

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](#); [Aguilar and Gopinath, 2006](#); [Arellano, 2008](#)) extended with downward wage rigidity ([Schmitt-Grohé and Uribe, 2016](#); [Na, Schmitt-Grohé, Uribe, and Yue, 2014](#)). 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 distortionary, 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. Our key contribution to this literature is to consider the role for fiscal policy when there is an aggregate demand channel due to nominal rigidities.¹

Second, our paper also relates to a large literature that studies the role of government spending as a macroeconomic stabilization tool. Examples in this literature include Eggertsson (2011), Christiano, Eichenbaum, and Rebelo (2011), Werning (2011) Gali and Monacelli (2008), Farhi and Werning (2012). This literature shows that 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. We contribute to this literature by introducing the possibility of sovereign default, and studying 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.

Roadmap. 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

¹With the exception of Na, Schmitt-Grohé, Uribe, and Yue (2014), this literature abstracts entirely from nominal rigidities. The focus of Na, Schmitt-Grohé, Uribe, and Yue is on rationalizing why depreciations of the exchange rate and defaults tend to occur together in the data.

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 \(2016\)](#)).

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 distortionary. 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 consumption are described by the intertemporal utility function:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \{u(c_t) + v(g_t^N) - \Omega(\tau_t) - \eta_t \psi_{\chi,t}\}, \quad (1)$$

where c_t denotes private consumption in period t , g_t^N denotes public spending in nontradable goods, and τ_t denotes lump-sum taxes in period t . Let $u(\cdot)$ and $g(\cdot)$ be strictly increasing and concave functions, and $\Omega(\cdot)$ is a strictly increasing and convex function capturing deadweight losses from taxation. Also, as it will become clear later, ζ_t is an indicator function that takes the value of 0 if the government can issue bonds in period t and 1 if it is in financial autarky. The last term in the per-period payoff captures a utility cost from default, where $\psi_{\chi,t} > 0$ depends on the exogenous state of the economy. Finally, $\beta \in (0, 1)$ 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:

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

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

Our choice of a utility loss from taxes and default, rather than an output cost, is 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.

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:

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

2.2 Firms

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

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

where y_t^N denotes output of nontradable goods in period t , $F(\cdot)$ 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 is given by

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

2.3 Government

The government determines public spending, taxes, borrowing, and repayment decisions. Borrowing consists on one-period non-state-contingent bonds. The government lacks commitment in repaying external debt.

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. 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:

$$\zeta_t = (1 - \xi_t)\zeta_{t-1} + \chi_t(1 - \zeta_{t-1}) \quad (7)$$

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.

We consider long-term debt. We assume that a bond issued in period t promises an infinite stream of coupons that decreases at an exogenous constant rate δ , as in [Arellano and Ramanarayanan \(2012\)](#), [Hatchondo and Martinez \(2009\)](#), and [Chatterjee and Eyigungor \(2012\)](#). 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:

$$b_{t+1} = (1 - \delta)b_t + i_t, \quad (8)$$

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 issues these bonds at a price q_t , which in a Markov equilibrium will depend on the governments' current borrowing decisions and the exogenous shocks.

The government's sequential budget constraint is therefore given by

$$p_t^N g_t^N + \delta b_t + (1 - \zeta_t)q_t i_t = \tau_t, \quad (9)$$

2.4 Foreign Lenders

It is assumed that the sovereign bonds are traded with atomistic, risk-neutral foreign lenders. In addition to investing through the defaultable bonds, lenders have access to one-period riskless security paying a gross interest rate R . By an arbitrage condition, bond prices are then given by:

$$q_t = \frac{1}{R} \mathbb{E}_t((1 - \delta)q_{t+1} - \chi_{t+1}). \quad (10)$$

Lenders anticipate the government's default decisions and demand lower bond prices, or equivalently, higher returns, to compensate for a higher equilibrium probability of default.

2.5 Equilibrium

In equilibrium, the market for nontradable goods clears:

$$c_t^N + g_t^N = F(h_t). \quad (11)$$

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

$$p_t^N = \mathcal{P}(c_t^T, h_t, g_t^N) = \frac{1 - \omega}{\omega} \left(\frac{c_t^T}{F(h_t) - g_t^N} \right)^{\mu+1} \quad (12)$$

Combining the households' budget constraint (2) with the definition of the firms' profits and market clearing condition (11), the resource constraint of the economy is given by

$$c_t^T = y_t^T + (1 - \zeta_t)[-q_t i_t + \delta b_t] \quad (13)$$

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

$$w_t \geq \bar{w}, \quad (14)$$

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:

$$h_t \leq \bar{h}. \quad (15)$$

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

$$(w_t - \bar{w})(\bar{h} - h_t) = 0. \quad (16)$$

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

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 (9), subject to (7).*
3. *Bond pricing equation (10) holds.*
4. *The market for nontradable goods clears.*
5. *The labor market satisfies (14)-(16).*

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:

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

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

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

subject to

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

and the value of default, given by:

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

subject to

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

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

Let $s = (y^T, b, \zeta)$ denote the aggregate state of the economy. Let $\{\chi(s), c^T(s), g^N(s), \tau(s), b'(s), h(s)\}$ 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 $\{\chi(s), c^T(s), g^N(s), \tau(s), b'(s), h(s)\}$, and a bond price schedule $q(s, b')$ such that*

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

$$q(y^T, b') = \frac{1}{R} \mathbb{E}(1 - \chi(y^{T'}, b')). \quad (17)$$

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 (12), 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 (9)). Both alternatives are costly: Increasing taxes leads to direct welfare losses; increasing borrowing raises default risk and the possibility of perceiving 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.² 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. In each panel, the red dot indicates the level of the variable of interest at the optimal level of public spending. The third panel of the first column shows that the relative price of nontradable goods is an increasing function of g^N . The first panel of the right column shows how this change in relative prices translates to employment, with higher levels of public spending being associated with higher levels of employment. The last panels of Figure 1 show 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. The last panel of

²To conduct this exercise we used the calibrated economy of Section 3.

Figure 2 in turn shows how if debt is unchanged increasing public spending leads to large changes in distortionary taxes.

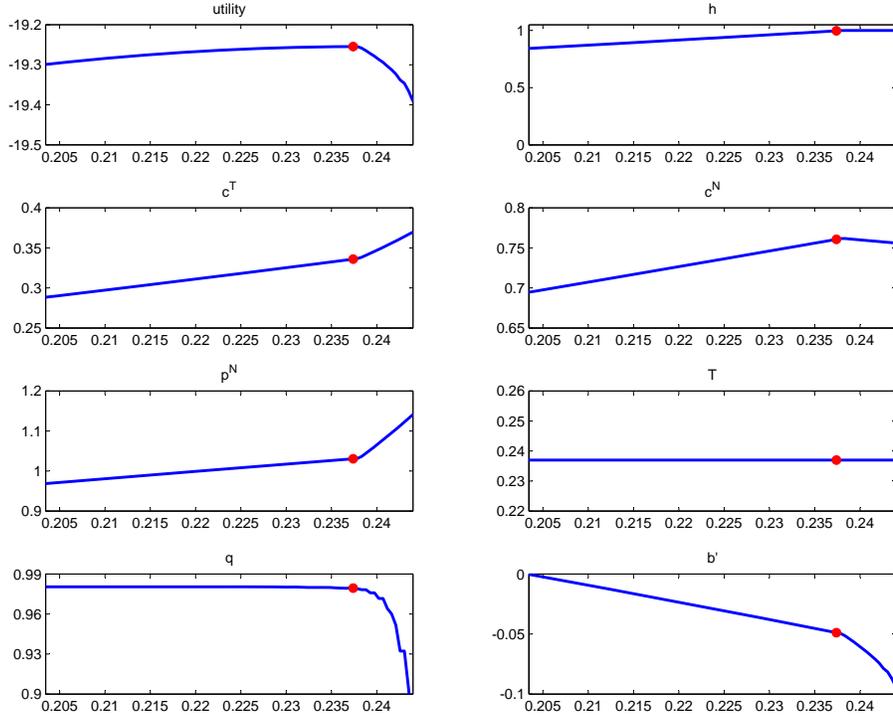


Figure 1: UTILITY, PRICES AND ALLOCATIONS UNDER REPAYMENT FOR ALTERNATIVE VALUES OF CURRENT g^N .

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 for current state $(y^T, b) = (1.0496, -0.04)$. Red dots indicate equilibrium levels given optimal g^N .

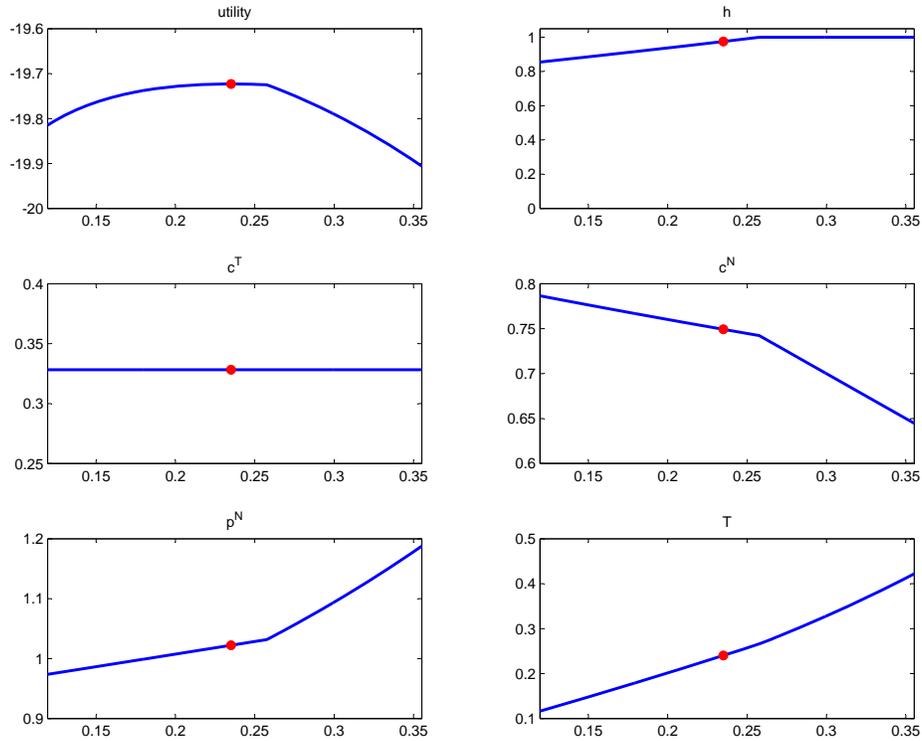


Figure 2: UTILITY, PRICES AND ALLOCATIONS IN AUTARKY FOR ALTERNATIVE VALUES OF CURRENT g^N .

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 1.0496. Red dots indicate equilibrium levels given optimal g^N .

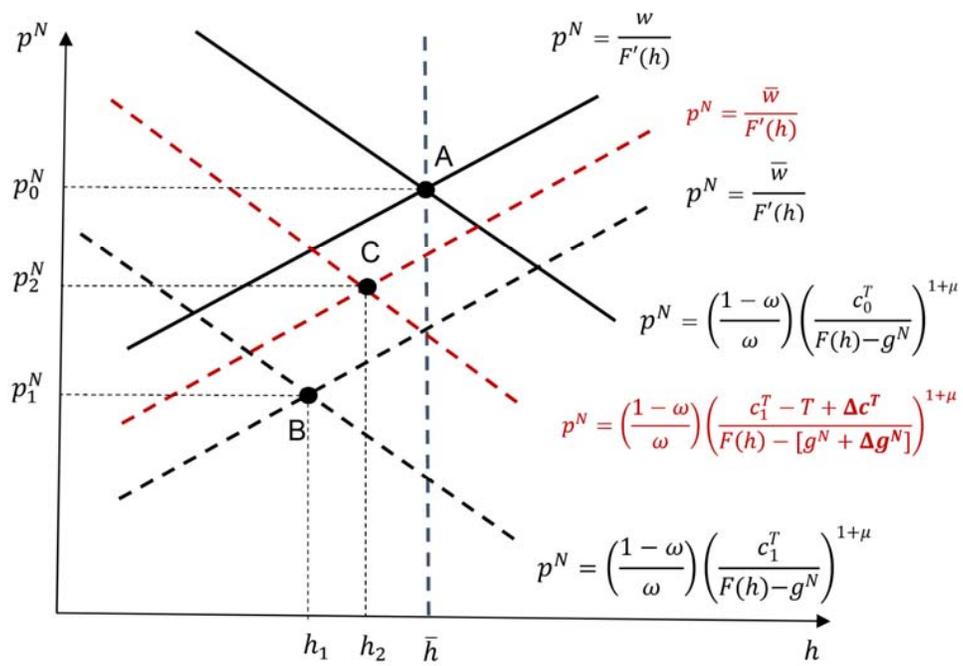


Figure 3: Illustration of Effects of Government Spending

3 Quantitative Analysis

3.1 Calibration

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 1995-2015. We consider the following functional forms. We assume constant relative risk aversion (CRRA) utility functions for private and public consumption:

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

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:

$$F(h) = h^\alpha, \quad \alpha \in (0, 1). \quad (18)$$

The maturity of long-term debt will be calibrated to the average duration in the data. For now, we consider one period debt only.

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

$$\Omega(\tau) = \psi_\tau \tau^2, \quad (19)$$

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.

As mentioned before, in addition to temporary exclusion from financial markets, the government suffers a direct utility cost of default given by $\psi_\chi(y^T)$. We assume the following form for this utility loss in autarky:

$$\psi_\chi(y_t^T) = \max\{0, \psi_\chi^0 + \psi_\chi^y \log(y_t^T)\}, \quad (20)$$

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 subduing spreads volatility.

All parameter values used in the baseline calibration are shown in [Table 1](#). 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, 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 0.25, in line with the data. 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 1998 to 2015, which amounts to 18.3 percent of total output.

The time discount factor β is set to 0.9, within the range of values used in the sovereign default literature. The utility costs parameters ψ_χ^0 and ψ_χ^1 chosen to generate a mean and volatility of bond spreads consistent with the data.

The international risk-free rate R is equal to 1.02, 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 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.

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

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

Table 1: BASELINE PARAMETER VALUES

Parameter	Value	Description
β	0.90	Subjective discount factor
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_g	0.041	Weight of public consumption in utility function
ψ_τ	0.5	Tax distortion parameter
ψ_χ^0	0.112	Utility loss from default (intercept)
ψ_χ^y	1.685	Utility loss from default (slope)
α	0.63	Labor share in nontradable sector
R	1.02	Gross world risk-free rate
θ	0.2	Reentry probability
\bar{w}	0.65	Lower bound on wages
\bar{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

where the shock $\varepsilon_{t+1}^y \sim i.i.d. \mathcal{N}(0, 1)$. The space of y_t^T is discretized into 41 points, and the stochastic process is approximated with a Markov chain using Tauchen and Hussey (1991) quadrature method.³ 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 output in these sectors (and overall economy) are taken from the National Accounts in the National Statistics Office (INE) of Spain. Public spending, external debt and tradable production are computed as a percentage of total output. Data on annual public spending (General Government), external debt, and total tax revenues has been taken from the World Development Indicators (WDI) database of the World Bank.

3.2 Policy Functions

This section analyzes the policy functions of the calibrated economy under the optimal fiscal policy. Figure 4 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 light and dark blue lines in each panel correspond to a

³For bond holdings, we use 200 gridpoints to solve the model and no interpolation.

low and a high realization of the tradable endowment y^T , respectively.⁴ Solid lines are used when repayment is optimal, dotted lines when default is. In order to better understand the effect of optimal government policy, we compare the results with the decision rules and relative prices for an identical economy where government spending is set to attain full employment ($h_t = \bar{h}$) at all times and states, which are plotted in Figure 5. In this latter economy the government is still free to choose bond holdings and transfers to maximize households' utility.

Figure 5 shows that to attain full employment, government spending should be higher for high levels of debt and low levels of tradable endowment. The reason for this is that with incomplete markets, the optimal tradable consumption is lower for high levels of debt and low levels of tradable endowment which, in the absence of government spending, would lead to a real exchange-rate depreciation and, given the downward wage rigidity, to higher unemployment. The government can attain full employment despite the fall in tradable consumption by increasing government spending and stabilizing the real exchange rate. Clearly, more g^N is required with low levels of the tradable endowment. Without wage rigidities public spending would be decreasing in debt since the higher the indebtedness level, the lower c^T would be and, hence, the higher would be the marginal utility of nontradable consumption. In contrast, in this economy, as debt increases, higher g^N is required to prevent p^N from falling and thus sustain full employment. Figure 5 also shows that the government finances higher g^N through more borrowing and higher taxes.

However, Figure 4 shows that this policy would not be optimal. The large increase in taxes necessary to finance the full-employment policy leads to inefficiencies associated with welfare losses from taxation.

It is interesting to note that the optimal response of public spending to tradable endowment shocks depends on the debt position. For low levels of debt, a lower tradable endowment would be associated with higher public spending. For relatively higher levels of debt, a lower tradable endowment would be associated with lower public spending. Next sections studies the endogenous dynamics of debt simulating the calibrated economy.

⁴More specifically, the low (high) realization corresponds to the one unconditional standard deviation below (above) the unconditional mean of y^T .

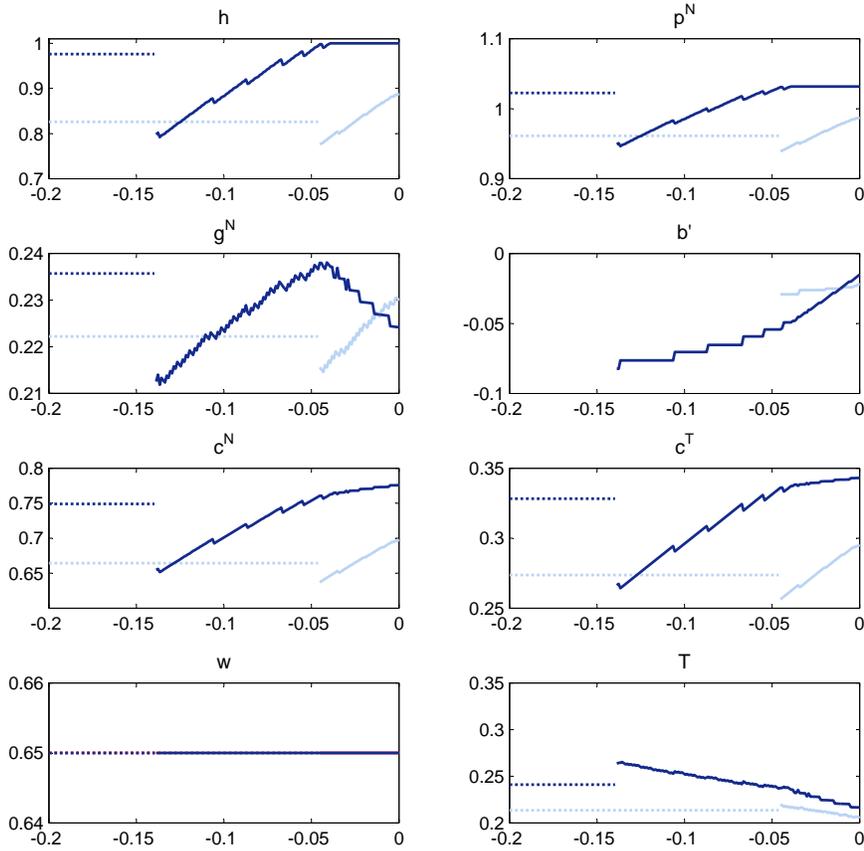


Figure 4: POLICY FUNCTIONS WITH OPTIMAL GOVERNMENT SPENDING, AS FUNCTION OF CURRENT DEBT b .

Note: Light blue lines correspond to the low y^T realization and dark blue lines correspond to the high y^T realization. Solid lines represent policy functions when repayment is optimal and dotted lines represent policy functions in autarky.

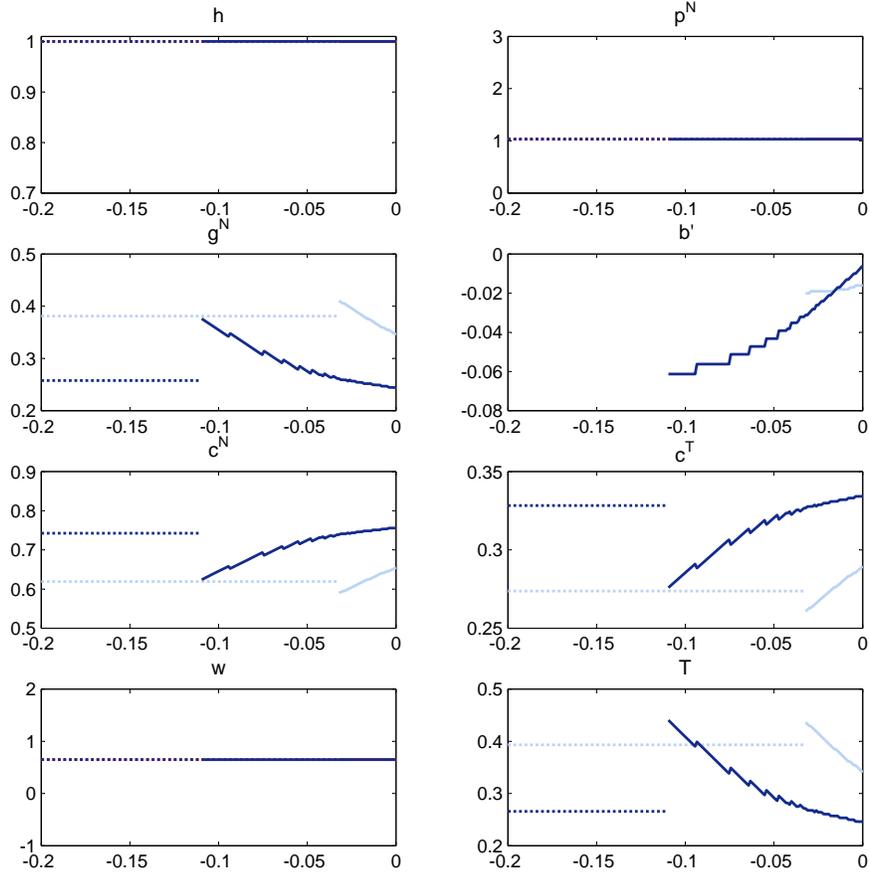


Figure 5: POLICY FUNCTIONS WITH FULL EMPLOYMENT, AS FUNCTION OF CURRENT DEBT b .

Note: Light blue lines correspond to the low y^T realization and dark blue lines correspond to the high y^T realization. Solid lines represent policy functions when repayment is optimal and dotted lines represent policy functions in autarky.

3.3 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 2,000 Monte Carlo (MC) simulations of the model with 2,000 periods each, and consider subsamples of 32 periods of financial access.⁵

Table 2: BUSINESS CYCLE STATISTICS FOR THE BASELINE MODEL, NO DISTORTIONARY TAXATION MODEL, FLEXIBLE WAGE MODEL, AND CREDIT FRICTION MODEL

Statistic	Baseline Model	No Distortionary Taxes	Flexible Wages	Credit Frictions
mean(spreads)	0.83	0.77	0.68	0.79
mean(b/y)	-3.16	-2.84	-10.56	-3.06
mean(pg^N/y)	18.29	20.95	12.29	18.47
mean(T)	0.023	0.027	0.015	0.023
mean(h)	0.902	0.943	1	0.903
freq($h = 1$)	0.129	0.379	1	0.132
freq(default)	0.791	0.742	0.655	0.769
cor(g^N, y)	0.62	0.13	0.78	0.27
cor(g^N, y^T)	0.50	-0.11	0.59	0.24
cor(g^N, h)	0.65	0.22	0	0.46
cor(y, c)	1.00	0.98	1.00	0.99
cor($y, \text{spreads}$)	-0.50	-0.51	-0.66	-0.46
std.dev.(y)	0.049	0.044	0.091	0.049
std.dev.(g^N)	0.030	0.060	0.007	0.044
std.dev.(c)/std.dev.(y)	0.878	0.987	0.322	0.887
std.dev.(T)	0.008	0.015	0.009	0.009
std.dev.(b/y)	0.006	0.005	0.014	0.006
std.dev.(spreads)	0.007	0.006	0.006	0.008

Note: Bond spreads are computed as the differential between the annual sovereign bond return and the annual risk-free rate.

⁵To 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.

The model predicts two key features about the optimal fiscal policy. First, the optimal fiscal policy is procyclical, with a correlation between public spending and output of 0.62. This prediction contrast with the -0.30 correlation between public spending and output observed in the data for the period 1998-2011. Second, public spending is relatively smooth. The volatility of public spending is 60 percent that of output, which compares to almost 90 percent of private consumption volatility relative to output. In the data government spending is also found to be relatively smooth with 30 percent of the volatility of output.

To disentangle the mechanisms driving the optimal fiscal policy, Table 2 also reports the moments of an economy with no distortionary taxes an an economy with flexible wages. Both ingredients seem to be relevant explaining the patterns of the optimal policy. On the one hand without distortionary taxation, the optimal policy would be only mildly procyclical (0.13 correlation of public spending with output) and significantly more volatile (50 percent more volatile than output). On the other hand, without wage rigidity fiscal policy would be even more procyclical (0.78 correlation with output) and would practically not vary over the cycle.

One caveat of this analysis is that the results presented have a debt in the model, which is much lower than in the data. In future updates, we plan to consider long-term, which allows for a better fit of the data, as shown by ?.

3.4 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.⁶ 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

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

⁶Technically, 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.

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 6 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.⁷ 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.⁸ 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 compensation of adopting policy i relative to conducting policy j , denoted by $\bar{\lambda}^{i,j}$ satisfies

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

with $\bar{\Delta V} \equiv \sum_{s \in \mathcal{S}} \mu^i(s) V^i(s) - \sum_{s \in \mathcal{S}} \mu^j(s) V^j(s)$, and $(\bar{c}^j)^{-1} \equiv \sum_{s \in \mathcal{S}} \mu^j(s) c^j(s)$, and where μ^i and μ^j are the ergodic distributions of the state $s \in \mathcal{S}$ under policy i and j , respectively.⁹ 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

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.

⁷The low (high) endowment level are one unconditional standard deviation below (above) the unconditional mean of y^T .

⁸The 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.

⁹For 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.

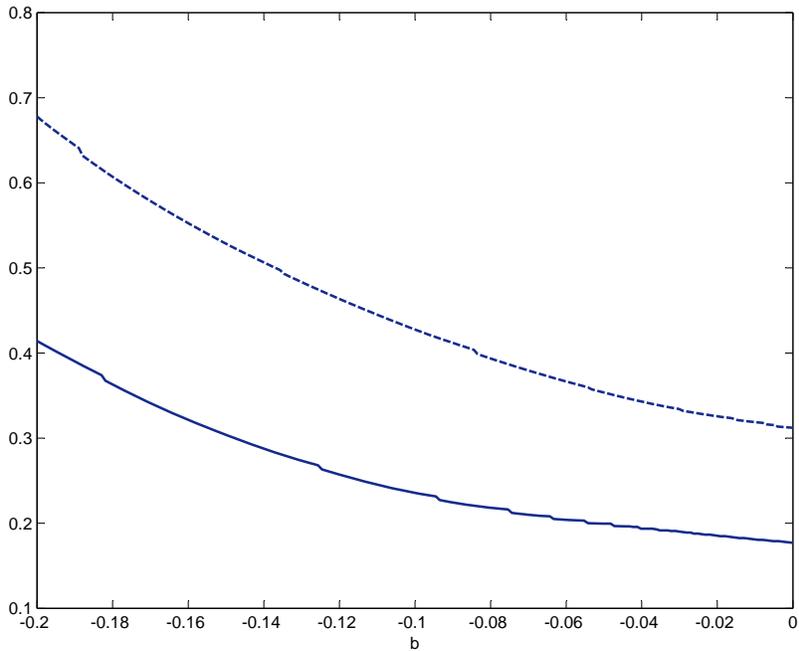


Figure 6: WELFARE GAINS IN REPAYMENT OF OPTIMAL FISCAL POLICY RELATIVE TO FULL-EMPLOYMENT POLICY, AS FUNCTION OF CURRENT DEBT b .

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.

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

$$y_t^T = A_t^T F^T(m_t), \quad (21)$$

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:

$$p_m m_t \leq \kappa_t (y_t^T + p_t^N y_t^N). \quad (22)$$

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 (22) 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 (21) and (4) and the collateral constraint (22), given prices p_t^N and wages w_t .

Let λ_t denote the Lagrange multiplier associated with the collateral constraint (22). The first-order conditions with respect to m_t and h_t are

$$\begin{aligned} A_t^T F_m^T(m_t)(1 + \kappa_t \lambda_t) &= p_m(1 + \lambda_t) \\ p_t^N F_h^N(h_t)(1 + \kappa_t \lambda_t) &= w_t \end{aligned}$$

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

$$\lambda_t \geq 0, \quad \lambda_t (\kappa_t (y_t^T + p_t^N y_t^N) - p_t m_t) = 0. \quad (23)$$

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 7 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

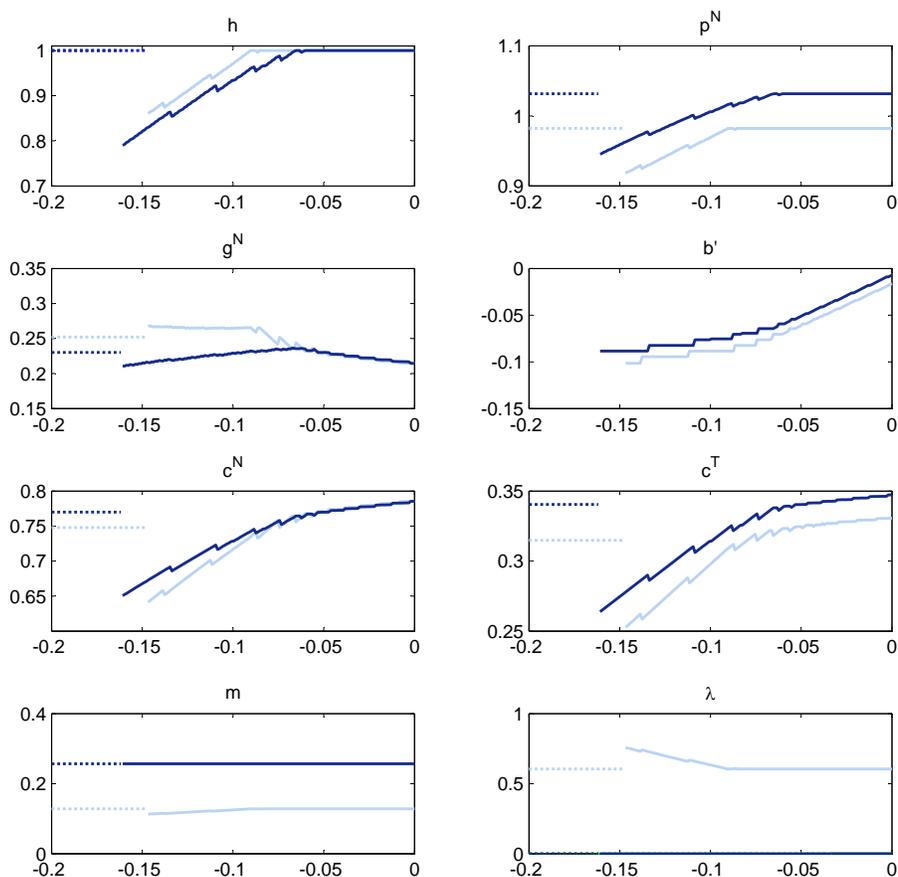


Figure 7: OPTIMAL POLICY FUNCTIONS WITH CREDIT FRICTIONS, AS FUNCTION OF CURRENT DEBT b .

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.

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.

The reduction in nontradable consumption—due to the crowding out of government spending—is more than compensated by a rise in government spending and in tradable consumption—following the relaxation of collateral constraints—leading to higher welfare for households.

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 how long-term debt maturity allows for a more active stabilization policy. Moreover, we are also considering aspects of commitment in the conduct of optimal fiscal policy and in the design of fiscal rules.

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