Unemployment, Sovereign Debt, and Fiscal Policy in a Currency Union

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Abstract

Is fiscal stimulus desirable when financing the government spending might imply a surge in borrowing costs and potentially lead to a sovereign debt crisis? This paper studies the optimal fiscal policy for a small open economy in a currency union in which the government cannot commit. In our two-sector dynamic model, the presence of downward nominal wage rigidity coupled with financial frictions may give rise to the welfare-improving effects of an expansionary fiscal policy. The government is confronted with a trade-off between the benefits of reducing unemployment and the financial costs of increasing external borrowing. A quantitative analysis is conducted to assess the desirability of austerity plans and stimulus programs in the context of the ongoing European debt crisis. In our theoretical framework, the response of the economic activity to government expenditures is highly nonlinear in the stock of external debt and the magnitude of the shocks.

1 Introduction

The slump of economic activity that started in 2008 in the Euro Area renewed the policy debate on the role of fiscal stimulus during financial crises. On the one hand, a "Keynesian view" argues that high unemployment in the context of a constrained monetary policy calls for expansionary government spending (see, for example, Krugman (2015)). On the other hand, an "austerity view" argues that, with the Euro economies' high initial levels of external debt, expansionary government spending can increase further financial costs and the probability of a sovereign default (see, for example, Cochrane (2011) and Barro (2012).

Motivated by this debate, the objective of this paper is to study the trade-off facing fiscal policy between reducing unemployment and increasing sovereign debt and thereby borrowing costs. The environment is a two-sector small open economy with a currency peg in which nominal wages are downwardly rigid and firms face occasionally binding borrowing constraints linking working capital to the value of tradable and nontradable output. Following a negative shock to productivity, the economy can exhibit inefficiently low production. First, the combination of a fixed exchange rate regime and a downward wage rigidity leads to a real wage rigidity that can cause involuntary unemployment. Second, low household spending can lead to low collateral values, reducing firms' borrowing capacity. Wasteful government spending can affect relative prices and therefore simultaneously reduce unemployment and relax firms' borrowing constraints. Nontradable output can be boosted as real wages decline and firms raise their labor demand. Gross tradable output can rise as collateral values are driven up allowing firms to borrow more in order to finance working capital. To our knowledge, this constitutes a novel mechanism through which expansionary fiscal policy can boost output and reduce unemployment improving households' welfare.

In our economy the government cannot commit and has only access to lump-sum transfers and non-state-contingent external borrowing to finance government expenditures. International investors charge a debt elastic interest rate on sovereign bonds capturing the fact that higher indebtness levels tend to induce more default risk. In this context, although fiscal policy can increase production and consumption (as in the Keynesian view), it can also lead to higher debt and borrowing costs (as in the austerity view).

Conducting a quantitative study calibrated to the recent Euro Area debt crisis, the paper provides positive and normative contributions. We show that the optimal size of government purchases depends critically on the sovereign debt level and the magnitude of the productivity shocks. Furthermore, the response of economic aggregates is highly nonlinear in the state of the economy. This can potentially help reconcile a wide range of empirical estimates of fiscal multipliers.

In a welfare analysis, we find that optimal government spending can lead to welfare gains of around 0.075 percent of permanent consumption relative to the case without government purchases, and of 0.5 percent relative to fiscal policy aimed at ensuring full employment in all states.

Related Literature. The paper belongs to a growing literature focused on the role of government spending as a macroeconomic stabilization tool. Several papers have found empirical support for the fact that government purchases raise private consumption and real wages.[1] Providing a theoretical framework that can reconcile this feature in general equilibrium has been challenging in the literature. The reason is simple: an increase in government spending implies that the net present value of taxes has to rise, which brings about a negative wealth effect on households. In response to this negative effect, they reduce consumption and increase their labor supply to firms.

Some papers, however, have managed to explain this finding within an equilibrium model. Ravn, Schmitt-Grohé and Uribe (2012) can generate a positive response of private consumption to a surge in government spending using a deep-habit mechanism.[2]

In a model with sticky prices, in which markups tend to fall with an increase in government spending, Galí, López-Salido and Vallés (2007) show that the presence of rule-of-thumb consumers without access to borrowing or saving technology can help reconcile the desired response of private consumption.[3]

Monacelli and Perotti (2008) find that in a model with price rigidity under preference specifications with a high degree of complementarity between hours and consumption

[1] See, for example, Blanchard, and Perotti (2002) , Galí, López-Salido and Vallés (2007), Monacelli, and Perotti (2008) and Ravn, Schmitt-Grohé and Uribe (2012)

[2] When households exhibit deep habits in consumption (that is, habits at the level of individual goods rather than consumption bundles), the expansion of domestic demand following the increase in government purchases induces firms to cut their domestic markups shifting outward the labor demand curve. Consequently, real wages increase and households end up substituting consumption for leisure. If this substitution effect dominates the negative wealth effect, private consumption expands in equilibrium.

[3] As domestic demand expands, employment and real wages rise and therefore consumption of rule-of-thumb households increases pushing up aggregate consumption, which further expands output and employment magnifying the overall effect.

—such as GHH preferences—, the wealth effect on labor supply can be sufficiently low that an increase in government spending may cause private consumption to rise.[4]

The mechanism in our model differs from the ones in these studies along two main dimensions. First, rather than the size of government expenditures and transfers, its composition in terms of tradables and nontradables plays a key role in altering relative prices and thereby boosting output and consumption. Second, given the assumption of an inelastic supply of hours to work, no wealth effect on labor supply emerges in our model. An increase of the relative price leads to a downward move along the labor demand, causing involuntary unemployment to drop. Additionally, tradable output expands as firms' collateral constraints relax, a channel not present in these other studies. Private consumption, in turn, rises as firms' profits and labor income increase.

Also, while several studies have focused on reconciling the positive response of consumption and output to an increase in government spending, little progress has been made on understanding why wasteful government spending can improve social welfare. A notable exception is Bilbiie, Monacelli and Perotti (2014). Even though output multipliers of government purchases can be significantly higher at the zero lower bound, they find quite low levels of optimal government spending in that situation for a reasonable parametrization of the economy. Our paper contributes to this line of research as well.[5]

Our paper also builds on Schmitt-Grohé and Uribe (2015) which proposes an open economy model with downward nominal wage rigidity, an empirical regularity they document for emerging economies. The combination of this friction with a currency peg and free capital mobility gives rise to a negative externality: overborrowing in goods times and excessive involuntary unemployment in bad times. While their focus is on the optimal exchange rate policy and management of the capital account, we analyze fiscal and debt policies in the context of the the ongoing debates in the Euro Area on fiscal stimulus vs. austerity plans. Na, Schmitt-Grohé, Uribe, and Yue (2014) extends this framework to incorporate sovereign default risk.

Finally, our work relates to Arellano, and Bai (2013). This paper examines the desirability of fiscal austerity programs and concludes that they can be beneficial only if

[4]In recent years, a lot of attention has been put on the impact of government spending on economic activity at the zero lower bound for the nominal interest rate. Christiano, Eichenbaum and Rebelo (2011), Werning (2011), Woodford (2011), among others, find that the output multiplier of government purchases can be significantly higher that in normal times.

[5]Werning (2011), Eggertsson and Krugman (2012) and Farhi and Werning (2012) study optimal government spending in liquidity traps. Galí and Monacelli (2008) analyze the design of optimal monetary and fiscal policy in a currency union. In a recent paper with wasteful government spending, Galí (2014) shows that fiscal stimulus entirely financed with money creation can increase households' welfare.

they help reduce the likelihood of sovereign defaults triggered by the government's inability to raise sufficient tax revenues, and not by strategic considerations under which servicing the debt is feasible but too costly in terms of welfare.

Roadmap. The paper is organized as follows. Section 2 presents the model and defines the equilibrium. Section 3 introduces different fiscal policy regimes and formulates the government problem. Section 4 presents the quantitative analysis of the model calibrated to the Spanish economy. It also evaluates the welfare implications under the different policy schemes. Section 5 concludes.

2 Model

2.1 Households

Households' preferences over consumption are described by the intertemporal utility function:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \tag{1}$$

where c_t denotes consumption in period t; $u : \mathbb{R}_+ \to \mathbb{R}$ is a twice continuously differentiable, strictly increasing, strictly concave function; $\beta \in (0,1)$ is the subjective discount factor, and $\mathbb{E}_t$ denotes expectation operator conditional on the information set available at time t. It should be stressed that the government spending does not provide utility directly to the household.

The consumption good is assumed to be a composite of tradable and nontradable goods, 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 $1/(1+\mu)$.

Each period, households receive profits Π_t from the ownership of firms producing nontradable and tradable goods. They inelastically supply $\overline{h}$ hours of work to the labor market. As in Schmitt-Grohé and Uribe (2015), due to the presence of the wage rigidity (discussed in detail in the next subsection), households will only be able to sell $h_t \leq \overline{h}$ hours in the labor market. The actual hours worked h_t is determined by firms and taken as given by the households. Households do not have access to external borrowing; only the government can borrow from abroad. Households' sequential budget constraint is therefore given by

$$c_t^T + p_t c_t^N = \Pi_t + w_t h_t - T_t, \tag{2}$$

where $p_t \equiv \frac{P_t^N}{P_t^T}$ denotes the relative price of nontradables in terms of tradables, w_t denotes the wage rate in terms of tradable goods and T_t is the lump-sum transfers (subsidies or taxes) from the government in tradable goods.

The households' problem consists of choosing c_t^T and c_t^N to maximize (1) given prices p_t and w_t, profits Π_t and government transfers T_t. The first-order condition of this problem yields

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

2.2 Firms

Firms have access to a dimishing-returns-to-scale (DRS) technology to produce tradable goods with an imported intermediate good as single input, and to a DRS technology to produce nontradable goods with labor. Production functions are given by:

$$y_t^T = A_t^T F^T(m_t), \tag{4}$$

$$y_t^N = A_t^N F^N(h_t) \tag{5}$$

where y_t^T denotes the gross output of tradable goods in period t, y_t^N denotes the gross output of nontradable goods in period t, A_t^T and A_t^N denote exogenous and stochastic productivity shocks, m_t denotes the imported intermediate goods used in tradable production, and $F^T : \mathbb{R}_+ \to \mathbb{R}$ and $F^N : \mathbb{R}_+ \to \mathbb{R}$ are twice continuously differentiable, strictly increasing, strictly concave functions. Let $A_t \equiv \begin{bmatrix} A_t^T & A_t^N \end{bmatrix}'$ denote the vector of productivity shocks, which is assumed to follow a stationary first-order Markov process.

Total firms profits each period are then given by

$$\Pi_t = y_t^T + p_t y_t^N - p_m m_t - w_t h_t, \tag{6}$$

where p_m is the (constant) price of imported inputs in terms of tradable goods, purchased by firms in a competitive international market.

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

$$p_m m_t \leq \kappa_t \left(y_t^T + p_t Y_t^N \right). \tag{7}$$

where Y_t^N is the aggregate nontradable output in the economy. To some extent, this is similar to the collateral constraint assumed by Bianchi (2012) and Benigno, Chen, Otrok, Rebucci and Young (2013), among others, where borrowing is limited to a constant fraction of gross output denominated in tradable goods. 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 (7) will be occasionally restricting the quantity of imported inputs to firms, depending on the state of the economy.

Let m_t^* be the quantity of imported inputs demanded by firms when the collateral constraint is slack, ie.

$$m_t^* = \left(\frac{p_m}{a_t \gamma} \right)^{\frac{1}{\gamma - 1}}. \tag{8}$$

The firms' problem is to choose m_t and h_t to maximize (6), subject to the technology constraints (4) and (5) and the collateral constraint (7), given prices p_t and wages w_t.

Denoting by λ_t the Lagrange multiplier associated with the collateral constraint (7), the first-order condition with respect to m_t is:

$$\text{If } \lambda_t > 0, \qquad \lambda_t = \frac{A_t^T F_m^T(m_t) - p_m}{p_m - \kappa_t A_t^T F_m^T(m_t)}. \tag{9}$$

where $F_m^T(m) \equiv \frac{\partial F^T(m)}{\partial m}$.

$$\text{If } \lambda_t = 0, \qquad m_t = m_t^*, \tag{10}$$

The labor choice h_t is given by

$$p_t A_t^N F_h^N(h_t) = w_t. \tag{11}$$

where $F_h^N(h) \equiv \frac{\partial F^N(h)}{\partial h}$.

And the complementary slackness conditions are

$$\lambda_t \geq 0, \qquad \lambda_t \left(\kappa_t \left(y_t^T + p_t y_t^N\right) - p_m m_t\right) = 0. \tag{12}$$

Since individual firms do not internalize the impact of their labor choice h_t on aggregate nontradable output, their labor demand is the same as in an economy without collateral constraints, i.e. it equates the marginal product of labor to real wages.

2.3 Government

The government is benevolent and maximizes households' utility. It determines each period public spending g_t^N, a lump-sum transfers T_t, and has access to one-period, non-state-contingent bonds denominated in units of tradable goods that can be traded internationally paying a debt-elastic gross interest rate $R(b_{t+1})$. The government's sequential budget constraint is therefore given by

$$p_t g_t^N + \frac{b_{t+1}}{R(b_{t+1})} = b_t + T_t, \tag{13}$$

and b_{t+1} denotes bonds due in period $t+1$.

As usual, the government spending is assumed to be nonnegative

$$g_t^N \geq 0, \tag{14}$$

Finally, the government is subject to an *ad hoc* borrowing limit:

$$b_{t+1} \geq \underline{b}. \tag{15}$$

Section 3 defines different fiscal policy regimes.

2.4 Labor Market

It is assumed that nominal wages have a lower bound $\overline{W}$, by which $W_t \geq \overline{W}$ 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

$$w_t \geq \overline{w}, \tag{16}$$

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

$$h_t \leq \overline{h}. \tag{17}$$

Following Schmitt-Grohé and Uribe (2015), labor market closure requires that the following slackness condition must hold for all dates and states:

$$(w_t - \overline{w})\left(\overline{h} - h_t\right) = 0. \tag{18}$$

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.

2.5 Equilibrium

In our economy we assume that the government has no ability to commit. We are interested in a Markov recursive equilibrium in which all agents —government, households and firms— choose sequentially.

In equilibrium, the market for nontradable goods clears at all times, i.e.

$$c_t^N + g_t^N = A_t^N F(h_t). \tag{19}$$

Combining the equilibrium price equation (3) with resource constraint (19), the relative price p_t can be expressed as

$$p_t = \frac{1-\omega}{\omega}\left(\frac{c_t^T}{A_t^N F(h_t) - g_t^N}\right)^{\mu+1} \tag{20}$$

Combining the households' budget constraint (2) with the definition of the firms' profits and market clearing condition (19), tradable consumption is

$$c_t^T = A_t^T F^T(m_t) - p_m m_t + p_t^N g_t^N - T_t \tag{21}$$

The equilibrium level for imported input m_t is determined jointly with the dynamics of the Lagrange multiplier λ_t, as reflected by conditions (9) and (10).

The general equilibrium dynamics are then given by stochastic processes for households and firms' allocations $\{c_t^N, c_t^T, m_t, h_t\}_{t=0}^{\infty}$, Lagrange multipliers $\{\lambda_t\}_{t=0}^{\infty}$, prices $\{p_t, w_t\}_{t=0}^{\infty}$, satisfying the set of equations (GE): (9)-(21), given a fiscal policy $\{g_t^N, T_t\}_{t=0}^{\infty}$, a debt policy $\{b_{t+1}\}_{t=0}^{\infty}$, initial conditions b_0, and exogenous stochastic processes for productivity $\{A_t\}_{t=0}^{\infty}$.

3 Fiscal Policy: Definitions and Analytical Results

3.1 Fiscal Policy Regimes

This section defines two possible fiscal regimes: optimal policy and full-employment policy.

Optimal Fiscal Policy. The optimal fiscal policy is defined as follows:

Definition 1 *The optimal fiscal policy is the set of processes $\left\{g_t^N, T_t\right\}$ that, jointly with an optimal debt process $\left\{b_{t+1}\right\}$, maximize households' expected lifetime utility (1) subject to the set of equations describing the general equilibrium dynamics (GE).*

The optimal fiscal and debt policies solve the government problem, given by the following Bellman equation:

$$
\begin{aligned}
V(A,\kappa,b) = & \max_{c^T,m,h,p,w,\lambda,b',g^N,T} \left\{ u\left(C\left(c^T, A^N F(h) - g^N\right)\right) + \beta \mathbb{E}_{A'}\left[V(A',\kappa',b')\,|A\right]\right\} \\
\text{s.t. } & c^T = A^T F^T(m) - p_m m + p g^N - T, \\
& p = \frac{1-\omega}{\omega}\left(\frac{c^T}{A^N F^N(h) - g^N}\right)^{\mu+1}, \\
& \lambda = \frac{A^T - p_m}{p_m - \kappa A^T}, \\
& p A^N F_h^T(h) = w, \\
& \lambda = \frac{A^T F_m^T(m) - p_m}{p_m - \kappa A^T F_m^T(m)}, \\
& \lambda\left(\kappa\left(A^T F^T(m) + p A^N F^N(h)\right) - p_m m\right) = 0, \\
& \kappa\left(A^T F^T(m) + p A^N F^N(h)\right) - p_m m \geq 0, \\
& p g^N + \frac{b'}{R(b')} = b + T, \\
& w \geq \overline{w}, \\
& h \leq \overline{h}, \\
& (w - \overline{w})\left(\overline{h} - h\right) = 0, \\
& g^N \geq 0, \\
& b' \geq \underline{b},
\end{aligned} \tag{22}
$$

where time subscripts for variables dated in period t have been dropped, and a prime is used to indicate variables dated in period $t+1$. Let $V(A,\kappa,b)$ denotes the value function for households under the optimal fiscal policy.

Full-Employment Fiscal Policy. For this regime, consider a fiscal policy aimed at maintaining full employment at all states and dates. Under the full-employment policy,

$$
h_t = \overline{h}, \qquad \forall t. \tag{23}
$$

Definition 2 *The full-employment fiscal policy is the set of processes* $\left\{g_t^N, T_t\right\}$ *that, jointly with an optimal debt process* $\{b_{t+1}\}$*, maximize households' expected lifetime utility (1) subject to the set of equations describing the general equilibrium dynamics (GE), and the full-employment constraint (23).*

The dynamics under the optimal full-employment policy can be thus expressed with the Bellman equation,

$$
\begin{aligned}
V^{\mathrm{FE}}(A,\kappa,b) = &\max_{c^T,m,p,w,\lambda,b',g^N,T} \left\{ u\left(C\left(c^T, A^N F^N\left(\overline{h}\right) - g^N\right)\right) + \beta \mathbb{E}\left[V^{\mathrm{FE}}\left(A',\kappa',b'\right)|A\right]\right\} \\
\text{s.t. } & c^T = A^T F^T(m) - p_m m + p g^N - T, \\
& p = \frac{1-\omega}{\omega}\left(\frac{c^T}{A^N F^N(\overline{h}) - g^N}\right)^{\mu+1}, \\
& \lambda = \frac{A^T - p_m}{p_m - \kappa A^T}, \\
& p A^N F_h^T\left(\overline{h}\right) = w, \\
& \lambda = \frac{A^T F_m^T(m) - p_m}{p_m - \kappa A^T F_m^T(m)}, \\
& \lambda\left(\kappa\left(A^T F^T(m) + p A^N F^N(\overline{h})\right) - p_m m\right) = 0, \\
& \kappa\left(A^T F^T(m) + p A^N F^N(\overline{h})\right) - p_m m \geq 0, \\
& p g^N + \frac{b'}{R(b')} = b + T, \\
& w \geq \overline{w}, \\
& g^N \geq 0, \\
& b' \geq \underline{b},
\end{aligned} \tag{24}
$$

where time subscripts for variables dated in period t have been dropped, and a prime is used to indicate variables dated in period $t+1$. Let $V^{\mathrm{FE}}(A,\kappa,b)$ denote the value function for households under the full-employment fiscal policy.

4 Quantitative Analysis

4.1 Calibration

To characterize the aggregate dynamics under the different exchange-rate regimes, calibrated versions of the functional equations (22) and (24) are solved numerically using value function iteration over a discrete state space. To do so, we specify our choices for functional forms and calibrate some parameter values to match key moments in the data at a quarterly frequency for the Spanish economy over the period 1980-2007.

For the calibration of our model, we consider the following functional forms. We assume a constant relative risk aversion (CRRA) utility function:

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

and an isoelastic form for the production functions in the tradable and nontradable sectors:

$$F^N(h) = h^\alpha, \qquad \alpha \in (0,1), \tag{25}$$

$$F^T(m) = m^\gamma, \qquad \gamma \in (0,1). \tag{26}$$

Following Schmitt-Grohé and Uribe (2003), we assume that the interest rate charged to the economy for a quantity b of loans is given by

$$R(b) = R + \psi e^b, \qquad \psi > 0, \tag{27}$$

where R is the world interest rate and the second term on the right hand side is a country-specific interest rate premium increasing in b.

We set $A_t^N = 1$ for all t, and assume that the productivity A_t^T in the tradable sector follows a log-normal AR(1) process,

$$\log A_{t+1}^T = \rho \log A_t^T + \sigma_\epsilon \epsilon_{t+1},$$

where the shock $\epsilon_{t+1} \sim i.i.d.\mathcal{N}(0,1)$. The space of A_t^T is discretized into 2 points, A_L^T and A_H^T, and the stochastic process is approximated with a Markov chain using Tauchen and Hussey (1991) quadrature method.[6]

Also, in this calibration κ_t follows a two-state Markov chain, which is perfectly correlated with the realization of A_t^T. In addition, we assume that when $A_t^T = A_H^T$, κ_t takes a value sufficiently high that the firms' collateral constraint does not bind. The value of κ_t when $A_t^T = A_L^T$, denoted by κ_L, plays a key role in the model dynamics, and is set to 0.11, which is within the range of values used in the literature.

All parameter values used in the baseline calibration are shown in Table 1.

The coefficient of relative risk aversion for the household is set to 2, which is standard in the literature. The value of the parameter μ implies a Cobb-Douglas specification for the consumption aggregator and an elasticity of substitution between tradable and

[6]For bond holdings, we use 150 gridpoints to solve the model and no interpolation. The *ad hoc* debt limit $\underline{b}$ is set to 1.

Table 1: BASELINE PARAMETER VALUES

Parameter	Value	Description
σ	2	Coefficient of risk aversion
$1+\mu$	1.0	Inverse of intratemporal elasticity of substitution
ω	0.3	Share of tradables
β	0.996	Subjective discount factor
κ_L	0.11	Share of income used as collateral
α	0.74	Labor share in nontradable sector
γ	0.48	Imported input share in tradable sector
$\overline{w}$	0.44	Lower bound on wages
$\overline{h}$	1	Inelastic supply of hours worked
ρ	0.63	AR(1) coefficient of productivity A_t^T
σ_ϵ	0.01	Standard deviation of ϵ_t
p_m	1	International price of imported input
R	1.005	Gross world risk-free rate
ψ	0.007	Interest rate premium parameter

nontradable consumption of 1, slightly above the range of values typically used in other studies.

The time discount factor β is calibrated to target the external debt-to-GDP ratio of 33 percent for Spain observed during the period 1980-2007 using the dataset of Lane and Milesi-Ferreti (2007). The share of tradables in the consumption composite implies a ratio of tradable output-to-total output of 0.29, in line with the data.

The households' inelastic supply of hours to work is normalized to 1. The labor share in the production of nontradable goods is 0.74, similar to the estimate found by Uribe (1997). Similarly, the imported input in total tradable output γ is set to 0.48, which is consistent with the evidence provided by Mendoza and Yue (2012).

The gross world risk-free rate R implies an annual net interest rate of 2 percent, which is approximately the average real return on German 10-year government bonds over the period 2002-2007. The parameter ψ that controls the sensitivity of the interest rate faced by the government to its indebtness level is set to 0.007 in order to match the average annual sovereign bond spread of 0.91 percent for Spain.

The parameters ρ and σ_ϵ for the stochastic process of A_t^T are estimated using quarterly data on the value-added in the agricultural and manufacturing sectors for Spain. Time series at a quarterly frequency for output in these sectors are taken from the National Accounts in the National Statistics Office (INE) of Spain. All these series are seasonally adjusted, and detrended using HP filter. Public spending, external debt and tradable production are computed as a percentage of total output. In the model, and throughout the remaining of the quantitative analysis, by tradable output y_t^T we will refer to the value-added in the production of tradable goods, i.e. $A_t^T m_t^\gamma - p_m m_t$. Total output y_t will be defined analogously.[7]

To compute the business cycle statistics, we run 2,000 Monte Carlo (MC) simulations of the model with 2,000 periods each.[8]

4.2 Model Statistics

Table 2 reports the moments of our baseline model under optimal policy, no government spending policy and full-employment policy. Overall, the model matches several features of the business cycle and the fiscal policy for the Spanish economy. Optimal government spending is on average 3 percent of total output, which is a non-negligible fraction of the total government expenditures of around 16 percent of GDP observed for Spain over the period 1970-2011. Under full employment it is 28 percent higher. Even though it does not provide utility directly to the household, the government spending is occasionally positive as it is used by the government to boost gross output only when firms are financially constrained. In normal times it remains at zero, but it can escalate in terms of tradables to over 8 percent of total output if collateral constraints tighten. The volatility of government purchases is thus high; the standard deviation of the ratio of government spending in terms of tradables to total output is almost 4 percent.

The mechanism through which fiscal policy boosts output works as follows. Public spending reduces nontradable consumption putting upward pressure on the relative price p_t. Nontradable output in terms on tradables rises through two different channels. Besides the direct price effect, the volume of nontradables produced in the economy expands. As firms are confronted with the downward nominal wage rigidity, the increase in p_t lowers the real wage and more labor is hired to produce nontradable goods. As reported in Table 2, employment h_t is five percentage points higher on average when government spending is optimally set than when it is zero. As a result of the increase in p_t, the market value of total gross output rises in terms of tradable goods and consequently the collateral constraint for firms is relaxed. Firms respond by increasing their demand of imported inputs and thereby tradable output goes up. The reduction in nontradable consumption —due to the crowding out of government spending— is more than compensated by a rise in

[7] The quantity $A_t^T m_t^\gamma$ will be referred to as *gross* tradable output.

[8] To avoid dependence on initial conditions, we disregard the first 1,000 periods from each simulation.

tradable consumption leading to higher welfare for households. For the welfare implications of optimal fiscal policy, see subsection 4.4.

As mentioned before, optimal government spending is typically zero, except in states with low productivity and high indebtness. When the productivity in the tradable sector is low, production and consumption of the tradable good fall leading to a drop of the relative price. Due to the presence of the wage rigidity, firms are forced to cut their labor demand causing involuntary unemployment. Without government spending, the value of nontradable production declines. In addition, the drop of the productivity leads to a slump as well in the production of the tradable sector. Consequently, firms' collateral value drops even further. At the same time, however, as A_t^T falls, the marginal product of imported input is lower and, in turn, so is the firms' demand for it. This latter force drives down the tightness of the collateral constraint when the productivity is low and hence the need for government spending. For our parametrization, the fact that the collateral constraint is further tightened when $A_t^T = A_L^T$ as $\kappa_t = \kappa_L$ —mimicking tighter credit conditions in bad states— ensures that the former force dominates making expansive fiscal policy more desirable with A_L^T realizations. For this reason optimal fiscal policy tends to co-moves negatively with the productivity A_t^T, as reported in Table 2. In addition, since total output is raised through government spending in some states with $A_t^T = A_L^T$ and remains almost unchanged otherwise, the total output gap between different productivity levels over the debt interval shrinks. Consequently, the standard deviation of total output drops over 20 percent relative to the case with no government spending.

Even though nontradable output in terms of tradables can sometimes be higher for states with low tradable productivity relative to those with high tradable productivity —in response to expansive fiscal policy—, total output tends to co-move with A_t^T. As a result, the correlation between g_t^N and y_t is negative as well.

In this economy, the government uses external borrowing to smooth consumption over time and across states. Indeed, private consumption exhibits low volatility relative to total output, compared with the data. In order to smooth consumption, when $A_t^T = A_L^T$, debt rises and so does the interest rate premium charged to the government. For high productivity states, the opposite occurs. Since total output tends to co-move with A_t^T, it follows that the interest rate is countercyclical in our economy, consistent with the empirical regularity observed in emerging economies.

Table 2: Business Cycle Statistics for the Baseline Model under Optimal Policy, No Government Spending Policy and Full-Employment Policy

Statistic	Optimal Policy	No Govt. Spending	Full Employment
mean(spreads)	0.91	0.93	0.84
mean(b/y)	0.33	0.36	0.27
mean(y^T/y)	0.29	0.30	0.29
mean(h)	0.990	0.941	1
mean(pg^N/y)	0.0295	0	0.038
mean(g^N/y^N)	0.0406	0	0.0520
cor(g^N, y)	-0.49	0	-0.77
cor(g^N, c)	-0.94	0	-0.99
cor(g^N, a)	-0.69	0	-0.81
cor(g^N, h)	0.33	0	0
cor(g^N, p)	-0.32	0	-0.53
cor(g^N, r)	0.83	0	0.83
cor(y, c)	0.74	0.97	0.84
cor(y, r)	-0.66	-0.86	-0.62
std.dev.(pg^N)/std.dev.(y)	0.057	0	0.054
std.dev.(c)/std.dev.(y)	0.84	0.50	0.93
std.dev.(y)	0.121	0.157	0.118

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

4.3 Policy Functions

This section analyzes the policy functions under the optimal fiscal policy. Figure 1 shows the decision rules for government spending, taxes, external debt, labor, imported inputs, tradable and nontradable consumption and relative prices as a function of the current debt level. The two lines in each panel correspond to the two levels of productivity, A_L^T (dashed red line) and A_H^T (solid blue line). 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 zero at all times and states, which are plotted in Figure 2. In this latter economy the government is still free to choose bond holdings and transfers to maximize households' utility.

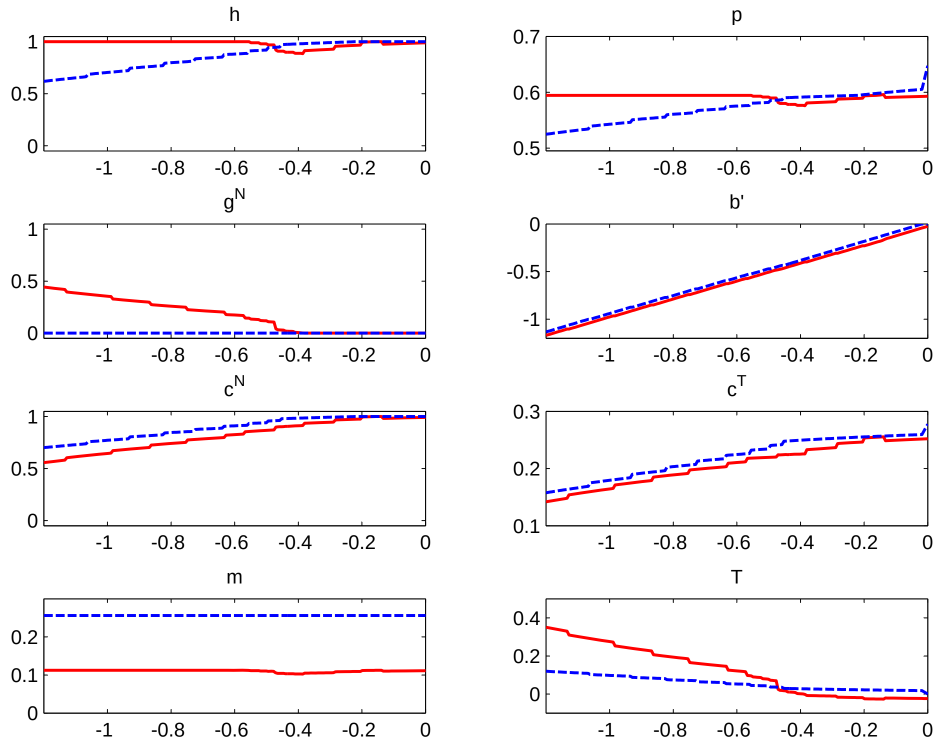

Figure 1: Policy Functions with Optimal Government Spending.

Note: The dashed blue lines correspond to the low realization A_L^T and the solid red lines correspond to the high realization A_H^T.

As shown in Figure 1, when government spending is set optimally, it reaches high levels in states with low productivity A_L^T and high debt levels. To see why this is the case, let us focus first on the economy without government spending.

For $A_t^T = A_L^T$, 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 and lower productivity translate into lower volumes of tradable output. As the economy is more constrained in its external credit, the tradable good becomes more valuable and hence the relative price p_t is lower which 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_t decreases, real wages improve, eventually bringing about involuntary unemployment. This last observation is not restricted to the states with low productivity in tradable production, but applies as well when A_t^T is high.

In this economy, the government may find it optimal to choose positive wasteful government spending in order to relax firms' collateral constraints and hence boost tradable output. Since firms are only credit constrained in low productivity states, only in those states we may observe positive levels of g_t^N. Not surprisingly, as noted from Figure 1 when $A_t^T = A_H^T$, the only presence of the downward wage rigidity does not motivate government spending. Positive g_t^N is therefore desirable only in A_L^T states where, otherwise, p_t would be sufficiently low to make firms be financially constrained. By setting positive government spending, the government crowds out nontradable consumption pushing up the relative price p_t, as shown in Figure 1. Even though government purchases in our model exert upward pressure on the real exchange rate, the correlation between g_t^N and p_t is negative reaching -0.33, in line with the findings of Ravn, Schmitt-Grohé, and Uribe (2012) using panel structural VAR analysis for four industrialized economies.[9]

Because nominal wages are downwardly rigid, higher p_t reduces real wages expanding the labor demand by firms. As a result, unemployment falls and nontradable production increases. The production of tradable goods rises as well, as firms' borrowing capacity is enhanced. Firms' market value of collateral in terms of tradables rises due to a price effect and a quantity effect, that is, the increases in both the nontradable volume and the relative price p_t. Following the relaxation of their borrowing limits, firms demand more imported input and expand tradable production. Indeed, over a large range of debt levels, government spending is sufficiently high to allow firms to achieve their unconstrained efficient level of production.[10]

As pointed out earlier, government purchases have no direct impact on households' welfare, neither by delivering direct utility nor by constituting an input used for production of final goods. Through its incidence in relative prices, however, fiscal policy can increase tradable and nontradable output and aggregate private consumption, as in the Keynesian view.

[9] Ravn, Schmitt-Grohé, and Uribe (2012) propose a model based on a deep-habit mechanism that can rationalize the real exchange rate response to an increase in government spending. Due to the households' deep habits of consumption, firms are willing to cut their markups in the domestic economy after the expansion in aggregate demand due to government purchases. Consequently, as domestic markups decrease relative to foreign markups, the domestic economy becomes relatively less expensive, which means that its real exchange rate depreciates.

[10] Government purchases are financed through lump-sum taxes and external borrowing. Borrowing in this economy is typically used for consumption smoothing purposes. On average, debt levels in absolute terms are on average 7 percent higher that when the government demands zero nontradable goods.

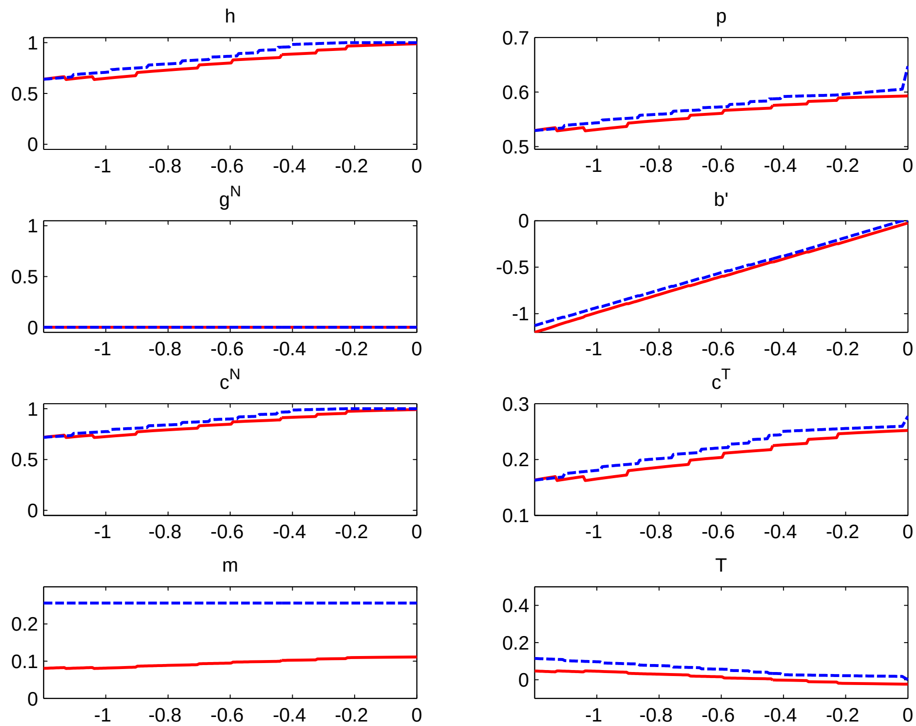

Figure 2: Policy Functions with no Government Spending.

Note: The solid red lines correspond to the low realizations A_L^T and the dashed blue lines correspond to the high realization A_H^T.

Some final remarks are in order. As optimal g_t^N increases when debt rises —as the collateral constraints become otherwise tighter—, the lump-sum taxes required to finance the expenditures increase sharply.

Also, as noted in Figure 1, the decision rule for labor for low productivity A_L^T lies above its counterpart for A_H^T over the debt interval where positive g_t^N was optimal for $A_t^T = A_L^T$. It is worth stressing, however, that, as reported in Table 1, employment remains strongly procyclical along the equilibrium path.

4.4 Welfare Analysis

In what follows we compare households' welfare under different fiscal policies. To do so, we compute the welfare gain of fiscal policy i with respect to fiscal policy j as the percentage increase rate in the consumption plan under policy j that would make the representative household indifferent between the two polices. Formally, given the CRRA preference specification, this compensation denoted by $\lambda^{i,j}(A,b)$ in current state (A,b) is given by

$$(1 + \lambda^{i,j}(A, b))^{1-\sigma} V^j(A, b) = V^i(A, b)$$

after exploiting the homotheticity property of the value function, and where V^j and V^i correspond to the lifetime utility values under policies i and j, respectively.

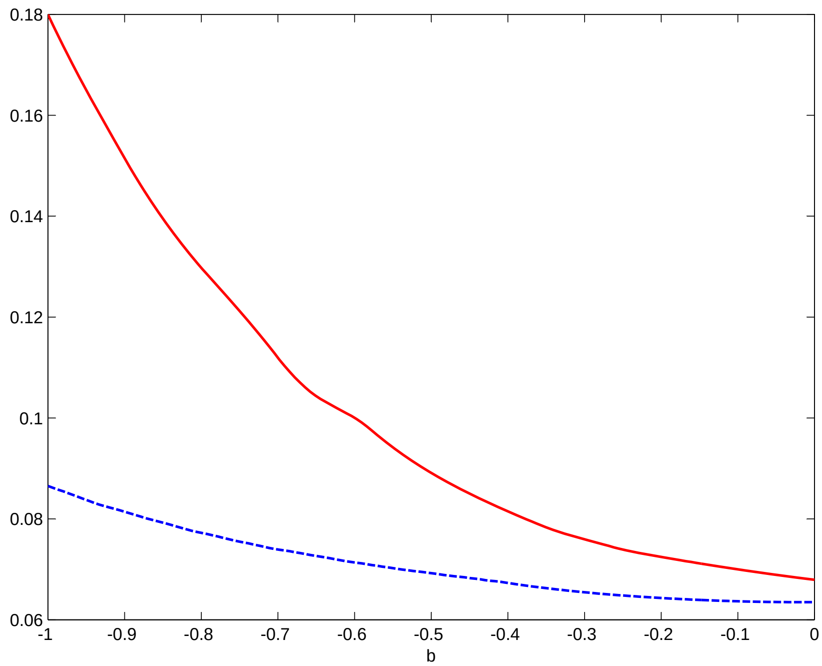

Figure 3: Welfare Gains of Optimal Fiscal Policy.

Note: The solid red lines correspond to the low realization A_L^T and the dashed blue lines correspond to the high realization A_H^T. Welfare gains are expressed in percentage points.

Figure 3 plots the welfare gain of optimal policy with respect to the no government spending policy, as a function of the current debt level. The two lines in each panel correspond to two levels of productivity, A_L^T (solid red line) and A_H^T (dashed blue line). Welfare gains vary significantly with the state of the economy, taking values that range from around 0.06 percent to almost 0.18 percent. For the A_H^T realization, the compensation rate is quite inelastic to debt and quite lower, as no government purchases are prescribed there in the current period given that firms remain credit unconstrained. On the other hand, when $A_t^T = A_L^T$, welfare gains of optimal policy are sizable and increase exponentially with the indebtness level as collateral constraints become tighter.

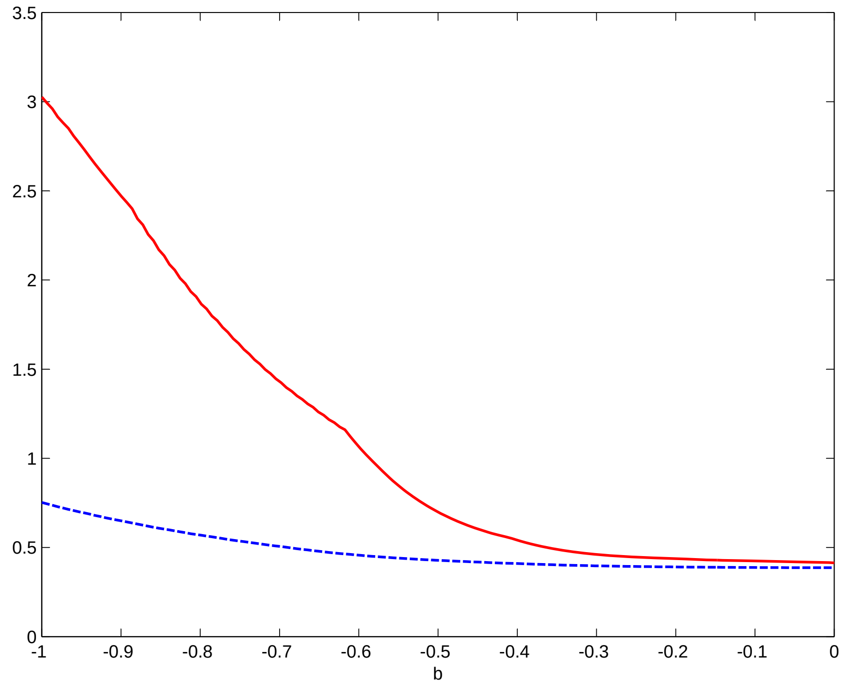

Figure 4: Welfare Gains of Optimal Fiscal Policy relative to Full-Employment Policy.

Note: The solid red lines correspond to low realization A_L^T and the dashed blue lines correspond to the high realization A_H^T. Welfare gains are expressed in percentage points.

The compensation rate of optimal policy with respect to the full-employment spending policy, as a function of the current debt level, is presented in Figure 4. Welfare gains of setting government spending optimally are much larger than in the previous case. In certain states of the economy the representative household would require an increase of over 3 percent of permanent consumption to be indifferent between an economy with optimal fiscal policy and an economy in which government policy guarantees full employment in all states. Eliminating involuntary unemployment can be very costly in terms of welfare, especially since for A_H^T realizations it does not help expand tradable production —which was already at the unconstrained level— but wastes nontradable resources that could otherwise be allocated to private consumption.

Finally, we compute the unconditional welfare gains of optimal government policy using the ergodic state distributions under the different policy regimes. Formally, the

Table 3: Unconditional Welfare Gains of Optimal Fiscal Policy relative to Other Policies

No Government Spending	0.0756
Full-Employment Policy	0.4920

Note: Welfare gains are expressed in percentage points.

compensation of adopting policy i relative to conducting policy j, denoted by $\overline{\lambda}^{i,j}$ satisfies

$$(1+\overline{\lambda}^{i,j})^{1-\sigma} \sum_{(A,b)\in\mathcal{A}\times\mathcal{B}} \mu^j(A,b)V^j(A,b) = \sum_{(A,b)\in\mathcal{A}\times\mathcal{B}} \mu^i(A,b)V^i(A,b),$$

where μ^i and μ^j are the ergodic distributions of the state $(A,b) \in \mathcal{A}\times\mathcal{B}$ under policy i and j, respectively. Relative to no government spending, optimal policy delivers a welfare gain on average of 0.0756 percent. The unconditional compensation rate of optimal policy with respect to the full-employment regime is 0.492, significantly lower than the high state-contingent levels as the government borrows relatively little.

5 Conclusion

This paper proposes a new mechanism through which wasteful government spending can boost private consumption and total output improving households' welfare in the context of downward wage rigidities and firms' collateral constraints. By raising the real exchange rate, government purchases of nontradables may increase the market value of nontradable production through two different channels. Besides the direct price effect, the quantity of nontradables produced increases as real wages decline and firms expand their labor demand reducing involuntary unemployment. Additionally, tradable output rises as firms improve their borrowing capacity following the surge of their collateral values. The government finds it optimal to set positive public spending only under occasional circumstances when firms' collateral constraints tighten.

A quantitative analysis is conducted to assess the desirability of austerity plans and stimulus programs in the context of the ongoing European debt crisis. In this context the government faces a trade-off between the benefits of increasing current output and reducing unemployment and the financial costs of increasing external borrowing and thereby raising the risk of default.

We view our model as a suitable framework to analyze the dynamics of fiscal multipliers. Given the high nonlinearity of optimal government purchases in this environment as function of the state of the economy, we expect to reconcile a wide range of empirical estimates of fiscal multipliers.

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