FISCAL LIMITS, EXTERNAL DEBT, AND FISCAL POLICY IN DEVELOPING COUNTRIES

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Abstract. This paper studies fiscal policy effects in developing countries with external debt and sovereign default risk. State-dependent distributions of fiscal limits are simulated based on macroeconomic uncertainty and fiscal policy specifications. The analysis indicates that expected future revenue plays an important role in the observed low fiscal limits of developing countries relative to those of developed countries. External debt also carries additional risk since large devaluation of the real exchange rate can suddenly raise default probabilities. Consistent with majority views, fiscal consolidations are counterproductive in the short and medium runs, but growth under a faster consolidation eventually outpaces that under a slower one. When an economy approaches it fiscal limits, government spending can be less expansionary. As more revenues are required to service debt in a high-debt state, higher income tax rates raise the economic cost of consumption in terms of leisure foregone, reducing the fiscal multiplier.

Keywords: fiscal limits; fiscal policy; sovereign default risk; external debt; developing countries; state-dependent fiscal multiplier

JEL Codes: E62; H30; H60

1. Introduction

Sovereign debt is generally perceived riskier in developing than developed countries with the exception of the recent European debt crisis. Developing countries with relatively low debt-to-GDP ratios (by developed countries' standard) can have much lower credit ratings than developed countries with higher debt ratios.[1] For example, Belgium, United Kingdom, and the United States all have net government debt-to-GDP ratios exceeding 0.7 at the end

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[1]The relative high risk of sovereign debt in developing countries have been recognized, see, e.g., Reinhart et al. (2003), Hausmann (2004) and Alvarado et al. (2004).

of 2012 and sovereign ratings at or above AA. At the same time, Argentina and Ecuador have debt-to-GDP ratios below 0.5, but the sovereign ratings are at $B-$ and B (December, Standard & Poor's (2013)). This implies that fiscal limits—defined as the maximum debt level a government is able and willing to service—are generally lower in developing countries.

Using a dynamic stochastic general equilibrium (DSGE) model with sovereign default risk, this paper studies important factors that shape fiscal limit distributions of developing countries. It also analyzes fiscal policy effects against a backdrop of different government indebtedness. Fiscal limits in the model (and most likely in reality) are uncertain and forward-looking. Since sovereign default is ultimately a political decision, which may or may not be grounded in economic rationales, our approach abstracts from the complicated factors underlying default decisions.[2] Instead, we assume that whether a government defaults each period depends on if the existing debt exceeds an effective fiscal limit realized at that period, drawn from a distribution simulated based on economic fundamentals. Because fiscal limits are based on expected maximum future primary surplus that can be generated, our approach emphasizes repayment ability in sovereign defaults, as in Bi (2012), and Juessen et al. (2012).[3] Sovereign risk premia in our model arise endogenously and nonlinearly as a function of government indebtedness as observed in practice.[4]

The paper consists of two parts. The first part simulates fiscal limit distributions of two countries—Argentina and Ecuador—to demonstrate how our framework can assess fiscal limits, as well as to explain important factors affecting the distributions. To make empirical relevance of simulated distributions, the shock processes are estimated, fitting the linearized

[2]Borensztein and Panizza (2009) find that, among various costs considered to make default decisions, the economic cost (losing access to international capital markets, trade exclusion, and disturbances through financial systems) is short-lived and the political cost is high.

[3]Our approach to modeling default differs from the sovereign default literature, in which a utilitarian government accounts for some economic costs in making default decisions, e.g. Eaton and Gersovitz (1981), Aguiar and Gopinath (2006), Arellano (2008), Yue (2010), Mendoza and Yue (2012), and Derasmo and Mendoza (2012). It retains the DSGE framework convenient for fiscal experiments and incorporating economic and policy shocks.

[4]Using a sample of 26 emerging markets, Belhocine and Dell'Erba (2013) find that the sensitivity of sovereign risk premia to the difference between primary balances and debt stabilizing balances doubles as public debt increases above 45 percent of GDP.

version of the model using the two countries' post-default data from early 2000s. Our results highlight two factors important in explaining the relatively low fiscal limits in developing countries. Revenue mobility capacity, characterized by the maximum effective tax rate a government can implement and the political risk factor in the model, plays an important role in the level of fiscal limits. The literature has recognized that a smaller tax base contributes to sovereign default risk in developing countries (see Hausmann (2004), and Mendoza and Oviedo (2004)). 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 percent, much lower than the average of industrial countries, which is above 30 percent. Low effective tax rates imply small repayment ability, especially in bad times.

Another factor is real exchange rate fluctuations, which change the dispersion of a distribution. As many developing countries rely on external borrowing to a large extent, a substantial devaluation elevates default risk through the balance-sheet effect, which can also shift the distribution. Among the explanations for relatively high risk of sovereign debt in developing countries, Eichengreen et al. (2003) emphasize a country's inability to borrow in its own currency, the so-called "original sin." From foreign creditors' prospective, fluctuations in real exchange rates increase the uncertainty associated with a country's ability to repay its debt. Since revenues a government can collect are mostly denominated in local currency, the problems of currency mismatch add additional risk for a given size of debt (Krugman (1999), Cespedes et al. (2004), and Bordo et al. (2006)). In explaining Argentina's 2001 default, Calvo et al. (2004b) argue that steep real depreciation led by sudden stops turned an otherwise sustainable fiscal position into an unsustainable one in an economy with heavily dollarized liabilities.[5]

[5]Another important factor explains the relatively high risk of sovereign debt in developing countries is "debt intolerance," as a result of poor credibility and a default history, emphasized in Reinhart et al. (2003). Our analysis overlooks this factor.

The second part of the analysis studies fiscal policy effects in different states of debt, focusing on fiscal consolidation and government spending effects in a high-debt state. Consistent with majority views, faster consolidations return the risk premium to the steady-state level more quickly, but they are more counterproductive than slower ones. Upon implementing a fiscal consolidation through income tax hikes, households face higher current and future tax rates. Higher current taxes suppress consumption and labor. Moreover, expecting higher future tax rates discourages current investment.

Next, we investigate how government indebtedness affects spending effects. To have model-implied government consumption effects in line with most empirical evidence, government consumption in our model enters the households' utility function as a complement.[6] We find that fiscal multipliers are smaller when an economy is near its fiscal limits, although the difference is moderate. In our thought experiment, a high-debt state is associated with a higher income tax rate because the government requires additional resources in coping with higher payment to service debt. Since the economic costs of raising consumption in terms of leisure foregone increases (due to the lower after-tax wage rate), government consumption becomes less expansionary in a high-debt state than in a low-debt state.

Our paper is related to several recent studies that assess fiscal sustainability. Celasun et al. (2007) propose a "fan-chart" algorithm to simulate debt distributions based on an empirical framework that captures interactions of debt dynamics with macroeconomic shocks. The distributions are then used to assess debt sustainability by a somewhat arbitrary indicator. Motivated by Bohn (1998, 2008), Ostry et al. (2010) and Ghosh et al. (2011) estimate fiscal space (the distance between fiscal limits and current level of debt) in developed countries based on historical fiscal reactions to debt without explicitly modeling the specific shocks

[6]Most empirical evidence finds positive government spending effects on consumption (e.g., Blanchard and Perotti (2002) and Perotti (2008)), but Ramey (2011) finds the opposite for military spending. For developing countries, Ilzetzki et al. (2013) find positive consumption response to a government spending shock when the exchange rate regime is fixed. In addition to complementarity between private and government consumption, other theoretical explanations, such as liquidity-constrained households Galí et al. (2007) and deep habits (Zubairy (forthcoming)), have also been proposed.

that can affect the movement in primary surplus. The partial equilibrium framework is less informative about how a particular policy or economic shock can affect sovereign risk premia and default probabilities. Our fully-specified macroeconomic model allows us to study the interactions among the macroeconomy, fiscal policy, and fiscal limits.

Similar to our structural approach, Mendoza and Oviedo (2004), and Buffie et al. (2012) also assess fiscal sustainability in a general equilibrium model. Mendoza and Oviedo (2004) introduce the "natural debt limit," capturing the maximum debt level that a government remains able to fully service, but the interest rate in their analysis is fixed at a constant level. Buffie et al. (2012), instead, consider an exogenous risk premium but do not allow sovereign default, similar to Uribe and Yue (2006), García-Cicco et al. (2010), and Corsetti et al. (2013). Our model constructs a general equilibrium framework that endogenizes risk premia and accounts for the sovereign risk channel of fiscal policy effects.

2. Model

The model is a small open economy with nontradables and tradables (denoted by N and T, respectively). As one of our interests is to see how macroeconomic uncertainty affects the distribution of the fiscal limit, the model features important shocks that drive business cycles in developing countries, including total factor productivity (TFP), fiscal policy, and terms-of-trade shocks.

2.1. Households.

Households. Households derive utility from effective consumption ($\tilde{c}_t$) and leisure ($1 - l_t$). Following Bouakez and Rebei (2007), effective consumption is assumed to be a constant-elasticity-of-substitution (CES) index of private consumption (c_t) and government consumption (g_t):

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

where ω is the weight of private consumption in effective consumption, and $\nu > 0$ is the elasticity of substitution between private and government consumption. When $\nu = 0$, c_t and g_t are perfect complements; $\nu \to \infty$, they become perfect substitutes.[7]

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

$$E_t \sum_{t=0}^{\infty} \beta^t \underbrace{\left(\log \tilde{c}_t + \phi \log\left(1 - l_t\right)\right)}_{U_t}, \tag{2}$$

subject to the budget constraint

$$c_t + i_t^N + i_t^T + \frac{\kappa}{2}\left(\frac{i_t^N}{k_{t-1}^N} - \delta\right)^2 k_{t-1}^N + \frac{\kappa}{2}\left(\frac{i_t^T}{k_{t-1}^T} - \delta\right)^2 k_{t-1}^T = \left(1 - \tau_t\right)\left(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T\right) + z. \tag{3}$$

$\beta \in (0,1)$ is the discount factor. Capital is sector specific, and r_t^N and r_t^T are returns to capital in each sector. τ_t is the income tax rate, and z is government transfers to households.[8] Investment is subject to adjustment costs with the adjustment parameter κ. The law of motion of capital is

$$k_t^j = (1-\delta) k_{t-1}^j + i_t^j, \quad j \in \{N, T\}. \tag{4}$$

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,

$$x_t = \left[\varphi^{\frac{1}{\chi}} \left(x_t^N\right)^{\frac{\chi-1}{\chi}} + (1-\varphi)^{\frac{1}{\chi}} \left(x_t^T\right)^{\frac{\chi-1}{\chi}}\right]^{\frac{\chi}{\chi-1}}, \quad x \in \left\{c_t, i_t^N, i_t^T\right\}. \tag{5}$$

Households supply labor to both sectors. Aggregate labor is

$$l_t = \left[\left(\varphi^l\right)^{-\frac{1}{\chi^l}} \left(l_t^N\right)^{\frac{1+\chi^l}{\chi^l}} + \left(1-\varphi^l\right)^{-\frac{1}{\chi^l}} \left(l_t^T\right)^{\frac{1+\chi^l}{\chi^l}}\right]^{\frac{\chi^l}{1+\chi^l}}, \tag{6}$$

[7] Bailey (1971) is the first to consider the relationship between the utility derived from private consumption and publicly provided goods and services. Subsequent papers, e.g., Barro (1981), Finn (1998), and Bilbiie (2011), allow government spending to affect household preference in studying fiscal policy effects.

[8] Government transfers are kept constant throughout the analysis. It is calibrated to close the government budget in the steady state for a given government consumption-to-GDP ratio, the income tax rate, and external debt-to-GDP ratio from sample averages.

where φ^l is the steady-state share of labor in the nontraded good sector. While capital is specific to each sector, we allow some labor mobility across sectors, and $\chi^l > 0$ is the elasticity of substitution between sectors. From the cost minimization problem, the aggregate wage index can be derived as

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

We normalize the price of composite consumption (or one unit of 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,

$$1 = \left[\varphi(p_t^N)^{1-\chi} + (1-\varphi)(s_t)^{1-\chi}\right]^{\frac{1}{1-\chi}}. \tag{8}$$

s_t is also the CPI-based real exchange rate.

2.2. **Firms.** Firms in both sectors are perfectly competitive, producing by Cobb-Douglas technology,

$$y_t^j = a_t \left(k_{t-1}^j\right)^{1-\alpha^j}\left(l_t^j\right)^{\alpha^j}, \quad j \in \{N, T\}. \tag{9}$$

a_t is the total factor productivity, following the process

$$\ln\frac{a_t}{a} = \rho_a \ln\frac{a_{t-1}}{a} + \varepsilon_t^a, \tag{10}$$

where $\varepsilon_t^a \sim N(0, \sigma_a^2)$ is the common technology shock. Variables without a time subscript indicate their steady-state values.

At each period, a representative nontradable firm chooses labor and capital to maximize the profit $p_t^N y_t^N - w_t^N l_t^N - r_t^N k_{t-1}^N$. Similarly, a representative tradable firm maximizes the 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 for exports. To introduce terms-of-trade shocks, the model assumes that tradable 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 an exogenous process

$$\ln\frac{\xi_t}{\xi} = \rho_\xi \ln\frac{\xi_{t-1}}{\xi} + \varepsilon_t^\xi, \tag{11}$$

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

2.3. **Government.** Denote the unit in foreign goods by $*$. At each period, the government collects taxes and issues external bond (b_t^*) to pay for expenditures, including government consumption (g_t), transfers, and debt services. Government consumption is also a CES basket of nontradables and tradables with a degree of home bias $\left(\varphi^G\right)$ and the intra-temporal elasticity of χ. The relative price of government consumption is

$$p_t^G = \left[\varphi^G \left(p_t^N\right)^{(1-\chi)} + \left(1-\varphi^G\right)(s_t)^{1-\chi}\right]^{\frac{1}{1-\chi}}. \tag{12}$$

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 if no default for each unit of b_t^*. In the case of a 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

$$\underbrace{\tau_t\left(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T\right)}_{\equiv T_t,\text{ revenue}} + q_t s_t b_t^* = s_t \underbrace{(1-\Delta_t)\, b_{t-1}^*}_{\equiv b_t^{d*}} + p_t^G g_t + z. \tag{13}$$

Foreign creditors are assumed to be risk-neural. Their demand for government bond is

$$q_t = \beta E_t \left(1-\Delta_{t+1}\right). \tag{14}$$

The government's intertemporal budget constraint is

$$(1-\Delta_t)\, b_{t-1}^* = \sum_{i=0}^{\infty} \beta^i E_t \frac{1}{s_{t+i}} \left(T_{t+i} - p_{t+i}^G g_{t+i} - z\right).^{9} \tag{15}$$

2.3.1. *Default Scheme.* 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 reneges a fixed fraction of its liabilities ($\Delta_t = d$). Specifically,

$$\Delta_t = \left\{ \begin{array}{ll} 0 & \text{if } b_{t-1}^* < B_t^{max} \\ d & \text{if } b_{t-1}^* \geq B_t^{max} \end{array} \right\}, \quad B_t^{max} \sim \mathcal{B}^{max}(\mathcal{S}_t). \tag{16}$$

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

[9]To derive (15), we use (14) in (13), iterate it forward, and impose the transversality condition for government debt, $\lim_{j\to\infty} E_t \beta^i \left(1-\Delta_{t+i+1}\right) b_{t+i}^* = 0$.

2.3.2. *Fiscal Policy.* Since government spending as a share of GDP in developing countries is generally low, retiring debt through cutting government spending may be difficult, instead in this model we assume that income taxes adjust to maintain debt sustainability. Since the income tax rate is often progressive as an automatic stabilizer in reality, it is allowed to respond to output contemporaneously (y_t). To capture procyclical fiscal policy observed in developing countries (e.g., Gavin and Perotti (1997), Kaminski et al. (2004), and Alesina et al. (2008)), government consumption responds to output with a one-quarter delay. Thus, tax and government consumption rules are specified as

$$\ln \frac{\tau_t}{\tau} = \rho_\tau \ln \frac{\tau_{t-1}}{\tau} + \gamma \ln \frac{b_t^{d*}}{b^*} + \varepsilon_t^\tau, \quad \gamma > 0 \tag{17}$$

$$\ln \frac{g_t}{g} = \rho_g \ln \frac{g_{t-1}}{g} + \eta_g \ln \frac{y_{t-1}}{y} + \varepsilon_t^g, \quad \varepsilon_t^\tau, \varepsilon_t^g \sim N(0, \sigma_i^2),\ i \in \{\tau, g\}. \tag{18}$$

2.4. **Aggregation and Market Clearing.** Output in units of local goods is

$$y_t = p_t^N y_t^N + \xi_t s_t y_t^T. \tag{19}$$

The market clearing condition for nontradables is

$$y_t^N = (p_t^N)^{-\chi} \left\{ \varphi \left[c_t + i_t + \frac{\upsilon}{2} \left(\frac{i_t^N}{k_{t-1}^N} - \delta \right)^2 k_{t-1}^N + \frac{\upsilon}{2} \left(\frac{i_t^T}{k_{t-1}^T} - \delta \right)^2 k_{t-1}^T \right] + \varphi^G (p_t^G)^\chi g_t \right\}. \tag{20}$$

Finally, the balance-of-payment condition is

$$c_t + i_t + \frac{\upsilon}{2} \left(\frac{i_t^N}{k_{t-1}^N} - \delta \right)^2 k_{t-1}^N + \frac{\upsilon}{2} \left(\frac{i_t^T}{k_{t-1}^T} - \delta \right)^2 k_{t-1}^T + p_t^G g_t - y_t = s_t \left[q_t b_t^* - (1 - \Delta_t) b_{t-1}^* \right]. \tag{21}$$

Appendix A lists the equilibrium conditions of the model.

3. Estimation and Calibration

To show how our framework can be used to assess fiscal limits of a country, the model is calibrated to the recent economic conditions of Argentina and Ecuador. Both have had substantial external public debt and a history of sovereign default. Bayesian techniques are applied to obtain parameters of those characterizing economic uncertainty and fiscal policy rules. The estimation is performed on the log-linearized model assuming no default.[10] The linearized model is solved by Sims's (2001) method. Four observables are used: real GDP, government spending, revenues, and real exchange rate. Appendix B describes data sources and the estimation details of posterior modes.

3.1. **Common Structural Parameters.** Table 1 summarizes the baseline values of the calibrated parameters. The model is at a quarterly frequency. Consistent with García-Cicco, et al's (2010) annual calibration for Argentina, the quarterly discount factor β is set to 0.98 and the depreciation rate δ to 0.03. Burstein et al. (2005) estimate that the tradable share in the consumer price index for Argentina is 0.53. Without estimates found for Ecuador, the tradable share $(1-\varphi)$ is set to 0.53 for both countries. For government consumption, since a large proportion of government spending goes to pay services of public servants, φ^G is set to 0.6, bigger than the degree of home bias in private consumption.

To calibrate effective consumption $\tilde{c}_t$, we follow Bouakez and Rebei (2007) to set the weight of private consumption in the effective consumption index $\omega = 0.8$. Since the elasticity of substitution between private consumption and government spending ν is not conventionally estimated, we set $\nu = 0.49$ to have the model-implied fiscal multipliers roughly match the estimates for average developing countries in Ilzetzki et al. (2013).[11] The elasticity of substitution between tradables and nontradables in c_t and g_t (χ) is set to be 0.44, as estimated by Stockman and Tesar (1995) using a sample including developed and developing countries. To calibrate sectoral mobility for labor, we follow Horvath (2000), who uses the U.S. data of 36 sectors and sets $\xi^l = 1$. Following Gourio (2012), the investment adjustment parameter κ is set to 1.7.

[10]In section 5.3, the model with default is solved nonlinearly when studying the fiscal policy effects; however, estimating such a nonlinear model is challenging, if possible at all. Bi and Traum (2012) and Bi and Traum (forthcoming) show how to estimate simple nonlinear DSGE models using particle filter.

[11] Based on a sample 24 developing countries, Ilzetzki et al. (2013) estimate that the peak spending multiplier is slightly above 0.2 and the long-run multiplier is -0.63, although both are insignificant. Also, we set ν to 0.49, implying that private and government consumption are complements, which is in line with the conclusion from Karras (1994).

Our default scheme assumes a constant haircut rate d. Based on Sturzenegger and Zettelmeyer's (2008) estimated haircut rates in sovereign debt restructures in emerging market economies between 1998 and 2005, Bi (2012) calculates that 90 percent of the annual haircut rates (as a share of all sovereign debt) falls below 0.3. For both countries, we assume a constant quarterly haircut rate of 0.07 (equivalent to 0.28 for the annual rate).

3.2. **Argentina.** To calibrate the labor income share in each sector, we use Frankema's estimate (2010) of the labor shares in national income for Argentina, which has the labor income share near 0.55 in 2000. Since nontradable sectors tend to be at least as labor-intensive as tradable sectors (Obstfeld and Rogoff (1996)), we set $\alpha^N = 0.6$ and $\alpha^T = 0.55$. The leisure weight ϕ is set such that the steady-state labor share is 0.2.

Fiscal policy in the steady state is calibrated to the average of the sample used in Bayesian estimation (2003Q1:2012Q2): the government spending share of output is 0.1476, and the tax rate, measured by the ratio of tax revenues to GDP, is 0.227. Since the model only has external public debt, the debt-to-annual output ratio is calibrated to the average share of external debt issued by the non-financial public sector and the central bank in GDP, equal to 0.24. Given these fiscal values, the government budget constraint implies that the transfers to output ratio in the steady state is 0.06, matching the average transfer-to-GDP share in the sample.

Bayesian estimation of the posterior mode for economic shocks and fiscal policy rules is summarized in Table 2. Since not much information is available to guide our prior choices, all the priors are relatively dispersed. The priors for all of the AR(1) coefficients (ρ's) have a beta distribution with a mean 0.5 and a standard deviation of 0.2. The priors for the standard deviations (σ's) of all shocks have an inverse gamma distribution with a mean of 0.1 and a standard deviation of infinity. For the cyclical fiscal parameter, priors for η_g follows a normal distribution with a mean of 0.5 and a standard deviation of 0.2, which imposes more weight on procyclical spending policy. The fiscal adjustment parameter γ has a gamma distribution of a mean 0.05 and a standard deviation 0.02. Since the income tax rate is the only instrument for fiscal adjustments, restricting $\gamma > 0$ is necessary to yield an equilibrium. The posterior mode suggests that government spending is weakly procyclical with $\eta_g = 0.1$, and the income tax rate's response to debt is $\gamma = 0.06$.

3.3. **Ecuador.** Taking the estimate of the labor income share for Ecuador by Gollin (2002), $\alpha^N = \alpha^T = 0.5$. We assume a higher steady-state labor share for Ecuador ($l = 0.25$), because gross national income per capita in Ecuador is less than half of that in Argentina, and higher income is likely to have a negative income effect on labor supply. Consistent with the average of the sample used in estimation (2001Q1:2012Q1), the government spending share of output is 0.17, the tax rate is 0.207, and the external debt-to-annual GDP ratio is 0.25. The government budget constraint implies a transfers-to-output share of 0.017, close to the average in the sample of 0.02. The priors imposed for Ecuador estimation are the same as those for Argentina. Posterior mode estimation, $\eta_g = 0.40$ and $\sigma_g = 8.98$, suggests that government spending in Ecuador is more procyclical and volatile than that in Argentina.

4. Fiscal Limit Distribution

The default scheme in the model requires simulating fiscal limit distributions. We first simulate the baseline—also unconditional—distributions (i.e., the distribution with an initial state at the steady state) for Argentina and Ecuador and show how revenue mobilization capacity can affect distributions. To see the role of current economic shocks in affecting fiscal limits, a state-dependent distribution is also simulated with a large terms-of-trade shock for Argentina.

4.1. **Simulating Fiscal Limit Distribution.** We define fiscal limits as the maximum level of debt in units of local goods that a government is able and willing to service. In terms of ability to pay, the maximum debt level equals the sum of all future discounted maximum primary surplus. When computing the maximum surplus of each period, the tax rate is set to the maximum tax rate τ^{max}, chosen to be slightly above the highest revenue-output ratio in the sample.[12] In the baseline simulations, we set $\tau^{max} = 0.29$ for Argentina and $\tau^{max} = 0.31$ for Ecuador.[13] In terms of willingness to pay, we proxy it by a political risk factor $0 < \theta \leq 1$. State-dependent fiscal limits, as derived in Appendix C.1, are computed as

$$\mathcal{B}^{max}(\mathcal{S}_t) \sim \left[\sum_{i=0}^{\infty} \beta^t \theta \frac{1}{s^{max}_{t+i}} \left(T^{max}_{t+i} - p^G_{t+i} g_{t+i} - z \right) \right], \tag{22}$$

where the state of the economy is $\mathcal{S}_t = \left\{ a_t, g_t, \xi_t, k^N_{t-1}, k^T_{t-1} \right\}$, T^{max}_t is the tax revenue and s^{max}_t is the real exchange rate associated with τ^{max}. To calibrate θ, we resort to the International Country Risk Guide's (ICRG's) index of political risk.[14] The average ratings for the sample periods are 66.5 out of 100 for Argentina and 55.3 for Ecuador. We set $\theta = 0.67$ for Argentina and $\theta = 0.55$.[15] Appendix C.2 provides details for simulating fiscal limit distributions.

Figure 1 plots the cumulative density function (CDF) of the baseline fiscal limit distributions for Argentina (solid line) and Ecuador (dotted-lines line). The x-axis plots fiscal limits in the ratio of government debt to steady-state annual GDP. Both distributions exhibit the property that when sovereign default risk rises, it tends to rise quickly. Default probabilities are roughly zero when the debt-to-GDP ratio is below 0.45 for Argentina and 0.64 for Ecuador. However, the probability climbs to almost 1 when the debt-to-GDP ratio reaches 0.7 for Argentina and 0.85 for Ecuador. The higher estimated fiscal limits for Ecuador are mainly driven by a higher τ^{max}.

[12] Bi (2012) sets τ^{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 Laffer curve approach is less suitable.

[13] The maximum revenue-to-output ratio for Argentina in the sample is 0.261 and for Ecuador is 0.296.

[14] Arteta and Galina (2008) show that ICRG's index significantly affects the amount of external credit in emerging markets. The index's political risk rating includes components of government stability, socioeconomic conditions, internal and external conflict, corruption, law and order, bureaucracy quality, etc. The range of rating is from 0 to 100, and a high rating indicates low political risk. Developed countries tend to have a rating above 80.

[15] ICRG's index of political risk is an ordinal measurement, yet our political risk factor θ is cardinal. Using ICRG's index to capture political risk is a short cut; however, to properly model a country's willingness to service debt requires to model a structural political economy and is beyond the scope of this paper.

Our estimated fiscal limits for Argentina cover the actual debt levels in recent two sovereign default episodes. 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)). The actual debt levels in recent Ecuador episodes, however, fall outside of our estimated the range of fiscal limits: the external debt to GNP ratios were 0.60 in 1982, 0.89 in 1999, and 0.19 in 2008 sovereign default. The 2008 Ecuador sovereign default was generally perceived as driven more by a political motivation than by an economic one.[16] The wide range of Ecuador's default levels of debt highlights the random political components in default decisions, which are difficult to capture by typical macroeconomic models.

4.2. **Revenue Mobilization Capacity.** The simulated fiscal limits in Figure 1 generally are smaller than observed in many developed countries. One important factor driving the difference in fiscal limits between developed and developing countries is revenue mobilization capacity. This capacity is related to the maximum tax rate a government can implement, subject to political willingness and institution quality in revenue collection. Figure 2 compares the baseline distribution for Argentina ($\tau^{max} = 0.29$, $\theta = 0.67$, solid line) to two alternative assumptions. The dashed-solid line has $\tau^{max} = 0.35$ and $\theta = 0.67$, in which the maximum tax rate is more in line with the average effective tax rate in the developed countries (Callen et al. (2003)). The dashed line has $\tau^{max} = 0.35$ and $\theta = 0.8$, in which the political risk factor hits the lower bound of ICRG's index for developed countries. With the same political risk factor, raising the maximum tax rate from 0.29 to 0.35 increases the mean of the fiscal limit distribution from 0.61 to 1.02. If the political risk factor is further raised to 0.8, then the mean of the distribution rises to 1.22.

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 7 percent of GDP for Argentina. The formulation of fiscal limits,

[16]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.

equation (22), indicates that government spending is also important. Since government spending as a share of GDP for Argentina and Ecuador (or developing countries in general) is low, the room to increase fiscal limits through cutting government spending may be limited. On the other hand, developed and developing countries differ greatly in revenue collection, suggesting that strengthening revenue collection can be an effective way in raising fiscal limits in developing countries.

4.3. **Devaluation and Balance Sheet Effects.** Relative to domestic debt, external government debt carries additional risk due to fluctuations in the real exchange rate. In our baseline, the volatility of the real exchange rate 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. Figure 3 compares the baseline distribution for Argentina to the one with a twice as large standard deviation of the terms-of-trade shock ($\sigma_\xi = 5.74$ vs. 2.87 in the baseline). When the debt-to-GDP ratio is 0.55, the default probability raises from 0.06 under the baseline to 0.25 in the alternative distribution.

Another perspective to show the additional default risk carried by external debt is to examine the conditional distribution with a large devaluation in the real exchange rate. We subject the estimated Argentina economy by a -30-percent terms-of-trade shock, which leads to a real depreciation of 20 percent from its steady state initially. Figure 4 compares the CDF of the baseline distribution (solid line) and of the conditional distribution (dotted-dashed line). It shows that a large external shock substantially shifts the distribution to the left. At a debt-to GDP ratio at 0.55, the default probability increases from 0.06 to about 0.4, turning a likely sustainable fiscal path to an unlikely one. Although a negative terms-of-trade shock of 30 percent is rare, a sudden devaluation of the real exchange rate by 20 percent or more is not uncommon in developing countries around crisis times. The implication of large negative terms-of-trade shocks can be extended to other shocks. For example, capital flow shocks, which are important in the exchange rate movements can also be important in explaining fiscal limits in developing countries (Calvo et al. (2004a)).

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

5. Fiscal Policy in a Highly Indebted Economy

With simulated fiscal limit distributions, the model is used to analyze two fiscal issues often debated in highly indebted economies: fiscal consolidation and government spending effects in a high-debt state. The analysis is conducted using the model calibrated to Argentina.[17]

5.1. **The Economy in a High-Debt State.** To analyze the economy in a high-debt state, we need to first disturb the economy such that its debt is much above the steady-state level. We assume that a sequence of small negative TFP shocks (-1 percent) hit the economy for 57 quarters starting in the steady state ($t = -80$), where the debt-to-annual GDP ratio is 0.24. At $t = 0$ (defined as the initial period of a high-debt state analyzed here), the debt-to-annual GDP ratio climbs to 0.52, and a_t^N and a_t^T have returned to their steady-state values.[18] From $t = -80$ to -1, the government undertakes minimal fiscal adjustments by setting $\gamma = 0.04$, below the estimated $\gamma = 0.06$ for Argentina. The state at $t = 0$ is $\mathbf{S}_0 = \left\{b_0^{d*}, a_0, g_0, \xi_0, k_{-1}^N, k_{-1}^T\right\}$. Due to earlier negative TFP shocks, k_{-1}^N and k_{-1}^T are about 14 and 9 percent, respectively, below their steady-state values.

[17]In the model with fiscal limits, the tax rate is endogenously determined, and the AR(1) specification of the tax rule (17) further expands the state space. To increase computational efficiency, we rewrite the tax policy as $\ln \frac{\tau_t}{\tau} = \gamma_\tau \ln \frac{b_t^{d*}}{b^*}$, where the revised fiscal adjustment parameter $\gamma^{LR} = \gamma/(1-\rho_\tau)$ is the average long-term fiscal adjustment magnitude.

[18]From $t = -22$ to $t = -1$, $\varepsilon_t^a = 0$, and a_t^N and a_t^T gradually return to the steady-state level because $\rho_a > 0$.

The dotted-dashed line in Figure 5 depicts the transition dynamics returning from a high-debt state ($t = 0$) towards the steady state under $\gamma = 0.04$ or $\gamma^{LR} = 0.1739$. The x-axis is in years and the y-axis is in levels. The interest rate (or risk premium[19]) is reported as the annual rate in percent. For reference, the light dotted lines are the stochastic steady state as if there were no shocks through the simulation periods. We explain solid and dashed lines later. Under $\gamma = 0.04$ (the dotted-dashed line), since the government does not increase the fiscal adjustment speed (characterized by γ) in a high-debt state, it represents the scenario without deliberate fiscal consolidation efforts.

In a high-debt state, the risk premium increases by about 43 basis points relative to the steady-state level. A higher debt level plus a higher interest rate requires more payment to service debt. Under $\gamma = 0.04$, the tax rule (17) implies an income tax rate higher than the steady-state level (at about 0.26 vs. 0.23), but most additional tax revenue is devoted to interest payments. The debt-to-output ratio stays around 0.5 for ten years and declines very slowly to 0.475 20 years after; the risk premium only slowly returns to its steady state level in 20 years.

Even with little fiscal consolidation, the economy in a high-debt state produces less output relative to the steady state. A lower after-tax wage rate implies that households have less disposable income to consume (by 8.0 percent at $t = 0$ relative to the steady-state consumption). Lower capital stocks plus higher tax rates also induce households to save or invest less (by 5.6 percent at $t = 0$). Falling consumption increases the marginal benefit of labor, exerting a positive incentive to work more. The higher income tax rate, however, discourages work due to a negative substitution effect. The net effect is a small positive response on labor relative to the steady state (by 1.4 percent at $t = 0$). Overall, with lower capital and slightly higher labor, the output in a high-debt state is lower than the steady-state path (by 4.3 percent at $t = 0$).

[19]From interest rates, risk premia can be computed as the difference between the interest rate and a risk free real rate, which can be proxied by the average yield of the U.S. Treasury bond roughly at 3 percent (Trevino and Yates (2012)).

The initial state we simulate here is only one possible scenario of high government debt, as debt can be higher driven by other initial shocks. The fiscal adjustment channel triggered by higher debt services, however, operates in general. Although additional revenue to service debt needs not come from higher income tax rates, alternative funding methods from higher consumption taxes or lower government spending are also likely to produce lower output than the steady state's level.

5.2. **Fiscal Consolidation.** Highly indebted governments are often under the pressure to consolidate and reduce debt. To study fiscal consolidation, we also simulate the transition dynamics from a high-debt state by conducting unanticipated fiscal consolidations at time 0, switching from $\gamma = 0.04$ to $\gamma = 0.08$ (faster consolidation, dashed lines in Figure 5) or $\gamma = 0.06$ (slower consolidation, dashed lines).

As expected, the debt-to-output ratio falls more quickly under a faster consolidation. By the end of year five, the debt-to-output falls from 0.52 to 0.38, and the risk premium roughly returns to its steady state level two year after the consolidation starts. Despite the benefits of lowering risk premia, the comparison of $\gamma = 0.06, 0.08$ to $\gamma = 0.04$ (dotted-dashed lines, the scenario with little consolidation) indicates that fiscal consolidations are counterproductive in the short and medium runs. As income tax rates are higher to retire debt sooner, they have negative effects on labor, consumption, investment, and output, relative to the paths under $\gamma = 0.04$. In the longer run, as debt falls more quickly with consolidation, less tax revenue is needed to service debt; the tax rate falls below the rate under $\gamma = 0.04$ about eight years after consolidation. In contrast to earlier responses, lower tax rates generate positive consumption and investment responses relative to the paths under $\gamma = 0.04$. For labor responses, a faster consolidation generates more positive responses in the medium run, mainly due to substitution effects from lower tax rates under $\gamma = 0.08$. In later years, labor becomes less positive under $\gamma = 0.08$ mainly due to the income effect as output is higher between the two consolidation paths.

On the external side, the higher tax rates under a faster consolidation contracts domestic demand and depreciates the real exchange rate more than under a slower consolidation. However, a faster consolidation also discourages investment more because of higher income tax rates. The overall effect of a faster consolidation is that tradable output experiences a smaller decline under $\gamma = 0.08$ for the first seven quarters, because real depreciation improves competitiveness of the tradable sector more. As the magnitude of real depreciation falls later, the effects of lower capital under a faster consolidation dominates, and the tradable output falls more relative to a slower consolidation.

Although empirical evidence is inconclusive about the relationship between growth and debt (Reinhart and Rogoff (2010), Cecchetti et al. (2011), and Herndon et al. (2013)), our analysis supports that growth can be lower in a high-debt state than in the steady state—due to lower capital stocks and fiscal adjustments required to service debt. Lowering government debt, however, is not without pains. Fiscal consolidation has overall negative effects on the economy. We focus on fiscal consolidation through raising income tax rates. Adjustments through cutting government spending are also counterproductive. We study government consumption effects next.

5.3. **Government Spending Effects in Different States of Debt.** To see how government indebtedness matters for government spending effects, we examine an exogenous increase in government consumption in different states of debt. Before the spending increase, the high-debt state at $t = 0$ is simulated by a similar method in Section 5.1, except that $\gamma = 0.06$ (estimated value for Argentina) through the entire simulation periods. The low-debt state is the stochastic steady state. Given this initial state, a series of government consumption shocks are injected starting at $t = 0$; government consumption rises by 3.1 percent of the steady-state GDP on average for the first year.

Given that the economy has deviated from the steady state at time 0, conditional distributions of fiscal limits are simulated for solving the nonlinear model with sovereign default risk. Figure 6 shows that when comparing to the baseline (solid line), lower initial capital and positive government consumption shock shift the conditional distribution to the left (dotted-dashed lines). Lower initial capital implies that capital is likely to be below steady-state value for some time, which reduces production capacity and hence the maximum current and future revenues can be raised. Together with higher government spending, expected future government surplus is reduced, shifting fiscal limits to the left. The mean debt-to-output ratio of the conditional distribution is 0.57, compared to 0.61 of the baseline distribution.

Figures 7 compares the transition dynamics without spending shocks (dashed lines) to those with the shocks (solid lines) in a high-debt state. Figure 8 conducts the same experiment in a low-debt state. The dashed lines are the paths without government consumption shocks, so the differences between the two lines are the net spending effects. The two figures show that government spending has the same qualitative response patterns, except for the interest rate. In the high-debt state, the risk premium rises substantially by about 150 basis points at the peak, and the default probability rises from 0.6 percent under no shocks to 5 percent one years after the initial spending increase. In contrast, fiscal expansions in a low-debt state does not move the premium. Given the non-linear features of risk premia, spending increases raise the premium substantially, when an economy sufficiently approaches its fiscal limits.

From the output responses in Figures 7 and 8, government consumption is expansionary only for the first year in both states. To quantify government spending effects, Table 3 reports the cumulative multipliers for output, consumption, and investment. The top panel has the initial debt-to-annual GDP ratio of 0.50, and the bottom has 0.24. The cumulative multiplier k quarters after an increase in government consumption is defined as

$$\frac{\sum_{i=1}^{k} \beta^{i-1} \triangle y_{t+i-1}}{\sum_{i=1}^{k} \beta^{i-1} p^{G}_{t+i-1} \triangle g_{t+i-1}}, \tag{23}$$

where $\triangle y$ and $\triangle g$ are level changes relative to a path without government consumption shocks. When computing consumption, investment, and trade balance multipliers, $\triangle y$ is replaced by $\triangle c$, $\triangle i$, or $\triangle tb$ (see (A.33) for the computation of trade balance). The positive consumption multipliers contribute to the expansionary effects in the short run due to its complementarity to government consumption. Lower investment and trade balance, however, offset the expansionary effect, leaving the output multiplier much below 1.

Additional borrowing to finance the government consumption elevates the debt-to-output ratio. The temporary decline in the first year is due to real appreciation and reduced liabilities in local good units. As a result, the risk premium does not rise much initially in the high-debt state. In both states, the income tax rates rise in response to higher debt. Despite that government deficits are fully financed by external borrowing, government spending still "crowds out" investment through the fiscal adjustment channel.[20] As mentioned, the complementarity between government and private consumption induce households to consume more. Despite higher income tax rates, households work harder to support a higher level of consumption. The deteriorated trade balance implies that the expansionary effect comes from higher production in the nontradable sector. The tradable sector loses competitiveness because of the real appreciation in the first year. The small peak output multipliers (around 0.1-0.2) and long-run negative multipliers are consistent with recent empirical findings for average developing countries (see footnote 11).

Comparing across the two states, Table 3 shows that a smaller output multiplier in the high-debt state is mainly contributed by a smaller consumption multiplier. Government consumption is less stimulative for private consumption because the economic cost to increase consumption is higher in a high-debt state. Since the government has to collect more resources to service debt, higher income tax rates in a high-debt state implies the after-tax wage rate is lower. Thus, the cost of incremental consumption in terms of leisure sacrificed

[20]In a closed economy, a higher government consumption crowds out investment through a higher domestic interest rate.

is higher, so an increase in government consumption becomes less effective in raising private consumption. In a high-debt state, investment is less crowded out than in the low-debt state, mainly because of less positive consumption responses.

Our result that government spending multipliers become smaller when an economy approaches its fiscal limits echoes the findings of several recent papers. Ilzetzki et al. (2013) obtain smaller multipliers (essentially zero) when debt exceeds 60 percent of GDP. They argue that as fiscal adjustments loom large in a highly indebted economy, anticipation of the adjustments can offset the expansioanry effects of government spending. In our model economy, if tax increases are postponed, it is foreseeable that expecting future higher tax rates can also have a more negative effect on current investment, reducing the output multiplier. Corsetti et al. (2013) also conclude the higher the initial debt level, the smaller the government spending multipliers. Their results are driven by the positive links between sovereign default risk and funding costs of the private sector.

6. Conclusion

We study fiscal limits and fiscal policy effects in developing countries with external debt. A DSGE framework with sovereign default risk is constructed to simulate fiscal limit distributions. Simulations for Argentina and Ecuador show that expected future revenue plays an important role in explaining the relatively low fiscal limits observed in developing countries than in developed countries. State-dependent distributions inform 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 two fiscal issues analyzed are fiscal consolidation and government spending effects in different states of debt. Fiscal consolidation is counterproductive in the short and medium runs, but an economy with lower debt enjoys higher growth than a highly-indebted one.

We focus on raising income tax rate as an instrument. The positive spending multipliers—regardless of a high- or low-debt state—imply that fiscal consolidation through cutting government consumption is also contractionary in spite of the falling interest rate. While fiscal multipliers are positive in the short run, a deficit-financed spending increase pushes the economy closer to its fiscal limits, and its expansionary benefits are small and short-lived.

Although the model used here embeds sovereign default risk, it does not incorporate the negative costs associated with a default. In addition, our thought experiments are crafted such that a fiscal expansion in the high-debt state increases default risk but default probabilities are still moderate. In practice, if an economy is much closer to its fiscal limits than the debt state we simulate or the size of spending increases is bigger than we assume, expanionary fiscal actions could trigger more imminent and drastic fiscal adjustments. Fiscal multipliers in these circumstances can be even smaller than what we obtain here, and the economy can expose to higher default risk and its potential negative consequences.

Appendix A. Equilibrium Conditions

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

$$\lambda_t = \omega c_t^{\frac{-1}{\nu}} \tilde{c}_t^{\left(\frac{1}{\nu}-1\right)} \tag{A.2}$$

$$\phi \left(1-l_t\right)^{-1} = \lambda_t (1-\tau_t) w_t \tag{A.3}$$

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

$$Q_t^T = 1 + \kappa \left(\frac{i_t^T}{k_{t-1}^T} - \delta\right) \tag{A.5}$$

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

$$Q_t^T = \beta_t E_t \frac{\lambda_{t+1}}{\lambda_t} \left[(1-\tau_{t+1}) r_{t+1}^T - \frac{\kappa}{2}\left(\frac{i_{t+1}^T}{k_t^T} - \delta\right)^2 + \kappa \left(\frac{i_{t+1}^T}{k_t^T} - \delta\right)\left(\frac{i_{t+1}^T}{k_t^T}\right) + Q_{t+1}^T (1-\delta)\right] \tag{A.7}$$

$$l_t = \left[\left(\varphi^l\right)^{-\frac{1}{\chi^l}} \left(l_t^N\right)^{\frac{1+\chi^l}{\chi^l}} + \left(1-\varphi^l\right)^{-\frac{1}{\chi^l}} \left(l_t^T\right)^{\frac{1+\chi^l}{\chi^l}}\right]^{\frac{\chi^l}{1+\chi^l}} \tag{A.8}$$

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

$$l_t^T = \left(1-\varphi^l\right) \left(\frac{w_t^T}{w_t}\right)^{\chi^l} l_t \tag{A.10}$$

$$i_t = i_t^N + i_t^T \tag{A.11}$$

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

$$k_t^T = (1-\delta)k_{t-1}^T + i^T \tag{A.13}$$

$$y_t^N = a_t^N \left(k_{t-1}^N\right)^{1-\alpha^N} \left(l_t^N\right)^{\alpha^N} \tag{A.14}$$

$$\alpha^N p_t^N y_t^N = w_t^N l_t^N \tag{A.15}$$

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

$$(1-\alpha^T)p_t^x y_t^T = r_t^T k_{t-1}^T \tag{A.17}$$

$$y_t^T = a_t^T \left(k_{t-1}^T\right)^{1-\alpha^T} \left(l_t^T\right)^{\alpha^T} \tag{A.18}$$

$$\alpha_T \xi_t s_t y_t^T = w_t^T l_t^T \tag{A.19}$$

$$1 = \left[\varphi(p_t^N)^{1-\chi} + (1-\varphi)(s_t)^{1-\chi}\right]^{\frac{1}{1-\chi}} \tag{A.20}$$

$$p_t^G = \left[\varphi^G \left(p_t^N\right)^{(1-\chi)} + \left(1-\varphi^G\right)(s_t)^{1-\chi}\right]^{\frac{1}{1-\chi}} \tag{A.21}$$

$$D_t^N = \varphi\left[c_t + i_t + \frac{\kappa}{2}\left(\frac{i_t^N}{k_{t-1}^N} - \delta\right)^2 k_{t-1}^N + \frac{\kappa}{2}\left(\frac{i_t^T}{k_{t-1}^T} - \delta\right)^2 k_{t-1}^T\right] + \varphi^G (p_t^G)^\chi g_t \tag{A.22}$$

$$y_t^N = (p_t^N)^{-\chi} D_t^N \tag{A.23}$$

$$y_t = p_t^N y_t^N + \xi_t s_t y_t^T \tag{A.24}$$

$$c_t + i_t + \frac{v}{2}\left(\frac{i_t^N}{k_{t-1}^N} - \delta\right)^2 k_{t-1}^N + \frac{v}{2}\left(\frac{i_t^T}{k_{t-1}^T} - \delta\right)^2 k_{t-1}^T + p_t^G g_t - y_t = s_t\left[q_t b_t^* - (1-\Delta_t)b_{t-1}^*\right] \tag{A.25}$$

$$q_t = \beta E_t\left[(1-\Delta_{t+1})\right] \tag{A.26}$$

$$\tau_t \left(w_t l_t + r_t^N k_{t-1}^N + r_t^T k_{t-1}^T \right) + q_t s_t b_t^* = s_t \underbrace{(1-\Delta_t)\, b_{t-1}^*}_{b_t^{d*}} + p_t^G g_t + z_t \tag{A.27}$$

$$\ln \frac{\tau_t}{\tau} = \rho_\tau \ln \frac{\tau_{t-1}}{\tau} + \gamma \ln \frac{b_t^{d*}}{b^*} + \varepsilon_t^\tau \tag{A.28}$$

$$\ln \frac{g_t}{g} = \rho_g \ln \frac{g_{t-1}}{g} + \eta_g \ln \frac{y_{t-1}}{y} + \varepsilon_t^g \tag{A.29}$$

$$\ln a_t^N = \rho_a \ln a_{t-1}^N + \varepsilon_t^a \tag{A.30}$$

$$\ln a_t^T = \rho_a \ln a_{t-1}^T + \varepsilon_t^a \tag{A.31}$$

$$r_t = \frac{1}{q_t} \tag{A.32}$$

$$tb_t = y_t - c_t - i_t - \frac{v}{2}\left(\frac{i_t^N}{k_{t-1}^N} - \delta \right)^2 k_{t-1}^N - \frac{v}{2}\left(\frac{i_t^T}{k_{t-1}^T} - \delta \right)^2 k_{t-1}^T - p_t^G g_t \tag{A.33}$$

$$\ln \xi_t = \rho_\xi \ln \xi_{t-1} + \varepsilon_t^\xi \tag{A.34}$$

Appendix B. Bayesian Estimation

The purpose of the estimation is to calibrate the process of economic shocks and fiscal policy rules adopted during normal times. The estimation is performed on the log-linearized model assuming no default.

The post-default sample from 2003:Q1 to 2012:Q2 is used for Argentina. The most recent economic crisis in Argentina lasted from 1999 to 2002, and a sovereign default occurred at the end of 2001. For Ecuador, although the most recent default occurred in 2008, the economy was not facing an economic crisis.[21] Thus, the estimation uses the post-1999 default data from 2001:Q1 to 2012:Q1 to get a sufficiently long data.

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 X12 program. For Argentina, real GDP is in 1993 millions of pesos. Fiscal data are taken from the consolidated government budget. Government spending is the sum of public consumption and capital expenditures. Revenues include tax revenues, contributions to social security, and all sources of non-tax revenue. Capital expenditures and revenues are all in current millions of pesos and deflated by the GDP implicit price index. Real exchange rate data are taken from the JP Morgan's trade-weighted exchange rate index, and the trade weights are based on the country's 2000 bilateral trade in manufactured goods. The deflator used is WPI-domestic manufactured goods.

For Ecuador, real GDP is in 2007 thousands of U.S. dollars. Government spending is the sum of government consumption and capital expenditure. Revenues consist of petroleum and non-petroleum revenues, including tax and non-tax receipts. All fiscal variables are deflated to 2007 thousands of U.S. dollars by the GDP deflator, constructed from nominal and real GDP. The real exchange rate is deflated by CPI-all items.

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 2008Q1=1 for Argentina and 2000Q1=1 for Ecuador.

[21]The sovereign default in 2008 was generally deemed more for a political and less economic motivation. Ecuador's President Rafael 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.

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 is initiated for 20 different initial values, and all converged to the values reported in Table 2.

Appendix C. Simulating Fiscal Limit Distributions

This appendix describes the derivation of our fiscal limit definition and procedures in simulating its distributions.

C.1. **Definition.** To reach the expression of fiscal limits (22), we first compute the intertemporal government budget constraint under the assumption that the tax rate is at τ^{max} each period. We also assume that in the initial period t, the government does not default ($\Delta_t = 0$). The distribution of the fiscal limit is,[22]

$$B^{max}(\mathcal{S}_t) \sim \left[\sum_{i=0}^{\infty} \beta^i \theta \frac{1}{s_{t+i}^{max}} \left(T_{t+i}^{max} - p_{t+i}^G g_{t+i} - z \right) \right], \tag{C.1}$$

where θ is the political risk factor. $B^{max}(\mathcal{S}_t)$ is a particular fiscal limit drawn from the distribution $\mathcal{B}^{max}(\mathcal{S}_t)$, conditional on the initial state $\mathcal{S}_t = \left\{a_t, g_t, \xi_t, k_{t-1}^N, k_{t-1}^T\right\}$.

C.2. **Simulation Procedures.** Computing fiscal limits requires computing first the maximum tax revenue T_t^{max} for each given state $\mathcal{S}_t$.

Assume the decision rule for the relative price in 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 rule for $T_t^{max} = m^T(\mathcal{S}_t)$ and $s_t^{max} = m^s(\mathcal{S}_t)$ can be derived, which is consistent with the optimization conditions from the household's and the firms' problems. To proceed:

[22]The derivation of fiscal limits is similar to (15).

(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) At each grid point, solve the nonlinear model under the assumption that the tax rate is always at τ^{max} using the given rules m_{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 p_t^G and s_t in terms of p_t^N using (A.20) and (A.21).

(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.14)-(A.16).

(c) From the labor supply in the tradable and the non-tradable sectors, (A.9) and (A.10), we can derive

$$\frac{l_t^T}{l_t^N} = \frac{1-\varphi^l}{\varphi^l}\left(\frac{w_t^T}{w_t^N}\right)^{\chi^l}. \tag{C.2}$$

From the wage equations, (A.15) and (A.19), derive

$$l_t^T = l_t^N (\Gamma)^{\frac{\chi_l}{(\alpha^N-1)\chi_l-1}} \tag{C.3}$$

$$\text{with} \quad \Gamma = \frac{\alpha^N p_t^N a_t \left(k_{t-1}^N\right)^{1-\alpha^N}}{\alpha^T \xi_t s_t a_t \left(k^T\right)^{1-\alpha^T}}\left(\frac{\chi_l}{1-\chi_l}\right)^{\frac{1}{\chi_l}}. \tag{C.4}$$

Then, we can compute w_t^T, l_t^T, and l_t using (A.8)-(A.10), and the aggregate wage using

$$w_t^{1+\varphi^l} = \chi^l (w_t^N)^{1+\varphi^l} + (1-\chi^l)(w_t^T)^{1+\varphi^l}. \tag{C.5}$$

(d) Next, use a nonlinear solver to compute consumption c_t and the marginal utility of consumption λ_t from (A.3), combined with (A.1) and (A.2),

$$\omega c_t + (1-\omega) g_t^{\frac{\nu-1}{\nu}} c_t^{\frac{1}{\nu}} = \frac{w_t}{\lambda_t}. \tag{C.6}$$

(e) Given k_t^N and the initial state k_{t-1}^N, i_t^N can be computed from (A.12). Also, from (A.4), Tobin's Q in the non-tradable sector Q_t^N can be computed.

(f) Given c_t, g_t, and D_t^N from (A.23), we can solve the variables in the tradable sector: the investment i_t^T from (A.22), the capital k_t^T from (A.13), return to capital in the tradable sector r_t^T from (A.15), and the Tobin's Q in tradable sector Q_t^T from (A.5).

(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 $\mathcal{S}_{t+1} = (a_{t+1}, g_{t+1}, \xi_{t+1}, k_t^N, k_t^T)$. 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.6), (A.7) and the combined equation of (A.25) and (A.27), 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 (a_{t+i}^j), government spending (g_{t+i}^j), and terms of trade (ξ_{t+i}^j) for 1000 periods, $i = \{1, 2, 3, ...1000\}$, conditional on the starting state $\mathcal{S}_t = \left\{a_t, g_t, \xi_t, k_{t-1}^N, k_{t-1}^T\right\}$. At each period, we obtain $T_{t+i}^{max,j}$ and $s_{t+i}^{max,j}$ $(i = 1, ..., 1000)$ 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,

$$\sum_{i=0}^{\infty} \beta^i \theta \frac{1}{s_{t+i}^{max,j}} (T_{t+i}^{max,j} - p_{t+i}^{G,j} g_{t+i}^j - z) \tag{C.7}$$

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

Appendix D. Solving Nonlinear Model

When solving the nonlinear model, the state space is $\mathbf{S}_t = \left\{b_t^{d*}, a_t, g_t, k_{t-1}^N, k_{t-1}^T\right\}$.[23] Define the decision rules for the end-of-period government bond as $b_t^* = f^b(\mathbf{S}_t)$, the relative price in the non-tradable sector as $p_t^N = f^p(\mathbf{S}_t)$, labor in the non-tradable sector as $l_t^N = f^l(\mathbf{S}_t)$, and capital in the non-tradable sector as $k_t^N = f^k(\mathbf{S}_t)$. The decision rules are solved as follows.

(1) Define the grid points by discretizing the state space. Make initial guesses for f_0^b, f_0^p, f_0^l, and f_0^k over the state space.
(2) At each grid point, solve the nonlinear model and obtain the updated rules f_i^b, f_i^p, f_i^l, and f_i^k using the given rules f_{i-1}^b, f_{i-1}^p, f_{i-1}^l, and f_{i-1}^k:
   (a) Derive τ_t in terms of b_t^{d*} using (A.28).
   (b) Derive p_t^G and s_t in terms of p_t^N using (A.20) and (A.21).
   (c) 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.14)-(A.16).
   (d) Compute l_t^T from the labor supply in the tradable and non-tradable sectors, (A.9) and (A.10), and the wage equations, (A.15) and (A.19). Then compute w_t^T, l_t^T, and l_t using (A.8)-(A.10), and the aggregate wage;
   (e) Use a nonlinear solver to compute consumption c_t from (A.1)-(A.3).
   (f) We can obtain i_t^N given k_t^N and the initial state k_{t-1}^N from equation (A.12) and compute Tobin's Q in the non-tradable sector Q_t^N from equation (A.4).
   (g) Given c_t, g_t, and D_t^N from (A.23), solve the variables in the tradable sector: the investment i_t^T from (A.22), the capital k_t^T from (A.13), return of capital in tradable sector r_t^T from (A.15), and the Tobin's Q in the tradable sector Q_t^T from (A.5).

[23]The state space when solving the model with defaults, $\mathbf{S}_t$, is different from the space when computing fiscal limit distributions, $\mathcal{S}_t$. In the latter, the tax rate is always fixed at the maximum level τ^{max}, while in the former case it depends on the endogenous state b_t^{d*}.

(h) Use linear interpolation to obtain $f^b_{i-1}(\psi_{t+1})$, $f^p_{i-1}(\psi_{t+1})$, $f^l_{i-1}(\psi_{t+1})$ and $f^k_{i-1}(\psi_{t+1})$ where $\psi_{t+1} = (b^{d*}_{t+1}, a_{t+1}, g_{t+1}, k^N_t, k^T_t)$. Then follow the above steps to solve λ_{t+1}, τ_{t+1}, i^N_{t+1}, i^T_{t+1}, Q^N_{t+1}, Q^T_{t+1}, r^N_{t+1}, and r^T_{t+1}, and also compute q_t using (A.26).

(i) Update the decision rules f^b_i, f^p_i, f^l_i, and f^k_i using (A.6), (A.7), (A.25), and (A.27).

(3) Check convergence of the decision rules. If $|f^b_i - f^b_{i-1}|$, or $|f^p_i - f^p_{i-1}|$, or $|f^l_i - f^l_{i-1}|$, or $|f^k_i - f^k_{i-1}|$ are above the desired tolerance (set to $1e-7$), go back to step (2); otherwise, f^b_i, f^p_i, f^l_i, and f^k_i are the decision rules.

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	parameters	Argentina	Ecuador
β	the discount factor	0.98	0.98
δ	capital depreciation rate for capital (non-tradable and tradable sectors)	0.03	0.03
χ	substitution elasticity b/w tradables and nontradables for c_t, g_t	0.44	0.44
χ^l	substitution elasticity b/w l_t^N and l_t^T for l_t	1	1
φ	home bias in c_t, i_t^N	0.47	0.47
φ^l	steady-state labor income share of the nontradable sector in labor income	0.5019	0.4827
φ^g	home bias in g_t	0.6	0.6
ϕ	utility weight on leisure	40.6	23.4
α^N	labor income share of the nontradable sector	0.6	0.5
α^T	labor income share of the tradable sector	0.55	0.5
κ	investment adjustment cost (non-tradable and tradable sectors)	1.7	1.7
ω	preference weight on c_t in effective consumption	0.8	0.8
ν	elasticity of substitution b/w c_t and g_t	0.49	0.49
τ	income tax rate	0.227	0.207
d	haircut rate if default	0.07	0.07

TABLE 1. **Calibrated Parameters**.

	parameters	priors(mean, s.d.)	posterior mode	
			Argentina	Ecuador
η_g	government spending response to y_{t-1}	$N(0.5, 0.2)$	0.10	0.40
γ	τ_t response to stabilize debt	$G(0.05, 0.02)$	0.06	0.05
ρ_g	AR(1) coefficient in g_t	$B(0.5, 0.2)$	0.37	0.75
ρ_τ	AR(1) coefficient in τ_t	$B(0.5, 0.2)$	0.77	0.67
ρ_a	AR(1) coefficient in a_t^N and a_t^T	$B(0.5, 0.2)$	0.82	0.54
ρ_ξ	AR(1) coefficient in ξ_t	$B(0.5, 0.2)$	0.76	0.28
σ_g	standard deviation of ε^g	$IG(0.1, \infty)$	2.32	8.98
σ_τ	standard deviation of ε^τ	$IG(0.1, \infty)$	9.11	9.17
σ_a	standard deviation of ε^a	$IG(0.1, \infty)$	1.48	1.64
σ_ξ	standard deviation of ε^ξ	$IG(0.1, \infty)$	2.87	2.86

TABLE 2. **Estimated Parameters**. N, G, B, and IG denote normal, gamma, beta, and inverse gamma distributions. s.d. is standard deviation.

	output	consumption	investment	trade balance
a high-debt state				
impact	0.15	0.98	−0.86	−0.96
1 year	0.09	0.86	−0.84	−0.93
2 years	−0.09	0.68	−0.92	−0.84
5 years	−0.58	0.08	−1.14	−0.52
a low-debt state				
impact	0.20	1.13	−0.97	−0.95
1 year	0.13	1.00	−0.97	−0.89
2 years	−0.06	0.79	−1.08	−0.76
5 years	−0.56	0.18	−1.30	−0.44

TABLE 3. **Cumulative Multipliers of Government Consumption**

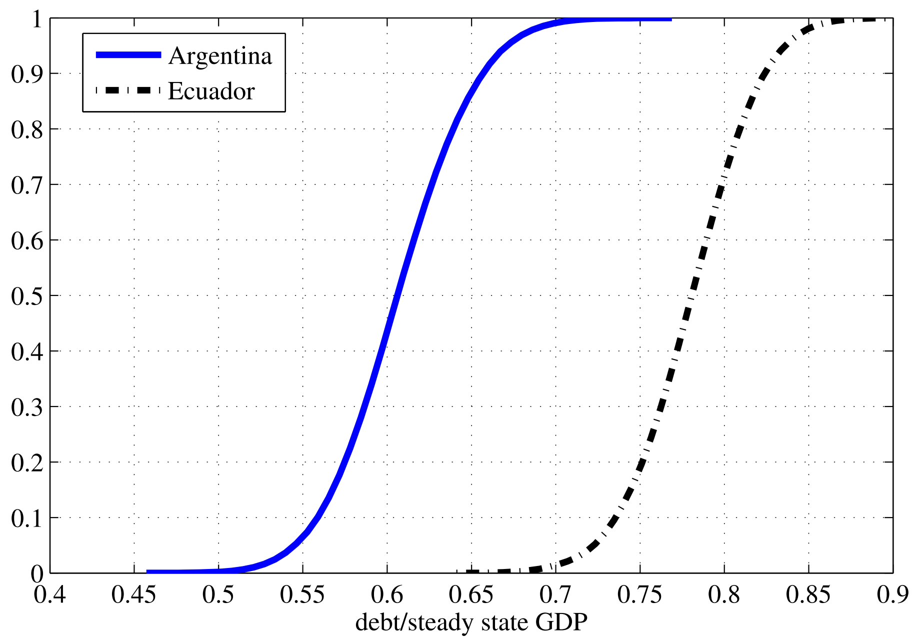

FIGURE 1. **Estimated CDF of the baseline fiscal limit distributions: unconditional distributions.**

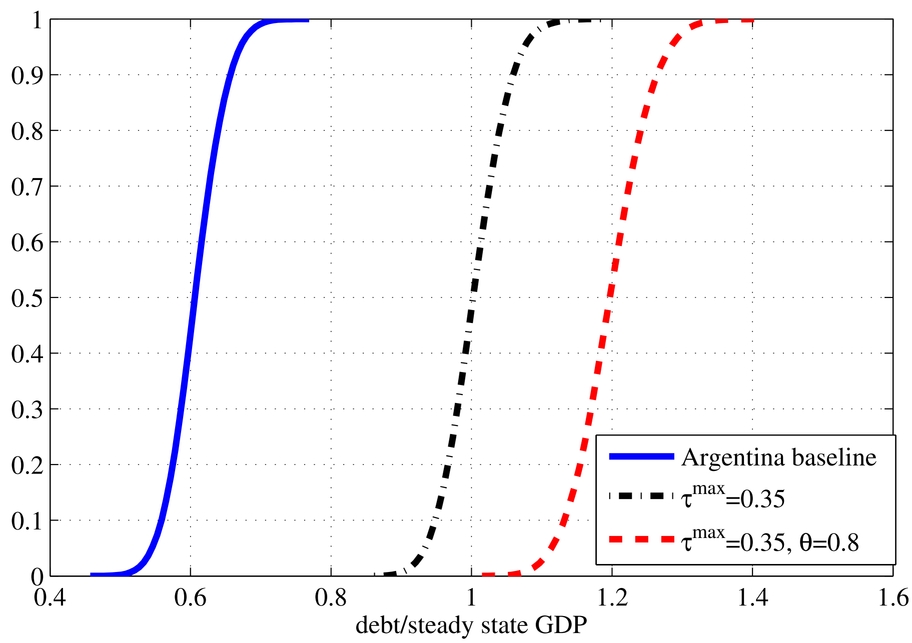

FIGURE 2. **Estimated CDF for different revenue mobilization capacity for Argentina.** Solid line—$\tau^{max} = 0.29$ and $\theta = 0.67$ (Argentina baseline); dotted-dashed line—$\tau^{max} = 0.35$ and $\theta = 0.67$; dashed line—$\tau^{max} = 0.35$ and $\theta = 0.8$.

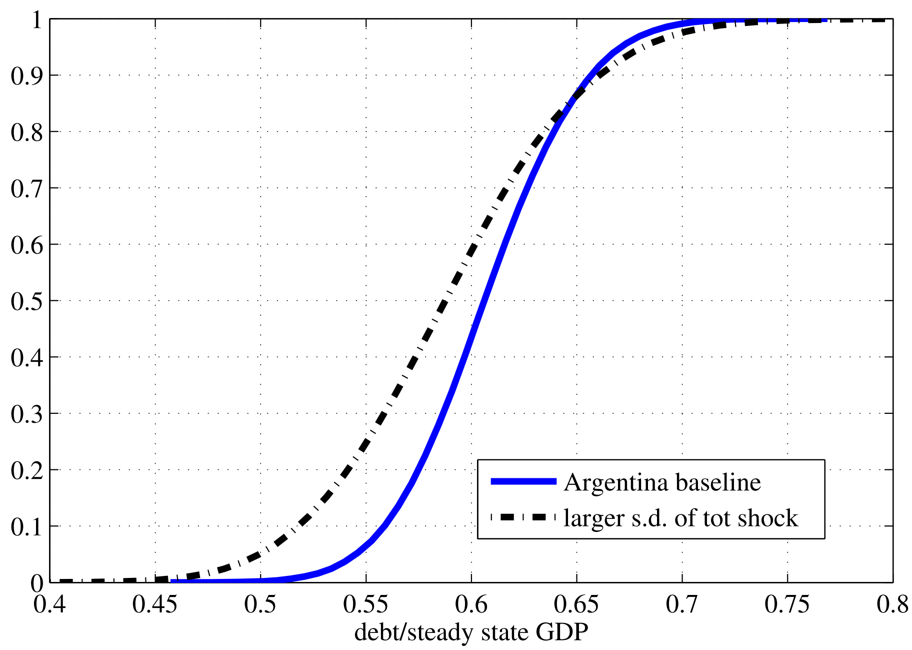

FIGURE 3. **Estimated CDF of with more fluctuations in the real exchange rate.** The dotted-dashed line assumes a larger standard deviation of term-of-trade shocks $\sigma_\xi = 5.74$; the solid line has $\sigma_\xi = 2.87$.

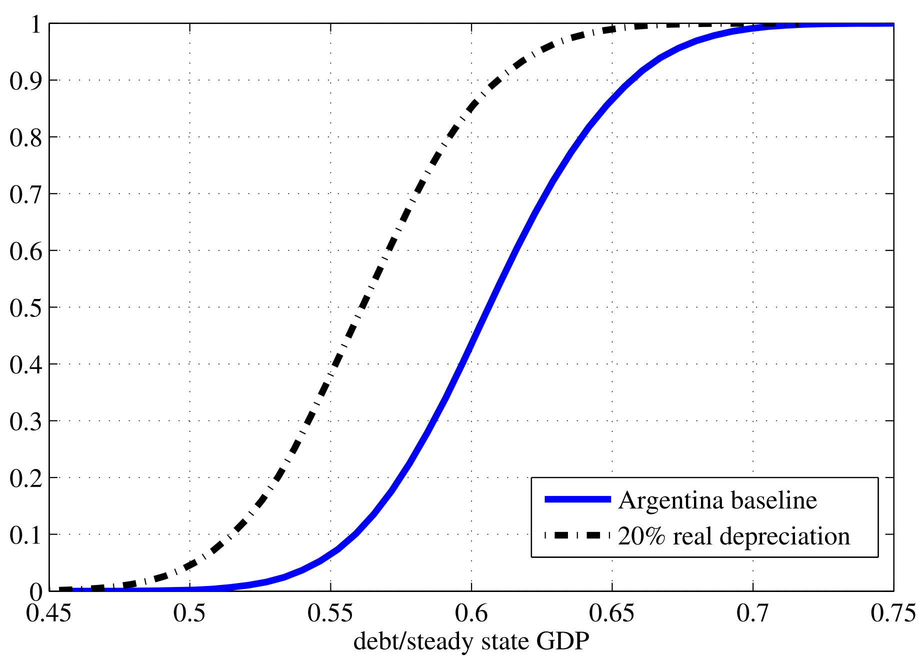

FIGURE 4. **Estimated CDF of large devaluation of the real exchange rate.** Real depreciation is induced by a large negative terms-of-trade shock in the initial state.

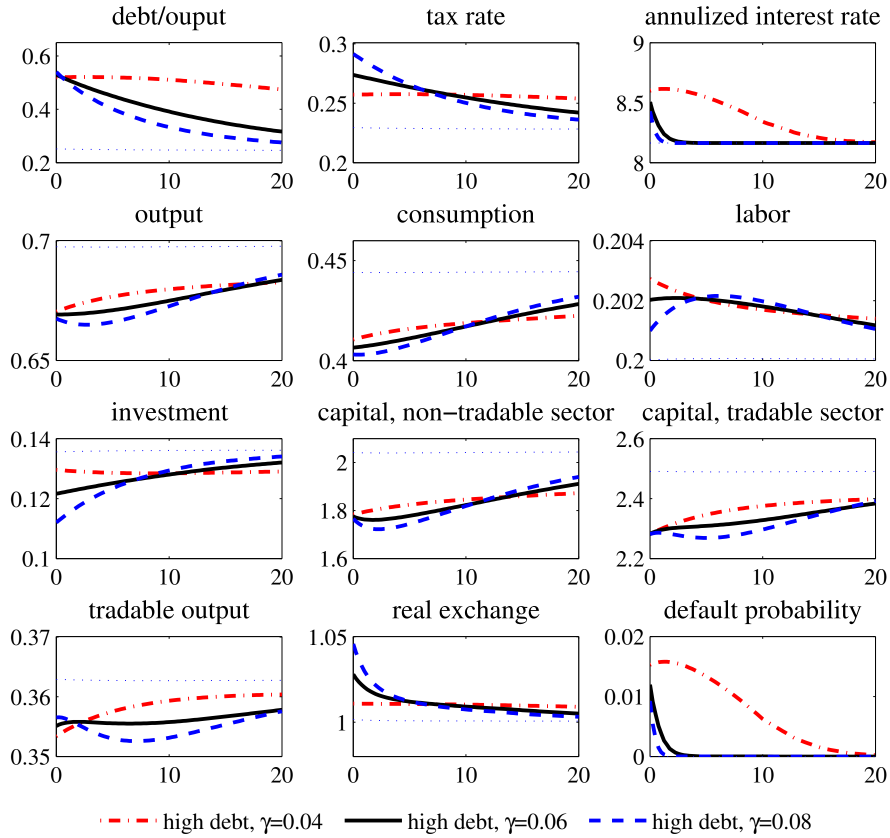

Figure 5. **Transition dynamics of fiscal consolidation.** The x-axis is in years. The y-axis is in levels. Annualized interest rate is in percent. Light dotted lines are the stochastic stead state.

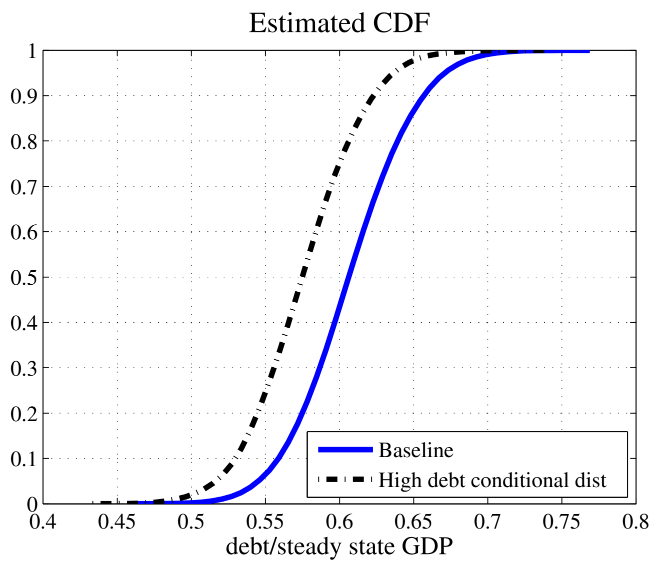

Figure 6. **Estimated CDF of a high-debt conditional distribution**: incorporating the initial injected government spending shocks.

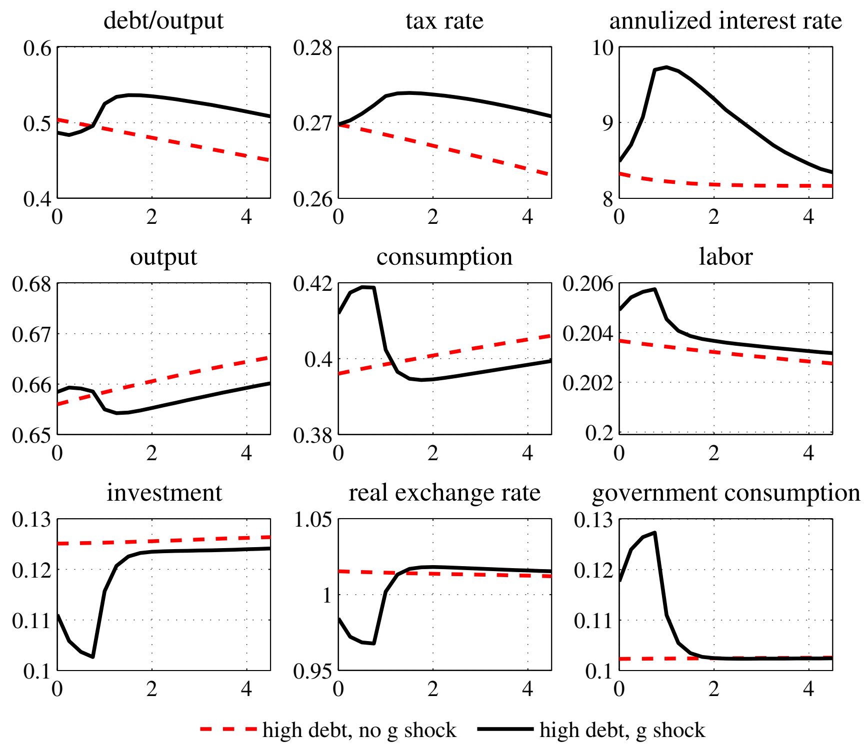

FIGURE 7. **Impulse responses to government spending shocks in a high-debt state.** The x-axis is in years. The y-axis is in levels.

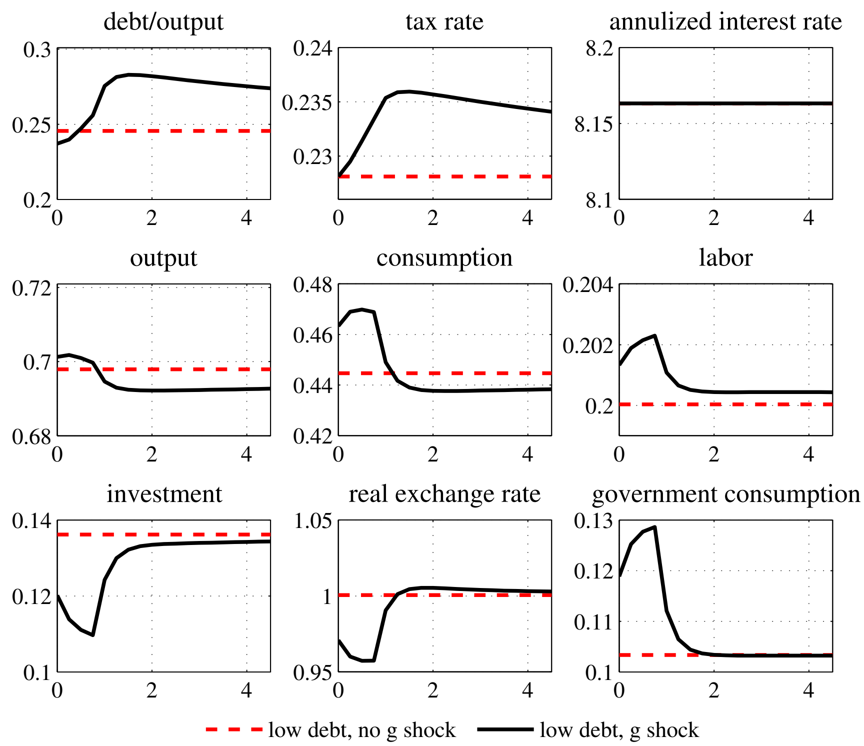

FIGURE 8. **Impulse responses to government spending shocks in a low-debt state.** The x-axis is in years. The y-axis is in levels.