules—m^p, m^l, and m^k—to compute the decision rules for m_i^T and m_i^s.

After solving the maximum tax revenue $m^T(.)$ and $m^s(.)$, the distribution of fiscal limits is obtained using Markov Chain Monte Carlo simulations. To proceed,

1. For each simulation j, we randomly draw the exogenous shocks for TFP ($\varepsilon_{t+i}^{a,j}$), government consumption ($\varepsilon_{t+i}^{g,j}$), terms of trade ($\varepsilon_{t+i}^{\xi,j}$), and maximum tax rate ($\tau_{t+i}^{max,j}$) for 1000 periods, $i = \{1, 2, 3, \ldots 1000\}$, conditional on the starting state $\mathcal{S}_t = \{\varepsilon_t^a, \varepsilon_t^g, \varepsilon_t^\xi, \tau_t^{max}, k_{t-1}^N, k_{t-1}^T\}$. At each period, we obtain $T_{t+i}^{max,j}$ and $s_{t+i}^{max,j}$ ($i = 1, \ldots, 1000$) by interpolating on the decision rules $m^T(.)$ and $m^s(.)$. Then, the fiscal limit for simulation j is computed, conditional on $\mathcal{S}_t$ and particular sequences of shocks,

$$B^{max,j}(\mathcal{S}_t) = \sum_{i=0}^{\infty} \beta^i \frac{1}{s_{t+i}^{max,j}} (T_{t+i}^{max,j} - g_{t+i}^j - z) \tag{C.5}$$

2. Repeat the simulation for 10, 000 times ($j = \{1, \ldots, 10000\}$) to have $\left\{B^{max,j}(\mathcal{S}_t)\right\}_{j=1}^{10000}$, which form the distribution of $\mathcal{B}^{max}(\mathcal{S}_t)$.

References

Aguiar, M., Gopinath, G., 2006. Defaultable debt, interest rates and the current account. J. Int. Econ. 69, 64–83.
Alesina, A., Tabellini, G., Campante, F., 2008. Why is fiscal policy often procyclical? J. Eur. Econ. Assoc. 6 (5), 1006–1036.
Alvarado, C. D., Izquierdo, A., Panizza, U., 2004. Fiscal sustainability in emerging market countries with an application to Ecuador.
Arellano, C., 2008. Default risk and income fluctuations in emerging economies. Am. Econ. Rev. 98 (3), 690–712.
Artuc, E., Lederman, D., Porto, G., 2013. A mapping of labor mobility costs in developing countries. Policy Research Working Paper 6556, World Bank, Washington, D.C.
Bi, H., 2012. Sovereign defaut risk premia, fiscal limits, and fiscal policy. Eur. Econ. Rev. 56 (3), 389–410.
Bi, H., Shen, W., Yang, S.-C. S., 2014. Fiscal limits, external debt, and fiscal policy in developing countries. IMF Working Paper 14/49, International Monetary Fund, Washington, D.C.
Bi, H., Traum, N., 2012. Estimating sovereign default risk. Am. Econ. Rev. Pap. Proc. 102 (3), 161–166.
Bi, H., Traum, N., 2014. Estimating fiscal limits: The case of Greece. J. Appl. Econ. 29 (7), 1053–1072.
Bohn, H., 1998. The behavior of U.S. public debt and deficits. Q. J. Econ. 113 (3), 949–963.
Bohn, H., 2008. The Sustainability of Fiscal Policy in the United States. MIT Press, Cambridge, MA.
Boz, E., Durdu, C.B., Li, N., 2015. Emerging market business cycles: the role of labor market frictions. J. Money Credit Bank. 47 (1), 31–72.
Buffie, E.E., Berg, A., Pattillo, C., Portillo, R., Zanna, L.-F., 2012. Public investment, growth, and debt sustainability: Putting together the pieces. IMF Working Paper 12/144, International Monetary Fund, Washington, D.C.
Burstein, A., Eichenbaum, M., Rebelo, S., 2005. Large devaluations and the real exchange rate. J. Polit. Econ. 113 (4), 742–784.
Callen, T., Terrones, M., Debrun, X., Daniel, J., Allard, C., 2003. Public Debt in Emerging Markets: Is It Too High? September, International Monetary Fund, Washington, D.C.

Calvo, G., Izquierdo, A., Mejía, L.-F., 2004a. On the empirics of sudden stops: the relevance of balance-sheet effects. Federal Reserve Bank San Francisco Proc. (June).
Calvo, G.A., Izquierdo, A., Talvi, E., 2004b. Sudden Stops, the Real Exchange Rate and Fiscal Sustainability: Argentina's Lessons. Oxford University Press.
Celasun, O., Debrun, X., Ostry, J.D., 2007. Primary surplus behavior and risks to fiscal sustainability in emerging market countries: a "fan-chart" approach. IMF Staff Pap. 53 (3), 401–425.
Daniel, B.C., Shiamptanis, C., 2012. Fiscal risk in a monetary union. Eur. Econ. Rev. 56 (6), 1289–1309.
Daniel, B.C., Shiamptanis, C., 2013. Pushing the limit? Fiscal policy in the European Monetary Union. J. Econ. Dyn. Control 37 (11), 2307–2321.
Davig, T., 2004. Regime-switching debt and taxation. J. Monetary Econ. 51 (4), 837–859.
Eaton, J., Gersovitz, M., 1981. Debt with potential repudiation: theoretical and empirical analysis. Rev. Econ. Stud. 48 (2), 289–309.
Frankel, J.A., Végh, C.A., Vuletin, G., 2013. On graduation from fiscal procyclicality. J. Dev. Econ. 100 (1), 32–47.
García-Cicco, J., Pancrazi, R., Uribe, M., 2010. Real business cycles in emerging countries? Am. Econ. Rev. 100 (5), 2510–2531.
Gavin, M., Perotti, R., 1997. Fiscal Policy in Latin America. MIT Press, Cambridge, MA.
Ghosh, A.R., Kim, J.I., Mendoza, E.G., Ostry, J.D., Qureshi, M.S., 2013. Fiscal fatigue, fiscal space and debt sustainability in advanced economies. Econ. J. 123 (566), F4–F30.
Gourio, F., 2012. Disaster risk and business cycles. Am. Econ. Rev. 102 (6), 2734–2766.
Guerriero, M., 2012. The labour share of income around the world: evidence from a panel dataset. Development Economics and Public Policy Working Paper 32/2012.
Hausmann, R., 2004. Good Credit Ratios, Bad Credit Ratings: The role of Debt Structure. Palgrave Macmillan, New York.
Horvath, M., 2000. Sectoral shocks and aggregate fluctuations. J. Monetary Econ. 45 (1), 69–106.
Ilzetzki, E., Vegh, C. A., 2008. Procyclical fiscal policy in developing countries: Truth or fiction? NBER Working Papers 14191.
International Monetary Fund, 2011. Revenue mobilization in developing countries. Washington, D.C.
International Monetary Fund, 2016. World economic outlook database.
Kaminski, G., Reinhart, C., Vegh, C., 2004. When it Rains it Pours: Procyclical Capital Flows and Macroeconomic Policies. MIT Press, Cambridge, MA.
Mendoza, E.G., Uribe, M., 2000. Devaluation risk and the business-cycle implications of exchange-rate management. Carnegie-Rochester Conf Series Public Pol. 53 (1), 239–296.
Ostry, J.D., Reinhart, C.M., 1992. Private saving and terms of trade shocks: evidence from developing countries. IMF Staff Pap. 39 (3), 495–517.
Polito, V., Wickens, M., 2015. Sovereign credit ratings in the european union: a model-based fiscal analysis. Eur. Econ. Rev. 78, 220–247.
Reinhart, C., Rogoff, K.S., Savastano, M.A., 2003. Debt intolerance. Brookings Pap. Econ. Activity 2003 (1), 1–62.
Smets, F., Wouters, R., 2003. An estimated dynamic stochastic general equilibrium model of the Euro area. J. Eur. Econ. Assoc. 1 (5), 1123–1175.
Standard & Poor's, 2013. Sovereign Rating and Country T&C Assessment Histories. Standard & Poors Financial Services LLC. January (4)
Yue, V.Z., 2010. Sovereign default and debt renegotiation. J. Int. Econ. 80, 176–187.