Fiscal Policy, Sovereign Risk, and Unemployment *

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Abstract

How should fiscal policy be conducted in the presence of default risk? We address this question using a sovereign default model with downward wage rigidity. An increase in government spending during a recession stimulates economic activity and reduces unemployment. Because the government lacks commitment to future debt repayments, expansionary fiscal policy increases sovereign spreads making the fiscal stimulus less desirable. We analyze the optimal fiscal policy and study quantitatively whether austerity or stimulus is optimal during an economic slump.

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JEL Codes: E62, F34, F41, F44, H50.

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1 Introduction

Much of the policy debates on fiscal policy during the Great Recession and the Eurozone crisis have been centered on whether fiscal stimulus is desirable when there are concerns about public debt sustainability. There is one view that argues that high unemployment calls for expansionary government spending (e.g. Krugman, 2015). On the other hand, the austerity view argues that, with high levels of debt, expansionary government spending can increase further borrowing costs and the probability of a sovereign default crisis (e.g. Barro, 2012).

Motivated by this austerity-versus-stimulus debate, we present a model in which debt-financed government spending can mitigate an economic slump, but the resulting surge in borrowing increases the vulnerability to a sovereign debt crisis. We study the optimal fiscal policy and show how the government trades off the stimulus benefits of expanding government spending with the costs from higher sovereign spreads.

We study optimal fiscal policy in a sovereign default model (Eaton and Gersovitz, 1981; Aguiar and Gopinath, 2006; Arellano, 2008) extended with downward wage rigidity, as in Schmitt-Grohé and Uribe (2016). We consider a small open economy with a tradable and a nontradable sector and a fixed exchange rate regime, or equivalently an economy member of a currency union. Lacking the ability to depreciate the exchange rate, the economy faces the possibility of involuntary unemployment. When the economy faces adverse shocks to tradable income, this depresses aggregate demand and puts downward pressure on the price on nontradables. Because the wage is sticky, this reduces labor demand and generates unemployment.

An increase in government spending in nontradables goods raises the relative price of nontradables and stimulates labor demand, thereby reducing unemployment. Because taxes are distortional, the government finances the expansion in spending partly by raising taxes and partly by increasing debt. Confronted with a larger sovereign debt, investors demand higher spreads on the government bonds to compensate for the risk of default. Is it then optimal for the government to raise spending, given the increased burden of sovereign debt and rising borrowing costs? This the key question we address in our analysis.

Conducting a quantitative study calibrated to the recent Euro Area debt crisis, we study both the positive and normative implications of fiscal policy. On the positive side, we show that the fiscal multipliers are highly non-linear in the severity of the recession.

On the normative side, we show that the optimal size of government purchases depends critically on the sovereign debt level. When the stock of debt is relatively low, government spending displays a strongly countercyclical role. As debt increases, and the government becomes more exposed to a sovereign default, the optimal response becomes more austere.

Related Literature. Our paper bridges two strands of the literature. First, our paper builds on the sovereign debt literature (Eaton and Gersovitz, 1981; Aguiar and Gopinath, 2006; Arellano, 2008). Cuadra, Sanchez, and Sapriza (2010) show that fiscal policy is optimally procyclical in a canonical sovereign debt model. Because spreads are higher in recessions, the government finds it optimal to contract spending and reduce tax rates, and do the opposite during expansions. In Arellano and Bai (2016), the government faces rigidities of fiscal revenues, which can either trigger the need for fiscal austerity programs, or lead to government default. Balke and Ravn (2016) study optimal time consistent policy in a model featuring unemployment due to search and matching frictions. However, because these papers do not consider nominal rigidities, they do not incorporate the stabilization benefits behind fiscal stimulus, and hence do not feature the trade-off we analyze in this paper.[1] Na, Schmitt-Grohé, Uribe, and Yue (2014) introduce downward wage rigidity in a canonical sovereign debt model. Differently from us, they focus on rationalizing why depreciations of the exchange rate and defaults tend to occur together in the data, and do not consider fiscal policy. Our paper is the first, to our knowledge, to study optimal fiscal policy in an environment featuring Keynesian features and sovereign default risk, and to articulate the trade-off between austerity and stabilization policy.

Second, our paper also relates to a large literature that studies the role of government spending as a macroeconomic stabilization tool. When there are constraints on monetary policy, either because of a zero lower bound or a fixed exchange rate regime, countercyclical fiscal policy becomes desirable. Examples in this literature include Eggertsson (2011), Christiano, Eichenbaum, and Rebelo (2011), Werning (2011), Gali and Monacelli (2008), and Farhi and Werning (2017). Our central contribution to this literature is to introduce the possibility of sovereign default, and study the implications for optimal fiscal policy.

Our paper is also related to the empirical literature on fiscal multipliers (for a recent survey see Ramey (2011)). This literature estimates a wide set of fiscal multipliers. Fiscal multipliers in our model can be closer to zero or bigger than one, depending on the initial

[1] Recently, Anzoategui (2017) has estimated fiscal rules for the Eurozone and evaluated counterfactuals using a similar environment to our paper.

states and whether they are financed with debt or taxes.

The paper is organized as follows. Section 2 presents the model and defines the competitive equilibrium. Section 3 presents the quantitative analysis of the model calibrated to the Spanish economy. It also evaluates the welfare implications under the different policy schemes. In section 5 we extend the framework incorporation credit frictions and study the implications for optimal fiscal policy. Section 6 concludes.

2 Model

This section describes the model economy in which fiscal policy will be studied. We consider a two-sector small open economy within a currency union populated by a representative risk-averse household, a representative firm, and a government. The economy receives a stochastic endowment of tradable goods and has access to decreasing-returns-to-scale technology operated by the firm to produce nontradable goods using labor. The household is hand-to-mouth, consumes tradable and nontradable goods, and inelastically supplies labor in competitive markets. The labor market is characterized by a downward nominal wage rigidity, which can give rise to involuntary unemployment as in Schmitt-Grohé and Uribe (2016), and Na, Schmitt-Grohé, Uribe, and Yue (2014).

The government is benevolent, and decides external borrowing, taxes, and public spending on nontradable goods. The government cannot choose monetary policy, assumed to be determined by a fixed exchange-rate regime. Public spending provides utility to the household. Due to the presence of nominal wage rigidity and the fixed exchange rate, public spending can help reduce unemployment in the labor markets by affecting relative prices. The government, however, has only imperfect instruments to finance surges in public spending. First, taxes are assumed to be distortionary. Second, external borrowing consists of one-period bonds, traded with risk-neutral competitive foreign lenders, whose promised payoff is non-state-contingent. The government does not have commitment to repay and can default on these bonds, generating a utility cost to the households and temporary exclusion from international credit markets.

2.1 Households

Households' preferences over private and public consumption are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[u(c_t) + v(g_t^N) \right], \tag{1}$$

where c_t denotes private consumption in period t, g_t^N denotes public spending in nontradable goods, $\beta \in (0,1)$ is the subjective discount factor, and $\mathbb{E}_t$ denotes expectation operator conditional on the information set available at time t.

The consumption good is assumed to be a composite of tradable (c^T) and nontradable goods (c^N), with a constant elasticity of substitution (CES) aggregation technology:

$$c = C(c^T, c^N) = [\omega(c^T)^{-\mu} + (1-\omega)(c^N)^{-\mu}]^{-1/\mu},$$

where $\omega \in (0,1)$ and $\mu > -1$. The elasticity of substitution between tradable and nontradable consumption is therefore $1/(1+\mu)$.

Each period households receive tradable endowment y_t^T, and profits from the ownership of firms producing nontradable goods ϕ_t^N. We assume that y_t^T is stochastic and follows a stationary first-order Markov process. Households inelastically supply $\overline{h}$ hours of work to the labor markets. Due to the presence of the wage rigidity (discussed in detail in the next subsections), households will only be able to sell $h_t \leq \overline{h}$ hours in the labor markets. The actual hours worked h_t is determined by firms' labor demand and taken as given by the households. As usual in the sovereign debt literature (see, for example, Aguiar and Gopinath, 2006 and Arellano, 2008), we assume that households are hand-to-mouth and that the government can distribute proceedings from external borrowing to the households using lump-sum taxes or transfers τ_t, expressed in tradable units. Households' sequential budget constraint, expressed in terms of tradables, is therefore given by

$$c_t^T + p_t^N c_t^N = y_t^T + \phi_t^N + w_t h_t - \tau_t, \tag{2}$$

where p_t^N denotes the relative price of nontradables in terms of tradables, w_t denotes the wage rate in terms of tradable goods.

The households' problem consists of choosing c_t^T and c_t^N to maximize (1) given the sequence of prices $\{p_t^N, w_t\}$, endowments $\{y_t^T\}$, profits $\{\phi_t^N\}$, and taxes $\{\tau_t\}$. The optimality condition of this problem yields the equilibrium price of nontradable goods as a function of the ratio between tradable and nontradable consumption:

$$p_t^N = \frac{1-\omega}{\omega}\left(\frac{c_t^T}{c_t^N}\right)^{\mu+1}. \quad (3)$$

That is, the relative price of nontradables is equal to the marginal rate of substitution between tradables and nontradables.

2.2 Firms

Firms are competitive and have access to a decreasing-returns-to-scale technology to produce nontradable goods with labor:[2]

$$y_t^N = F\left(h_t\right), \quad (4)$$

where y_t^N denotes output of nontradable goods in period t, $F(.)$ is a continuous, differentiable, increasing and concave function. Firms' profits each period are then given by

$$\phi_t^N = p_t^N y_t^N - w_t h_t. \quad (5)$$

The optimal choice of labor h_t equates the value of the marginal product of labor and the wage rate, all expressed in tradable units,

$$p_t^N F'\left(h_t\right) \;=\; w_t. \quad (6)$$

[2]From 1996 to 2016, 71% of the registered unemployed in Spain–the country we calibrate our model to— proceeded from the construction and service sectors, according to unemployment data collected from the National Employment Institute Survey (INEM). Only 17% were coming from industry and agriculture sectors. Also, regarding the relative variability of the flow of unemployed in tradable and nontradable sectors, we find that

$$\frac{\text{std. dev. (\# registered unemployed in construction \& service)}}{\text{std. dev. (\# total registered unemployed)}} = 0.85$$

$$\frac{\text{std. dev. (\# registered unemployed in industry and agriculture)}}{\text{std. dev. (\# total registered unemployed)}} = 0.13.$$

2.3 Government

The government determines public spending, taxes, borrowing, and repayment decisions to maximize households' lifetime utility. The government lacks commitment to all future policies.

We consider long-term debt, as in Arellano and Ramanarayanan (2012), Hatchondo and Martinez (2009), and Chatterjee and Eyigungor (2012). A bond issued in period t promises an infinite stream of coupons that decreases at an exogenous constant rate δ. In particular, a bond issued in period t promises to pay $\delta(1-\delta)^{j-1}$ units of the tradable good in period $t+j$, for all $j \geq 1$. Hence, debt dynamics can be represented by the following law of motion:

$$b_{t+1} = (1-\delta)b_t + i_t, \tag{7}$$

where b_t is the stock of bonds due at the beginning of period t, and i_t is the stock of new bonds issued in period t. The government can trade this long-term bond with atomistic international lenders not only to smooth consumption and allocate it optimally over time, but to boost employment through the keynesian channel as well. Debt contracts cannot be enforced and the government may decide to default at any point of time.

The government's sequential budget constraint each period in which it has access to debt markets is given by

$$p_t^N g_t^N - \delta b_t = \tau_t - q_t i_t, \tag{8}$$

where q_t is the equilibrium price of the bond. The budget constraint indicates that tax revenues and new debt issuance have to finance public spending and the repayment of outstanding debt obligations.

Default costs and taxation costs. Government's default entails two punishments. First, the government switches to financial autarky and cannot borrow for a stochastic number of periods. While excluded from credit markets, the government runs a balanced budget, i.e. $p_t^N g_t^N = \tau_t$. Second, there is a utility loss $\psi_{\chi,t}$, which we assume to be increasing in tradable income. We think of this utility loss as capturing various default costs related to reputation, sanctions, or misallocation of resources. It can also be thought of representing the adverse political or institutional repercussions of defaulting in a currency union, which might be particularly relevant for our countries of interest, the peripheral

EU members. [3]

To capture the presence of distortional taxes, we model a simple convex cost from taxation in the utility function, which we denote by $-\Omega(\tau_t)$, and is assumed to enter separably from the utility over consumption and the default costs.

Timing and Notation. Let χ_t be the default decision, which takes value 1 if the government decides to default at time t, and 0 otherwise. Also, ζ_t is a variable that takes value 1 if the government cannot issue bonds in period t, and zero otherwise. Throughout the paper, we will say that the economy is under repayment if $\zeta_t = 0$, and in autarky if $\zeta_t = 1$.

At the beginning of each period with access to financial markets, and after the shock to the tradable endowment is realized, the government has the option to default on the outstanding debt carried from last period. If the government honors its debt contracts, it can issue new bonds and remains with access to financial market next period. If instead the government defaults, it switches to financial autarky and cannot borrow that period. While in autarky, in each period with probability θ, the government regains access to financial markets, in which case it starts over with zero outstanding debt. Let ξ_t be a random variable that captures the fact that the government exits financial autarky, taking a value of 1 in that event, and zero otherwise.

The law of motion for ζ_t is then as follows:

$$\zeta_t = (1 - \xi_t)\zeta_{t-1} + \chi_t(1 - \zeta_{t-1}) \tag{9}$$

If at time $t-1$, the government could issue bonds ($\zeta_{t-1} = 0$), then $\zeta_t = \chi_t$. If instead it was in financial autarky ($\zeta_{t-1} = 1$), then $\zeta_t = (1 - \xi_t)$, reflecting the fact that the government would only be able to borrow at time t if it recovers access to financial markets.

2.4 Foreign Lenders

Sovereign bonds are traded with atomistic, risk-neutral foreign lenders. In addition to investing through the defaultable bonds, lenders have access to a one-period risk-less security paying a net interest rate r. By a no-arbitrage condition, equilibrium bond

[3] Our choice of a utility loss both from taxes and default, rather than an output cost, is also motivated by the fact that with the former the marginal rate of transformation between tradable and nontradable goods is not altered when the economy defaults and switches to autarky.

prices are then given by

$$q_t = \frac{1}{1+r}\mathbb{E}_t[(1-\chi_{t+1})(\delta + (1-\delta)q_{t+1})]. \tag{10}$$

Equation (17) indicates that in equilibrium an investor has to be indifferent between selling a government bond in period t at price q_t and keeping the bond until next period bearing the risk of default. In case of repayment next period, the payoff is given by the coupon δ plus the market value q_{t+1} of the non-maturing fraction of the bonds. In case of default, the price q_{t+1} is equal to zero since we assume no recovery of defaulted bonds.

Equation (17) will play a critical role when we turn to the optimal fiscal policy. If lenders anticipate a fiscal policy in the future that will make default more likely, they will demand lower bond prices, or equivalently higher bond returns, to compensate for a higher default risk. Similarly, if the government wants to run a debt-financed stimulus, this will be increasing future default probability and reducing the bond price today.

2.5 Equilibrium

In equilibrium the market for nontradable goods clears:

$$c_t^N + g_t^N = F(h_t). \tag{11}$$

For the labor markets, it is assumed that nominal wages have a lower bound $\bar{w}$, by which $W_t \geq \bar{w}$ for all t, following Schmitt-Grohé and Uribe (2016).[4] Given that the economy is under a currency peg and assuming that the law of one price holds for tradable goods and that the price of foreign tradable goods is constant and normalized to one, the wage rigidity can be expressed as

$$w_t \geq \bar{w}, \tag{12}$$

where w_t is the real wage and $\bar{w}$ is the wage lower bound, both in terms of the tradable good.

Actual hours worked cannot exceed the inelastically supplied level of hours:

$$h_t \leq \bar{h}. \tag{13}$$

[4]In Schmitt-Grohé and Uribe (2016), $\bar{w}$ depends on the previous period wage. For numerical tractability, we take $\bar{w}$ as an exogenous (constant) value.

Labor market equilibrium implies that the following slackness condition must hold for all dates and states:

$$(w_t - \bar{w})\left(\overline{h} - h_t\right) = 0. \tag{14}$$

This condition implies that when the nominal wage rigidity binds, the labor market can exhibit involuntary unemployment, given by $\overline{h} - h_t$. Similarly, when the nominal wage rigidity is not binding, the labor market must exhibit full employment.

Combining the equilibrium price equation (3) with resource constraint (11), the relative price p_t^N can be expressed as

$$p_t^N = \mathcal{P}^N(c_t^T, h_t, g_t^N) = \frac{1-\omega}{\omega}\left(\frac{c_t^T}{F(h_t) - g_t^N}\right)^{\mu+1} \tag{15}$$

Using the households' budget constraint (2) and the definition of the firms' profits and market clearing condition (11), the resource constraint of the economy can be rewritten as

$$c_t^T = y_t^T + (1-\zeta_t)[\delta b_t - q_t i_t] \tag{16}$$

A competitive equilibrium given government policies in our economy is then defined as follows:

Definition 1 (Competitive Equilibrium)**.** *Given initial debt b_0 and ζ_0, an exogenous process $\{y_t^T, \xi_t\}_{t=0}^{\infty}$, government policies $\{g_t^N, \tau_t, b_{t+1}, \chi_t\}_{t=0}^{\infty}$, a competitive equilibrium is a sequence of allocations $\{c_t^T, c_t^N, h_t\}_{t=0}^{\infty}$ and prices $\{p_t^N, w_t, q_t\}_{t=0}^{\infty}$ such that:*

1. *Allocations solve household's and firms' problems at given prices.*
2. *Government policies satisfy the government budget constraint (8), and the law of motion for ζ satisfies equation (9).*
3. *Bond pricing equation (17) holds.*
4. *The market for nontradable goods clears.*
5. *The labor market satisfies conditions (12)-(14).*

2.6 Optimal Government Policy

We consider the optimal policy of a benevolent government with no commitment, that chooses public spending, external borrowing, and taxes to maximize households welfare, subject to the implementability conditions. We focus on the Markov recursive equilibrium in which all agents choose sequentially.

Every period the government enters with access to financial markets, it evaluates the lifetime utility of households if debt contracts are honored against the lifetime utility of households if they are repudiated. Given current (y^T, b), the government problem with access to financial markets can be formulated in recursive form as follows:

$$V(y^T, b) = \max_{\chi \in \{0,1\}} \{(1-\chi)V^r(y^T, b) + \chi V^d(y^T)\}, \qquad (P)$$

where $V^r(y^T, b)$ and $V^d(y^T)$ denote, respectively, the value of repayment, given by the Bellman equation

$$V^r(y^T, b) = \max_{g^N, \tau, b', h} \{u\left(C\left(c^T, F(h) - g^N\right)\right) + v(g^N) - \Omega(\tau) + \beta \mathbb{E}\left\{V(y^{T'}, b')\}|y^T\right\} \quad (P^r)$$

subject to

$$\begin{aligned} c^T + q(y^T, b')i &= y^T + \delta b \\ \tau &= \mathcal{P}^N(c^T, h, g^N)g^N + \delta b - q(y^T, b')i, \\ \mathcal{P}^N(c^T, h, g^N)F'(h) &\geq \bar{w}, \\ (\mathcal{P}^N(c^T, h, g^N)F'(h) - \bar{w})(h - \overline{h}) &= 0, \end{aligned}$$

and the value of default, given by:

$$\begin{aligned} V^d(y^T) = \max_{g^N, \tau, h} \{u\left(C\left(y^T, F(h) - g^N\right)\right) + v(g^N) - \Omega(\tau) - \psi_\chi(y^T) \\ + \beta \mathbb{E}\left\{(1-\theta)V^d(y^{T'}) + \theta V(y^{T'}, 0)|y^T\right\}\} \quad (P^d) \end{aligned}$$

subject to

$$\begin{aligned} \tau &= \mathcal{P}^N(y^T, h, g^N)g_t^N, \\ \mathcal{P}^N(y^T, h, g^N)F'(h) &\geq \bar{w}, \\ (\mathcal{P}^N(y^T, h, g^N)F'(h) - \bar{w})(h - \overline{h}) &= 0. \end{aligned}$$

where $q(y^T, b')$ denotes the bond price schedule, taken as given by the government.[5]

Let $s = (y^T, \zeta)$ and let $\{\chi(b,s), \hat{c}^T(b,s), \hat{g}^N(b,s), \tau(b,s), \hat{b}(b,s), \hat{h}(b,s)\}$ be the optimal policy rules associated with the government problem. A Markov perfect equilibrium is then defined as follows.

Definition 2 (Markov perfect equilibrium). *A Markov perfect equilibrium is defined by value functions* $\{V(y^T, b), V^r(y^T, b), V^d(y^T)\}$*, policy functions* $\{\chi(b,s), \hat{c}^T(b,s), \hat{g}^N(b,s), \tau(b,s), \hat{b}(b,s), \hat{h}(b,s)\}$*, and a bond price schedule* $q(y^T, b)$ *such that*

1. *Given the bond price schedule, policy functions solve problems* (P)*,* (P^r)*, and* (P^d)*,*

2. *The bond price schedule satisfies the bond pricing equation,*

$$q(y^T, b') = \frac{1}{1+r}\mathbb{E}[(1-\chi')(\delta + (1-\delta)q(y^{T\prime}, b''))|y^T]. \tag{17}$$

where

$$\begin{aligned} b'' &= \hat{b}(b', s') \\ \chi' &= \chi(b', s') \end{aligned}$$

with $s' = (y^{T\prime}, 0)$.

2.7 Fiscal Policy Trade-offs

The choice of government spending faces a trade-off between the benefits of reducing unemployment and the inefficiencies associated with its financing. This trade-off can be illustrated with the first-order conditions of the government problem. The optimality condition with respect to g^N yields

$$v'(g_t^N) = u_N(c_t^N)(1 - \underbrace{\frac{\partial \mathcal{Y}_t^N}{\partial g_t^N}}_{\text{Stimulus}}) + \underbrace{\Omega'(\tau_t)\left(p_t^N + \left(\frac{\partial \mathcal{P}_t^N}{\partial g_t^N} + \frac{\partial \mathcal{P}_t^N}{\partial h_t}\frac{\partial \mathcal{H}_t}{\partial g_t^N}\right)g_t^N\right)}_{\text{Distort. Tax}}$$

[5] The bond price q_t depends on the stock of bonds b_{t+1} carried into next period and the endowment y^T, since these two variables affect the government's incentives to default.

where $\frac{\partial \mathcal{Y}^{\mathcal{N}}}{\partial g}$ denotes the fiscal multiplier, to be analyzed below. At the optimum, the government has to be indifferent between spending one additional unit, which provides a direct marginal utility benefit of $v'(g_t^N)$, and the marginal costs. In a model without nominal rigidities or distortionary taxes, the marginal costs would be simply given by the resources given up for private consumption, $u_N(c_t^N)$, as indicated by the Samuelson rule. However, the presence of downward wage rigidity implies that higher spending will increase output when the economy has slack on the labor markets. The strength of this effect depends on the fiscal multiplier, which in turn can be decomposed in three terms:

$$\frac{\partial \mathcal{Y}^{\mathcal{N}}}{\partial g} = \frac{\partial \mathcal{P}^{\mathcal{N}}}{\partial g^N} \frac{\partial \mathcal{H}}{\partial p^N} F'(h)$$

The first term denotes how much the increase in spending raises the relative price of non-tradables. The second term denotes how much labor demand respond to the increase in relative prices. The last term denotes the marginal product of labor. In the presence of distortionary taxes, there is an additional term in the marginal costs. An increase in spending tightens the government budget constraint by a direct effect of larger spending and an indirect effect that arise from the general equilibrium effects on the initial level of spending. The marginal costs are represented by the Lagrange multiplier on the government budget constraint, that at the optimum is given by $\Omega'(\tau_t)$. Therefore, the government would want to smooth the excess burden of taxation by having relatively constant tax rates, following the standard principles of public finance. Keeping taxes relatively constant, however, implies that surges of government spending have to be financed with debt. In the presence of default risk, more borrowing is costly as it drives up bonds spreads and can put the government at the verge of default. The trade-offs involved from using debt rather than taxes to finance spending are represented by the Euler equation with respect to debt.

$$(\lambda_t + \Omega'(\tau_t)) \left(q_t - \frac{\partial q_t}{\partial b'} i_t \right) = \beta \mathbb{E}[(\lambda_{t+1} + \Omega'(\tau_{t+1}))(1 - \chi_{t+1})(\delta + q_{t+1}(1 - \delta))$$

where λ represents the Lagrange multiplier on the resource constraint.

To further illustrate this trade-off, Figures 1 and 2 show how the equilibrium allocations change with a one-period deviation in the level of government spending from its optimal level.[6] Figure 1 makes this exercise under the assumption that changes in government spending are financed with debt, Figure 2 under the assumption that it is financed with taxes. The tradable endowment is set to its unconditional mean and the current debt level is given by the mean of its asymptotic distribution in the calibrated model. In each panel, the red dot indicates the level of the variable of interest at the optimal level of government spending.

As Figure 1 shows, the relative price of nontradable goods is an increasing function of g^N (see the third panel of the first column). In turn, this translates into higher employment (see the first panel). As employment rises, so does the private nontradable consumption.[7] Since additional spending is only financed with debt, tradable consumption increases as well. As a result, the fiscal multiplier is larger than one. On the cost side, the last panel of Figure 1 shows that increasing government spending above the optimal level leads to a sharp decline in bond prices, reflecting the higher risk of future default associated with higher debt levels. In addition to the rising borrowing costs, a higher likelihood of defaulting also entails larger expected welfare losses associated to it. As it can be seen from the equilibrium allocations under optimal policy, such costs deter the government from providing sufficient stimulus to attain full employment.

Figure 2 shows similar patterns when the increase in spending is financed with taxes. An important difference, however, is that in this case the fiscal multiplier is lower than one since private nontradables consumption is crowded out by government spending and tradable consumption remains constant.

[6] To conduct this exercise we used the calibrated economy of Section 3.

[7] Eventually, as full employment is achieved, further increases of g^N start crowding out c^N.

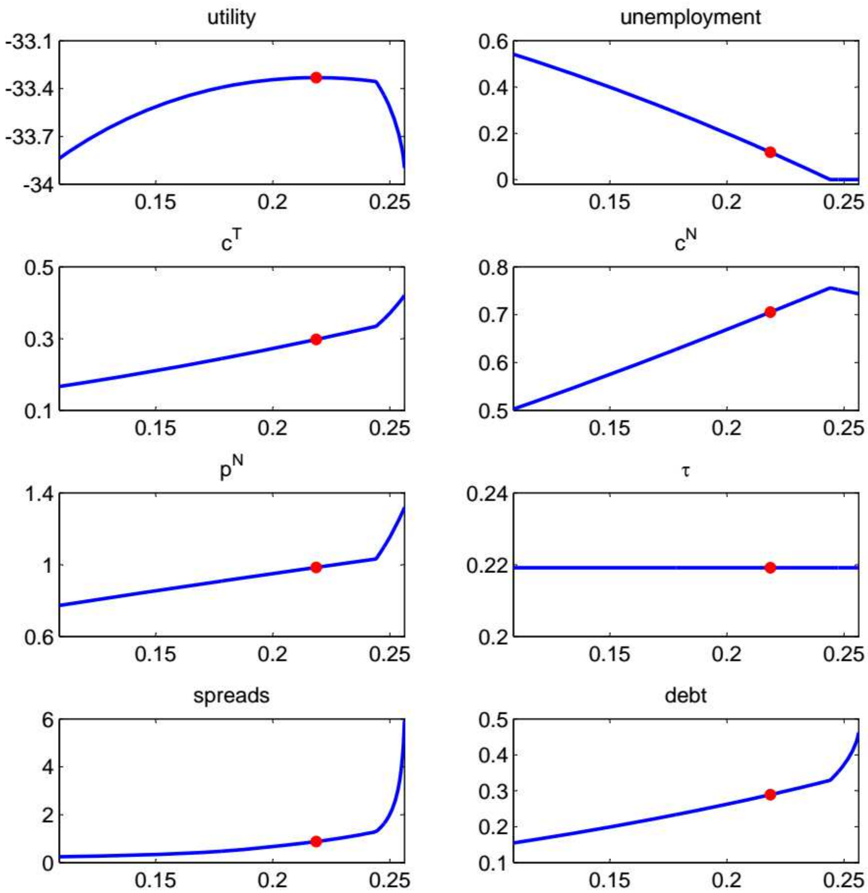

Figure 1: Utility, prices and allocations under repayment for alternative values of current g^N.

Note: Blue lines correspond to repayment levels of utility, unemployment, tradable consumption, nontradable consumption, relative price of nontradable goods, taxes, spreads, and borrowing, as function of current government spending, given current tradable endowment equal to its unconditional mean and average debt level. Red dots indicate equilibrium levels given optimal government spending.

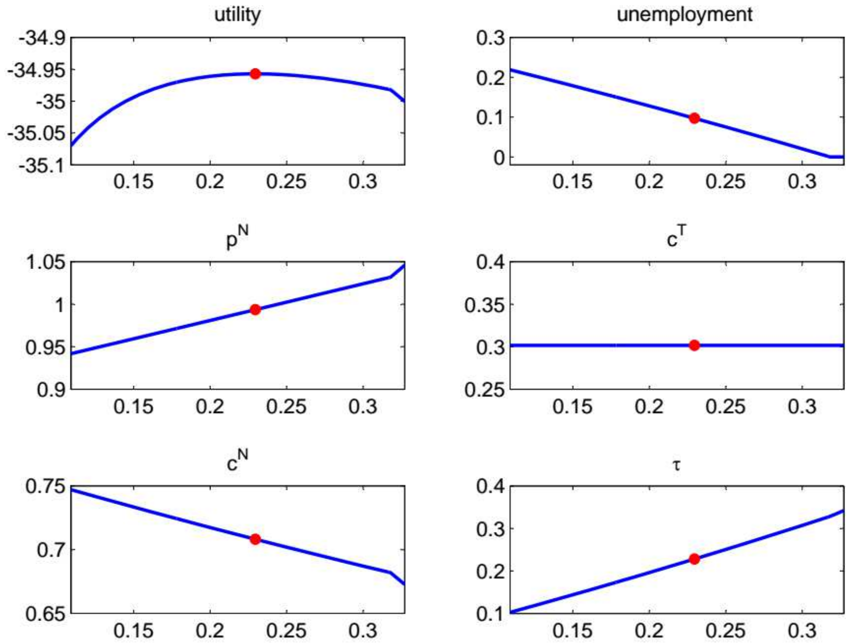

Figure 2: UTILITY, PRICES AND ALLOCATIONS IN AUTARKY FOR ALTERNATIVE VALUES OF CURRENT g^N.

Note: Blue lines correspond to autarkic levels of utility, unemployment, tradable consumption, non-tradable consumption, relative price of nontradable goods, and taxes as function of current government spending, given current tradable endowment equal to its unconditional mean and average debt level. Red dots indicate equilibrium levels given optimal government spending.

3 Quantitative Analysis

3.1 Calibration

The model is solved numerically using value function iteration with interpolation. More specifically, linear interpolation is used for the endowment and cubic spline interpolation for debt levels.[8]

To characterize the aggregate dynamics under the optimal fiscal policy we calibrate the model to match key moments in the data at an annual frequency for the Spanish economy over the period 1996-2015.

Functional Forms. We assume constant relative risk aversion (CRRA) utility functions for private and public consumption:

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma},$$
$$v(g) = \frac{g^{1-\sigma_g}}{1-\sigma_g},$$

scaled by the relative weights $(1-\psi_g)$ and ψ_g, respectively. Also, we consider an isoelastic form for the production functions in nontradable sector:

$$F(h) \quad = \quad h^{\alpha}, \qquad \alpha \in (0,1).$$

For the direct utility cost of default given by $\psi_\chi(y^T)$, we follow **?** and assume the following form:

$$\psi_\chi(y_t^T) = \max\{0, \psi_\chi^0 + \psi_\chi^y \log(y_t^T)\}, \tag{18}$$

with $\psi_\chi^y > 0$. A similar specification but for output costs has been shown by Chatterjee and Eyigungor (2012) to be crucial for matching bond spreads dynamics, in particular reproducing spreads volatility.

The specification of the iceberg cost is assumed to be quadratic and symmetric for taxes and subsidies,

$$\Omega(\tau) = \psi_\tau \tau^2, \tag{19}$$

[8] 71 gridpoints are used for endowment and debt in the solution algorithm. To compute expectations, 15 quadrature points are used for the endowment realizations.

where $\psi_\tau > 0$ is a parameter that controls for the curvature of function $\Omega(\cdot)$ and, hence, plays a key role in the desirability for tax smoothing in our economy. The more convex $\Omega(\cdot)$ is, the higher the potential benefits are from adopting a smooth path for government transfers. While the iceberg cost does not affect the implementability conditions in the government problem, it directly subtracts per-period utility from households.

We assume that the tradable endowment y_t^T follows a log-normal AR(1) process,

$$\log y_{t+1}^T = \rho \log y_t^T + \sigma_y \varepsilon_{t+1},$$

with $|\rho| < 1$, and where the shock $\varepsilon_{t+1}^y \sim i.i.d.\, \mathcal{N}(0,1)$.

Parameter Values. All selected parameter values used in the baseline calibration are shown in Table 1. The parameters ρ and σ_ϵ for the stochastic process of y_t^T are estimated using log-quadratically detrended data on the value-added in the agricultural and manufacturing sectors for Spain. Time series at an annual frequency for real output in these sectors (and overall economy), as well as for unemployment, are taken from the National Accounts in the National Statistics Office (INE) of Spain. The estimation yields $\rho = 0.777$ $\sigma_y = 0.029$.

The maturity parameter δ is set to generate an average bond duration of 5 years, in line with the data.[9] The debt level $\bar{b}_t$ in the model is computed as the present value of future payment obligations discounted at the risk-free rate r. Given our coupon structure, we thus have that $\bar{b}_t = \frac{\delta}{1-(1-\delta)/(1+r)} b_t$.

The coefficient of relative risk aversion of private consumption is set to 2, which is standard in the literature. Similarly, the coefficient of risk aversion of public consumption σ_g is also set to 2. The value of the parameter μ implies a Cobb-Douglas specification for the consumption aggregator and an elasticity of substitution between tradable and nontradable consumption of 1, only slightly above the range of values typically used in other studies. The share of tradables in the consumption composite implies a ratio of tradable output-to-total output of around 0.25, in line with the data.

[9]The Macaulay duration of a bond with price q and our coupon structure is given by

$$D = \sum_{t=1}^{\infty} t \frac{\delta}{q} \left(\frac{1-\delta}{1+i_b} \right)^t = \frac{1+i_b}{\delta + i_b},$$

where the constant per-period yield i_b is determined by $q = \sum_{t=1}^{\infty} \delta (\frac{1-\delta}{1+i_b})^t$.

Table 1: PARAMETERS SELECTED DIRECTLY

Parameter	Value	Description
σ	2	Coefficient of risk aversion, private consumption
σ_g	2	Coefficient of risk aversion, public consumption
$1+\mu$	1.0	Inverse of intratemporal elasticity of substitution
ω	0.3	Share of tradables
ψ_τ	0.5	Tax distortion parameter
α	0.63	Labor share in nontradable sector
r	0.02	Gross world risk-free rate
θ	0.2	Reentry probability
$\overline{h}$	1	Inelastic supply of hours worked
ρ	0.777	AR(1) coefficient of productivity y_t^T
σ_y	0.029	Standard deviation of ε_t
Parameters set by simulation		
β	0.94	Subjective discount factor
ψ_g	0.041	Weight of public consumption in utility function
ψ_χ^0	0.67	Utility loss from default (intercept)
ψ_χ^y	6.48	Utility loss from default (slope)
ψ_τ	0.50	Tax distortion function
$\bar{w}$	0.65	Lower bound on wages

The international risk-free rate r is equal to 2 percent, which is roughly the average annual gross yield on German 5-year government bonds over the period 2000-2015. Data on bond yields for Germany and Spain has been taken from Deutsche Bank and Banco de España, respectively. The reentry probability θ is set to generate an average autarky spell of 5 years, which is very close to the average 4.7 years until resumption of financial access reported by Gelos, Sahay and Sandleris (2011) over the period 1980-2000 for 150 developing countries.

The households' inelastic supply of hours to work is normalized to 1. The labor share in the production of nontradable goods is 0.63, which is the estimate found by Uribe (1997) for Argentina.

The six remaining parameters are calibrated to match six moments from the data: the time discount factor β, the scalar pre-multiplying the government spending term in the utility function ψ_g, the two parameters determining the utility loss of default, ψ_χ^0 and ψ_χ^y, the parameter from the tax distortion function ψ_τ, and lower bound on wages, $\overline{w}$.

The discount factor β is chosen to match the average external debt-GDP ratio.[10] This yields $\beta = 0.94$, which is within the range of values used in the sovereign default literature (see, for example, Aguiar and Gopinath, 2006 and Chatterjee and Eyigungor (2012)). The relative weight on the public consumption term in the utility function ψ_g is calibrated to replicate the average government spending observed in the data for Spain from 1996 to 2015, which amounts to 18.3 percent of total output. The lower bound on wages $\bar{w}$ is set to generate an unemployment rate of 10 percent on average in the simulations, which is lower than the 15 percent observed for Spain during the period in consideration.[11] The tax distortion parameter ψ_τ is calibrated to match relative volatility of tax revenues to government spending. Finally, the parameters ψ_χ^0 and ψ_χ^y are chosen to mimic the mean and volatility of spreads in the data. For the reasons described in Aguiar et. al (2016), the model falls short of replicating the volatility of spreads in the data, so we choose the value of ψ_χ^y that delivers the maximum volatility of spreads in our simulations.

3.2 Model Statistics

Table 2 reports the moments of our baseline model under optimal policy and full-employment policy. To compute the business cycle statistics, we run 100,000 Monte Carlo (MC) simulations of the model with 100,000 periods each, and construct 200 sub-samples of 32 periods of financial access.[12] In order to have a measure of total real output in our model, we compute $\hat{y}$ as the sum of tradable and nontradable output, where the latter is multiplied by the *average* relative price of nontradables in the simulations (in contrast, y is computed using the current p^N in each period).

As is standard in the literature (e.g. Aguiar and Gopinath, 2006; Arellano, 2008), the model can replicate several features regarding the reoccurrence of default events, the high variability of bond spreads and their comovement with economic activity and debt flows, and the volatility of consumption relative to output. We focus here on the predictions for optimal fiscal policy, which are the central aspects of our model. There

[10] For external debt, we use total gross debt of the general government held by external creditors, as a fraction of GDP, available at the OECD Government Statistics database.

[11] In our calibration, the economy spends roughly 6 percent of the time with full employment.

[12] To avoid dependence on initial conditions, we disregard the first 1,000 periods from each simulation. Also, while in our model the borrower regains access to credit with no liabilities after defaulting, in the data countries typically do so carrying a positive amount of debt settled at a restructuring stage. We therefore impose that our candidate subsamples cannot be preceded by reentry episodes for less than four years.

are two key predictions. First, the optimal fiscal policy is procyclical, with a correlation between government spending and output of 0.85 versus 0.46 in the data. This long-run positive correlation is in line with the results of Cuadra, Sanchez, and Sapriza (2010). In our calibration, with considerable unemployment and significant borrowing on average, austerity forces tend to dominate, giving rise to a strongly procyclical fiscal policy. While this is true in general over the simulations, it is the case that over some periods government spending and output negatively comove, as shown in the impulse responses in Section 3.4. In those periods, typically with high or full employment and low borrowing costs, it is optimal for the government to follow the keynesian prescription. As a matter of fact, there is a significant state dependency in the optimal response of government spending. In particular, we will show later that government spending is procyclical in regions of the state space with low debt levels.

Note that a negative comovement between government spending and output has also been observed in the data for Spain over the period 2007-2009 when sovereign debt and spreads were still low. In fact, even though real GDP contracted by roughly 4 percent in 2009, government spending remained on the rise increasing by almost 2 percent.

Second, our model generates a strong positive correlation between government spending and the real exchange rate. In line with the data, expansions of government spending usually come along with a real appreciation. Finally, our model fails to generate sufficient relative variability of government spending (and taxes). In the data government spending is twice as volatile as output while in the model it is 53 percent that of output.

To disentangle the mechanisms driving the optimal fiscal policy, Table 2 also reports the moments of an economy when the government has access to nondistortionary taxes. In this case, relative to our baseline model, optimal policy would be significantly less procyclical (0.45 correlation of government spending with output versus 0.8 in the baseline) because the government does not need to be so austere. As the welfare costs associated with the financing of government spending are lower, fiscal policy is more often used as an active stabilization tool allowing the government to sustain higher levels of employment on average. Government spending therefore becomes higher and more volatile.

Finally, we compare the business cycle statistics between our baseline model and two other benchmark environments. The first environment features flexible wages, i.e. $\bar{w} = 0$, and optimal policy. The second environment preserves the wage rigidity but under a different policy regime. In particular, we assume that the government sets public spending

Table 2: Business Cycle Statistics: Data and Model

Statistic	Data	Baseline Model	No Distortionary Taxes
mean(spreads) (%)	1.1	1.1	1.0
mean($\bar{b}/y$)	22.8	23.3	21.9
mean(y^T/y)	20.2	25.0	24.0
mean($p^N g^N/y$)	18.1	18.3	21.3
mean(T/y)	14.6	18.9	21.9
mean(h)	0.83	0.89	0.94
freq(default) (%)	NA	1.2	1.2
cor(g^N, y)	0.46	0.85	0.50
cor(g^N, RER)	0.77	0.89	0.59
cor(y, RER)	0.31	0.99	0.97
cor(y, c)	0.98	1.00	0.98
cor(y,spreads)	−0.38	−0.91	−0.92
$\sigma(p^N g^N)/\sigma(\hat{y})$	2.0	0.5	1.1
$\sigma(c)/\sigma(\hat{y})$	1.1	1.1	1.1
$\sigma(T)/\sigma(\hat{y})$	1.8	0.2	0.4
σ(spreads) (%)	1.4	0.9	0.9

to guarantee full employment in all periods and states. Table 3 reports the moments for the three environments.

If wages are flexible, they fully adjust to clear the labor markets. As a result, we observe full employment in that environment. As in Cuadra, Sanchez, and Sapriza (2010), absent the keynesian benefits for fiscal policy, government spending becomes more volatile and even more strongly procyclical than in the baseline model. At the same time, spending decreases on average while borrowing rises. In contrast, when the government conducts a full-employment policy in the presence of the wage rigidity, government spending and output display a strong negative comovement, as the keynesian mechanism kicks in. More (and more variable) government spending is required to prevent deflationary pressures on the real exchange rate that can give rise to unemployment. Tax revenues therefore have to be higher on average.

Table 3: Business Cycle Statistics under Alternative Model Assumptions

Statistic	Baseline Model	Flexible Wages	Full-Employment Policy
mean(spreads) (%)	1.1	0.6	1.1
mean($\bar{b}/y$)	23.3	76.5	14.0
mean(y^T/y)	25.0	27.5	22.8
mean($p^N g^N/y$)	18.3	12.6	25.0
mean(T/y)	18.9	14.5	25.4
mean(h)	0.90	1.0	1.0
freq(default) (%)	1.2	0.7	1.2
cor(g^N, y)	0.84	0.99	-0.95
cor(g^N, RER)	0.89	1.0	0.00
cor(y, RER)	0.99	0.99	0.01
cor(y, c)	0.99	0.99	0.93
cor(y,spreads)	-0.91	-0.92	-0.78
$\sigma(p^N g^N)/\sigma(\hat{y})$	0.5	0.7	8.1
$\sigma(c)/\sigma(\hat{y})$	1.1	1.2	2.7
$\sigma(T)/\sigma(\hat{y})$	0.2	0.6	2.7
σ(spreads) (%)	0.9	0.6	1.0

3.3 Policy Functions

This section analyzes the policy functions of the calibrated economy under the optimal fiscal policy. Figure 3 shows the decision rules for government spending, taxes, external debt, labor, wages, tradable and nontradable consumption and relative prices as a function of the current debt level. The dashed red and and solid blue lines in each panel correspond to a low and a high realization of the tradable endowment y^T, respectively.[13] The discontinuity point is to the default threshold: allocations and prices to the left of it (lower debt) are plotted for repayment; to the right of it (higher debt) they are plotted for autarky.

Figure 3 shows an interesting pattern for optimal government spending, which is highly dependent on the current debt position. Let us focus on the blue lines, which correspond to the high income realization. There are three different regions in this Figure. The first region to the right is the default region. Here, high levels of debt imply that the

[13] More specifically, the low (high) realization corresponds to the one unconditional standard deviation below (above) the unconditional mean of y^T.

government finds it optimal to default, and has more resources available to spend in public goods. For levels of debt below, the government enters the repayment region and spending is reduced discretely relative to the autarkic level. This occurs because the government uses some of its available resources to make the coupon payments. (While the government is able to borrow, it reduces overall its debt issuance, given the steep spread schedule.) In this second region, government spending is *decreasing* in the current level of debt. This decrease in spending for higher levels of debt is the outcome of opposing keynesian and austerity forces. On one hand, as current debt is increased, there is more need for active stabilization by the government. Higher levels of debt are associated with lower levels of aggregate demand, which in turn lead to a more depreciated real exchange rate and higher unemployment. That is, the keynesian channel is stronger as current debt is increased. On the other hand, higher current levels of debt are associated with higher new debt levels, and hence higher spreads. Since bond proceedings fall (depressed bond prices, higher coupon repayments and lower debt issuance), more taxes are required. As a result, we observe a growing need for austerity as it becomes more costly to do expansionary fiscal policy. Overall, we find that the second effect dominates, and the government spends *less* when debt increases. Put it differently, the higher is the debt, the stronger is the austerity channel relative to the keynesian channel. For low levels of debt, the economy enters a third region, characterized by full employment. At this current debt level, government spending is sufficiently large that brings the economy to full employment. In this region, the wage rigidity constraint is still binding, though. Consequently, given full employment, the real exchange rate is held constant over this interval. It is the active stabilization policy that keeps the economy at full employment. The optimal size of government spending becomes increasing in the level of debt. As debt is reduced, less stimulus is needed to keep the economy at full employment. Hence, in order to avoid crowding out of private consumption, government spending is optimally cut. It is worth pointing out that for savings levels (not shown in the figure), the market wage would increase above the sticky wage. Also, in that case p^N would jump and government spending would become even more increasing in debt given the absence of keynesian benefits.

Figure 3 also shows the impact of tradable endowment on the level of government spending and the overall economy. The role of the tradable endowment is twofold. First, as emphasized in standard models of default, a low income shock leads to higher incentives to default in the future and a deterioration of borrowing opportunities. Facing adverse income shocks, the government raises taxes and cuts spending (see Cuadra, Sanchez, and Sapriza, 2010). Second, as tradable income falls, this leads to a decline in aggregate demand setting in motion a recession in the nontradable sector. Since preferences are homothetic and there is an infinitely elastic demand for tradables, the price of nontradable goods needs to fall to clear the excess supply of nontradable goods that results from the decline in income. Due to the downward wage rigidity, the decline in the price of nontradables leads to increases in the real wage measured in units of nontradables, and firms contract labor demand.

An increase in government spending in nontradable goods contributes to offset the reduction in private demand, thereby mitigating the deflationary spiral and the increase in unemployment. Does government spending increase or decrease when the tradable endowment falls? The answer to this question depends on which of the three regions the economy is in. If the economy is in default for both levels of endowment realizations, government spending is higher for the high income shock. At low levels of income, the government needs to collect more distortionary tax revenue for the same level of spending, which is costly. As debt level falls below 0.7, the economy repays for the positive shock, and remains in default for the adverse income shock. Here, the government spends more in case of a negative income shock. For the reasons described above, as the government stops repaying debt, there are more resources devoted for spending. As debt is reduced further, to the point that repayment is optimal for the adverse shock as well, and as long as unemployment prevails for both income realizations, the government spends more with higher income, in line with the austerity prescription. Interestingly, the difference between the two levels of spending for the two different shock shrinks as debt is reduced. Eventually, the keynesian channel dominates and spending is larger for lower levels of income. To shed further light on this, we will be conducting impulse responses to endowment shocks in Section 3.4.

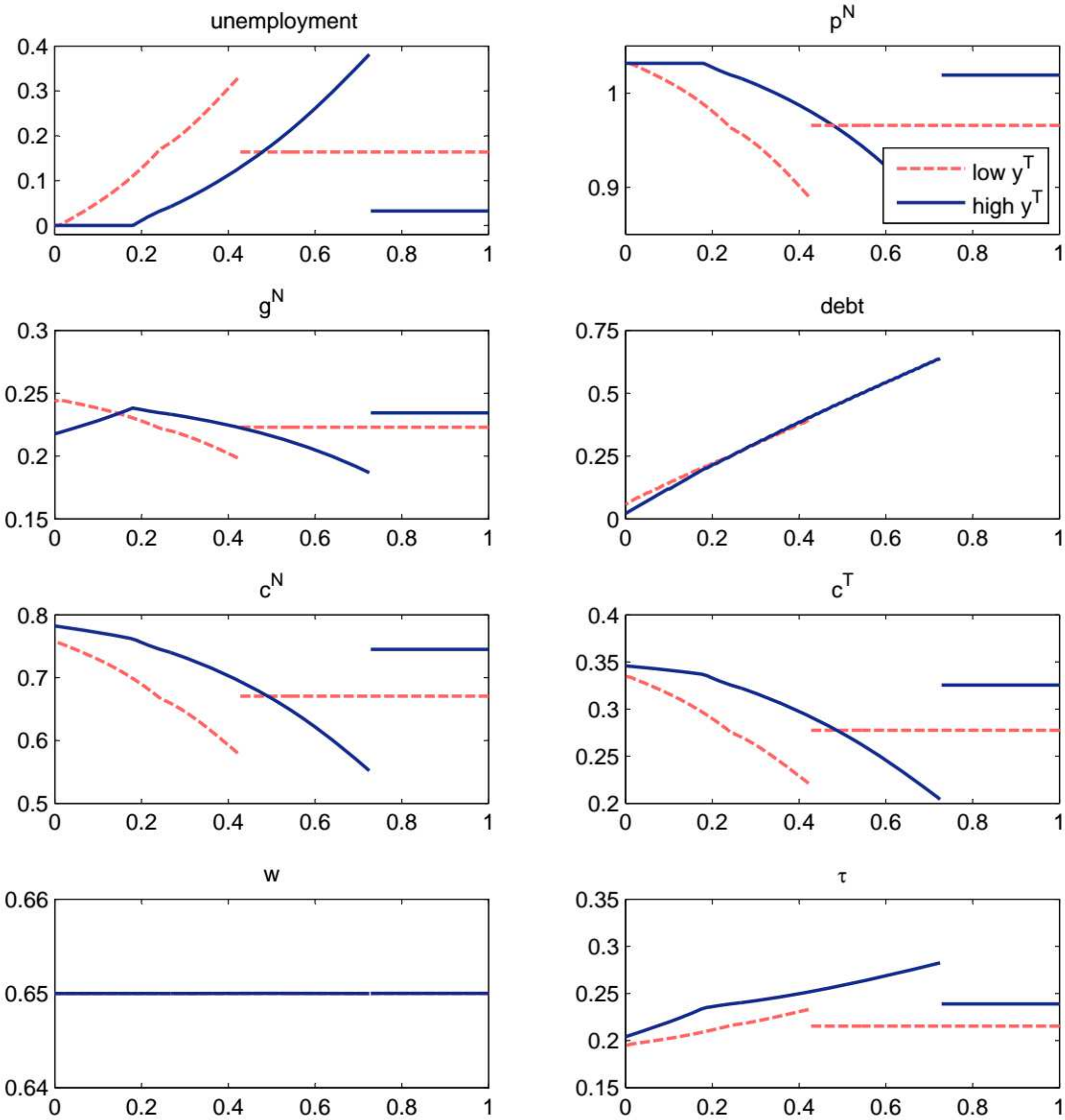

Figure 3: Policy Functions with Optimal Government Spending, as Function of Current Debt b.

Note: Dashed red lines correspond to the low y^T realization and solid blue lines correspond to the high y^T realization.

3.4 Impulse Responses

In this section, we investigate the response of the economy to a negative income shock, and show how the optimal size of government purchases depends critically on the sovereign debt level.

We examine the model dynamics after a negative shock to endowment y^T hits the economy. To do so, we initiate our economy from the repayment state with steady-state y^T level and three different debt levels, and consider a (one-time) shock ε_1 of size σ at time 1 and no additional shocks thereafter.[14] We then report in Figure 4 the simulated responses of p^N, c^T, c^N, g^N, h and debt for 20 periods. The three levels of debt we consider are $b = 0, 0.5b_0, 1.5b_0$, where b_0 is the ergodic mean of debt. For each initial debt level, we plot a different line in Figure 4.

As shown in the figure, a decrease in tradable endowment leads to a decline in consumption of both tradables and nontradables for all initial values of debt. Tradable consumption falls due to the wealth effect. Given that preferences are homothetic, households' demand for nontradables declines, pushing down the relative price p^N. Due to the downward wage rigidity, the decline in the price of nontradables increases the real wage measured in units of nontradables. Firms reduce labor demand and unemployment rises. Moreover, spreads go up reflecting higher incentives for future default.

A key finding illustrated in Figure 4 is that the optimal response of the government to a negative TFP shock depends critically on the level of debt. When the stock of debt is initially high, the government contracts sharply the amount of government spending, following the austerity prescription. Because the negative shock triggers an increase in sovereign spreads, the government finds it more costly to engage in an expansionary fiscal policy and reduces debt levels. As analyzed above, eventhough the keynesian stabilization motive is stronger in this case, the austerity channel dominates, and the government cuts spending severely.

When the stock of initial debt is in an intermediate region, the government still cuts spending, but at a lower pace compared to the case with high initial debt. Because spreads do not increase as much, the government is less austere. As a result, the government is able to moderate the increase in unemployment and mitigate the recession by offsetting

[14] We find this exercise more informative that computing standard impulse responses after simulating our model for a large number of different random sequences of y^T since in our environment default would typically occur for some income paths influencing the dynamics of the model in the subsequent periods.

the deflationary pressures on the real exchange rate. When the stock of government debt takes the lower value, government spending increases in response to a negative shock, following the standard keynesian prescription. Facing lower spreads, the government sharply increases borrowing to finance the stimulus and is able to avoid unemployment.

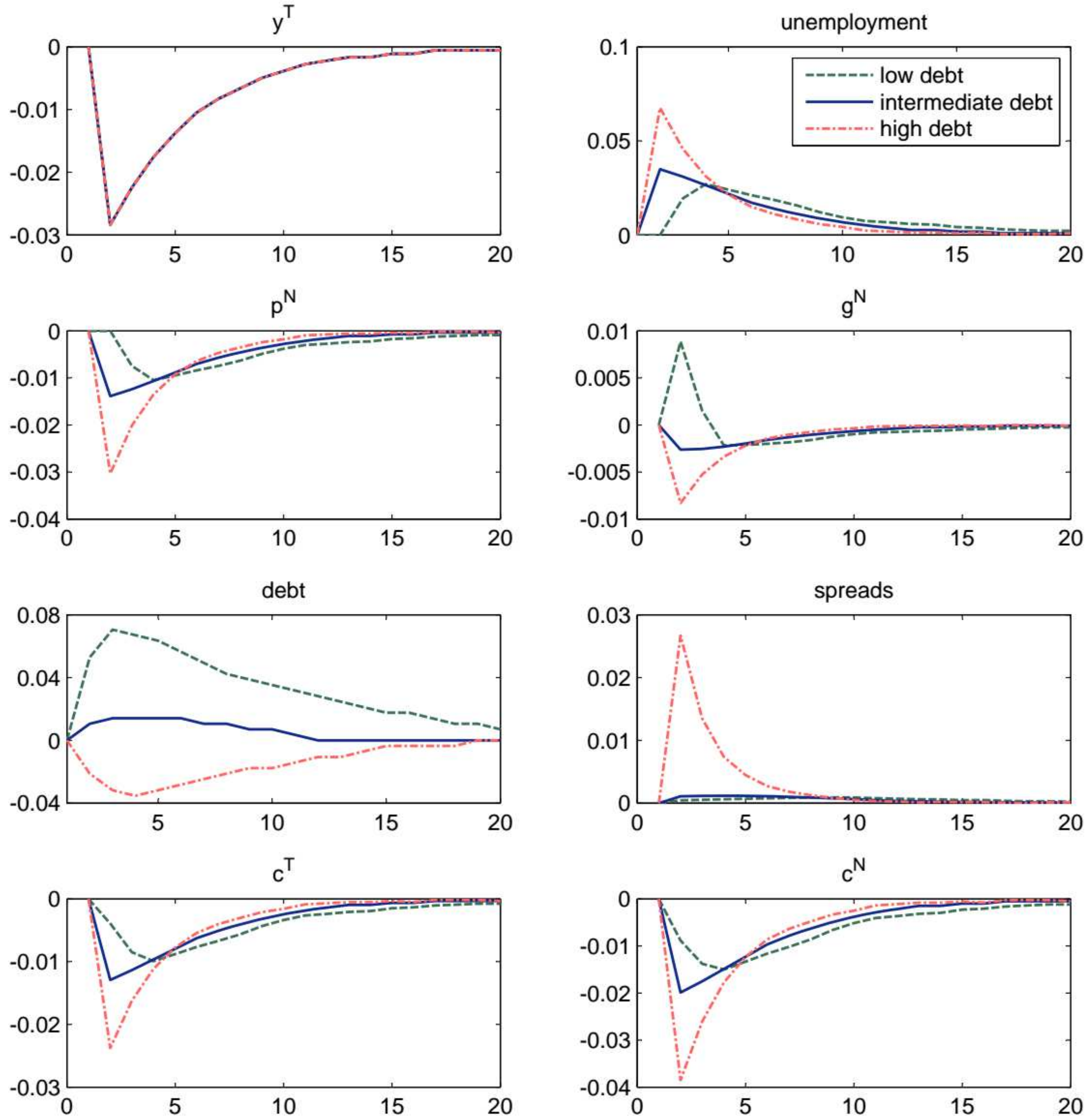

Figure 4: Responses of Key Variables to One-Time Negative Shock to y^T.

Note: given an initial state (y^T, b), responses of tradable endowment, unemployment, relative price of nontradables, government spending, borrowing, spreads, tradable consumption, and nontradable consumption, when y^T decreases one standard deviation in period 1. Responses are computed as absolute deviations from levels when y^T is set to its unconditional mean in all periods. The initial y^T equals its unconditional mean.

3.5 Dynamics around Default Events

To better understand the role of default in our economy and its interaction with fiscal policy, we show next the evolution of key macro variables around the default announcements. To that end, we pick 1,000 default announcements in our Monte Carlo simulations that were preceded by at least 6 periods of access to financial markets and that were followed by at least 4 periods of financial autarky. We then compute the equilibrium levels in those periods for tradable income, tradable and nontradable private consumption, taxes, employment, government spending, bond spreads, debt level, and relative price of nontradables. Figure 5 displays the dynamics of the cross-sectional medians of these variables in a 9-period window around the default announcements. Default occurs in period 0.

As shown in the top panel, default episodes are preceded by a decreasing sequence of income realizations, which hits the bottom in the period of the announcement. In line with the permanent income hypothesis, tradable consumption falls by around 10 percent over the periods prior to the default. When the government defaults in period 0, it makes available some tradable resources that prevent tradable consumption from falling further along with income. Similarly, as aggregate demand drops, nontradable consumption decreases and the real exchange rate depreciates. As wages cannot adjust downward, unemployment climbs 9 percentage points.

During the debt crises, with typically high indebtness levels and sizable borrowing costs, the government decides to moderately reduce its debt position, which cannot prevent bond spreads from rising even further as the state of the economy deteriorates. Despite the downward pressure on the relative price p^N, the government finds it optimal to follow the austerity prescription and cuts government spending by roughly 5 percent in nontradable units. After the default event, as tradable income recovers, so do private and public consumption.

Finally, we conduct the following counterfactual exercise around the default events. We compute the evolution for each of the variables assuming that the government is not allowed to default at time 0 nor in any of the following 4 periods. The dynamics are shown in Figure 6. Solid lines correspond to the actual values along the equilibrium path and dashed lines correspond to the counterfactual scenario. Had the government not defaulted in period 0, tradable consumption would have plunged by an additional 12 percent, doubling the overall drop in the crisis. This would follow in order to make coupon repayments despite the even lower income realization. Even though the government would

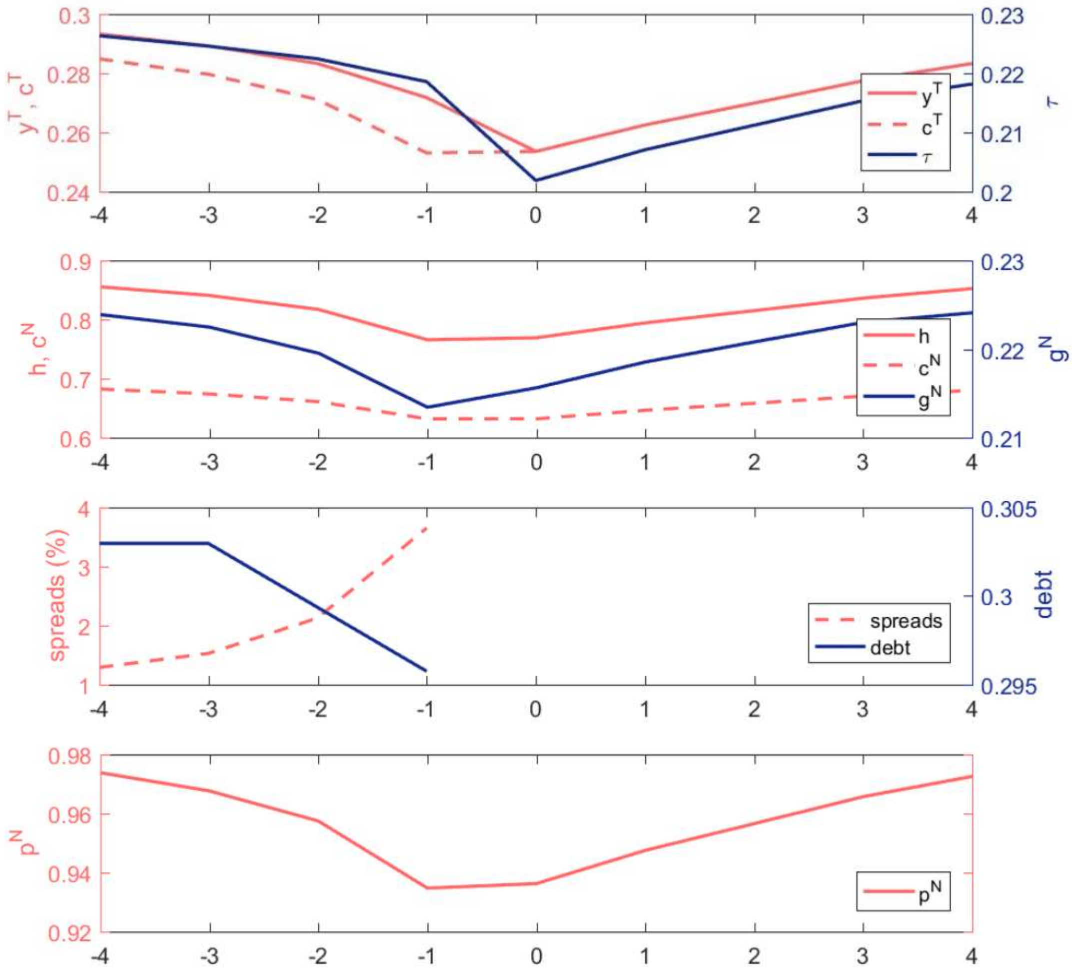

Figure 5: Dynamics around default events.

Note: Cross-sectional medians of levels of y^T, c^T, τ, h, c^N, g^N, bond spreads, debt, and p^N around default announcements. Default occurs in period 0.

keep on lowering the debt level, bond spreads would jump reaching a peak of 15 percent in the default period. Not surprisingly, given the worsening of the government financial conditions, more austerity would be pursued to shrink the government's budget and public spending would be slashed an additional 5 percent in nontradables units in period 0. Unemployment would remain on the rise and jump an additional 10 percentage points in the default period, magnifying the severity of the crisis.

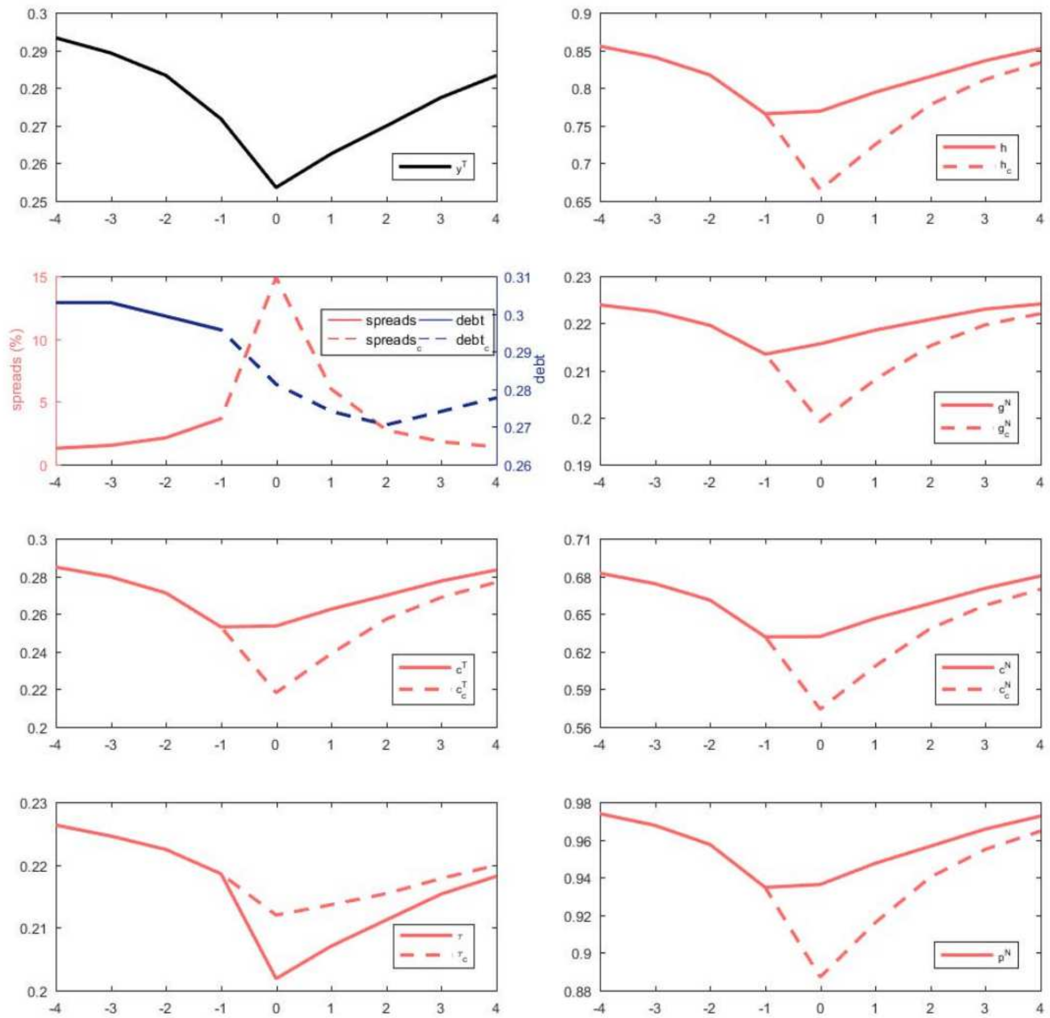

Figure 6: COUNTERFACTUAL DYNAMICS AROUND DEFAULT EVENTS.

Note: The evolution of the variables is computed under the assumption that the government is not allowed to default at time 0 nor in any of the following 4 periods. Solid lines indicate actual values on the equilibrium path. Dashed lines correspond to counterfactual scenario.

3.6 Welfare Analysis

In what follows we compare households' welfare associated with optimal policy against that resulting from the policy that guarantees full employment in all states, described in the previous subsection. To do so, we compute the welfare gain of fiscal policy i with respect to fiscal policy j as the percentage increase rate in current private consumption under policy j that would make the representative household indifferent between the two policies. Recall that (b, s) with $s = (y^T, \zeta)$ denotes the state of the economy.[15] Let $\mathcal{S}$ be the associated state space, i.e. $\mathcal{S} = \mathcal{Y} \times \times \{0, 1\}$. Formally, given the CRRA preference specification for $\sigma = 2$, this compensation denoted by $\lambda^{i,j}(b, s)$ in current state s is given by

$$\lambda^{i,j}(b, s) = \frac{\Delta V(b, s)}{c^j(b, s)^{-1} - \Delta V(b, s)}$$

with $\Delta V(b, s) \equiv V^i(b, s) - V^j(b, s)$, and where V^j and V^i correspond to the lifetime utility values under policies i and j, respectively, and $c^j(b, s)$ is the optimal total consumption decision rule under policy j.

Figure 8 plots the welfare gain of optimal policy under repayment with respect to the full-employment policy, as a function of the current debt level, for two different y^T levels. The dashed and solid lines correspond to a low and high realizations of the tradable endowment, respectively.[16] Welfare gains vary significantly with the state of the economy with access to financial markets, taking values that range from around 20 percent to almost 70 percent.[17] They are typically more pronounced with low levels of productivity and high debt, where p^N tends to be lower. Eliminating involuntary unemployment can be very costly in terms of welfare, especially in those states, due to its crowding-out effect on private consumption of nontradables and larger tax distortions associated with higher g^N.

Finally, we compute the unconditional welfare gains of optimal government policy using the ergodic state distributions under the different policy regimes. As before, welfare gains are expressed in terms of increment of current private consumption. Formally, the compensation of adopting policy i relative to conducting policy j, denoted by $\overline{\lambda}^{i,j}$ satisfies

$$\overline{\lambda}^{i,j} = \frac{\overline{\Delta} V}{(\overline{c}^j)^{-1} - \overline{\Delta} V}$$

with $\overline{\Delta} V \equiv \sum_{(b,s)\in\mathcal{B}\times\mathcal{S}} \mu^i(b, s) V^i(b, s) - \sum_{(b,s)\in\mathcal{B}\times\mathcal{S}} \mu^j(b, s) V^j(b, s)$, and $(\overline{c}^j)^{-1} \equiv \sum_{(b,s)\in\mathcal{B}\times\mathcal{S}} \mu^j(b, s) c^j(b, s)$, and where μ^i and μ^j are the ergodic distributions of

[15] Technically, in our model the value of b is only defined if the economy can issue bonds, i.e. $\zeta = 0$, as debt plays no role in autarky.

[16] The low (high) endowment level are one unconditional standard deviation below (above) the unconditional mean of y^T.

[17] The welfare gains of optimal policy in autarky for the same y^T realizations are 16.28 and 29.14 percent, which are not very different from their counterparts when the government can issue bonds.

the state $(b, s) \in \mathcal{B} \times \mathcal{S}$ under policy i and j, respectively.[18] The unconditional compensation rate of optimal policy with respect to the full-employment regime is 51.8 percent, a non-negligible amount for policy analysis.

4 Empirical Evidence

The model has two main testable implications. First, in recessions, governments should contract more spending when debt is high. Second, recessions should be more severe when debt is high. In this section we document that these predictions are consistent with data from the cross-section of a sample of recession episodes in emerging economies. We expand the analysis to several countries – rather than only analyzing our calibrated economy– to be able to analyze a larger set of recession episodes. We focus on emerging economies because these are countries integrated to international credit markets that typically have default risk.[19]

We follow the event-study approach around recession episodes, following standard practices in the empirical literature (see, for example Calvo, Coricelli, and Ottonello, 2014). We define a recession episode as a contraction of annual output (real per-capita GDP), obtaining a sample of 105 recession episodes. We then study the dynamics of government spending and output in a window around the recession episode. This window goes from the period displaying the maximum cyclical component of output preceding the recession event (recession peak) to the period after the recession event in which output recovers its trend level (recession recovery). The recession trough is the period between the peak recovery points displaying the minimum level of the cyclical output. We then sort episodes according to their external debt levels (net foreign liabilities) at the recession peak, and classify episodes into those with an initial debt level above the mean (high-debt episodes) and those with initial debt level below the mean (low-debt episodes).

Figure 7 depicts the dynamics of government spending, external debt, and output for high- and low-debt recession episodes. Results indicate that whereas during low-

[18]For each policy regime, the ergodic distribution of state vector (b, s) is computed by collecting the last observation from each of the 10,000 Monte Carlo simulated paths.

[19]In particular, we focus on economies that are part JP Morgan's Emerging Market Bond Index (EMBI), which is a measure typically used in the literature to capture middle-income economies integrated in global capital markets. Countries included in the sample are Argentina, Brazil, Bulgaria, Chile, Colombia, Croatia, the Czech Republic, the Dominican Republic, Ecuador, El Salvador, Hungary, Indonesia, Ivory Coast, Lebanon, Malaysia, Mexico, Morocco, Nigeria, Panama, Peru, the Philippines, Poland, Russia, South Africa, South Korea, Thailand, Tunisia, Turkey, Ukraine, Uruguay, and Venezuela.

debt episodes government spending is relatively flat from the recession peak-to-trough, it contracts by 5 percent for high-debt episodes. It is worth mentioning that output contracts more in high-debt episodes, suggesting that Keynesian motives to expand government spending should be higher in these episodes. Figure 7 also shows that external debt is relatively flat in the recession peak-to-trough in high-debt episodes, whereas it significantly increases in low-debt episodes. This evidence is consistent with government adjusting government spending to reduce default risk, as suggested by our theoretical framework.

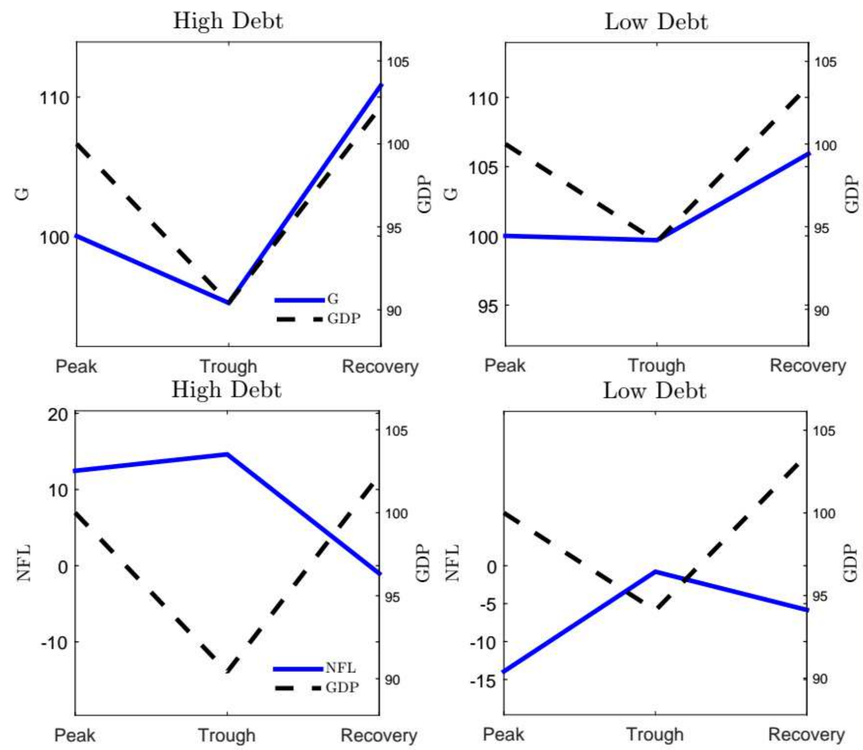

Figure 7: Fiscal Policy during Recession Episodes.

Note: G: real government spending per person in woking age, peak level =100; data source: WDI. GDP in real terms per person in woking age, peak level=100; data source: WDI. NFL: net foreign liabilities over GDP; data source: **?** dataset. Includes 105 recession episodes in emerging economies.

5 Firms' Financial Frictions

In this section, we consider an extension of the baseline model with credit frictions. We consider a working capital constraint and study the implications for optimal fiscal policy. As we will see, a financial channel of fiscal policy arises in this extended framework.

Through this new channel more government spending can alter relative prices boosting firms' collateral value and thereby enhance their borrowing capacity, which in turn could expand output. This provides an additional benefit for stabilization policy.

We begin by introducing production in the tradable sector. In particular, we assume that firms produce tradable output in competitive markets by using imported intermediate goods as single input and operating a decreasing-return-to-scale technology given by

$$y_t^T \;=\; A_t^T F^T(m_t), \tag{20}$$

where F^T is a continuous, differentiable, increasing and concave function, m_t is the quantity of imported inputs purchased at time t, and A_t^T is the productivity level in the tradable sector, which is stochastic and follows a Markov process.

It is assumed that the cost of purchasing imported inputs, $p_m m_t$, must be paid in advance of production. To finance this working capital, firms borrow through within-period external loans denominated in units of tradables. Due to limited enforcement problems, firms have to pledge a fraction $\kappa_t \in (0,1)$ of gross output as collateral:

$$p_m m_t \leq \kappa_t \left(y_t^T + p_t^N y_t^N \right). \tag{21}$$

As in Mendoza (2002) and Bianchi (2012), among others, income can be used as collateral and thus borrowing is limited to a constant fraction of gross output denominated in tradable goods. This is also a relevant assumption for emerging economies as it captures full liability dollarization on the firms' side. The fraction κ_t is assumed to be stochastic and can be interpreted as a financial shock, as in, for example, Jermann and Quadrini (2012). It is assumed to follow a stationary first-order Markov process.

This collateral constraint (21) will be occasionally restricting the quantity of imported inputs to firms, depending on the state of the economy.

In each period firms choose m_t and h_t to maximize profits now given by:

$$\max_{m_t, h_t} A_t^T F^T(m_t) + p_t^N F^N(h_t) - p_m m_t - w_t h_t$$

subject to the technology constraints (20) and (4) and the collateral constraint (21), given prices p_t^N and wages w_t.

Let λ_t denote the Lagrange multiplier associated with the collateral constraint (21).

The first-order conditions with respect to m_t and h_t are

$$A_t^T F_m^T(m_t)(1+\kappa_t\lambda_t) = p_m(1+\lambda_t)$$
$$p_t^N F_h^N(h_t)(1+\kappa_t\lambda_t) = w_t$$

where $F_m^T(m) \equiv \frac{\partial F^T(m)}{\partial m}$ and $F_h^N(h) \equiv \frac{\partial F^N(h)}{\partial h}$. Due to the collateral constraint, the FOCs are altered relative to the frictionless economy. As long as the collateral constraint binds, $\lambda_t > 0$, and hence the marginal product of each input does not equal its respective marginal cost.

Furthermore, the complementary slackness conditions are

$$\lambda_t \geq 0, \qquad \lambda_t\left(\kappa_t\left(y_t^T + p_t^N y_t^N\right) - p_m m_t\right) = 0. \tag{22}$$

For the quantitative results shown below, we assume that the financial shock κ_t can take only two values: κ_L and κ_H, with $0 < \kappa_L < \kappa_H$. In particular, we set $\kappa_L = 0.08$ to generate an average drop of total value-added of 10 percent on impact, which is roughly the fall observed in output during sudden stop episodes. And the value for κ_H is chosen sufficiently high that the collateral constraint does not bind for any state in equilibrium.

Also, we consider the following transition probability matrix for κ_t: $\Pi(\kappa_H|\kappa_H) = 0.9$ and $\Pi(\kappa_H|\kappa_L) = 1$. The latter probability is set to match the mean duration of a sudden stop of around one year, as observed in the data from 1970 to 2011. The former probability is then chosen to generate a 9-percent annual probability of occurrence of a sudden stop in the asymptotic distribution, which is in the range of the data.

Finally, for simplicity, we restrict the analysis to one-period bonds.

Figure 9 shows the decision rules for government spending, external debt, labor, imported input purchases, tradable and nontradable consumption, relative prices and Lagrange multiplier λ associated with the collateral constraint, as a function of the current debt level. The light and dark blue lines in each panel correspond to the low and high realizations of the financial shock, κ_L and κ_H, respectively. In both cases, productivity A^T is set to one unconditional standard deviation above its unconditional mean. Again, solid lines are used when repayment is optimal, dotted lines when default is.

For $\kappa_t = \kappa_L$, firms find their borrowing capacity limited as the size of the intra-period loans used to finance working capital is capped by the collateral value. Less working capital to purchase imported input translate into lower volumes of tradable output.

As the economy is more indebted, households' wealth declines. Because preferences are homothetic between tradable and nontradable consumption, the demand for both goods decreases. Under incomplete markets, given that the supply of nontradables does not fall enough, the tradable good becomes relatively more valuable as reflected in a lower relative price p^N. This in turn drives down the market value of total gross output and therefore tightens the collateral constraint. At the same time, due to the presence of downward rigidity of nominal wages and a fixed exchange-rate regime, as p^N decreases, real wages improve, eventually bringing about involuntary unemployment. This last observation is not restricted to the states with the low realization of the financial shock, but applies as well when κ is high. For $\kappa_t = \kappa_L$, however, this brings in more tightening in the collateral constraints of firms.

Therefore, in this environment the government has additional motives to use sizable amount of government spending: relax firms' collateral constraints and hence boost tradable output. As before, an increase in g^N financed through higher taxes and more borrowing puts upward pressure on p^N helping reduce unemployment in the nontradable sector. Nontradable output in terms of tradables rises through both a price effect and a quantity effect, pushing up firms' collateral values. Firms respond by increasing their demand of imported inputs and thereby tradable output expands. Interestingly, as shown in the figure, the government optimally chooses to sustain relatively higher employment with κ_L by allocating substantially more resources to government spending. By doing so, it partly mitigates the worsening of firms' credit conditions preventing the Lagrange multiplier λ associated with the collateral constraint from rising even further. As current debt continues increasing, it eventually becomes too costly for fiscal policy to avoid a credit tightening for firms and hence we observe λ drifting up. Not surprisingly, as shown in Table 2, fiscal policy becomes more volatile than in the baseline model. Also, optimal g^N is less procyclical.

6 Conclusion

We studied the positive and normative implications of fiscal policy in a sovereign default model extended with downward nominal rigidity. The presence of downward wage rigidity creates a role for stabilization policy during recession. Sovereign default risk, however, makes it costly to run debt financed stimulus.

We show that the stabilization effects of fiscal policy are highly non-linear in the severity of the recession. When the level of unemployment is high, fiscal multipliers are large, and can exceed unity when spending is debt financed. On the normative side, the optimal amount of government spending depends critically on the sovereign debt level. When the stock of debt is relatively low, recessions calls for strong stabilization policy. As debt increases and the government becomes more exposed to a sovereign default, the optimal response becomes more austere.

In work in progress we are considering aspects of commitment in the conduct of optimal fiscal policy and in the design of fiscal rules.

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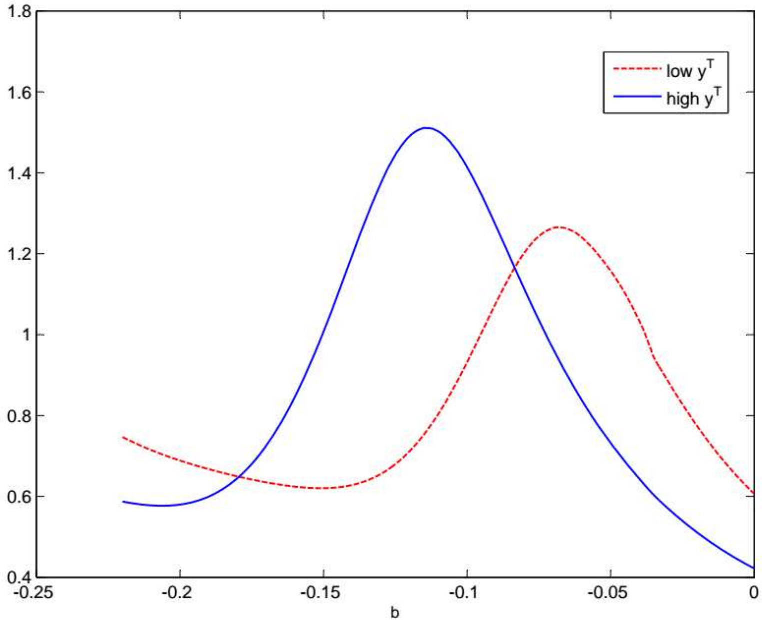

Figure 8: Welfare Gains in Repayment of Optimal Fiscal Policy relative to Full-Employment Policy, as Function of Current Debt b.

Note: The dashed line correspond to the low y^T realization and the solid line corresponds to high y^T realization. Welfare gains are expressed in percentage points of current private consumption.

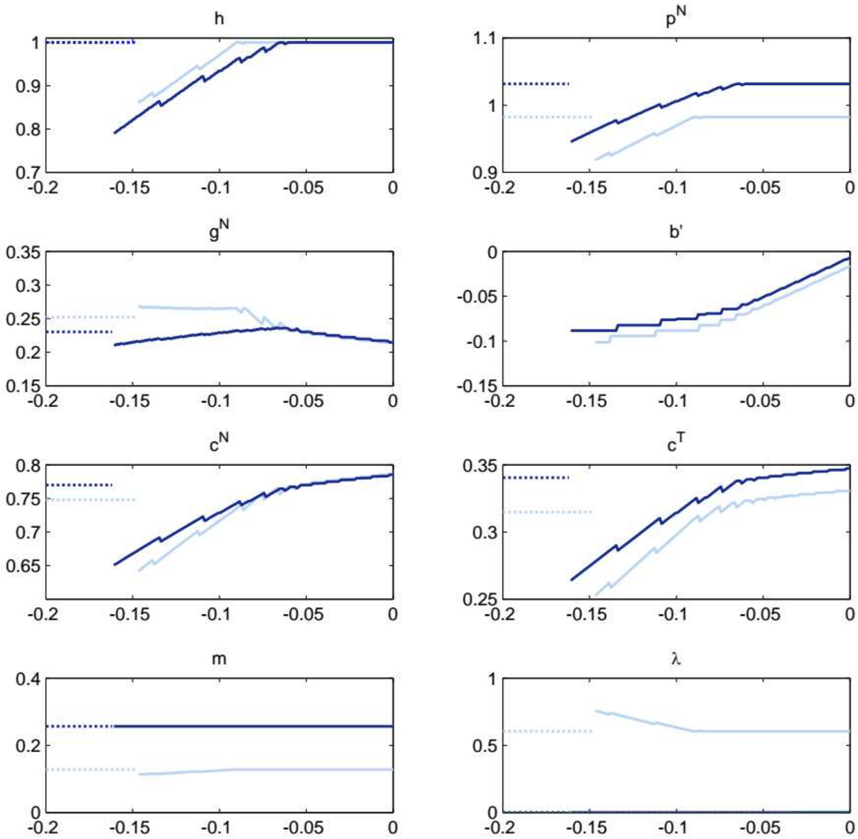

Figure 9: Optimal Policy Functions with Credit Frictions, as Function of Current Debt b.

Note: Light blue lines correspond to the low realization κ_L and dark blue lines correspond to the high realization κ_H, for high A^T productivity. Solid lines represent policy functions when repayment is optimal and dotted lines when default is optimal.