

# Fiscal Challenges to Monetary Dominance

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## Abstract

We study the interaction between government debt and monetary policy in a dynamic stochastic model in which the government may default. The central bank has a low inflation mandate and the government normally follows a fiscal rule that ensures solvency conditional on low inflation. However, the government is sometimes unable or unwilling to roll over its debt, following which the central bank has a choice between letting the government default, or provide monetary backstop to the debt crisis by purchasing government debt and increasing seigniorage. [We show that a higher likelihood of monetary backstop reduces not only the frequency of defaults but also, under some conditions, the average inflation rate.]

*WORKINPROGRESS.DONOTCIRCULATE*

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# 1 Introduction

Based on the fiscal fundamentals, it might come as a surprise that government debt problems arose in the euro area rather than in other parts of the world. Figure 1 shows the ratio of the primary balance to GDP (on the horizontal axis) and the ratio of net government debt to GDP (on the vertical axis) for the euro area, the US, Japan and the UK in 2009.<sup>1</sup> The fiscal fundamentals were bad everywhere, but they were worse in the US, Japan and the UK than in the euro area on average. Figure 2 shows that the fiscal fundamentals of the US, the UK or Japan were comparable to those of Greece, Portugal, Ireland or Spain, the euro area economies that were the most affected by the crisis.

Several differences between the euro area and the rest of the world can explain this puzzle. The euro area deprives its members from certain margins of flexibility, such as exporting their way out of low growth by depreciating their currencies. Euro area countries do not enjoy the benefits of issuing a reserve currency to the same extent as the US, and most of them cannot rely on a high domestic saving rate to the same extent as Japan. Finally—and this is the difference that I will focus on in this note—the relationship between monetary policy and fiscal policy is not the same in the euro area as elsewhere.

The euro area was explicitly designed to minimize the risk of monetization of government debts, that is, to enforce the maximum degree of “monetary dominance” (Sargent and Wallace, 1981). The risk of monetization is perhaps not zero, because it is not certain what the European Central Bank (ECB) would do in a large-scale government debt rollover crisis that would threaten the existence of the euro. But it is certainly more likely that the monetary authorities would let the fiscal authorities default in the euro area than elsewhere.<sup>2</sup>

If this is what makes the euro area special, then in order to study the European debt crisis one would need a theoretical framework in which mon-

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<sup>1</sup>The data come from the World Economic Outlook (October 2011). The data for the euro area are the GDP-weighted average of the 11 largest euro area economies.

<sup>2</sup>Martin Feldstein puts it in this way in his recent piece “The French Don’t Get It”: “When interest and principal on British government debt come due, the British government can always create additional pounds to meet those obligations. By contrast, the French government and the French central bank cannot create euros.” Project Syndicate at <http://www.project-syndicate.org/commentary/feldstein43/English>

etary dominance can be challenged, and the monetary authorities have a choice between monetizing government debt or letting the government default. We present a DSGE model with those features below.

The model has somewhat unconventional implications, but it sheds an interesting light on the current debates on European policies. This debate often takes the form of an opposition between two seemingly irreconcilable views. The first view is that the interest rate spreads associated with the threat of default may be a normal and even desirable feature of the equilibrium, to the extent that they give euro area governments incentives to keep their fiscal house in order. This view is defended by the ECB and the German government.

The second view is that the spreads are harmful, and that their presence in the euro area (and not elsewhere) comes from the ECB's failure to play its role of "lender of last resort" (De Grauwe (2011)). According to that view, the spreads reflect a vicious circle in government debt dynamics and market expectations—with high spreads leading to exploding debts, which in turn justifies the expectation of a default. By standing ready to buy government debt at the right price, the ECB could ensure that the economy stays in the good equilibrium with low interest rates. And like in the Diamond-Dybvig model, the commitment to lend would imply that lending-in-last-resort is not necessary in equilibrium.

One theme of this paper is that those two views are a bit too simple. On the one hand, the proponents of the Southern view make their lives too easy by simply assuming that government solvency would be ensured by low spreads. It is true that, other things equal, lowering spreads to zero would reduce the probability of default, but this does not mean that the probability of default would be reduced to zero. And a positive residual probability of default implies that the monetary authorities might be called to "lend in last resort" to an insolvent government in equilibrium. Debt monetization, thus, is not a purely notional out-of-equilibrium risk, it is a real risk that has to be weighted against the benefits from low spreads.

On the other hand, it is not obvious either that high spreads necessarily provide the appropriate incentives for fiscal adjustment. They could as well discourage fiscal adjustment by making the dynamics of debt unsustainable and reducing the probability that fiscal efforts eventually pay off. By reducing the likelihood of a successful fiscal adjustment, high spreads might actually make inflation more (not less) likely, as we will show in this paper. In the long run, furthermore, it might be necessary to accept a small risk of debt

monetization (occurring, say, once every century on average) in order to establish a relationship between fiscal policy and monetary policy that is sustainable—i.e., one that does not generate a government debt crisis every ten years.

**Relationship to the literature.** The distinction between monetary dominance and fiscal dominance was originally made by Sargent and Wallace (1981). There is monetary dominance when the monetary authorities are entirely focused on controlling inflation, whereas the fiscal authorities adjust fiscal policy to stay solvent conditional on an exogenous flow of seigniorage. Fiscal dominance, conversely, occurs when monetary policy is subject to the constraint of providing enough seigniorage to the government to ensure solvency. This distinction appears under different guises in the literature that looks at monetary and fiscal policy rules in recursive models. In Leeper’s (1991) terminology, monetary dominance corresponds to the case where monetary policy is “active” and fiscal policy is “passive”. In the analysis of Woodford (2003), monetary dominance results when the monetary rule follows the “Taylor principle” and the fiscal rule is “locally Ricardian”.

The approach in this paper is related to other contributions that explore the grey area between pure fiscal dominance and pure monetary dominance. For example, Davig and Leeper (2007) study an environment in which the monetary policy rule switches between an active stance and a passive stance. Davig, Leeper and Walker (2010) use a rational expectations framework to assess the implications of rising debt in an environment with a “fiscal limit”, i.e., a point where the government no longer has the ability to finance higher debt levels by increasing taxes, so that either a fiscal adjustment or inflation must occur to stabilize debt. Those papers, however, do not consider *default* as an alternative to fiscal adjustment or inflation.

Other papers introduce the possibility of government default in dynamic optimizing models of monetary and fiscal policy. Uribe (2006) makes the point that if fiscal and monetary policy are both “active”, then the only way that the government can satisfy its intertemporal budget constraint is by sometimes defaulting. He shows that the equilibrium behavior of default and rates and risk premiums may be quite sensitive to the specification of the monetary rule. Bi (2011) presents an intertemporal optimizing model in which default is an alternative to fiscal consolidation. However, Uribe’s model does not have fiscal adjustments and Bi’s model does not have monetary policy. This paper, by contrast, embeds the three options of default, inflation

and fiscal adjustment in the context of a single framework.<sup>3</sup>

## 2 Model

The economy is composed of four sectors: households, firms, the banking sector and the government.

### 2.1 Households

We consider an economy with a government and an infinitely-lived representative consumer. There is one homogeneous good. The consumer's intertemporal utility is given by

$$U_t = \sum_{s \geq t} \beta^{s-t} \left[ c_s - \frac{\ell_s^{1+1/\sigma}}{1+1/\sigma} + v(m_s) \right], \quad (1)$$

where  $\ell_s$  is labor supply at time  $s$  and  $m_s = M_s/P_s$  is real money balances. We will assume that,

$$v(m) = v \frac{m^{1-\gamma}}{1-\gamma}.$$

The consumer's budget constraint is

$$c_t + q_t b_{t+1} + x_t m_{t-1} = (1 - \tau_t) w_t \ell_t + (1 - \delta_t h_t) b_t + \phi_t z_t, \quad (2)$$

where  $b_{t+1}$  denotes the holdings of one-period government real bonds (promises to pay one unit of good in the next period) at the end of period  $t$ ;  $q_t$  is the price of a bond issued at time  $t$ ;  $\delta_t$  is a dummy variable for government default;  $h_t$  is the haircut conditional on a default at time  $t$ ;  $\tau_t$  is a tax on labor income;  $w_t$  is the real wage; and the last terms on the left-hand side and the right-hand side are respectively the opportunity cost of holding money and the profit received from the banking sector (to be explained in a moment when we present the assumptions about the banking sector).

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<sup>3</sup>A related contribution is Jeanne (2012). The difference is that the model in Jeanne (2012) is in continuous time and uncertainty is resolved at one point in time, so that the dynamics can be solved in closed form. By contrast the present model is a full-fledged dsge framework with recurring uncertainty

## 2.2 Firms

The consumption good is produced by perfectly competitive firms that use labor as their production input,

$$y_t = (1 - \delta_t \gamma_t) \theta_t \ell_t. \quad (3)$$

The main source of uncertainty in the model is the stochastic productivity parameter  $\theta_t$ , which is governed by the AR(1) process,

$$\theta_t - 1 = \rho(\theta_{t-1} - 1) + \varepsilon_t,$$

where  $\varepsilon$  is an iid shock.

The term  $(1 - \delta_t \gamma_t)$  reflects the assumption that productivity falls by  $\gamma_t$  if the government defaults, where  $\gamma_t$  is an exogenous stochastic parameter. The assumption that a default reduces productivity is a reduced-form way of capturing the negative impact on the productive sector of the financial disruption induced by the government default.<sup>4</sup> This assumption is standard in the dsge literature on sovereign default (Arellano (2008); Aguiar and Gopinath (2006)).

We also allow the cost of defaulting,  $\gamma_t$ , to be time-varying. This introduces a realistic degree of uncertainty as to the occurrence of default. As we will see, an assumption of this kind is necessary to generate the kind of default risk premium that we observe in the real world.<sup>5</sup> Without such an assumption, the default risk premium tends to be equal to zero unless the default is imminent (Arellano (2008)). Furthermore, the assumption itself—that there is some uncertainty as to the real cost of default—is not unrealistic.<sup>6</sup> For simplicity, we will assume that  $\gamma_t$  is independently and identically distributed, with a pdf denoted by  $f(\cdot)$ .

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<sup>4</sup>See Bolton and Jeanne (2011) for a micro-founded model in which government debt is used as a collateral in private financial contracts and default reduces the efficiency of resource allocation in the private sector.

<sup>5</sup>An alternative, for example, would be to assume that the policymaker who is in charge when the government defaults must bear a “political cost” which is determined by factors outside of the model. The properties of the model would be similar if the political cost of default varies over time. See Hatchondo and Martinez (2010) for a discussion of the political costs of default.

<sup>6</sup>For example, there was a wide range of views about the extent of economic disruption that would be induced by a Greek default in Europe.

## 2.3 The banking sector

The banking sector issues money and holds claims on households. Money in the model should be interpreted as a broad money aggregates such as bank deposits or M2. To simplify, we will represent the banking sector (including the central bank) as one single entity (hereafter called the “bank”). The behavior of the consolidating banking sector is determined by the central bank through monetary policy and banking regulation. Thus, the actions of the “bank” results from central bank policy.

Money creation is linked to credit. In period  $t$ , the bank provides money to households in exchange of claims on households. An household obtains  $m_{t-1}$  in period  $t - 1$  by borrowing it from the bank at rate  $r = 1/\beta - 1$ . In period  $t$  the household must repay  $m_{t-1}/\beta$  and holds  $m_{t-1}(1 + i_{t-1}^m)/(1 + \pi_t)$  where  $i_{t-1}^m$  and  $\pi_t$  are respectively the nominal rate of interest on bank deposits and the rate of inflation between  $t - 1$  and  $t$ . As mentioned above, variable  $m_t$  represents a broad money aggregate that yields a return. The opportunity cost of holding money, thus, is given by

$$x_t = \frac{1}{\beta} - \frac{1 + i_{t-1}^m}{1 + \pi_t}.$$

The cost of holding money for households is also the profit of the banking sector,

$$z_t = x_t m_{t-1}.$$

A share  $\phi_t$  of this profit is distributed to households, which explains the last term on the right-hand side of (2). The rest,  $(1 - \phi_t)z_t$ , is distributed to the government as seigniorage and taxation of banking profits. The inflation rate,  $\pi_t$ , the nominal interest rate on deposits,  $i_t^m$ , and the share of the banking profit that is distributed to households,  $\phi_t$ , are determined by the central bank. The central bank has a mandate to implement a low inflation rate  $\pi^*$ , but it may occasionally deviate from the target, as we will see below.

## 2.4 Government

The government issues debt and taxes labor to finance its expenditures. The government has an exogenous stream of expenditures,  $g_t$ , so that its budget constraint can be written,

$$g_t + (1 - \delta_t h_t)b_t = q_t b_{t+1} + \tau_t w_t \ell_t + (1 - \phi_t)z_t. \quad (4)$$

We assume for now that government expenditures are exogenous,  $g_t = g$ . We assume that in the event of default, government debt is reduced to a sustainable level  $\hat{b}$ . The haircut, thus, is given by

$$h_t = 1 - \frac{\hat{b}}{b_t}. \quad (5)$$

In order to maintain its solvency, the treasury follows a linear fiscal policy rule in which the tax rate is an increasing function of debt,

$$\tau_t = \tau(b_t) = \tau^* + \alpha(b_t - b^*). \quad (6)$$

Variable  $b^*$  is the debt target and the tax rate  $\tau^*$  will be chosen to be consistent with the debt target. We will choose  $\alpha$  high enough to ensure that debt is stationary conditional on a zero spread. Equation (6) defines a passive fiscal rule in the sense of Leeper (or a locally Ricardian one in the sense of Woodford).

## 2.5 Debt rollover crises and monetary policy

If the government always followed rule (6), government debt would satisfy the transversality condition, implying that debt would always be equal to the present discounted value of future taxes, and there would be no government debt rollover crisis or default in equilibrium.<sup>7</sup> In order to introduce rollover crises into the model, we assume that any time  $t$  the government could decide to follow rule (6), but replacing  $b_t$  by  $\hat{b}$ . We shall call this action *fiscal laxity*, by opposition with *fiscal discipline*, which means applying rule (6). The temptation of fiscal laxity, if  $b_t > \hat{b}$ , comes from the fact that it reduces the tax rate on labor and thus the induced distortion. On the other hand, fiscal laxity leads to a debt rollover crisis, since private investors are not willing to roll over  $b_t$  if they know that the government is going to levy an amount of taxes that is sufficient to repay only  $\hat{b}$ .

Fiscal laxity leads to a debt rollover crisis but a debt rollover crisis could occur even when the government is fiscally disciplined (i.e., follows rule (6)). This is the case if the government is unable to roll over its debt because the price at which it can sell new debt is too low. As we will see, debt

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<sup>7</sup>We leave aside the possibility of self-fulfilling debt crises, which is left for a later discussion.



rollover crises typically occur in equilibrium for this reason rather than fiscal laxity. At the same time, it is because there is a risk of fiscal laxity that the government may be unable to roll over its debt.

The central bank has a mandate to implement an inflation target  $\pi^*$ . We assume that the central bank strictly implements its inflation target in every period, unless there is a debt rollover crisis, in which case the central bank may increase inflation and seigniorage in order to rescue the government from a default. If the central bank raises inflation, the economy enters a new regime that is characterized by financial repression, that is, with a lower level of the interest rate on money balances, and a higher fraction of the banking profit transferred to the government.

More formally, we assume that in the normal low-inflation regime, the central bank keeps the inflation rate equal to  $\pi^*$ , the nominal interest rate on money balances to  $i^*$ , and leaves all the profit of the banking sector to the private sector ( $\phi^* = 1$ ). In the high-inflation regime, inflation is raised to a higher level  $\tilde{\pi}$ , the interest rate on money is lowered to  $\tilde{i} = 0$  whereas all the banking profit is transferred to the government ( $\tilde{\phi} = 0$ ).

We assume that once the economy is in the regime with high inflation and financial repression, it stays in that state with probability  $\nu$  in every period and returns to the normal state with probability  $1 - \nu$ . The government does not default in the inflation regime, it can default only in the normal state.

Next, we need to make assumptions about the process through which the government comes to opt for fiscal laxity. We assume that the government is benevolent and chooses fiscal laxity or fiscal discipline so as to maximize the welfare of the representative consumer. In taking this decision the government takes into account the probability that the central bank will respond to a debt rollover crisis by monetization, and the relative welfare cost of monetization versus that of an outright default.

The action of the central bank, when there is a government debt rollover crisis, are determined by the strength of the inflation objective in its mandate. As discussed in the introduction, the probability that the central bank would let the government default is higher in some settings (such as the euro area) than in others—although even in the euro area, this probability is probably less than 100 percent. Since the actions of the central bank are likely to be determined primarily by "constitutional" features of the monetary system (i.e., features that are have been built in the system when it was designed rather than optimized upon during the period under conderation), it is natural to consider this part of the model as exogenous at the time of

the crisis. We capture this situation by simply assuming that conditional on a debt rollover crisis, there is a probability  $\mu$  that the central bank will let the government default.

Parameter  $\mu$  is a measure of the central bank’s reputation for “hard monetary dominance”. Note that the kind of monetary dominance that is measured by  $\mu$  is not the same as monetary dominance as defined by Sargent and Wallace. In Sargent and Wallace (1981), monetary dominance is the assumption that the government sets the fiscal balance to a level that ensures solvency, taking the seigniorage as given. This is more closely captured in our model by  $\alpha$ , the strength with which fiscal policy responds to deviations from the debt target, than by  $\mu$ . Variable  $\mu$  is something different: it is the probability that the central bank will let the government default if the fiscal adjustment is not implemented. It is a measure of what one might call “ex post” (or “hard”) monetary dominance—the fact that monetary dominance is implemented when it is fiscally challenged.<sup>8</sup> It is useful to distinguish the two notions since the level of  $\alpha$  does not say anything about the level of  $\mu$ . For example, one can imagine situations where  $\alpha$  is high but  $\mu$  is low, i.e., monetary dominance is strong ex ante but weak ex post.

To sum up, the following sequence of events takes place in every period  $t$  (maybe add a figure). First, the government opts for fiscal discipline or fiscal laxity so as to maximize domestic welfare. Then, there is a debt rollover crisis or not. There is a rollover crisis if the government has opted for fiscal laxity or because it is unable to roll over its debt under market conditions. If the government opts for fiscal discipline and can roll over its debt, period- $t$  fiscal policy is determined by rule(6) and the government issues new debt  $b_{t+1}$ . If there is a debt rollover crisis two things may happen: with probability  $\mu$  the central bank lets the treasury default, and with probability  $1 - \mu$  it comes to the rescue of the treasury to prevent a default.

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<sup>8</sup>The term “hard” is meant to evoke the distinction between “hard” and “soft” power that is made in the study of international relations. Soft monetary dominance means that the fiscal authorities do everything possible ex ante to reduce the risk of an open conflict between monetary dominance and fiscal dominance. Hard monetary dominance means that the monetary authorities enforce monetary dominance ex post when the conflict has not been avoided.

## 2.6 Equilibrium

There are three state variables at the beginning of period  $t$ : the level of government debt  $b_t$ , the level of productivity  $\theta_t$  and the default cost  $\gamma_t$ . Together, these variables constitute the state at the beginning of period  $t$ ,  $s_t = (b_t, \theta_t, \gamma_t)$ .

We denote by  $\eta_t$  the dummy variable for the occurrence of a debt rollover crisis in period  $t$ . It is not the same as  $\delta_t$ , the dummy variable for the occurrence of a default, because a debt rollover crisis may not result in a default. An important policy function to characterize the recursive equilibrium is  $\eta(s)$ . Before we come to the question of how this policy function is derived, we present a few important equilibrium relationships.

The first order condition for labor supply implies

$$\ell_t = [(1 - \tau_t)w_t]^\sigma. \quad (7)$$

The first-order condition for labor demand implies

$$w_t = (1 - \delta_t \gamma_t) \theta_t. \quad (8)$$

The equation for money demand is,

$$v'(m_t) = 1 - \beta E_t \left( \frac{1 + i_t^m}{1 + \pi_{t+1}} \right).$$

When there is a switch to the high-inflation regime, real money balances decrease from  $m^*$  to  $\tilde{m}$  satisfying

$$v'(\tilde{m}) = 1 - \frac{\beta}{1 + \tilde{\pi}}.$$

If there is a switch at time  $t$ ,  $(1 - \phi_t)z_t = 0$  but  $(1 - \phi_{t+1})z_{t+1}$  is equal to

$$\tilde{z} = \frac{\tilde{m}v'(\tilde{m})}{\beta},$$

and remains at that level as long as the economy stays in the high-inflation regime.

Budget constraint of the government in normal times

$$g + b_t = q_t b_{t+1} + \tau_t w_t \ell_t$$

and in high-inflation regime

$$g + b_t = q_t b_{t+1} + \tau_t w_t \ell_t + \tilde{z},$$

and in both cases  $\tau_t$  is given by the fiscal rule (6).

By adding up the budget constraints (2), (??) and (4) we obtain that private consumption is equal to output minus government consumption

$$c_t = y_t - g. \quad (9)$$

It follows that the consumer's utility flow can be written (if there is no default)

$$c_t - \frac{\ell_t^{1+1/\sigma}}{1 + 1/\sigma} + v(m_t) = \underbrace{\theta_t^{1+\sigma} \left[ (1 - \tau_t)^\sigma - \frac{(1 - \tau_t)^{1+\sigma}}{1 + 1/\sigma} \right]}_{u(\theta_t, \tau_t)} + v(m_t). \quad (10)$$

We now write the continuation values for the different regimes. We denote by  $V^n(b_t, \theta_t, \gamma_t)$  the continuation in period  $t$  in the regime with low inflation ( $n$  stands for *no* inflation or *normal* times), by  $V^c(b_t, \theta_t, \gamma_t)$  the value associated with repaying the debt (staying in *contract*), by  $V^r(b_t, \theta_t, \gamma_t)$  the value associated with having a rollover crisis,  $V^d(b_t, \theta_t, \gamma_t)$  the value associated with default, and by  $V^i(b_t, \theta_t, \gamma_t)$  the value associated with high-inflation.

The continuation value  $V^c(b_t, \theta_t, \gamma_t)$  is not always defined because it may be impossible to find a value for  $b_{t+1}$  that satisfies the budget constraint (4). In this case there is a debt rollover crisis caused by the government's inability (rather than unwillingness) to roll over its debt. The debt rollover crisis is caused by the government's unwillingness to roll over if  $V^c(b_t, \theta_t, \gamma_t)$  is well defined but lower than  $V^r(b_t, \theta_t, \gamma_t)$ . If by convention we set  $V^c(b_t, \theta_t, \gamma_t)$  to zero when it is not defined, then we have

$$V^n(b_t, \theta_t, \gamma_t) = \max [V^c(b_t, \theta_t, \gamma_t), V^r(b_t, \theta_t, \gamma_t)], \quad (11)$$

and

$$\eta(b_t, \theta_t, \gamma_t) = 0 \iff V^c(b_t, \theta_t, \gamma_t) \geq V^r(b_t, \theta_t, \gamma_t). \quad (12)$$

The second equation says that the government rolls over the debt if and only if this yields a higher welfare than a rollover crisis.

A rollover crisis is followed by a default with probability  $\mu$  and by inflation with probability  $1 - \mu$ , so

$$V^r(b_t, \theta_t, \gamma_t) = \mu V^d(b_t, \theta_t, \gamma_t) + (1 - \mu) V^i(b_t, \theta_t, \gamma_t). \quad (13)$$

The continuation value under default satisfies

$$V^d(b_t, \theta_t, \gamma_t) = u\left((1 - \gamma_t)\theta_t, \tau(\hat{b})\right) + v(m^*) + \beta E_t V^n(b_{t+1}, \theta_{t+1}, \gamma_{t+1}). \quad (14)$$

The continuation value in the inflation regime satisfies

$$V^i(b_t, \theta_t) = u(\theta_t, \tau(b_t)) + v(\tilde{m}) + \beta E_t \left[ \nu V^i(b_{t+1}, \theta_{t+1}) + (1 - \nu) V^n(b_{t+1}, \theta_{t+1}, \gamma_{t+1}) \right]. \quad (15)$$

Finally, the continuation value with repayment is

$$V^c(b_t, \theta_t) = u(\theta_t, \tau(b_t)) + v(m^*) + \beta E_t V^n(b_{t+1}, \theta_{t+1}, \gamma_{t+1}). \quad (16)$$

Note that there is no maximization with respect to  $b_{t+1}$  since if the tax rate  $\tau_t$  is pinned down by the fiscal rule (6) there is only one level of  $b_{t+1}$  that satisfies the budget constraint (4).

### 3 Quantitative results [to be completed]

The benchmark calibration is given in Table 1. We have simulated the model in the two extreme cases  $\mu = 0$  and  $\mu = 1$ . If  $\mu = 1$  the central bank never provides monetary backstop so that  $q = \beta(1 - E\delta)$ . If  $\mu = 0$  the central bank provides systematic monetary backstop so that  $q = \beta$  (there is no default premium).

Figure 3 shows how the default probability depends on the state  $(\theta, b)$  if  $\mu = 1$  (left-hand side panel) and if  $\mu = 0$  (right-hand side panel). The default probability is higher and increases more steeply with the level of debt when there is no monetary backstop.

### 4 Extensions and discussion

To be completed

Table 1: Parameters

Parameters	Values	
Discount factor	$\beta = 0.98$	
Labor elasticity coefficient	$\sigma = 0.01$	
Government spending	$g = 0.2$	
Responsiveness of tax rate to debt	$\alpha = 0.1$	
Mean default output cost	$\bar{\gamma} = 2.56\%$	Standard sovereign debt literature
Stochastic structure	$\rho = 0.91$ $\eta = 0.012$	Bi & Traum (2011)'s estimates for Greece
Debt upper limit	$b^{max} = 3$	300% of mean output
Target debt level	$b^* = 0.6$	Stability and Growth Pact debt target
Debt after a default	$\hat{b} = 0.8$	

## Figures

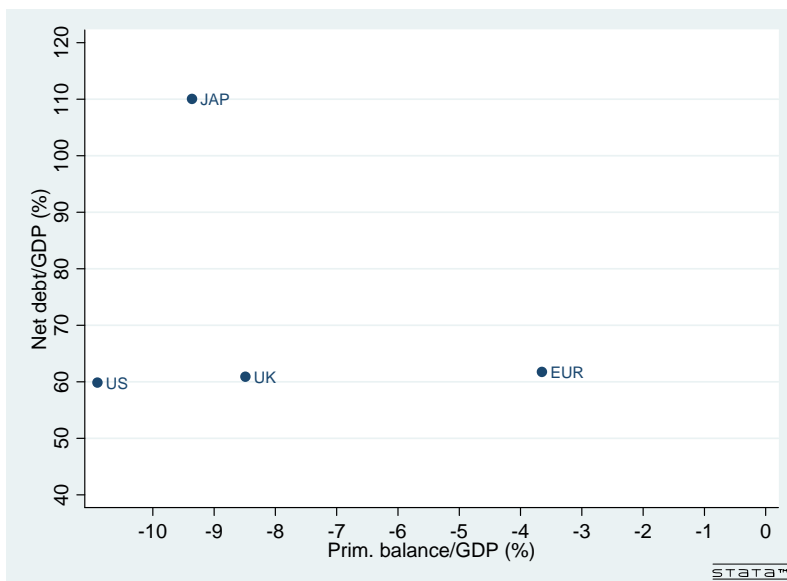


Figure 1: Ratio of fiscal primary balance and net government debt to GDP in the US, Japan, the UK and the euro area (2009). Source: World Economic Outlook.

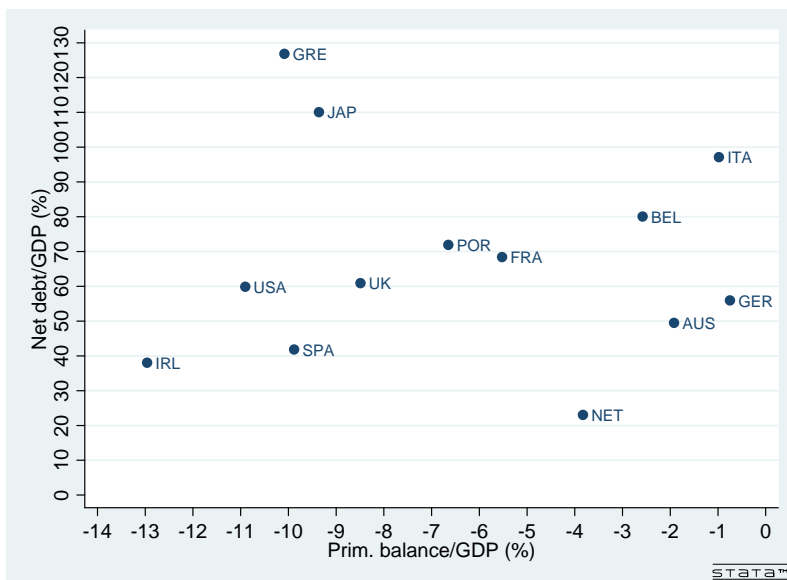


Figure 2: Ratio of fiscal balance and net government debt to GDP in the US, Japan, the UK and euro area economies (2009). Source: WEO.

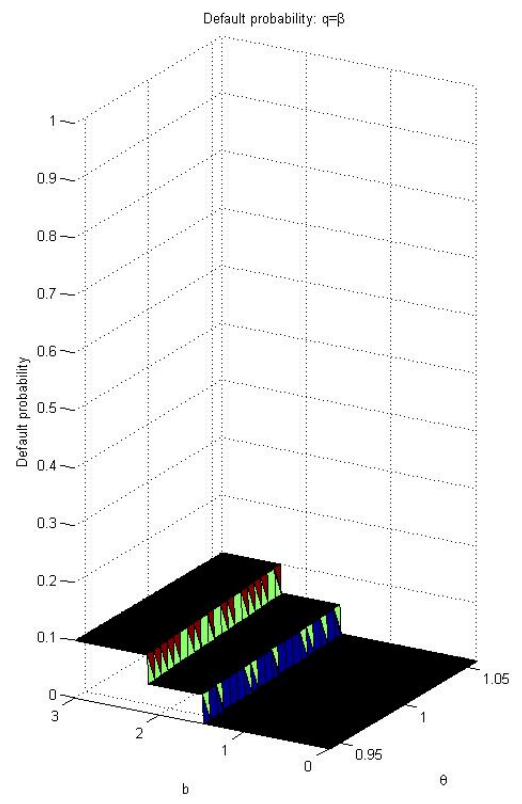
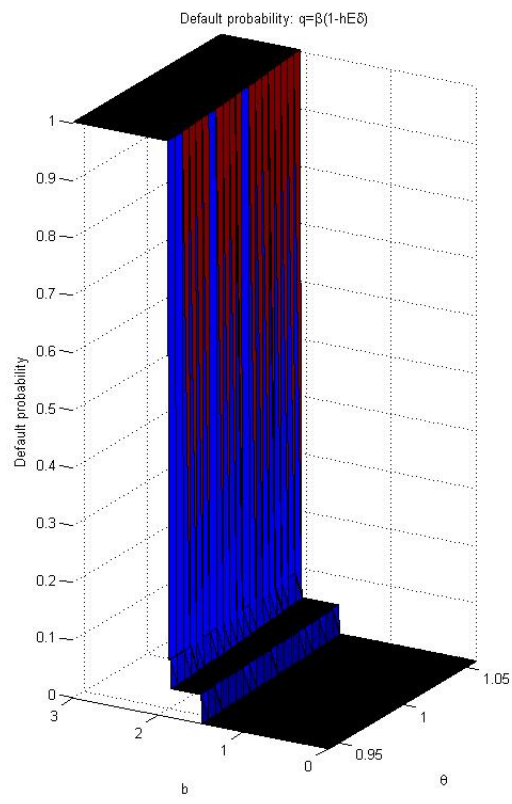


Figure 3: Default Probability



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## **A Appendix**

To be completed.