Sovereign Risk and the Fiscal Multiplier

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Abstract

Data shows that fiscal policy is mostly pro-cyclical in emerging market economies and counter-cyclical in advanced economies. I portray sovereign risk as the explanation. My model results from the combination of a simple model of a small open economy with nominal rigidities with the canonical quantitative sovereign default model. Importantly, I incorporate the passthrough of sovereign risk to the private sector. In equilibrium, the quantitative model features an inverse relation between spreads and the size of the fiscal multiplier. Hence, the cyclicality of fiscal policy is optimally state dependent. In particular, countries that experience a sharp increase in sovereign spreads after a shock, optimally prefer to follow a pro-cyclical fiscal policy as borrowing conditions deteriorate and the fiscal multiplier diminishes in size. In contrast, governments that continue to face good borrowing terms after a shock, are able to expand government spending, finance it with more debt, and have small movements in sovereign spreads, which creates little to no distortion on the private sector and has a larger impact on output.

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1 Introduction

Fiscal policy response differs across countries and the recent spread of COVID-19 through the world provides telling evidence. While many countries are experiencing a similar shock, governments have taken different economic policies in response. For example in the United States, Congress approved more than 2.3 trillion dollars through the Coronavirus Aid, Relief and Economy Security Act, around 11 percent of gross domestic product (GDP). Meanwhile, its southern neighbor, Mexico, has only requested additional resources from the Mexican Congress of up to 180 billion pesos (0.7 percent of GDP).[1] Cavallo and Cai (2020) estimate that the average fiscal response in developed economies has been 5.5 percent of GDP, compared to 2.3 percent in emerging market economies.[2] This is not an isolated event. Over the past four decades, fiscal policy has behaved very differently in emerging market economies than in advanced economies. Figure 1 provides support for this claim. In panel (a) I present the fiscal response to the recent COVID-19 pandemic by G20 Economies.[3] The ten countries to the left of the vertical blue line, are considered to be emerging market economies and the ten countries to the right are advanced economies. The comparison is stark. Advanced economies have responded with a more aggressive expansion in government spending relative to their emerging market peers. In panel (b), I present the correlation between the cyclical components of GDP and government spending for the years 1980-2016. This panel covers many more countries and shows that over a longer time horizon most advanced economies display a counter cyclical fiscal policy behavior while emerging market economies instead have pro-cyclical fiscal policies.

In this paper, I look into a potential explanation for this phenomenon: sovereign risk. This is motivated from the fact that data also shows that countries with high default risk tend to have a more pro-cyclical fiscal policy than countries with low risk of default. Figure 2 provides some evidence. Panel (a) presents the change in credit default swaps (CDS) for government bonds during the recent COVID-19 pandemic.[4] Credit risk increased sharply across emerging markets while it remained low and stable in advanced economies. Panels (b) and (c) plot this change against the government's fiscal response previously mentioned. Total fiscal response includes loans and guarantees in addition to

[1] Data are from the IMF policy tracker consulted on April 1, 2020.

[2] The estimated numbers in the paper are for April 22, 2020.

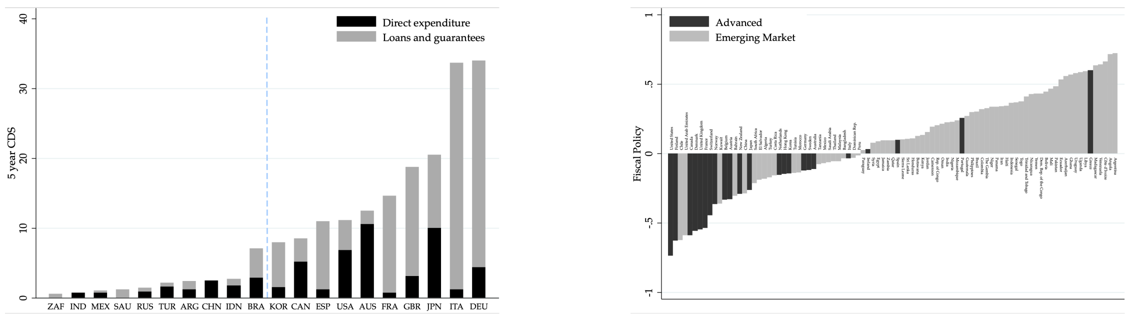
[3] Data for the response to the COVID-19 pandemic is from the International Monetary Fund (IMF) Policy Response Tracker to COVID-19 consulted on 4/16/2020 as well as Figure 1.1 from the April 2020 Issue of the Fiscal Monitor published by the IMF.

[4] Credit Default Swaps intend to capture the likelihood that market participants place on a country defaulting on its debt.

Figure 1: Fiscal Policy in Advanced and Emerging Market Economies

(a) Response to COVID-19 Pandemic

(b) Cyclicality of Fiscal Policy



Notes: Panel (a) is taken from the April 2020 issue of the Fiscal Monitor published by the IMF. It shows the policy response by G20 economies to the COVID-19 pandemic. Panel (b) shows the correlation between the cyclical components of GDP and government spending. Black bars correspond to advanced economies and grey ones to emerging market economies. Data is from the IMF for the years 1980-2016.

direct expenditure. A clear relation can be observed. Countries that experienced sharper increases in their credit risk (emerging market economies), are also the ones that have shown a weaker fiscal response to the shock. This characteristic is also true for a much broader set of countries and a more comprehensive time horizon. Panel (d) shows that countries with higher levels of CDS over the 1980-2016 period, are also those where governments followed a more pro-cyclical fiscal policy in the form of higher correlation between the cyclical components of GDP and government spending.

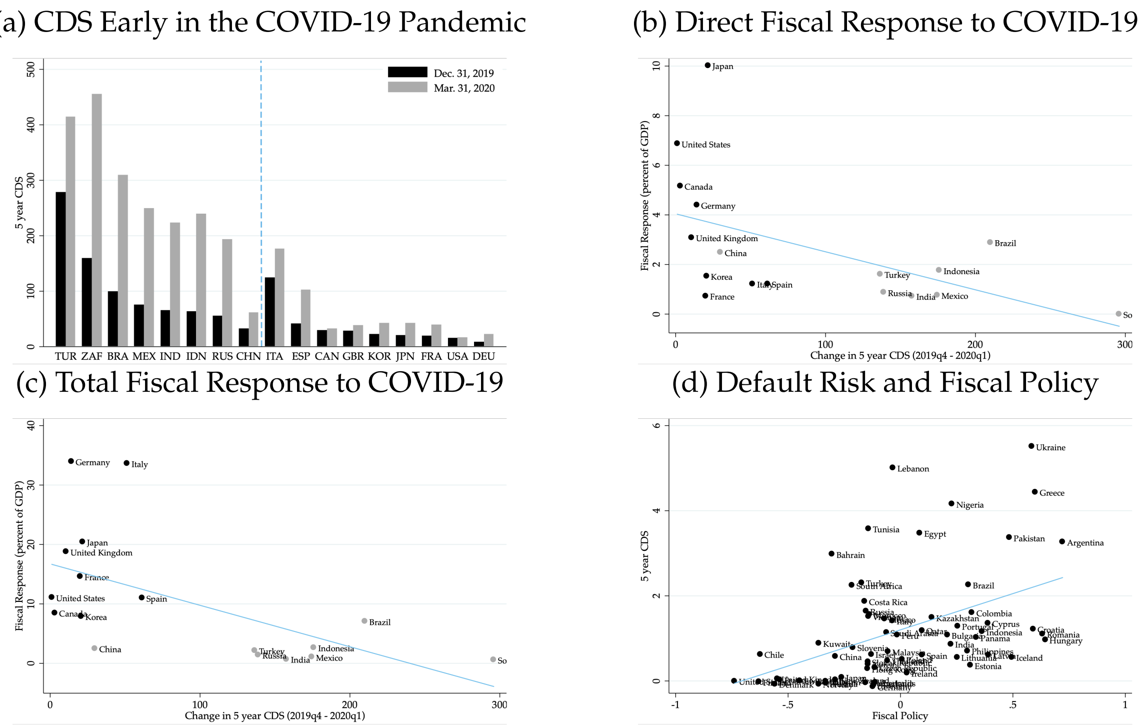
The empirical evidence above shows a sharp contrast between the behavior of fiscal policy in emerging market economies and advanced economies, it is well known that the canonical sovereign default model does not allow for these differences to arise. Models of this type typically display a pro-cyclical fiscal policy behavior. This feature comes as a result of having very impatient governments. In these models the agent oscillates near the cliff of the pricing schedule. A negative shock moves the price of debt against the government and forces spending to go down.[5]

To move a step forward in matching the data the first step I take is to build a sovereign default model in which fiscal policy has an impact on output. My model arises from the combination of a simple model of a small open economy with nominal rigidities with the canonical quantitative sovereign default model. Rigidities are introduced in the form of a constraint on wage reductions. As documented by Bianchi et al. (2017), this type of rigidities allows for fiscal policy to have positive effects on output in sovereign default models.

In addition, I incorporate in the model an endogenous link between sovereign risk

[5]Unless default occurs, in which case default costs play an important role.

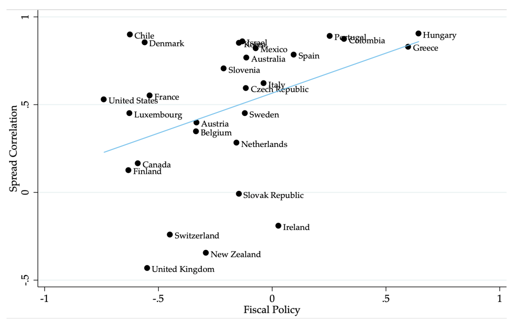
Figure 2: Sovereign Risk and Fiscal Policy



Notes: Panel (a) shows the level of credit default swaps (CDS) for sovereign bonds. Panel (b) shows the change in the level of CDS between 12/31/2019 and 02/31/2020 on the horizontal axis and the direct fiscal expenditure response to the COVID-19 pandemic on the vertical axis. Panel (c) also incorporates loans and guarantees to the fiscal response. Panel (d) shows the correlation between the cyclical components of GDP and government spending on the horizontal axis. On the vertical axis the figure plots the yield of CDS for sovereign bonds. Fiscal policy data is from the IMF for the years 1980-2016. Credit default swap data was obtained from the Bloomberg terminal.

(understood as the probability of government default) and the effectiveness of fiscal policy to increase output. Using a reduced form approach, I link the private sector marginal cost to the cost of government funding and show that this framework delivers a state contingent fiscal policy response inline with the data. My choice for modeling government risk pass-through to the private sector strives from two main reasons. First, I consider the widespread idea that there exists a sovereign ceiling on domestic interest rates (e.g. Borensztein et al., 2013 and Corsetti et al., 2013). The main result behind this literature is that domestic agents are bounded by the sovereign interest rate. On average, the private sector can only take loans under more unfavorable conditions than the government. Second, I consider the notion of government spending crowding out private investment. Figure 3 shows that countries in which there is a high correlation between borrowing costs of the private sector and the government are the ones that tend to follow a more pro-cyclical policy. This suggests that a high pass-through of sovereign risk to firms also relates to the observed cyclicality of fiscal policy across countries.

Figure 3: Sovereign Risk Passthrough and Fiscal Policy



Notes: This figure shows on the vertical axis the correlation between government spreads and firms spreads. Spreads are the difference between funding costs and the US Government long term rate. For the US, Germany is used as a benchmark rate. The correlation between the cyclical components of GDP and government spending is shown on the horizontal axis. Fiscal policy data is from the IMF for the years 1980-2016. Spreads data was obtained from the OECD for the years 2007-2015.

I find that the fiscal multiplier in my model varies with the level of government spreads. In particular, it is smaller once I account for higher sovereign risk. Across model simulations, the mean correlation between the spread on government debt and the size of the fiscal multiplier is -0.27. This implies that if the government is currently in a region of the state space where default risk is low, the fiscal multiplier is high. Increasing government spending has an expansionary effect on output. On the contrary, if agents face a high risk of default, then increasing government spending has a very limited scope on raising output, and the fiscal multiplier is small and might even be negative. A further increase in government spending, leads to an increase in sovereign borrowing costs that pass through to the private sector as higher marginal costs. Firms respond by cutting back on production, yielding a lower impact of fiscal policy.

The main contribution of this paper is to establish a link between the size of the fiscal multiplier, and the optimal fiscal response to shocks. In my model, I find that the optimal cyclicality of fiscal policy is state dependent. This observation helps towards explaining the stark difference between the behavior of fiscal policy in emerging market and developed economies. Countries that experience a sharp increase in sovereign spreads from shocks, might optimally prefer to follow pro-cyclical fiscal policy as borrowing conditions deteriorate and the fiscal multiplier diminishes in size. This is a typical characteristic that distinguishes emerging market economies. In contrast, advanced economies continue to have good borrowing terms after a shock. In the model, these governments are able to optimally expand government spending and finance it via an increase in debt with little movement in spreads. This creates little to no distortion on the private sector and has a larger impact on output, making counter-cyclical fiscal policy desirable.

Related Literature. This paper relates to the sovereign default literature and the fiscal policy literature. Since Eaton and Gersovitz (1981), a rich body of quantitative literature on sovereign debt has developed in recent years. Perhaps the most representative works are Aguiar and Gopinath (2006) and Arellano (2008). A shortfall of these models is the limited role of fiscal policy. Cuadra et al. (2010) highlight that in the canonical sovereign default model fiscal policy is pro-cyclical. In these models, there is no space for government spending to have any impact on output. Further, as governments are impatient, a negative output shock moves the economy closer to the default region which moves the price schedule of debt against the government forcing it to cut down its financial leverage to avoid paying high borrowing costs. In this paper, by incorporating a downward rigidity of nominal wages, I put forward a model in the style of Bianchi et al. (2017) in which fiscal policy has a potential to increase output. The main contribution of my paper is to study the effects of sovereign risk on the fiscal multiplier, and how these shape the optimal behavior of fiscal policy. In recent work, Arellano et al. (2020) incorporated a sovereign default module into the standard New Keynesian model. Although their focus is on the interaction between sovereign risk, inflation, and monetary policy, it would be interesting for future research to study fiscal policy in that setting.

Arellano and Bai (2016), Anzoategui (2017), Hatchondo et al. (2017), and Corsetti et al. (2013) have also studied the interaction between sovereign risk and fiscal policy in different settings. The difference between this work and previous papers is the effect that sovereign risk has on output through its impact on the firm's marginal cost. This channel is intended to illustrate a crowding-out effect of private investment caused by an increase in borrowing costs for the firm and is important in matching the observed behavior of fiscal policy in the data. Relative to Corsetti et al. (2013), the main difference is that my model features an endogenous link between sovereign default and sovereign spreads.

The passthrough from sovereign risk to the private sector is similar to Arellano et al. (2017). An increase in sovereign risk causes the marginal cost of private sector firms to rise. This is modeled as the interest rates paid by firms that need to finance their working capital. Bocola (2016) puts forward a microfoundation of this channel in which the banks' balance sheet is affected, and the cost is passed through to firms. My work is novel because I do not look into the implications that sovereign risk passthrough has on firms, but instead focus on its implications for optimal fiscal policy.

As Ramey (2018) and Ramey and Zubairy (2018) point out, the impact of government spending on output depends, among other things, on the state of the economy when the policy took effect. In Romer and Romer (2017) the authors find that fiscal policy is more effective when the economy has fiscal space (low debt to GDP ratios).[6] This is also true in my model. My work further contributes towards this literature by better understanding the role played by sovereign risk. In particular, from a theoretical perspective my paper supports the view that we should expect the fiscal multiplier to be lower in emerging market economies than in advanced economies. This is in line with the empirical evidence provided by Ilzetzki (2011), Ilzetzki et al. (2013), and International Monetary Fund (2014).

Finally, the paper seeks to contribute to the recent discussion on the economic impact of the COVID-19 pandemic. In particular, the policy constraints that government in emerging market economies might face in reacting to the economic consequences of this shock.[7]

Layout. The remainder of the paper is organized as follows. In Section 2 I describe the theoretical model I use throughout the paper where sovereign risk plays an important role. Section 3 defines the equilibrium and shows the dynamic problem. In Section 4 I parametrize and estimate the model. In Section 5 I discuss the fiscal multiplier in the model, while in Section 6 I study the optimal fiscal policy response to shocks. Section 7 concludes.

2 Model

The model is that of a small open economy with a fixed exchange rate. The economy is populated by a representative risk-averse household, a representative firm, a government and international investors. Households consume foreign and domestic goods, pay taxes and work. Firms' productivity is stochastic and uses labor (provided by households) to produce goods. It faces downward wage rigidities that are introduced as in Schmitt-Grohé and Uribe (2016). Firms must also finance a fraction of their working capital. Although they do not default on these debt obligations, I assume firms borrow at an interest rate that is positively correlated with the governments cost of borrowing. In addition to consumption, households also value government spending. It is provided by a government that must set tax rates and make borrowing or savings decisions. The government is benevolent, maximizes households' utility and is allowed to strategically default on its debt à la Eaton and Gersovitz (1981).

[6] In Christiano et al. (2011) the authors find that fiscal multipliers are larger when the interest rate hits the zero-lower bound.

[7] Interesting work has been published recently related to the COVID-19 pandemic. For example, Guerrieri et al. (2020) and Eichenbaum et al. (2020) among others.

2.1 Households

The economy is populated by a representative household with preferences described by the utility function

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, g_t, l_t)$$

where c_t denotes consumption, g_t denotes government spending, l_t denotes labor, $\beta \in (0,1)$ is the subjective discount factor, and $u(\cdot)$ is the per-period utility function which is assumed to satisfy the standard regularity conditions.

Consumption c_t is a Cobb-Douglas aggregate of a home good $c_{h,t}$ and a foreign good $c_{f,t}$,

$$c_t = \omega^{-\omega}(1-\omega)^{-(1-\omega)} c_{h,t}^{\omega} c_{f,t}^{1-\omega}$$

Households are hand to mouth, so the per-period budget constraint is given by,

$$P_t c_t = (1-\tau_t) w_t l_t + d_t$$

where P_t is the domestic CPI, defined below, $(1-\tau_t)w_t$ is the after tax wage per unit of labor, and d_t are the dividends the household gets from the firm.

The domestic consumer price index P_t includes the price of the home and foreign good and is

$$P_t = P_{h,t}^{\omega} P_{f,t}^{1-\omega} \tag{1}$$

2.2 Firms

The home good is produced by a representative firm taking labor l_t as input. Production is affected by productivity shocks, z_t.

$$y_t = f(z_t, l_t) \tag{2}$$

To model the effect of credit in the economy, I introduce a working capital constraint in which firms are required to pay a fraction λ of their input costs before production takes place. To finance their working capital needs, firms issue non-defaultable intraperiod debt x_t at price $\tilde{q}_t$ (in Section 2.6 I look into sovereign risk passthrough and explain how this price is determined). Thus,

$$\tilde{q}_t x_t = \lambda w_t l_t$$

where w_t is the factor price that is taken as given by firms. Profits of the firm, payed as dividends to the households, are

$$d_t = P_{h,t}y_t - (1-\lambda)w_t l_t - x_t.$$

Any losses are subsidized with a lump sum transfer from the government.

2.3 Foreign Supply and Demand

The demand of home goods by the rest of the world is given by,

$$c^*_{h,t} = \left(\frac{P_{h,t}}{P^*_t}\right)^{-1} \xi_t$$

where ξ is stochastic. The foreign good is in perfectly elastic supply at the exogenous price P_f.[8]

2.4 Labor Market

The model features wage rigidities in the labor market as in Schmitt-Grohé and Uribe (2016). At time t nominal wages cannot be lower than a proportion γ of the wage level at $t-1$.

$$w_t \geq \gamma w_{t-1}$$

This assumption, together with the fixed price of the foreign good, implies that unemployment can arise in equilibrium whenever the constraint binds.

2.5 Government

The government is benevolent and wants to maximize households' utility. It collects revenue from labor income taxes and borrows from international lenders to finance its desired level of government spending. The government has limited commitment to repay its debt à la Eaton and Gersovitz (1981). In this framework each period the government chooses between repaying its debt or defaulting and incurring in a default cost. Government issues debt in the form of one-period bonds. The government budget constraint is given by:

$$\tau_t w_t l_t - b_t + q_t b_{t+1} \geq P_{h,t} g_t,$$

[8]Note the foreign good price is fixed over time $P_{f,t} = P_f$.

where τ is the tax rate on labor income, b_t corresponds to the payment of outstanding debt entering period t, and b_{t+1} represents the issuance of new debt. The price of debt maturing in the future has a price of q_t at time t. Government spending is given by g_t.

Government policy is the quadruple consisting of a default decision δ_t, level of spending g_t, borrowing b_{t+1}, and taxes τ_t. One can note that given a level of government spending and a decision for the level of government debt, it is possible to back out the tax rate from the fiscal budget constraint of the government.

2.6 International Creditors

International creditors are risk neutral, have unlimited resources, and have the outside option of investing their funds at a risk-free interest rate r. Therefore, the lender's no-arbitrage conditions require that,

$$q_t = \mathbb{E}_t \left\{ \frac{1 - \delta_{t+1}}{1 + r} \right\} \tag{3}$$

In this setting q_t represents the brake-even condition for creditors (in expectation). That is, the price of debt must equal the discounted expected payoff flow to investors at $t + 1$. This future income stream depends on the default decision next period δ_{t+1}. If the government chooses not to default next period ($\delta_{t+1} = 0$) creditors are repaid in full. If the government instead decides to default ($\delta_{t+1} = 1$), debt is fully wiped-out, and creditors receive no repayment.[9]

In this model, firms do not default. However, I consider the idea of a sovereign risk passthrough to the private sector via borrowing costs. Hence, firms must borrow at a price given by:

$$\tilde{q}_t = \psi q_t + (1 - \psi) \frac{1}{1 + r}, \tag{4}$$

which represents a weighted average between the governments cost and the risk-free rate. In my benchmark model I consider the idea of a sovereign ceiling on interest rates. Therefore, my modeling assumption is that firms can borrow at the same price as the government does (i.e., $\psi = 1$. Later in the paper, I conduct a sensibility analysis with respect to the passthrough rate, ψ.

[9] A full wipeout of debt is assumed for tractability. One could assume other recovery structures under default without the qualitative results in the paper changing. For example, Yue (2010) incorporates Nash bargaining upon default.

3 Equilibrium

3.1 Competitive equilibrium

A competitive equilibrium in the private sector is a set of allocation $\{c, c_h, c_f, l\}$ such that given the government's policies $\{\delta, g, b', \tau\}$ and prices $\{P, P_t, P_f, w, q, \tilde{q}\}$, consumers and home good producers optimize and markets clear.

The private sector competitive equilibrium for the household is characterized by the optimal consumption-leisure choice condition,

$$\frac{u_l(c_t, g_t, l_t)}{u_c(c_t, g_t, l_t)} = -\frac{w_t(1-\tau_t)}{P_t}. \tag{5}$$

Consumer optimality implies that the domestic demand for home and foreign goods are,

$$c_{h,t} = \omega \left(\frac{P_{h,t}}{P_t}\right)^{-1} c_t, \tag{6}$$

$$c_{f,t} = (1-\omega) \left(\frac{P_{f,t}}{P_t}\right)^{-1} c_t. \tag{7}$$

Market clearing condition in the home good requires that,

$$f(z_t, l_t) = c_{h,t} + c^*_{h,t} + g_t. \tag{8}$$

The household budget constraint rewritten here for completeness,

$$P_t c_t = (1-\tau_t) w_t l_t + d_t. \tag{9}$$

Firms optimality is given by the labor choice condition,

$$P_{h,t} f_l(z_t, l_t) = \left(1 - \lambda + \frac{\lambda}{\tilde{q}_t}\right) w_t, \tag{10}$$

and the complementary slackness condition in the labor market is given by,

$$\begin{aligned} (w_t - \gamma w_{t-1})(l_t^s - l_t^d) = 0, \\ w_t \geq \gamma w_{t-1}. \end{aligned} \tag{11}$$

Profits are transferred to the household as dividends,

$$d_t = P_{h,t} f(z_t, l_t) - \left(1 - \lambda + \frac{\lambda}{\tilde{q}_t}\right) w_t l_t. \tag{12}$$

Whenever appropriate, $\tilde{q}$ is defined as in Equation (4).

3.2 Government's Recursive Problem

I consider a recursive Markov equilibrium. The government is benevolent and starts each period with a state $\boldsymbol{s}$ that consists of the level of sovereign debt b, the productivity shock z, a foreign demand shock ξ, and, due to nominal rigidities, the level of wages for last period w_{t-1}. Taking the behavior of the private sector and the bond price schedule $q(b', \tau, \boldsymbol{s})$ as given, the government chooses optimally to maximize the utility of consumers. The value function for the option to default is

$$\vartheta(\boldsymbol{s}) = \max_{\delta \in \{0,1\}} \left\{(1-\delta) \upsilon^{rp}(\boldsymbol{s}) + \delta \upsilon^{d}(\boldsymbol{s})\right\} \tag{13}$$

where $\upsilon^{rp}(\boldsymbol{s})$ is the value of repaying its debt and $\upsilon^{d}(\boldsymbol{s})$ is the value of defaulting.

If the government chooses to repay, then it must choose consumption, government spending, borrowing, labor, and taxes. The value of such problem is given by,

$$\begin{aligned}
\upsilon^{rp}(\boldsymbol{s}) = & \max_{c,g,b',\tau,l} \; u(c,g,l) + \beta \mathbb{E}\{\vartheta(\boldsymbol{s'})\} \\
\text{s.t.} \quad & Pc + P_h g \leq P_h f(z,l) - \frac{1-\tilde{q}}{\tilde{q}} \lambda(wl) + qb' - b, \\
& \tau_t wl - b + qb' \geq P_h g, \\
& \text{Private sector optimality (5)} - \text{(12)}.
\end{aligned} \tag{14}$$

If instead the government chooses to default, there is a complete wipeout of debt, the government is excluded from financial markets for that period, so that $b' = 0$, and the economy faces a utility loss $d(\boldsymbol{s})$. The value of such problem is given by,

$$\begin{aligned}
\upsilon^{d}(\boldsymbol{s}) = & \max_{c,g,\tau,l} \; u(c,g,l) - d(\boldsymbol{s}) + \beta \mathbb{E}\{\vartheta(\boldsymbol{s'})\} \\
\text{s.t.} \quad & Pc + P_h g \leq P_h f(z,l) - \frac{1-\tilde{q}}{\tilde{q}} \lambda(wl), \\
& \tau_t wl \geq P_h g, \\
& \text{Private sector optimality (5)} - \text{(12)}.
\end{aligned} \tag{15}$$

3.3 Recursive Markov Equilibrium

A recursive Markov equilibrium is a set of policies for the government $\{\delta(\boldsymbol{s})$, $g(\boldsymbol{s})$, $b'(\boldsymbol{s})$, $\tau(\boldsymbol{s})\}$, private allocations $\{c(\boldsymbol{s}), l(\boldsymbol{s})\}$, prices $\{w(\boldsymbol{s}), P(\boldsymbol{s}), P_h(\boldsymbol{s})\}$, and a price function for bonds $q(\boldsymbol{s}, b', \tau)$ such that:

1. The default decision is consistent with the government's default problem (13).

2. Taking the default decision as given, the price schedules solve the lenders no arbitrage problem (3).

3. Taking as given the bond price functions, the government policies and private allocations solve the value functions (14) and (15).

4 Quantitative Analysis

In this section I parametrize, calibrate, and numerically solve the model developed in the previous sections. I calibrate the model to match features of the Mexican economy. Mexico is a benchmark small open emerging market economy. As such, it is often used as example in the sovereign default literature.

In the rest of this section, I first introduce functional forms for the relevant objects of the model. I then proceed to calibrate the model and outline the computational strategy for solving the model numerically.[10] Finally, I analyze the fit of the model with respect to the data and study some characteristics of the equilibrium.

4.1 Parametrization

One period is one quarter. Whenever appropriate, the functional forms adopted in this paper follow the sovereign default literature. I assume the per-period utility function is separable in government spending and a variation of the Greenwood et al. (1988) form:

$$u(c, g, l) = (1-\pi)\frac{\left(c - \frac{l^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}\right)^{1-\sigma} - 1}{1-\sigma} + \pi\frac{g^{1-\sigma} - 1}{1-\sigma}. \tag{16}$$

where σ is the risk aversion parameter and ν is the Frisch elasticity.

Upon default a utility loss is imposed on the planer. A utility loss is often used in the sovereign default literature to capture various default costs that arise upon default. These

[10] The solution and simulation algorithms are described in detail in Appendix B.

could be related to reputation, bailouts, sanctions, or financial frictions, among others. A microfoundation of default costs is outside the scope of this paper.[11] I choose to model the utility loss to be increasing in both productivity, z, and the foreign demand shock, ξ:

$$d(\boldsymbol{s}) = \max\left\{0, d_0 + d_1 \log\left(\frac{P_h f(z,l)}{P}\right)\right\}, \tag{17}$$

where the equilibrium level of unemployment is solved without the wage rigidity binding and for a price of government debt equal to de discount rate for international creditors. This specification displays two important properties. First, it allows for a larger cost of default in good times relative to low output states. Second, the loss is only dependent on these two state variables, $\{z, \xi\}$, and is constant across level of sovereign debt and the level of wages for last period that determine the nominal rigidity in the model. Upon default, the government is excluded from financial markets. In this instance, there is no reference cost of borrowing to pass on to firms as defined in Equation (4). I collapse all default costs into d, and set firms borrowing costs in default equal to the risk-free rate.[12]

The production function of the home good in the economy is given by

$$f(z,l) = zl^{\alpha}, \tag{18}$$

where productivity follows a Gaussian AR(1) process in logarithm. Namely,

$$\log(z') = \rho_z \log(z) + \sigma_z \varepsilon_z'. \tag{19}$$

The coefficient ξ governing foreign demand of home goods also follows a Gaussian AR(1) process in logarithm:

$$\log(\xi') = \rho_\xi \log(\xi) + \sigma_\xi \varepsilon_\xi'. \tag{20}$$

The price of the foreign good is constant and normalized to $P_{f,t} = 1$. I consider the framework of a small open economy. In this context, consumption of home goods is a negligible fraction of spending in the rest of the world and the world CPI, P_t^*, is unaffected by $P_{h,t}$. This specification is consistent with an explicit model with a continuum of countries as in Galí and Monacelli (2005). The world CPI is set to be equal to the price of

[11] For reference see Bocola (2016), Hébert and Schreger (2017), and Perez (2018).

[12] In simulations of the model I only consider out of default states to compute business cycle statistics and fiscal multipliers. Hence, this assumption does not affect the ability of the model to match the data or the qualitative and quantitative interpretation of results.

foreign goods $P_t^* = 1$. Thus,

$$P_{f,t} = P_t^* = 1. \tag{21}$$

4.2 Calibration

The quantitative model contains 16 structural parameters: the risk-free rate, r; the discount factor, β; the degree of risk aversion, σ; the Frisch elasticity, ν; the utility weight for government spending, π; the home bias in consumption, ω; the persistence, ρ_z, and volatility, σ_z, of production technology; the labor share, α; the working capital constraint, λ; the wage rigidity, γ; the persistence, ρ_ξ, and volatility, σ_ξ, of foreign demand; the default cost parameters, d_0 and d_1; and the passthrough rate of sovereign risk to firms, ψ. The calibration of these parameters is performed in two steps. First, I set some parameters at values that follow standard parameters in the literature, or consistent with the data for Mexico. Then, the remaining parameters are jointly calibrated by matching some relevant empirical statistics in the data.

In particular, I set the risk-free rate, r, to 0.70 percent to match the rate of 5-year Treasuries from the United States over the 2000-2016 period. I set the coefficient of risk aversion, σ, to 2 in line with most of the macroeconomic literature. I follow Schmitt-Grohé and Uribe (2016) and set the Frisch Elasticity, ν to 2.2. The utility weight for government spending, π is set to 0.07 to match government spending to GDP in the non-stochastic steady state of the model. The same is done with the home bias consumption, ω, which I set to 0.75 to match exports to GDP in Mexico. To match the labor share of income I set α to 0.66. The working capital constraint, λ, follows the average constraint in Arellano et al. (2017) and is set to 0.30. I follow Schmitt-Grohé and Uribe (2016) and set the downward wage rigidity, γ, to 0.9975. Foreign demand is estimated from Mexican exports. Persistence, ρ_ξ, is set to 0.80 and volatility, σ_ξ, to 0.023. In my benchmark calibration, there is full passthrough from the government to the private sector. Accordingly, ψ is set to 1.

The remaining parameters, i.e., $\Theta \equiv \{\beta, \rho_z, \sigma_z, d_0, d_1\}$, are jointly calibrated with the method of simulated moments that consists in choosing parameters to best match some empirical targets in the data using their model's analogues. The parameters are chosen to minimize the distance between the data and model's empirical statistics according to the loss function $L(\Theta) = [M^d - M^m(\Theta)]'W[M^d - M^m(\Theta)]$. Where M^d and $M^m(\Theta)$ are the vectors of data targets and model analogues respectively. The matrix W weights the targets using the inverse of the moment in the data. As part of the empirical statistics chosen as targets I considerate persistence and volatility of output, in which ρ_z and σ_z can play a significant role. The other empirical targets are the average debt to GDP ratio, as well as the average level and volatility of interest rate spread, calculated as the yield difference between the benchmark 5-year sovereign bond in US Dollars for Mexico and the United States. It should be noted that the norm in the sovereign default literature is to match the consolidated external debt position of both the private and public sector. As this paper also studies the problem of a benevolent government that is the only agent that is able to intermediate with foreign investors, I follow this convention. Table 1 reports the choice of parameters.

Table 1: Model Parameters

Parameter	Notation	Value	Source
Interest rate	r	0.010	US Treasuries yield, 2000-2016
Risk aversion	σ	2.000	Standard in macroeconomics
Frisch elasticity	ν	2.198	Schmitt-Grohé and Uribe (2016)
Spending preference	π	0.070	Govt. spending to GDP, 2000-2016
Home bias	ω	0.750	Exports to GDP, 2000-2016
Production technology	α	0.660	Share of labor income, 2000-2016
Working capital constraint	λ	0.300	Arellano et al. (2017)
Wage rigidity	γ	0.998	Schmitt-Grohé and Uribe (2016)
Foreign demand, persistence	ρ_ξ	0.913	Quarterly exports, 2000-2016
Foreign demand, volatility	ρ_ξ	0.028	Quarterly exports, 2000-2016
Sovereign risk passthrough	ψ	1.000	Assumption in benchmark model
Output persistence	ρ_z	0.913	Method of Simulated Moments
Output volatility	σ_z	0.028	Method of Simulated Moments
Discount factor	β	0.960	Method of Simulated Moments
Default cost	d_0	3.950	Method of Simulated Moments
Default cost	d_1	15.150	Method of Simulated Moments

Notes: This table reports the choice of parameters for the model. The choices for parameter values either follow standard parameter values used in the macroeconomics literature or are selected to match certain moments in the data. A method of simulated moments is used to calibrate some parameters of the model to match the data for Mexico.

4.3 Model Fit

The quantitative model does a very good job in matching the data targets. In Table 2 I compare the average empirical statistic across model simulations with those calculated from Mexican Data. In the period between 2002:Q1 and 2018:Q4, Persistence and volatility of output estimated from Mexico's GDP (linearly detrended in logarithms) is 0.896 and 0.013 respectively. Meanwhile I obtain an average persistence of 0.854 and volatility of 0.060 over 10,000 simulations. The average gross external position of the Mexican economy over the same period was 25.80% of GDP. In my simulations of the model, the average debt to GDP ratio across model simulations is 29.85%. Finally, the average spread on government bonds over the same time period was 1.48% in the data. It is higher in my simulations, 2.53%. Similarly, the standard deviation of spreads was 0.77% in the data and it is 2.11% in simulations.

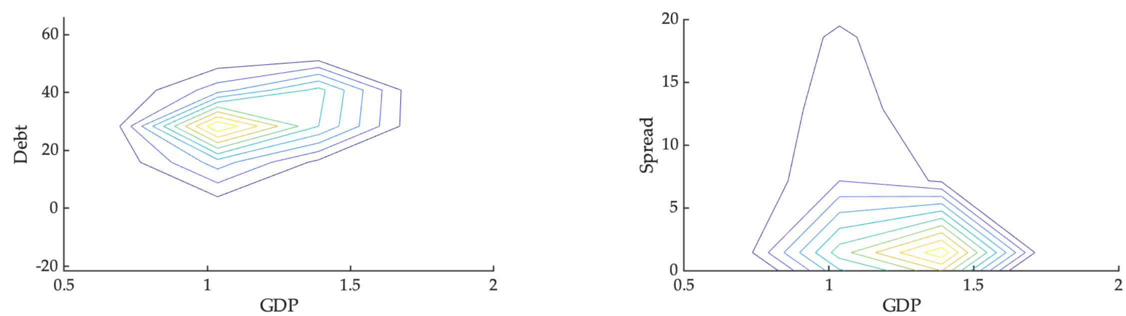
Table 2: Targeted and Non-targeted Empirical Statistics

Empirical Statistic	**Data**	**Model**
Targeted		
GDP persistence	0.896	0.854
GDP volatility	0.013	0.060
Average Debt to GDP Ratio	25.80%	29.85%
Average Spread	1.48%	2.53%
Std. Dev. of Spreads	0.77%	2.11%
Non-targeted		
Corr. GDP & Spread	-0.193	-0.564
Corr. GDP & Debt/GDP	-0.292	-0.029

Note: This table presents statistics for targeted moments. Data is for the period from 2002:Q1 to 2018:Q4. GDP in the data is linearly detrended in logarithms. Empirical statistics from the model are the average across 10,000 simulations 0f 68 periods each.

Figure 4 presents a useful cross-section of the ergodic distribution that help explain non-targeted moments. To construct the empirical ergodic distribution, I consider the distribution of model variables in a sufficiently large number of simulations, after a sufficiently long period of time. The latter, to avoid any unintended effects coming from the state in which simulations are initialized. I simulate the model over 10,000 simulations samples of 68 periods each after dropping the previous 100 periods. The panel on the left shows the debt and GDP in the ergodic distribution. It is possible to appreciate that higher levels of GDP, relax the government's borrowing constraint allowing the government to issue additional debt. This is a typical characteristic of sovereign default models. The relatively high degree of government impatience (low calibrated values for β), implies that governments oscillate near the fiscal cliff of the pricing schedule. A positive output shock relaxes that constraint, allowing the government to issue more debt.[13] In fact, the average correlation between GDP and debt across model simulations is 0.39. The average correlation between GDP and the debt to GDP ratio is instead counter-cyclical in line with the data, albeit small. This correlation is -0.29 in the data while it averages -0.029 across model simulations. The panel on the right shows GDP and the spread on government debt in the ergodic distribution. I highlight the negative correlation between the two, in line with the data for Mexico and other emerging market economies. It averages -0.564 across model simulations and -0.193 in the data. For low levels of output, the government is more likely to default. This increases the spread on public debt and tightens the governments access to financial markets.

Figure 4: Debt, Spreads, and GDP in the Ergodic Distribution



Notes: This figure presents the cross-section for selected variables in the empirical ergodic distribution. The distribution is constructed from 10,000 simulations of 68 periods each. Debt is relative to mean GDP. Debt and spread data are in percentage points.

5 Fiscal Multiplier

I begin my analysis of fiscal policy in the model looking at the fiscal multiplier. First, I look into a modified version of my model in which government spending is exogenous. This allows me to study the effect of a government spending shock in GDP. I then explore the fiscal multiplier across the state-space in the full model that features endogenous government spending. Finally, I explore the implications that sovereign risk passthrough in my model has on the fiscal multiplier.

[13]See Bocola et al. (2019) for a discussion on this property of sovereign default models.

5.1 A Model With Exogenous Government Spending

To grasp some intuition of the fiscal multiplier in the model, I first study how a government spending shock affects the economy. I consider a variation of the model in which government spending follows an exogenous process and the government must make savings decisions and set tax rates. It should be noted that given an exogenous level of government spending, g, one is able to back out the tax rate, τ, from the government's fiscal constraint, collapsing the choice variable to only debt, b'. Under this specification, government spending follows a Gaussian AR(1) process in logarithms that reverts to the steady state level of government spending $\bar{g}$,

$$\log(g') = (1 - \rho_g) \log(\bar{g}) + \rho_g \log(g) + \sigma_g \varepsilon_g'.$$

I calibrate the persistence, ρ_g, volatility, σ_g, and steady state level, $\bar{g}$, of government spending to match data from Mexico.[14]

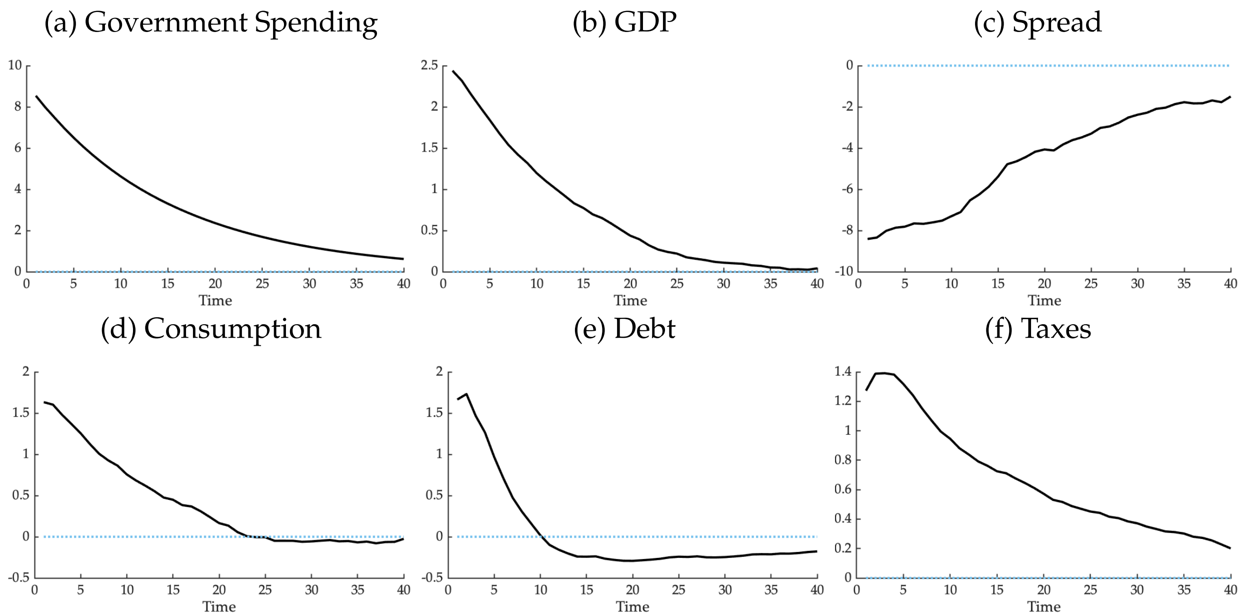
A well-known feature of sovereign default models is that they typically exhibit non-linearities. For this reason, I compute impulse response functions (IRFs) following Koop et al. (1996) as the average difference between 10,000 model simulations with and without the shock. I initialize all simulations by sampling from the ergodic distribution.[15] Figure 5 shows the impulse response function to a one standard deviation (8.5 percent of its steady state value) shock to government spending and its impact on GDP and other economic variables in the model. A positive shock to government spending leads to an increase in GDP, underscoring the existence of a positive fiscal multiplier in the model. To finance the increase in government spending the government uses a combination of both additional debt issuance and an increase in taxes.

In this version of the model, government spending is on average 17.8 percent of GDP. Hence, on-impact the fiscal multiplier is 1.26. If instead I calculate the commutative multiplier by discretely integrating all the area under the impulse response functions, as suggested by Ramey and Zubairy (2018), the cumulative long-run fiscal multiplier is 0.54. For comparison, for a panel of 17 emerging market economies Ilzetzki (2011) estimates a long-horizon multiplier of 0.3, smaller than the typical estimates for advanced economies of 0.6 (International Monetary Fund, 2014).

[14] The estimated value of the structural parameters are $\rho_g = 0.936, \sigma_g = 0.029$ and $\bar{g} = 0.128$.

[15] The simulation algorithm and the procedure to compute impulse response functions are detailed in Appendix B.2.

Figure 5: Government Spending Shock



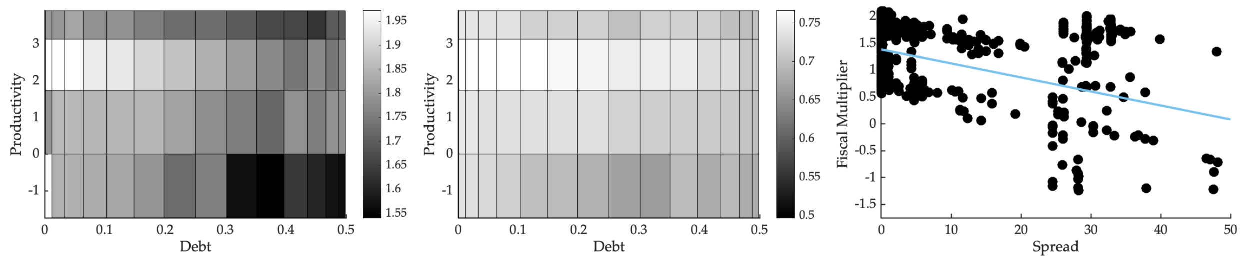
Notes: This figure presents the impulse response functions of government spending, GDP, spreads, consumption, debt, and taxes to a government spending shock. Values correspond to percentage deviations from their mean value in the ergodic distribution, except for spreads and the tax rate that corresponds to percentage points difference.

5.2 Fiscal Multiplier in the Endogenous Government Spending Model

I now return to the complete model described in Section 2 in which government spending is endogenous. To study the fiscal multiplier in the model, I consider the following exercise. What would the impact on GDP be if the government were to issue additional debt to finance an increase in government spending? This exercise allows me to estimate the on-impact size of the debt financed fiscal multiplier (going forward I refer to this measure as the fiscal multiplier). In Appendix C I provide further details on how the fiscal multiplier is estimated.

Figure 6 provides some useful representations of the results from this exercise. The panel on the left shows the estimated fiscal multiplier across the debt-productivity state-space. The fixed dimensions (i.e. external demand, ξ, and previous wages, w_{-}) are set at their mean value in the ergodic distribution. My first observation is that the heat-map shows a high on-impact multiplier in the range from 1.55 to 1.95. My second observation is that the multiplier is state dependent. In particular, it is smaller when productivity is low and debt levels are high; and it is high when productivity is high and debt is low. The center panel shows a similar cross-section of the state space. The only difference is that I relax the wage rigidity constraint by considering a previous period wage level equal to the tenth percentile in the ergodic distribution. As expected, the fiscal multiplier is lower, now in the range from 0.5 to 0.75. This result highlights the importance of the nominal rigidity in the model in order to get meaningful effects from fiscal policy. It is also important to note that the same state dependence can be seen in the behavior of the fiscal multiplier; it diminishes as the economic fundamentals deteriorate.

Figure 6: Fiscal Multiplier in the Model



Notes: The first two panels (left and center) present the fiscal multiplier across the productivity-debt state-space. External demand is set at the mean value in the ergodic distribution. Previous wages in the left panel are set at the mean value in the ergodic distribution, and at the tenth percentile in the center panel. The panel on the right shows a scatter plot of fiscal multiplier and spread across the state-space. The blue line corresponds to a linear fit of the data.

Finally, the panel on the right presents a scattered plot of the fiscal multiplier and the equilibrium spread on government bonds across all the state-space. The blue line corresponds to the best linear fit of the data. This figure shows an inverse relation between these two variables (the correlation between spreads and the fiscal multiplier across the state-space is -0.20) and reinforces my previous observation. When the fundamentals of the economy are weaker, and the probability of default increases, the fiscal multiplier is smaller. In fact, while the fiscal multiplier is positive and high during good times, for states in which the equilibrium spread on government debt is high, the fiscal multiplier might even take negative values.

5.3 Sovereign risk passthrough

My model directly incorporates the passthrough of sovereign risk on to the private sector. I do this by having the firms' working capital be financed at the same cost as sovereign debt. However, Equation (4) is more flexible and allows for a lower passthrough rate. I transcribe this equation bellow for convenience,

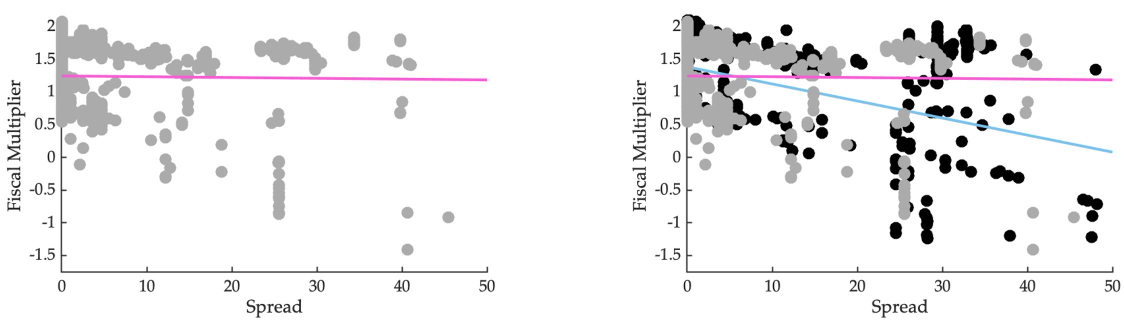
$$\tilde{q}_t = \psi q_t + (1-\psi)\frac{1}{1+r}.$$

This equation asserts that the financial cost of firms is a weighted average between the risk-free rate and the interest rate for government debt. The weight is controlled by the parameter ψ which is set to one in the benchmark calibration of the model, effectively having a full passthrough of public risk to the private sector. In order to analyze the effect that sovereign risk passthrough has on my modeled economy, I estimate the fiscal multipliers coming from the model under a passthrough rate of zero (i.e. set $\psi = 0$).[16]

Figure 7 presents the results from this exercise in the left panel. In gray I show the size of the fiscal multiplier across the state-space and show how it changes with the equilibrium spread on government debt. The pink line corresponds to the best linear fit of the data. The correlation between the two is negligible. Only -0.001, compared with -0.20 in the previous exercise with a full passthrough of risk. For comparison, the panel on the right directly overlays these results on top of the right panel of Figure 6. In black and blue I show the size of the fiscal multiplier, and the best linear fit of the data, when $\psi = 1$. In gray and pink, I show the same data for the case with $\psi = 0$.

This exercise illustrates the effects that incorporating sovereign risk passthrough has in the modeled economy. When borrowing costs for the government increase, the cost of financing the firm's working capital increases. From the firm's optimality conditions, equation (10) in particular, it is possible to appreciate that this maps into an increase in the firm's marginal cost. Faced with this increase in costs, the firm optimally chooses to cut back its production, curtailing the effectiveness of fiscal policy.

Figure 7: The Effects of Sovereign Risk Passthrough



Notes: This figure presents the relation between the size of the fiscal multiplier across the state-space and the spread in government debt. The panel on the left shows the counterfactual results under $\psi = 0$. The pink line corresponds to a linear fit of the data. The panel on the right overlays this results with those showed in the right panel of Figure 6.

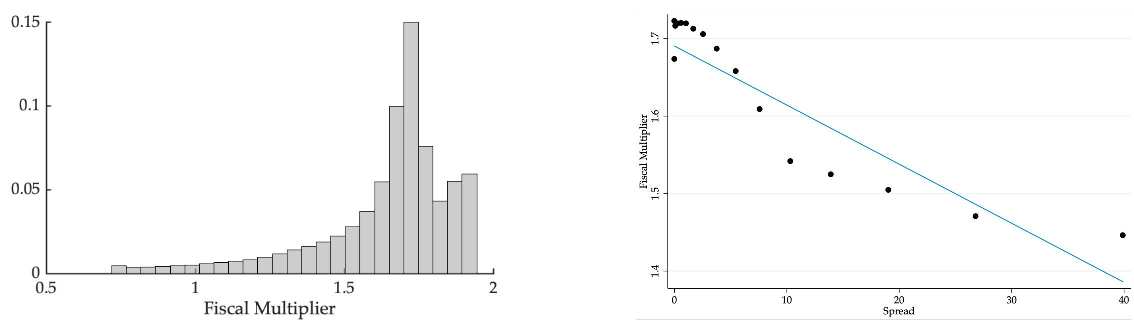
[16]It is important to stress that I do not re-solve the model under the new parameter configuration. Instead, I study the local effect by modifying the parameter in simulations of the model in which the parameter directly affects the competitive equilibrium allocation of the private sector.

5.4 Fiscal Multiplier Across Model Simulations

I perform a similar exercise to estimate the fiscal multiplier across simulations of the model. This allows me to study the fiscal multiplier in the ergodic distribution, rather than across the complete state-space. Figure 8 illustrates the behavior of the fiscal multiplier in the ergodic distribution. The panel on the left shows the distribution for the size of the fiscal multiplier normalized as probabilities. Although the mean size for the fiscal multiplier across simulations is 1.6, its size varies considerably across all states. While the 5th percentile is 0.7, the 95th percentile is 1.9, with the median size for the multiplier being 1.7. This highlights that the state dependent behavior of the fiscal multiplier is also present in the ergodic distribution of the model.

The panel on the right shows a bin-scattered plot to illustrate the relation between sovereign risk and the size of the fiscal multiplier. In the ergodic distribution the negative relation between the two persists. In fact, the mean correlation between spreads and the size of the fiscal multiplier across model simulations is -0.27. This is lower than my previous estimate across the complete state-space, confirming the observation that sovereign risk affects the ability of fiscal policy to stimulate output.

Figure 8: The Fiscal Multiplier Across Simulations



Notes: This figure presents the distribution for the size of the fiscal multiplier across the 10,000 simulations of the model. The panel on the left shows a normalized histogram of the fiscal multiplier. The panel on the left shows a bin-scattered plot of the relation between spreads and the size of the fiscal multiplier across simulations. The blue line corresponds to a linear fit of the complete data.

5.5 Discussion

The results in this Section provide useful insight to understand the empirical evidence presented in the introduction of this paper. Three observations can be made from that evidence, together with other empirical work. First, emerging market economies tend to have higher default risk, in the form of a higher spread of government bonds relative to advanced economies (Figure 2). Second, economies that display a higher correlation between private and public borrowing costs, which I interpret as a higher sovereign risk passthrough, typically display a more pro-cyclical behavior of fiscal policy (Figure 3). And third, emerging market economies typically follow a pro-cyclical fiscal policy. In contrast, advanced economies display a counter-cyclical behavior of fiscal policy (Figure 1).

Through the eyes of the model, the first two observations are useful to provide an explanation for the cyclicality of fiscal policy. In the model, when an economy exhibits higher sovereign risk in the form of a higher spread, the fiscal multiplier is smaller. A fundamental component for this behavior is the novel mechanism in the model that links sovereign risk to the firm's decisions through an increase in its marginal cost. This could very well be the situation of an emerging market economy, which typically feature higher spreads relative to advanced economies. In the model, if spreads are high enough, the fiscal multiplier might even be negative. In contrast, when an economy is far away from the default region and spreads are low, as is the case in most advanced economies, the fiscal multiplier is large.

The behavior of the fiscal multiplier in the model could lead a government to optimally follow a counter-cyclical fiscal policy when the economy is far away from the default region, while instead opting for a more pro-cyclical policy when sovereign risk is high. I explore this in the next Section where I study optimal fiscal policy in the model.

6 Optimal Fiscal Policy

In this section, I analyze impulse response functions to discuss the optimal fiscal response and the behavior of the economy to shocks. I conduct two exercises. First, I study the effect of a negative shock to productivity. The second exercise consists in analyzing the effect of a foreign demand shock. The latter shock is of particular interest since a negative shock to the foreign demand induces the wage rigidity constraint to bind. As previously discussed in Section 5, the fiscal multiplier is larger when the nominal rigidity is binding. Hence this type of shock allows for fiscal spending to be a good tool that government can use to expand output.

To further understand the state dependence of fiscal policy in the model, for each shock I compute three different IRFs by initializing the simulations at different regions of the state-space. Again, I compute IRFs as the average difference between 10,000 simulations with and without the shock. First, I initialize all simulations by sampling from the ergodic distribution. This constitutes the baseline IRF in the model. For the remaining two cases, I sample from a restricted subset of the ergodic distribution. First, I consider only the states in which the equilibrium spread is above the 75th percentile. I refer to these states as the high spread states. Finally, I sample only from states in which the spread is below the 25th percentile. This group corresponds to the low spread states. By comparing across these three IRFs, I am able to discern the state dependence of optimal fiscal policy in the model.

6.1 Productivity Shock

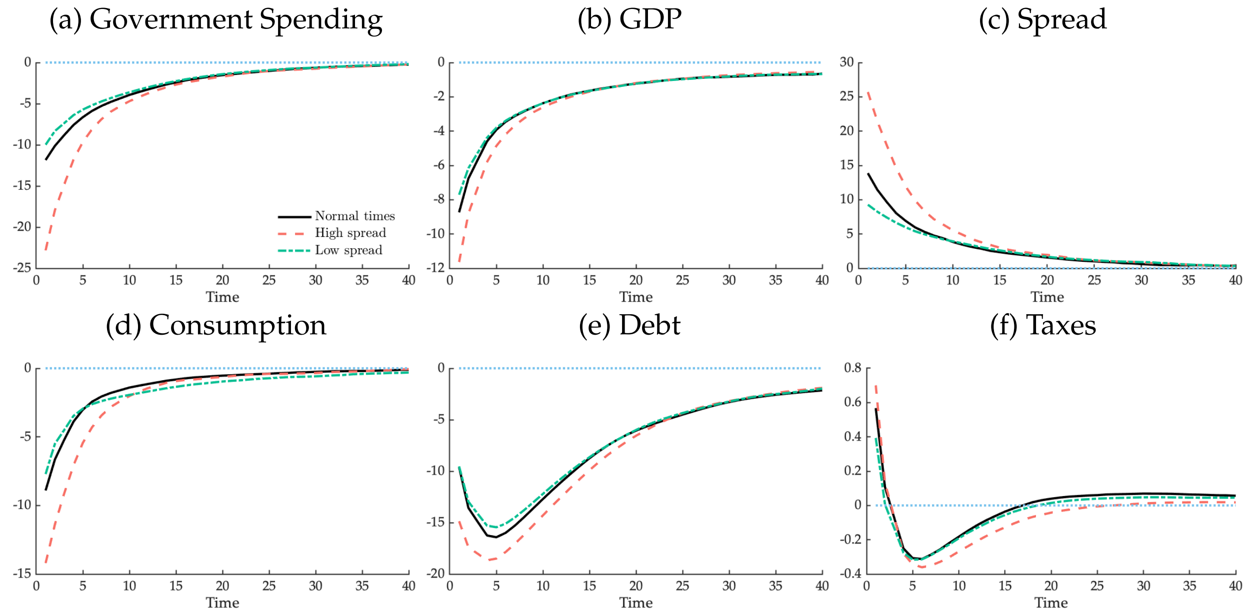
I first consider the effect of a one standard deviation negative shock to productivity. Figure 9 presents the impulse response functions for government spending, GDP, the spread of government debt, aggregate consumption, sovereign debt, and the tax rate. Values correspond to percent change relative to the mean value of the relevant variable in the ergodic distribution, except for spreads and the tax rate that correspond to percentage point differences. The black solid line shows the baseline response of the economy to this shock. A negative productivity shock leads to a contraction in output and an increase in sovereign risk. As debt becomes more expensive, the government is forced to cut back on new debt issuances and, at first, also to increase taxes. Both consumption and government spending drop as the economy becomes relatively poorer.

The observed response is a typical characteristic of sovereign default models. It has been amply documented that a negative output shock moves the economy closer to the default region. This moves the price schedule of debt against the government. Faced with this situation the government is forced to cut cut down its financial leverage or pay a big cost for borrowing.[17] Moreover, from the discussion in Section 5, it is clear that when productivity is low the fiscal multiplier is also low. Hence, the government has lower incentives to increase spending as it would stimulate output less.

Now, I compare the baseline response of the economy, to the response in high and low spread states. When spreads are high (red dashed lines), the economy is relatively weak before the shock so default is more likely. The shock amplifies this weakness, and the spread on government debt increases by more. This leads to a further contraction in output as sovereign risk leaks to the private sector through higher borrowing costs for working capital. This has a negative effect on welfare. The drop in government spending and consumption is amplified as taxes increase more, and the government is forced to issue even less debt. In contrast, when the economy is in a good standing before the shock (green dash-dot line), borrowing costs for the government increase by less, the govern-

[17]See for example Cuadra et al. (2010) and Bocola et al. (2019) for a discussion on this property of sovereign default models.

Figure 9: Optimal Response to a Productivity Shock



Notes: This figure presents impulse response functions (IRF) for government spending, GDP, spreads, consumption, debt, and taxes to a one standard deviation shock to productivity. Values correspond to percent change relative to the mean value of the ergodic distribution, except for spreads and the tax rate that correspond to percentage points difference. IRFs are the average response across 10,000 simulations initiated by sampling at random. For normal times I random from the ergodic distribution. For high and low spread, I sample from the constrained ergodic distribution defined by the top and lower quartile of spreads respectively.

ment is able to cut back less on debt as well as increase the tax rate more moderately. This has a positive effect on welfare and output. Government spending, consumption, and GDP all fall by less under this positive scenario.

This exercise underscores how the fiscal stance of the government can help contribute to attenuate or to amplify shocks. When fiscal space is available, even if limited, the spread on government debt increases by less and the government is able to favor debt relative to taxes. Both of these contribute to lower distortions in the economy, as taxes are distortionary and sovereign risk passes through to the private sector in the form of higher costs.

6.2 Foreign Demand Shock

I now consider the effect that a negative shock to foreign demand has on the economy. As previously discussed, the fact that a foreign demand shock induces the wage rigidity to bind makes this shock particularly important in the model. When the wage rigidity binds fiscal policy is more effective in rising output and thus the fiscal multiplier is large, as discussed in Section 5.

In Figure 10 I present the impulse response function to this shock. GDP falls and sovereign risk increases as the economy's fundamentals deteriorate and default risk increases. However, optimal fiscal policy now calls for the government to increase government spending, taking advantage of the fact that the fiscal multiplier is high. A known feature of models of fiscal policy with nominal rigidities is the fact that the cost of rising taxes is smaller if the wage rigidity constraint is binding. Thus, the government finances the increase in government spending both with an increase in taxes and additional debt issuance. The increase in government spending attenuates the drop in GDP but it does not completely overturn it, so consumption also falls. The comparison of the baseline response of the economy to the response in high and low spread states is very interesting. Particularly in the former. For the latter the response looks very similar. Albeit, the lower increase in government spreads allows the government to issue additional debt and raise taxes by less while significantly increasing government spending. This translates to an additional stabilization of GDP that observes a milder drop as does consumption which is good for welfare in the model.

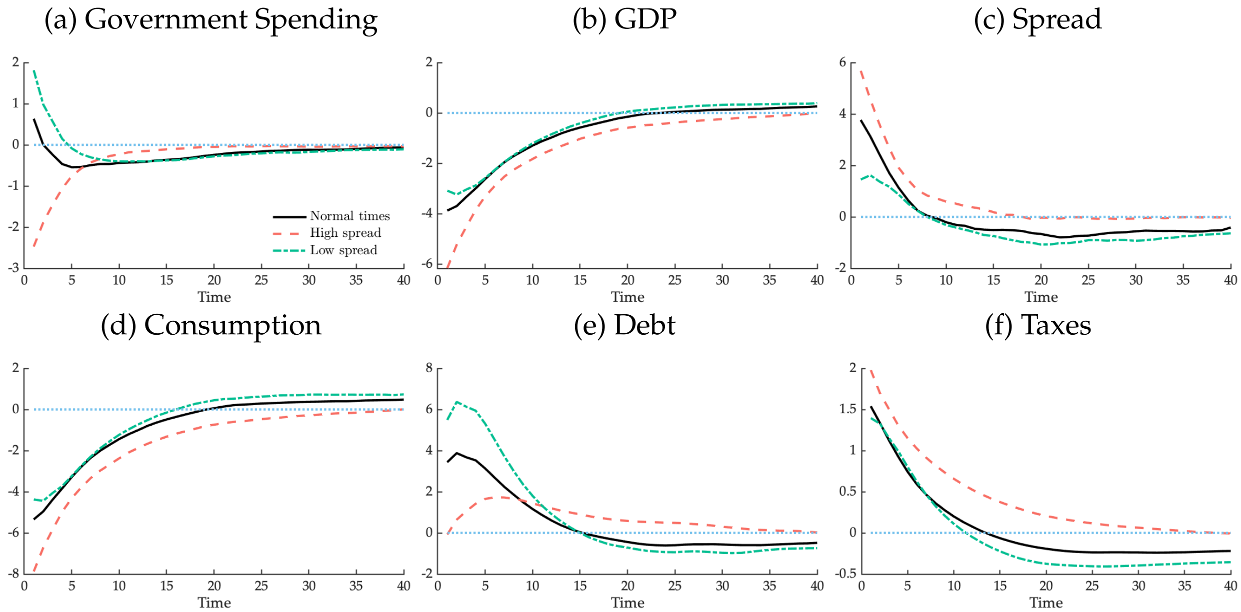
The more interesting comparison if for states in which the economy was in a weaker fiscal position and spreads where already high prior to the shock. The shock is amplified by the weaker fiscal stance. In sharp contrast, as spreads increase the government optimally chooses to cut back on government spending. GDP and consumption fall by more and the limited borrowing capacity forces the government to increase taxes by more.

This exercise highlights an important contribution of this paper. The cyclicality of fiscal policy might optimally be state-dependent. In particular, countries that experience a sharp increase in sovereign spreads from shocks, might optimally prefer to follow a pro-cyclical fiscal policy as borrowing conditions deteriorate and the fiscal multiplier diminishes in size. In contrast, governments that continue to have good borrowing terms after a shock, are able to expand government spending and finance it via debt with little movement in sovereign spreads. This creates little to no distortion on the private sector and has a larger impact on output.

7 Conclusion

Fiscal policy response differs across countries. Fiscal policy is mostly pro-cyclical in emerging market economies and counter-cyclical in advanced economies. I portray default risk by the government as the explanation to this phenomenon. Through the eyes of the model, advanced economies display counter-cyclical fiscal policy behavior because

Figure 10: Optimal Response to a Foreign Demand Shock



Notes: This figure presents impulse response functions (IRF) for government spending, GDP, spreads, consumption, debt, and taxes to a one standard deviation shock to foreign demand. Values correspond to percent change relative to the mean value of the ergodic distribution, except for spreads and the tax rate that correspond to percentage points difference. IRFs are the average response across 10,000 simulations initiated by sampling at random. For normal times I random from the ergodic distribution. For high and low spread, I sample from the constrained ergodic distribution defined by the top and lower quartile of spreads respectively.

they are relatively far away from the default zone so fiscal multipliers are large. Faced with a shock, the government is able to expand government spending and finance it via debt with no movement in sovereign spreads. This creates little to no distortion on the private sector. On the contrary, I think of emerging markets as being close to the fiscal cliff. Sovereign spreads move quickly against them if they choose to increase debt. These leads to small fiscal multipliers. For these reasons, most emerging market economies optimally choose to follow pro-cyclical fiscal policies. A fundamental component for these results, is the link in my model between sovereign risk (understood as the probability of government default) and the size of the fiscal multiplier due to the passthrough of sovereign risk to the private sector.

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A Data Appendix

Real gross domestic product (GDP) data are obtained from the OECD Quarterly National Accounts database. Values correspond to volume estimates in the GDP expenditure approach with reference year 2015. Data are obtained for the period 2002:Q1–2018:Q4. I linearly detrend the series in logarithms.

External debt data are obtained from the World Bank Quarterly External Debt Statistics SDDS. I consider gross external debt position for all sectors, all maturities, all instruments, and all currencies, in current US dollars. Gross external position is divided by the nominal Gross Domestic Product in current US dollars from the World Bank World Development Indicators. Data are obtained for the period 2002:Q1–2018:Q4.

Interest rates data on government bonds for Mexico and the United States of America are obtained from the Bloomberg Terminal for the period 2002:Q1–2018:Q4. I consider the yield on generic five-year maturity government bonds in US dollars. The spread is the difference in yield between Mexico and the US. The risk-free rate is estimated by subtracting inflation for the US from the US interest rate data.

B Computational Appendix

B.1 Model Solution Algorithm

The numerical solution of the model consists in approximating the value function on repayment, $\upsilon^{rp}(\cdot)$, the value function on default, $\upsilon^{d}(\cdot)$, as well as the price function, $q(\cdot)$, defined by Equations (14), (15), and (3) respectively. The state space is given by $\boldsymbol{s} = \{b, z, \xi, w_{-}\}$. The assumption of a complete wipeout of debt upon default simplifies the state space in default to only three variables $\{z, \xi, w_{-}\}$.

The value functions are approximated using projection method, in particular I use a Chebyshev approximation. Specifically, for the model described in Section 2, $\upsilon^{x}(\cdot)$ is approximated as follows,

$$\upsilon^{x}(\boldsymbol{s}) = \gamma^{x\prime}\boldsymbol{T}(\boldsymbol{s}),$$

where $\boldsymbol{s} = (b, z, \xi, w_{-})$ is a realization of the state variables, γ^{x} is a vector of coefficients and $\boldsymbol{T}(\cdot)$ is a vector collecting Chebyshev's polynomials. The numerical solution is {γ^{rp}, γ^{d}, q} which is obtained via value function iteration.

Before solving, I select the bounds and number of grid points for the four state variables. For debt, I consider 15 points in the interval $[0, 0.5]$ located at the Chebyshev's nodes. I label this grid as $\mathcal{B}$. The upper bound is consistent with a debt-to-GDP ratio at the mean of the ergodic distribution of 44 percent. Almost double of that observed in the data. For productivity and external demand, I consider 7 points each in an interval of plus and minus 4 standard deviations. The points are located at the Chebyshev's nodes. I label these grids, $\mathcal{Z}$ and $\mathcal{E}$, respectively. Finally, for the wage level in the previous period I consider 15 points at the Chebyshev's nodes in the interval $[3, 8]$, $\mathcal{W}$. The state-space grid $\boldsymbol{S}$ is constructed using tensor multiplication of these nodes, $\boldsymbol{S} = \mathcal{B} \times \mathcal{Z} \times \mathcal{E} \times \mathcal{W}$. These grid points, together with the Chebyshev's polynomials, are used in the approximation of the value functions using a collocation method. On the policy dimension for new debt issuances, b', I set 101 equally spaced points in the interval $[0, 0.5]$. For the tax rate, τ, I set 31 equally spaced points in the interval $[0.1, 0.5]$. Expectations are computed using a Gauss–Hermite quadrature of 5 for both productivity and external demand. I use a pruning procedure and consider 21 points. Table B.1 shows the value for the relevant computational parameters.

Table B.1: Computational Parameters

Variable or Parameter	**Min**	**Max**	**Points**
Debt, $\mathcal{B}$	0.0	0.5	15
Productivity, $\mathcal{Z}$	$-4\frac{\sigma_z}{\sqrt{1-\rho_z^2}}$	$4\frac{\sigma_z}{\sqrt{1-\rho_z^2}}$	7
External Demand, $\mathcal{E}$	$-4\frac{\sigma_\xi}{\sqrt{1-\rho_\xi^2}}$	$4\frac{\sigma_\xi}{\sqrt{1-\rho_\xi^2}}$	7
Wage at $t-1$, $\mathcal{W}$	3.0	8.0	15
Debt choice, $\mathcal{B}'$	0.0	0.5	101
Tax rate choice, $\mathcal{T}$	0.1	0.5	31
Order of Gauss–Hermite quadrature			$5 \times 5^*$

Notes: This table shows the choice of computational parameters used in the solution of the model following the algorithm outlines in the current section. As a collocation method is used, the order of the Chebyshev polynomial is equal to the number of nodes.
*For expectations, I utilize a pruning criterion over the tensor of Gauss–Hermite points and keep only 21 points.

1. Initialize the algorithm with an initial guess for the value functions and the price schedule $\{\hat{v}_0^{rp}, \hat{v}_0^d, q_0\}$.

2. Let $\{\hat{v}_n^{rp}, \hat{v}_n^d\}$ be the value functions at iteration n. Given these values use projection method to update the value of $\{\gamma^{rp}, \gamma^d\}$ used to approximate the value function.

3. For each element in the pricing grid compute the pricing schedule using the most

recent value function approximations to determine the governments default decision. Use a Gauss–Hermite quadrature to compute expectations. Use the previous iteration of wage prices to determine the nominal rigidity in the next period.

4. Update the value functions using their definitions. To compute expectations, use a Gauss–Hermite quadrature.

   (a) For every possible choice made by government for the tax rate τ and the level of sovereign debt next period b' obtain the competitive equilibrium at each grid point by solving the the system of equations given by Equations (1)-(12), with the exception of Equation (3), using a non-linear numerical solver. I transcribe the competitive equilibrium conditions next

$$
\begin{aligned}
P_t &= P_{h,t}^{\omega} && \text{(B.1)}\\
l_t^s &= \left(\frac{w_t(1-\tau_t)}{P_t}\right)^{\nu} && \text{(B.2)}\\
c_{h,t} &= \omega\left(\frac{P_{h,t}}{P_t}\right)^{-1} c_t && \text{(B.3)}\\
c_{f,t} &= (1-\omega)\left(\frac{P_{f,t}}{P_t}\right)^{-1} c_t && \text{(B.4)}\\
c_{h,t}^* &= \left(\frac{P_{h,t}}{P_t^*}\right)^{-1} \xi_t && \text{(B.5)}\\
y_{h,t} &= c_{h,t} + c_{h,t}^* + g_t && \text{(B.6)}\\
P_t c_t &= (1-\tau_t) w_t l_t + d_t && \text{(B.7)}\\
d_t &= P_{h,t} y_t - \left(1-\lambda+\frac{\lambda}{\tilde{q}_t}\right) w_t l_t && \text{(B.8)}\\
y_{h,t} &= z_t l_t^{\alpha} && \text{(B.9)}\\
P_{h,t}\alpha z_t (l_t^d)^{\alpha-1} &= \left(1-\lambda+\frac{\lambda}{\tilde{q}_t}\right) w_t && \text{(B.10)}\\
\tilde{q}_t &= \psi q_t + (1-\psi)\frac{1}{1+r} && \text{(B.11)}\\
(w_t - \gamma w_{t-1})(l_t^s - l_t^d) &= 0 && \text{(B.12)}\\
w_t &\geq \gamma w_{t-1} && \text{(B.13)}\\
P_t c_t + P_{h,t} g_t + b_t &= P_{h,t} f(z_t, l_t) - \frac{1-\tilde{q}_t}{\tilde{q}_t}\lambda(w_t l_t) + q_t b_{t+1} && \text{(B.14)}\\
P_{h,t} g_t &= \tau_t w_t l_t - b_T + q_t b_{t+1}. && \text{(B.15)}
\end{aligned}
$$

   This requieres using the estimate of the prie schedual $q(\boldsymbol{b}, b', \tau)$ computed in Step 3 above.

(b) Choose the government policy (τ, b') that maximizes the planers' problem to compute the value functions v^{rp} and v^d.

5. Check for convergence in the value functions using the norm of choice. If value functions have converged, then a solution has been achieved. If not, set $n = n + 1$ and repeat Steps from Step 2.

For convergence of the value functions and price schedule I consider the sup norm. Convergence of the value functions is achieved at a level of 10e-3. The pricing function converges at the 10e-2 level.

B.2 Simulation Algorithm and Impulse Response Functions

To simulate the model I consider the solution to the model given by $\{\gamma^{rp}$, γ^d, $\hat{q}\}$ as well as the policy functions $\{b'(\cdot), \tau^{rp}(\cdot), \tau^d(\cdot)\}$. The policy functions are defined over the state-space grid, and thus are a function of $\{b, z, \xi, w_-\}$. Before simulating the model I set the number of simulations N_{sim} as well as the length period of each simulation N_T. In what follows, I index the number of simulation with i, the time period with t, and the value of variable x in simulation i at time t as $x(t, i)$. To simulate the model, I then follow the following algorithm:

1. Initialize the state variables. That is, set a value for $\{b(1, i), z(0, i), \xi(0, i), w(0, i)\}$. Set $t = 1$.

2. Draw innovations for productivity, $\varepsilon_z(t, i)$, and the externaldemand, $\varepsilon_\xi(t, i)$, from standard normal distributions. Update z and ξ following their law of motions:

$$
\begin{aligned}
z(t, i) &= \rho_z z(t-1, i) + \sigma_z \varepsilon_z(t, i) \\
\xi(t, i) &= \rho_\xi \xi(t-1, i) + \sigma_\xi \varepsilon_\xi(t, i)
\end{aligned}
$$

3. Use $\{\gamma^{rp}$, $\gamma^d\}$ to compute the value function $\{v^{rp}(t, i)$, $v^d(t, i)\}$ at the state given by $\{b(t, i)$, $z(t, i)$, $\xi(t, i)$, $w(t-1, i)\}$.

4. Determine the default decision of the government.

   (a) If $v^d(t, i) > v^{rp}(t, i)$ then the government defaults. Set $\delta(t, i) = 1$ and move to step 9.

   (b) Otherwise, the government does not default and instead chooses to honor its outstanding liabilities. Set $\delta(t, i) = 0$ and move to the next step.

5. Using $\{b'_{rp}(\cdot), \tau^{rp}(\cdot)\}$ linearly interpolate the policy decisions of the government at the state given by $\{b(t,i)$, $z(t,i)$, $\xi(t,i)$, $w(t-1,i)\}$. Set $b(t+1,i)$ and $\tau(t,i)$ as the interpolated values.

6. Using $\{\hat{q}\}$ linearly interpolate the price of government debt at $\{b(t,i)$, $z(t,i)$, $\xi(t,i)$, $w(t-1,i)$, $b(t+1,i)$, $\tau(t,i)\}$ to compute $q(t,i)$. The last two arguments, $\{b(t+1,i), \tau(t,i)\}$ computed previously in Step 5.

7. Numerically compute the private sector equilibrium and government spending solving for equations (B.1)-(B.15) with a numerical solver.

8. If $t < N_T$, set $t = t+1$ and return to step 2. Otherwise finish the simulation procedure.

9. When the economy is in default I linearly interpolate the policy decision of the government using $\{\tau^d(\cdot)\}$ at the state $\{z(t,i), \xi(t,i), w(t-1,i)\}$.

10. Numerically compute the private sector equilibrium and government spending solving for equations (B.1)-(B.15) with a numerical solver. Noting that $\tilde{q} = {}^1\!/_{1+r}$ and both $b(t,i) = 0$ and $b(t+1,i) = 0$.

11. If $t < N_T$, set $t = t+1$ and return to step 2. Otherwise finish the simulation procedure.

In computing the moments from simulated data, I only consider periods when the government is not in default. Moreover, to avoid unintended effects coming from the state in which simulations are initialized, I drop the first 100 periods. In the paper, interest rate spreads are shown annualized. To compute spreads in the simulations I consider the following definition:

$$spread(t,i) = ({}^1\!/_{q(t,i)})^4 - (1+r)^4.$$

Impulse response functions. Models of sovereign default are known to exhibit nonlinearities. For this reason, I compute impulse response functions following Koop et al. (1996). Rather than initializing impulse response functions at the mean of the ergodic distribution, I sample with replacement from the ergodic distribution to initialize all simulations used to compute the response. The impulse response function is then computed as the average difference between the simulation with and without the shock.

C Estimating the Fiscal Multiplier in the Model

In this paper, I define the fiscal multiplier as the answer to the following question: what would the impact on GDP be if the government were to issue additional debt to finance an increase in government spending? That is, I look into the on-impact effect that a debt financed increase in spending would have on output. I take a quantitative approach and use the calibrated model to answer the question numerically.

Consider an economy in a state $\boldsymbol{s} = \{b, z, \xi, w_{-}\}$. At this state, the optimal policy of a government that chooses to repay its debt rather than to default is given by its issuance of debt and its tax rate policy, $\{b'(\boldsymbol{s}), \tau(\boldsymbol{s})\}$. These choices characterize the equilibrium price of government debt that is given by $q(\boldsymbol{s}, b'(\boldsymbol{s}), \tau(\boldsymbol{s}))$. The fiscal constraint, together with the competitive private sector equilibrium determines the level of government spending, $g(\boldsymbol{s})$, as well as output, consumption, labor, and prices for the economy. From these I compute GDP$(\boldsymbol{s})$.

I then consider the effect that changing the amount of debt that the government issues have on equilibrium outcomes. In particular, I consider a new debt level $\hat{b}' = b'\boldsymbol{s} + \varepsilon$.[18] This leads to a new equilibrium price of debt of $q(\boldsymbol{s}, \hat{b}'(\boldsymbol{s}), \tau(\boldsymbol{s}))$. Once again, the fiscal constraint, together with the competitive private sector equilibrium determines the new level of government spending, $\hat{g}(\boldsymbol{s})$, output, consumption, labor, and prices for the economy. From these I compute the new value for $\hat{\text{GDP}}(\boldsymbol{s})$.

Finally, I compute the fiscal multiplier as the ratio of the change in GDP relative to the change in government spending, and scale it by the original ratio of government spending to GDP. That is,

$$M(\boldsymbol{s}) = \frac{\Delta \text{GDP}}{\Delta g} \frac{g(\boldsymbol{s})}{GDP(\boldsymbol{s})},$$

where $M(\boldsymbol{s})$ is the fiscal multiplier at state $\boldsymbol{s}$, $\Delta g = g(\boldsymbol{s}) - \hat{g}(\boldsymbol{s})$, and $\Delta\text{GDP} = \text{GDP}(\boldsymbol{s}) - \hat{\text{GDP}}(\boldsymbol{s})$.

[18]For the numerical results in this paper I choose a value of $\varepsilon = -0.10$.