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.

Keywords: sovereign debt, optimal fiscal policy, downward nominal wage rigidity.
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 non-tradables. Because the wage is sticky, this reduces labor demand and generates unemployment.

An increase in government spending in non-tradables goods raises the relative price of non-tradables 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.

We also 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 public expenditures and tax rates are optimally procyclical in a canonical sovereign debt model. Because spreads are higher in recessions, the government finds it optimal to contract spending and raise revenues, and do the opposite during expansions. In Arellano and Bai (2014), the government faces rigidities of fiscal revenues, which can either trigger the need for fiscal austerity programs, or lead to government default. These papers, however, do not consider nominal rigidities and hence do not feature the trade-off we analyze in this paper.

Na, Schmitt-Grohé, Uribe, and Yue (2014) introduce downward wage rigidity in a canonical sovereign debt model. They consider both fixed and flexible exchange rates and show that the former supports less debt. 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. Balke and Ravn (2016) study time consistent policy in a model featuring unemployment due to search and matching frictions, but without nominal rigidities. Anzoategui (2016) estimates fiscal rules for the Eurozone and evaluates their effects using a similar environment to our paper. To the best of our knowledge, our paper is the first in the literature to study optimal fiscal policy in a model featuring nominal rigidities and endogenous sovereign default.

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), Farhi and Werning (2012). 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 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 4 we extend the framework incorporation credit frictions and study the implications for optimal fiscal policy. Section 5 concludes.

2 Model

This section describes the model economy in which fiscal policy will be studied. We consider a two-sector small open economy 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), 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 reduce unemployment in the labor markets by affecting relative prices. The government, however, has only imperfect instruments to finance surges in g^N. First, taxes are assumed to be distortional. Second, external borrowing consists of one-period securities, traded with risk-neutral competitive foreign lenders, whose promised repayment is non-state-contingent. The government does not have commitment to repay and can default on promised repayment, generating a utility cost to the households and 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 non-tradable 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 $\omega_c \in (0, 1)$ and $\mu > -1$. The elasticity of substitution between tradable and nontradable consumption is therefore $1/(1 + \mu)$.

Each period, households receive a stochastic 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 follow a stationary first-order Markov process. Households inelastically supply $\bar{h}$ 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 $h_t \leq \bar{h}$ hours in the labor markets. The actual hours worked h_t is determined by firms and taken as given by the households. Given that the main focus of the paper is on sovereign debt, we assume that households are hand-to-mouth and that the government can make 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 government 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:

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

2.2 Firms

Firms have access to a decreasing-returns-to-scale technology to produce nontradable goods with labor:

$$y_t^N = F\left(h_t\right), \tag{4}$$

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

$$\phi_t^N = p_t^N y_t^N - w_t h_t. \tag{5}$$

The optimal choice of labor h_t is given by

$$p_t^N F'\left(h_t\right) = w_t. \tag{6}$$

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 decisions.

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 number of bonds due at the beginning of period t, and i_t is the number 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

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

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 a form of capturing various default costs related to reputation, sanctions, or misallocation of resources.[1]

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, as mentioned before, 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 for a stochastic number of periods. While in autarky, with probability θ in each period, the government regains access to financial markets, in which case it starts over with zero outstanding debt.

[1] Our choice of a utility loss 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.

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 an arbitrage condition, bond prices are then given by

$$q(s, b') = \frac{1}{1+r}\mathbb{E}[(1 - \chi')(\delta + (1 - \delta)q(s', b''))]. \tag{10}$$

where

$$b'' \;\;=\;\; \hat{b}(b', s')$$

Equation (10) indicates that, in equilibrium, an investor has to be indifferent between selling a government bond today and keeping the bond and selling it in the next period. In case of repayment next period, the payoff is given by the coupon δ plus the market value of the non-maturing fraction of the bonds. In case of default, the price of defaulted bonds q_{t+1} is equal to zero since we assume a zero recovery rate.

Equation (10) 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. In turn, if a default in the future is relatively more likely (e.g. because the economy is in recession), the government will find it more costly to be finance an expansionary fiscal policy.

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. 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:

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

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.[2]

Combining the equilibrium price 3 with resource constraint 11, the relative price p_t can be expressed as

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

Combining the households' budget constraint 2 with the definition of the firms' profits

[2] 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.

and market clearing condition 11, the resource constraint of the economy is given by

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

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 9.*
3. *Bond pricing 10 holds.*
4. *The market for nontradable goods clears.*
5. *The labor market satisfies 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:

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

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

Bellman equation

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

subject to

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

and the value of default, given by:

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

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 $q(y^T, b')$ denote bond price schedule, taken as given by the government.

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* $\{\chi(b,s), \hat{c}^T(b,s), \hat{g}^N(b,s), \tau(b,s), \hat{b}(b,s), \hat{h}(b,$ *and a bond price schedule* $q(y^{T,\prime}, b')$ *such that*

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

2. *The bond price schedule satisfies* 10

2.7 Fiscal Policy Trade-offs

The choice of public spending faces a trade-off between the benefits of reducing unemployment and the inefficiencies associated with its financing. On the one hand, increasing public spending can reduce unemployment. As shown in equation 15, for a given level of employment and tradable consumption, expanding g^N leads to an increase in the marginal utility of nontradable goods, which raises their equilibrium relative price. An increase in the price of nontradable goods, in turn, makes firms willing to hire more labor at the given wage rate $\bar{w}$. On the other hand, public spending has to be financed either with taxes or with external borrowing (see equation 8). Both alternatives are costly: Increasing taxes leads to direct welfare losses; increasing borrowing raises default risk and the possibility of suffering the welfare losses from default.

To illustrate this trade-off Figures 1 and 2 show how the equilibrium allocations change with a one-period deviation in the level of public spending from its optimal level.[3] Figure 1 makes this exercise under the assumption that changes in public spending are financed with debt, Figure 2 under the assumption that it is financed with taxes. The 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 public 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). In fact, the fiscal multiplier is larger than one, and as a result private consumption of non-tradables also increases. On the cost side, the last panel of Figure 1 shows that increasing public spending above the optimal level leads to a sharp decline in debt prices, reflecting the higher risk of default associated with higher debt levels. While the increase in spreads reflect less average repayment by the government, this is costly because it exposes the government to larger default costs in the future.

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 and hence private consumption of non-tradables fall in response to an increase in government spending.

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

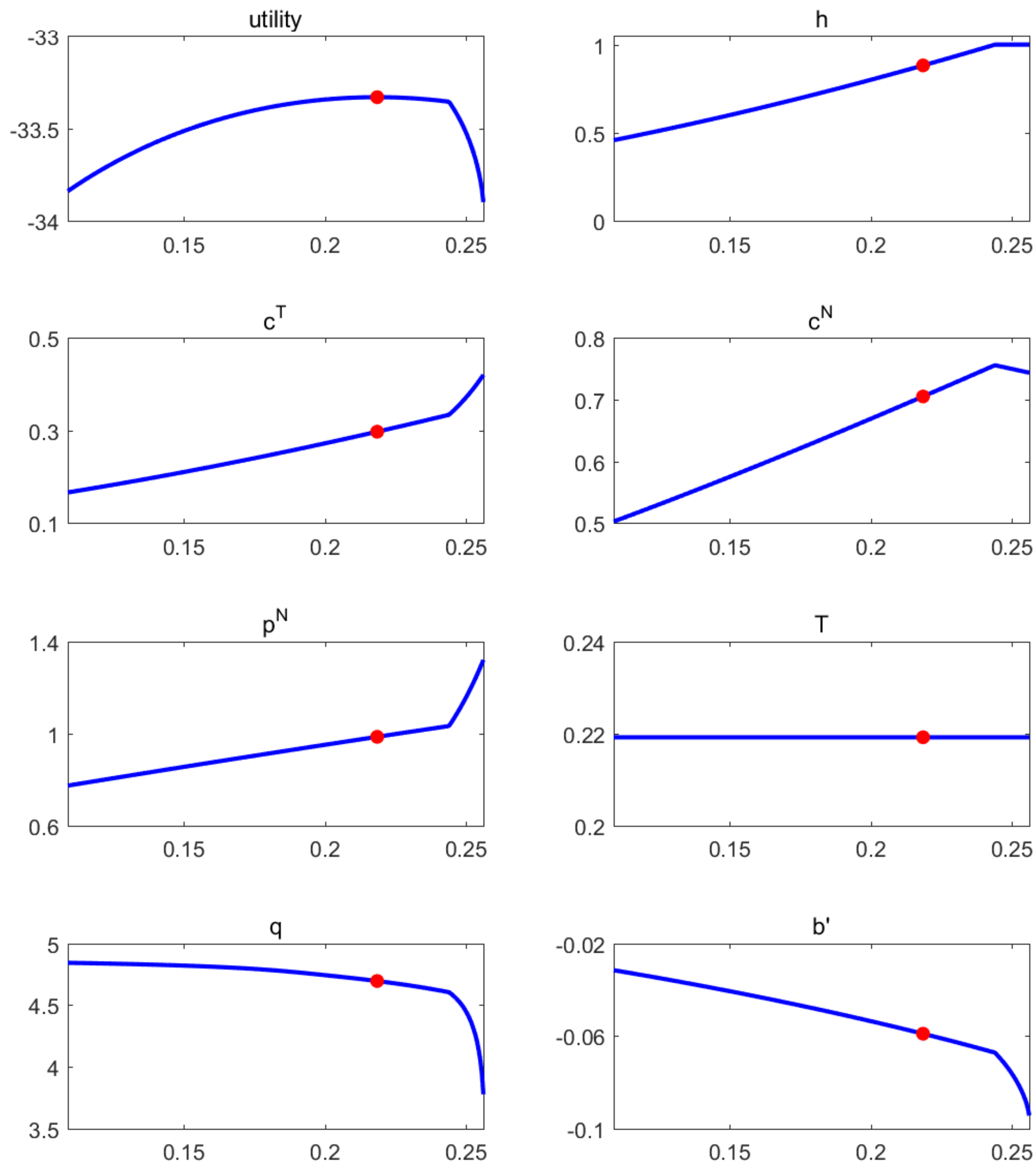

Figure 1: UTILITY, PRICES AND ALLOCATIONS UNDER REPAYMENT FOR ALTERNATIVE VALUES OF CURRENT g^N.

Note: Blue lines correspond to repayment levels of h, c^T, c^N, p^N, T, q and b', as function of current g^N, given a current state (y^T, b) with the unconditional mean of endowment and average debt level. Red dots indicate equilibrium levels given optimal g^N.

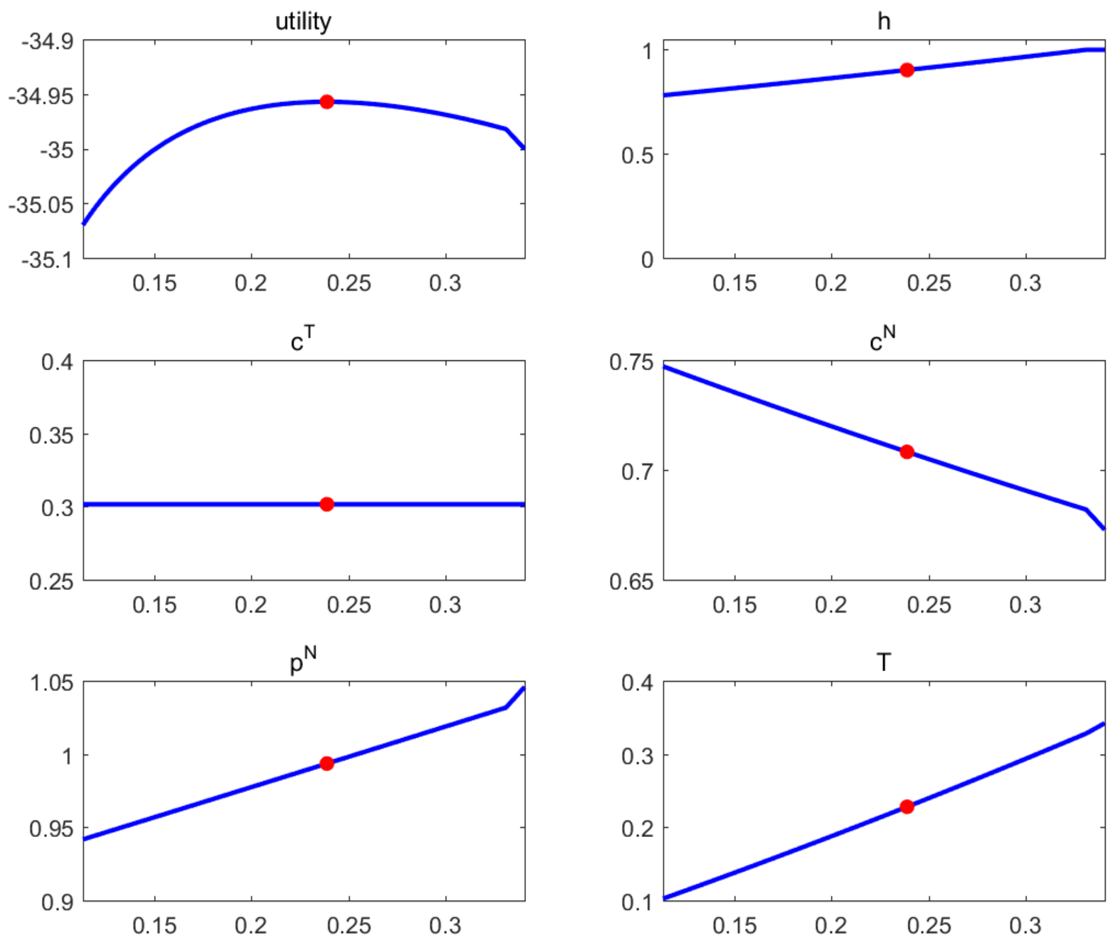

Figure 2: Utility, prices and allocations in autarky for alternative values of current g^N.

Note: Blue lines correspond to autarkic levels of h, c^T, c^N, p^N, and T, as function of current g^N, given current y^T equal to its unconditional mean. Red dots indicate equilibrium levels given optimal g^N.

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.[4]

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 the tradable and nontradable sectors:

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

The direct utility cost of default given by $\psi_\chi(y^T)$. As in Bianchi, Hatchondo, and Martinez (2012), we assume the following form for this utility loss in autarky:

$$\psi_\chi(y_t^T) = \max\{0, \psi_\chi^0 + \psi_\chi^y \log(y_t^T)\}, \tag{17}$$

with $\alpha_1 > 0$. 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,

$$\Omega(\tau) = \psi_\tau \tau^2, \tag{18}$$

[4]We use 71 gridpoints for endowment, and 71 for debt. 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,

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

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. [5] The debt level $\bar{b}$ 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 $\bar{b} = \frac{\delta}{1-(1-\delta)/(1+r)} b_t$.

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.

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

[5] The Macaulay duration of a bond with price q and our coupon structure is given by $D = \sum_{t=1}^{\infty} t \frac{\delta}{q} (\frac{1-\delta}{1+i_b})^t = \frac{1+i_b}{\delta+i_b}$, 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)
$\bar{w}$	0.65	Lower bound on wages

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.

There are 5 remaining parameters are calibrated to match 5 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, and lower bound on wages, $\overline{w}$.

The discount factor β is chosen to match the average external debt-GDP ratio.[6] This yields $\beta = 0.94$, which is within the range of values used in the sovereign default literature. 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

[6]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.

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.[7] 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.[8] 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 it is standard in the literature (e.g. Aguiar and Gopinath, 2006; Arellano, 2008), the model is successful at replicating several features regarding the comovement of spreads, with economic activity and debt flows, 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 are two key predictions. First, the optimal fiscal policy is procyclical, with a correlation between public spending and output of 0.85 versus 0.46 in the data. This long-run correlation is in line with the results of Cuadra, Sanchez, and Sapriza (2010). As we will show below, however, there is a significant state dependency in the optimal response of government spending. In particular, we will show that government spending is procyclical in regions of the state space with low debt levels. Second, public spending is relatively smooth. 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

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

[8] 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.

Table 2: Business Cycle Statistics

Statistic	Data	Baseline Model	No Distortionary Taxes
mean(spreads)	1.1	1.1	0.6
mean($\tilde{b}/y$)	22.8	23.3	21.9
mean(y^T/y)	20.2	25.0	24.0
mean(pg^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	
cor(y,spreads)	-0.38	-0.91	-0.92
$\sigma(pg^N)/\sigma(\hat{y})$	2.0	0.5	1.1
$\sigma(c)/\sigma(\hat{y})$	1.1	1.1	0.9
$\sigma(T)/\sigma(\hat{y})$	1.8	0.2	0.4
σ(spreads)	1.4	0.9	0.9

the moments of an economy when the government has access to no distortionary taxes. In this case, the optimal policy would be signficantly less procyclical (0.45 correlation of public spending with output versus 0.8 in the baseline) and significantly more volatile (50 percent more volatile than output). In addition, the access to no distortionary taxes allows the government to reduce the average level of unemployment and the frequency of default.

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.[9]

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

Figure 3 shows an interesting pattern for optimal government spending, which is highly dependent on the initial debt position. There are three different regions in this Figure. The first region to the left is the default region. Here, high levels of debt imply that the government finds it optimal to default, and has more resources available to spend in public goods. For levels of debt below 0.15 (i.e., $b > -0.15$) the government enters the repayment region and spending is reduced discretely relative to the level of spending in the default region. 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 the stock of debt, given the steep spread schedule.) In this second region, government spending is *decreasing* in the level of debt. This decrease in spending for higher levels of debt is the outcome of opposing keynesian and an austerity forces. On one hand, as the 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 debt is increased. On the other hand, higher initial levels of debt are associated with higher issuances of debt, and hence higher spreads. Thus, this increases the need for austerity as it more costly to do expansionary fiscal policy. Overall, we find that the second effect dominates, and the government spends *less* when debt is increased. Put it differently, the higher is the debt, the stronger is the austerity channel relative to the keynesian channel. A kink in the government spending policy occurs at $b = -0.03$, which results in the third region. At this initial debt, the increase in government spending is sufficiently large that takes the economy to full employment. The wage rigidity constraint is still binding, though. It is the active stabilization policy that keeps the economy at full employment. In this region, government spending is increasing in the level of debt. As debt is decreased, the keynesian channel becomes weaker, since the economy is already at full employment, and so optimal spending is reduced. It is worth pointing out that for positive levels of bonds (not shown in the figure), the market wage would increase above the sticky wage.

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 non-tradable sector. Since preferences are homothetic and there is an infinitely elastic demand for tradables, the price of non-tradable goods needs to fall to clear the excess supply of non-tradable goods that results from the decline in income. Due to the downward wage rigidity, the decline in the price of non-tradables leads to increases in the real wage measured in units of tradables, and firms contract labor demand.

An increase in government spending in non-tradable 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 shocks, government spending is higher for the high income shock. At low levels of income, the government needs to increase more distortionary tax revenue for the same level of spending, which is costly. As debt level falls below 0.15, the economy repays for the average shock, and remains in default for the one-standard-deviation 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, the government spends more when debt is lower, following the austerity channel. 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.

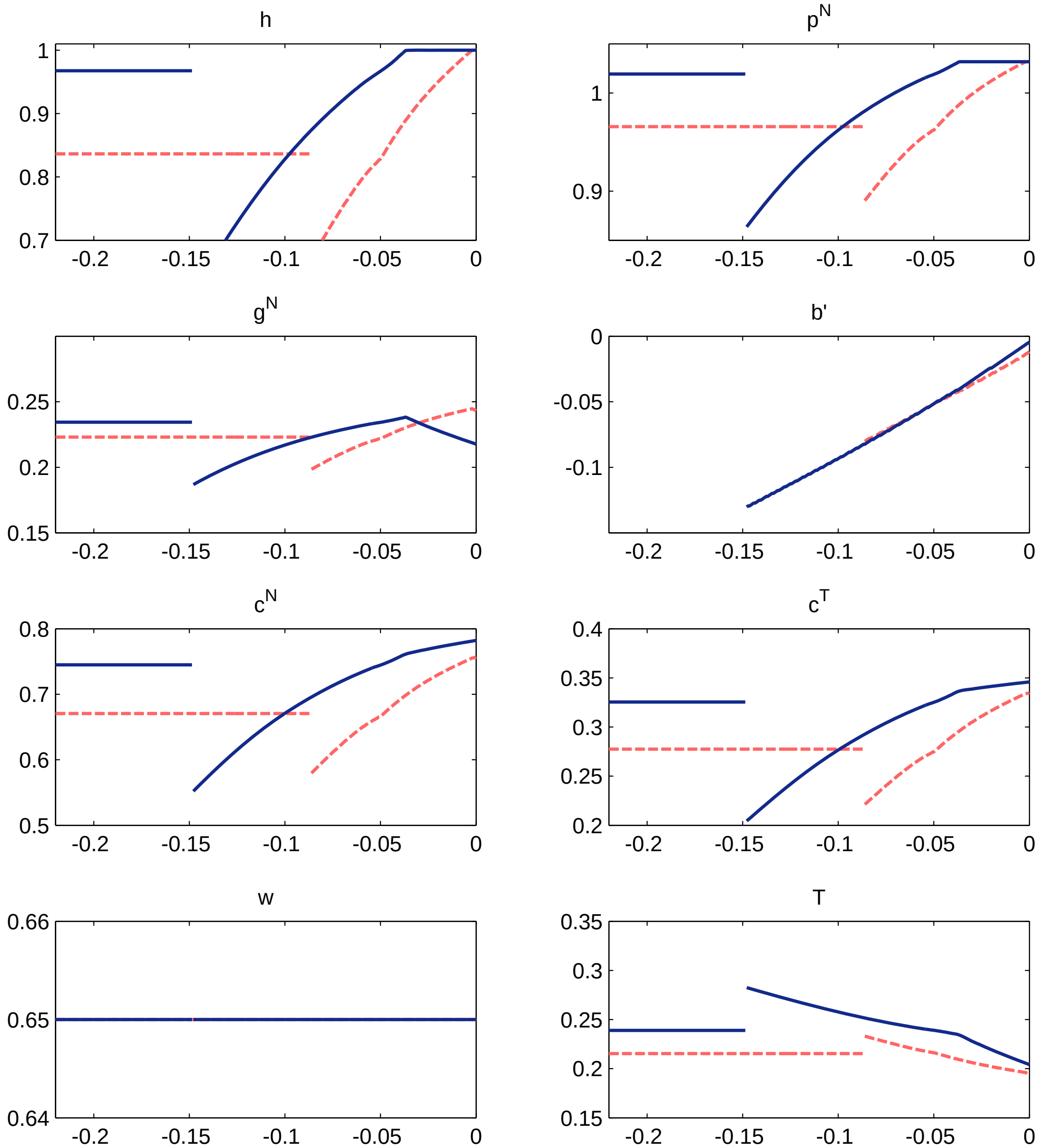

Figure 3: Policy Functions with Optimal Government Spending, as Function of Current Debt b.

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 that 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. [10] We then report in Figure 4 the simulated responses of p^N, c^T, c^N, g^N, h and b for 20 periods. The three levels of debt we consider are $b = 0, 0.5\bar{b}, 1.5\bar{b}$, where $\bar{b}$ is the ergodic mean of debt, each of which correspond to a different line in 4.

As Figure 4 shows, a decrease in tradable endowment leads to a decline in consumption of both tradables and non-tradables for all initial values of debt. Tradable consumption falls due to the wealth effect, and non-tradable consumption falls because of the decline in the price of non-tradables that results from the reduction in aggregate demand. 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 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,

[10] 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.

following the standard keynesian prescription. Facing lower spreads, the government sharply increases borrowing to finance the stimulus and is able to avoid unemployment.

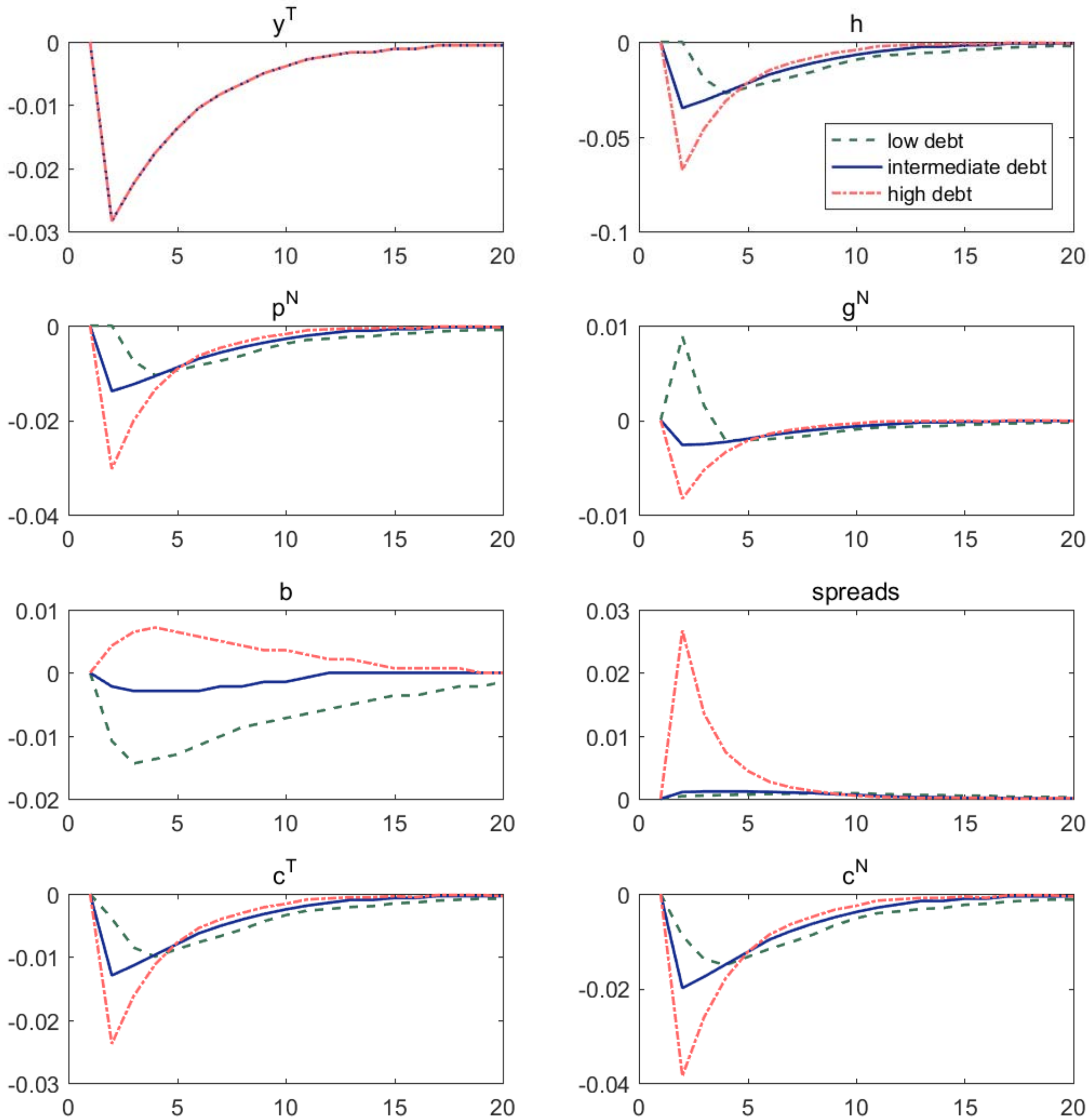

Figure 4: Responses of Key Variables to One-Time Negative Shock to y^T.

Note: given an initial state (y^T, b), responses of y^T, h, p^N, g^N, b, bond spreads, c^T and c^N, 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 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 $s = (y^T, b, \eta)$ denotes the state of the economy.[11] Let $\mathcal{S}$ be the associated state space, i.e. $\mathcal{S} = \mathcal{Y} \times \mathcal{B} \times \{0, 1\}$. Formally, given the CRRA preference specification for $\sigma = 2$, this compensation denoted by $\lambda^{i,j}(s)$ in current state s is given by

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

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

Figure 5 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.[12] 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.[13] They are typically more pronounced with low levels of productivity and high debt, where p 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

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

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

[13] 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.

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 $\overline{\Delta} V \equiv \sum_{s \in \mathcal{S}} \mu^i(s) V^i(s) - \sum_{s \in \mathcal{S}} \mu^j(s) V^j(s)$, and $(\overline{c}^j)^{-1} \equiv \sum_{s \in \mathcal{S}} \mu^j(s) c^j(s)$, and where μ^i and μ^j are the ergodic distributions of the state $s \in \mathcal{S}$ under policy i and j, respectively.[14] The unconditional compensation rate of optimal policy with respect to the full-employment regime is 19.96 percent, a non-negligible amount for policy analysis.

4 Firms' Financial Frictions

[RESULTS CORRESPOND TO ONE PERIOD DEBT]

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

$$y_t^T \quad = \quad A_t^T F^T(m_t), \tag{19}$$

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

[14] For each policy regime, the ergodic distribution of state vector $s = (y^T, b, \eta)$ is computed by collecting the last observation from each of the 10,000 Monte Carlo simulated paths.

problems, firms have to pledge a fraction $\kappa_t \in (0,1)$ of gross output as collateral:

$$p_m m_t \leq \kappa_t \left(y_t^T + p_t^N y_t^N \right). \tag{20}$$

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 20 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 19 and 4 and the collateral constraint 20, given prices p_t^N and wages w_t.

Let λ_t denote the Lagrange multiplier associated with the collateral constraint 20. 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

$$\lambda_t \geq 0, \qquad \lambda_t \left(\kappa_t \left(y_t^T + p_t^N y_t^N \right) - p_m m_t \right) = 0. \tag{21}$$

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.

Figure 6 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.

5 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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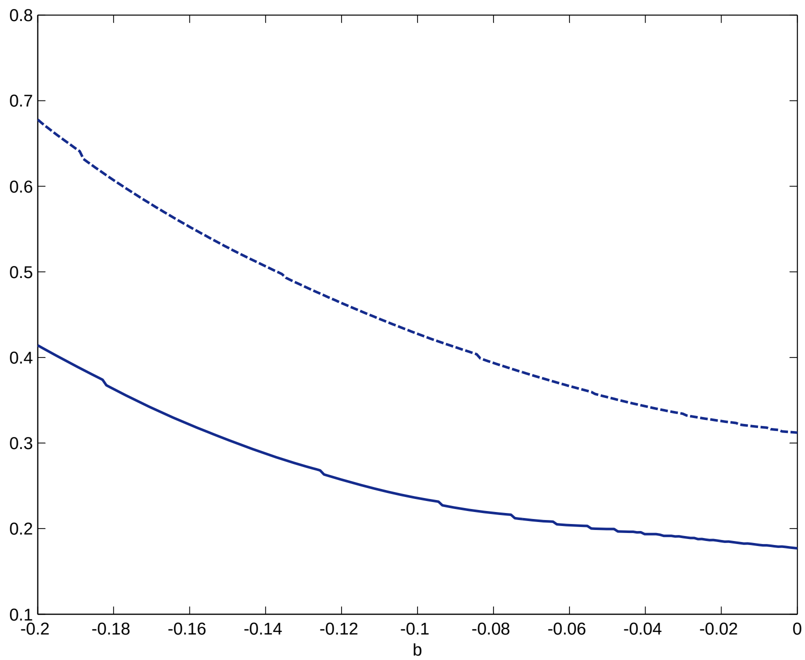

Figure 5: Welfare Gains in Repayment of Optimal Fiscal Policy relative to Full-Employment Policy, as Function of Current Debt b.

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.

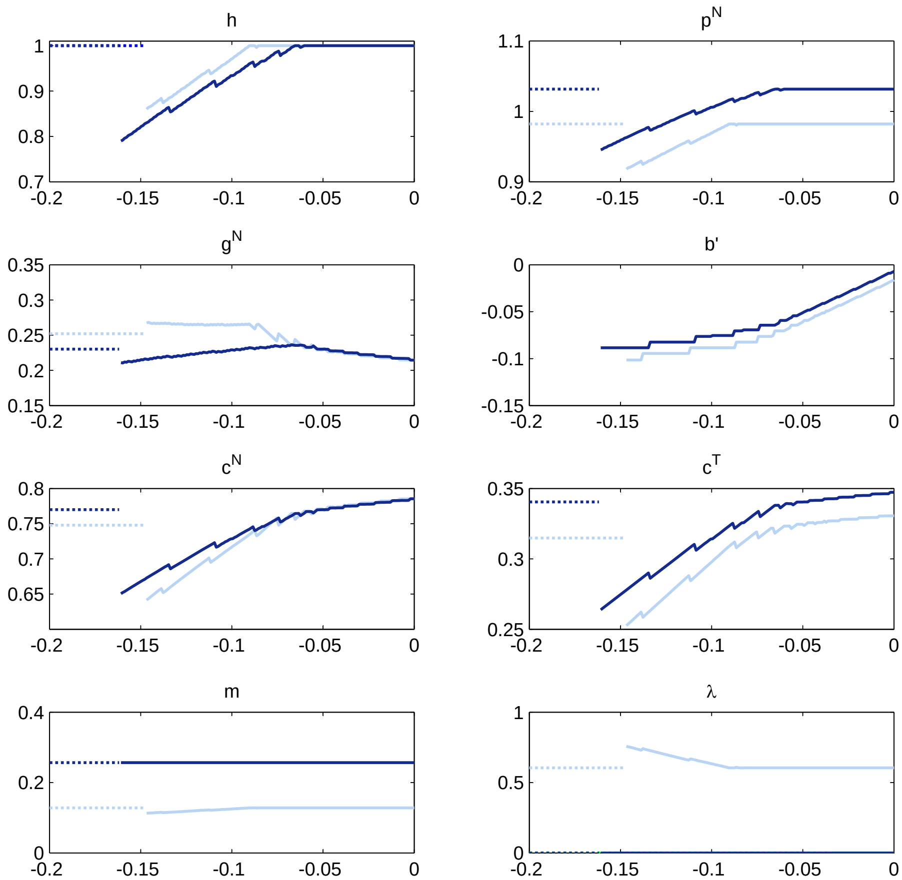

Figure 6: Optimal Policy Functions with Credit Frictions, as Function of Current Debt b.

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.