Monetary–fiscal policy mix with financial frictions*

Pedro Gomes† Hernán D. Seoane‡

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Abstract

We show that the distinct post-crisis dynamics of United States and the Euro area can be rationalized through different fiscal and monetary policy mixes. While the United States implemented an active fiscal–passive monetary policy, the Euro area implemented an active monetary–passive fiscal policy. We show that, in a financially constrained environment, this monetary dominance amplifies technology shocks and neutralizes the expansionary effects of fiscal shocks through debt deflation and real interest rate channels, leading to a deeper crisis and slower recovery.

Keywords: fiscal policy, monetary policy, financial frictions.

JEL Classification: E62, E63, E32, E44.

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†Department of Economics, Universidad Carlos III de Madrid, Calle Madrid 126, 28903 Getafe, Madrid, Spain; E-mail: pgomes@eco.uc3m.es

‡Department of Economics, Universidad Carlos III de Madrid, Calle Madrid 126, 28903 Getafe, Madrid, Spain; E-mail: hseoane@eco.uc3m.es

1 Introduction

This paper studies the interaction between monetary and fiscal policies in the context of a financial crisis. We build on Leeper (1991) and Fernández-Villaverde (2010) to design a prototypical model of the interaction between policy rules and financial frictions, as in Bernanke, Gertler, and Gilchrist (1999). We dissect the stylized model by studying determinacy regions and dynamic responses of output and inflation to policy, technology, and credit shocks, and we use it to understand the way different policy arrangements affected macroeconomic dynamics following the 2007 financial crisis in United States (US) and the Euro area (EA).

While the United States quickly implemented interest rate cuts and large increases in the monetary base and debt levels, the Euro area was substantially more conservative. These episodes, shown in Figure 1 and described in detail in the next section, suggest that the two regions implemented different policy mixes. To encapsulate these policies, we estimate fiscal and monetary rules using a post-2007 sample as in Leeper (1991). We find that the Euro area has an active monetary–passive fiscal policy (monetary dominance), whereas the United States has a passive monetary–active fiscal policy (fiscal dominance).[1] These different policy mixes can explain part of the post-crisis divergence, in particular, the weaker recovery in the Euro area.

Two main transmission mechanisms operate in our setup: the 'debt deflation channel' and the 'real interest rate channel'. Through the debt deflation channel, the interplay of monetary and fiscal policy is relevant in the context of financial frictions. The trade-off between taxes and inflation—which has no real effects in Leeper (1991)—now affects the stock of real private debt. In the case of fiscal dominance, higher inflation reduces the stock of public debt but also reduces private debt, which increases the net worth of entrepreneurs and allows them to invest more. This mechanism adds to the real interest rate channel already present in New-Keynesian models. An increase in inflation raises the real interest rate under monetary dominance but lowers it under

[1] The categories of 'active' and 'passive' policies are introduced by Leeper (1991). 'Active monetary policy' refers to cases in which the monetary authority responds strongly to inflation (otherwise, it would be 'passive'). 'Active fiscal policy' refers to cases in which fiscal policy does not respond to sovereign debt (otherwise, it would be 'passive'). Leeper (1991) shows that both monetary and fiscal dominance regimes can uniquely pin down the inflation path. In the monetary dominant regime, the Taylor principle guarantees the determinacy of a unique equilibrium, whereas the fact that taxes respond to debt guarantees that government debt is sustainable. Under fiscal dominance, taxes do not response to debt, but the path of inflation is pinned down such that the path of the real interest rate guarantees the sustainability of government debt. A crucial distinction between the two regimes is the behavior of the real interest rate. The terms 'active monetary–passive fiscal policy' and 'monetary dominance' are used interchangeably throughout this paper, as are 'active fiscal–passive monetary policy' and 'fiscal dominance'.

fiscal dominance, generating opposite effects on capital accumulation. A divergence of the real interest rate occurred between the United States and the Euro area in the early stages of the crisis, which is another indicator that they followed a different policy mix.

The main contribution of this paper is to develop a stylized model to understand how different policy mixes operate during periods of financial frictions. Specifically, our paper contributes to the literature on financial frictions and macroeconomic dynamics surveyed in Quadrini (2011). Jermann and Quadrini (2012) document cyclical properties of US firms' financial flows and develop a model that shows the importance of financial shocks in general and during the recent crisis in particular. Other contributions include Christiano, Motto and Rostagno (2008, 2010, 2014), Covas and Haan (2011), Cúrdia and Woodford (2010), Cooper and Ejarque (2003), and Leeper and Nason (2014). Most of these studies focus on the role of monetary policy and abstract from fiscal policy configurations despite that sovereign debt levels have been at the core of the policy discussion. Instead, we try to understand the channels by which financial frictions affect the economy conditional on different fiscal and monetary policy arrangements. We find that negative technology or credit shocks induce a deeper recession under monetary dominance, than under fiscal dominance.

This paper also contributes to the recent literature on the effects of fiscal policy with financial frictions. Fernández-Villaverde (2010) studies the effects of fiscal policy in the presence of financial frictions in the spirit of Bernanke, Gertler, and Gilchrist (1999) and focuses on the 2008–2009 recession. His main objective is very different from ours, as he focuses on the impact of distortionary taxation. Carrillo and Poilly (2013), who also use a financial accelerator model interacting with the zero-lower bound, reaffirm that government spending multipliers are substantially higher under credit market imperfections. On top of the Fisherian debt-deflation channel, they highlight a capital-accumulation channel. During the liquidity trap, an expansionary government spending shock reduces the real interest rate, allowing entrepreneurs to accumulate more capital. Eggertsson and Krugman (2012) set up a model with financial frictions in the spirit of Kiyotaki and Moore (1997), arguing that because of debt-constraint agents, the Ricardian equivalence breaks down. As a consequence, the government spending multipliers increase. Finally, Kollmann, Ratto, Roeger, and in't Veld (2013) setup a New-Keynesian model with a bank and study the effects of the government programs for the support of banks during the Euro area crisis. They find that this program contributes to output, consumption, and investment stabilization in the Euro area. While most of these papers focus on the size of government spending multipliers, less attention has been devoted to the role of debt and its financing With this aim, we show that both tax cuts and government spending shocks are more expansionary under fiscal dominance.

Moreover, transmission mechanisms under active/passive fiscal/monetary policies with financial frictions are, to our best knowledge, unexplored. In this sense, we relate this literature with that on the interaction between fiscal and monetary policies, such as Bianchi (2012), Bianchi and Ilut (2013), Leeper and Yun (2005), or Davig and Leeper (2011).

Finally, our paper contributes to the recent discussion on the importance of trend inflation by Coibion and Gorodnichenko (2011), Ascari and Ropele (2009), and Arias (2014). These papers study how a positive inflation target affects determinacy regions and reduces the likelihood of the economy hitting the zero lower bound. In relation to this literature, we are the first to introduce financial frictions and to study how they interact with trend inflation. We find that, with a positive inflation target, the stronger the financial frictions the larger has to be the response of the nominal interest rate to inflation to induce determinacy under monetary dominance.

The paper is structured as follows. In section 2 we estimate policy rules for United States and the Euro area and show the differences in the post-crisis dynamics between these economies. In section 3, we describe the simple model economy that combines financial frictions with fiscal and monetary policy configurations. Section 4 presents the main results. First, we analyse the determinacy properties of the model, highlighting the role of the interaction between trend inflation and financial frictions. Then, we examine the responses of endogenous variables to technology, credit and policy shocks, as well as the size of fiscal multipliers under different policy configurations. We also perform a variance decomposition exercise. In section 5, we show the results of a counterfactual exercise, that is, we investigate the potential US dynamics under the EA policy mix. We find that the recession would be deeper and the recovery slower if the US had implemented the EA policy.

Our baseline model and the estimation of the monetary policy rule abstracts from the zero lower bound in the interest rate. From an econometric point of view, our treatment of the monetary policy relies on the fact that the Taylor rule can be understood as a statistical relationship that fits the data well. However, from an economic point of view, the existence of a zero lower bound affects dynamics. Our baseline model is sufficiently general to accommodate both the case of a monetary policy at the zero lower bound with an active fiscal policy and that of a setup with an occasionally binding zero lower bound. In section 6, we extend the model to explicitly consider the zero lower bound. Section 7 concludes.

2 From crisis to recovery

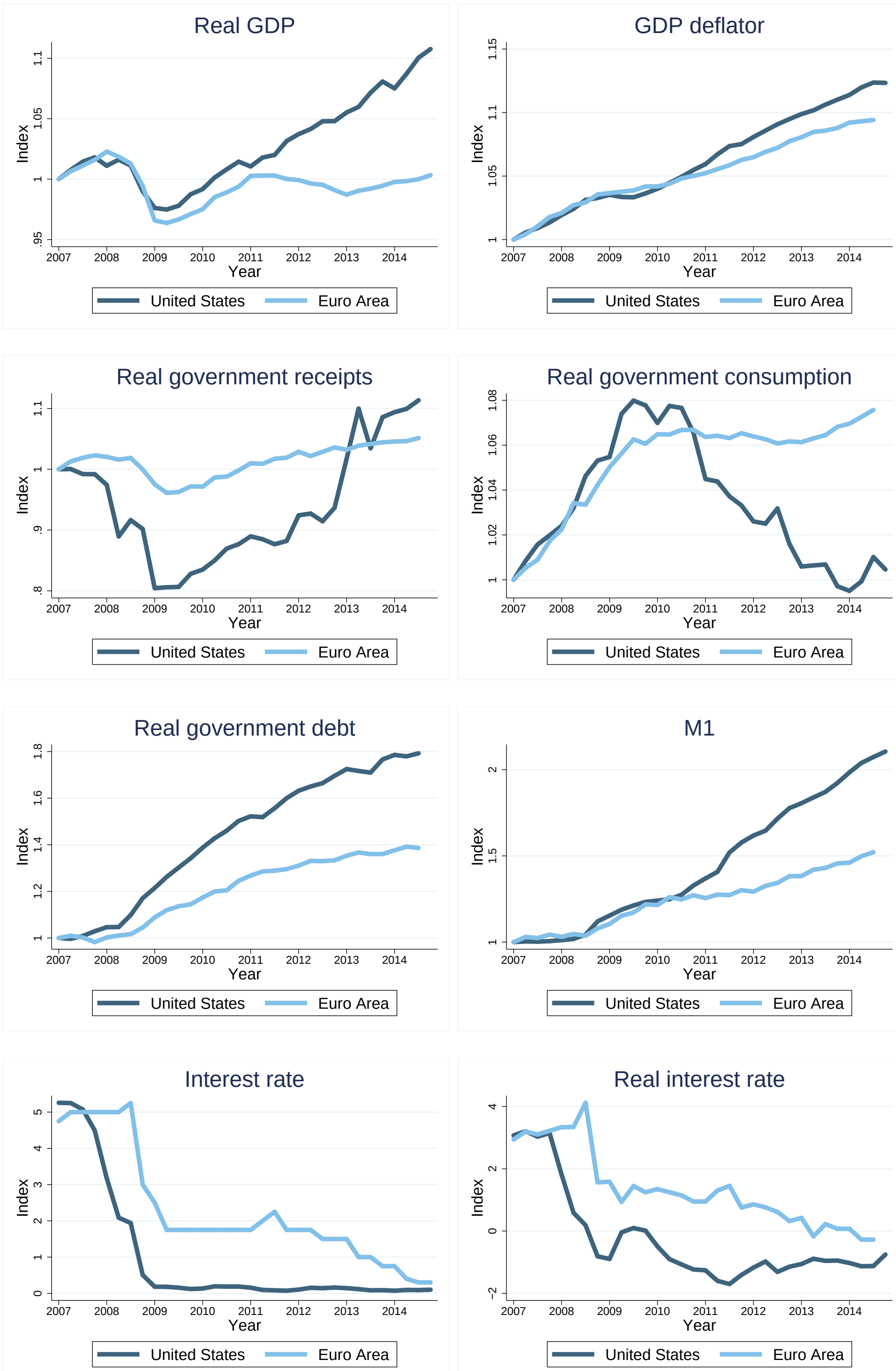
Figure 1 shows time series of key macro, fiscal, and monetary variables for the United States and the Euro area from the beginning of the financial crisis until the end of 2014. The figure shows that major differences exist in the evolution of prices and output as well as in the dynamics of key variables that characterize monetary and fiscal policy responses, such as the money supply, interest rates, debt, taxation, and government spending.

The US recovery has been more robust than that experienced by the Euro area. By the end of 2014, US real GDP was 10 per cent above its value in 2007, while the Euro area GDP matched the 2007 level. This faster recovery implied a 5-per cent cumulative higher price level in the United States measured using the GDP deflator.

The United States implemented expansionary monetary and fiscal policies. On the monetary side, interest rates quickly dropped to zero and quantitative easing contributed to an increase of the money supply that more than doubled in 7 years. On the fiscal side, the government followed a temporary counter-cyclical policy by both allowing for tax receipts to fall as much as 20 per cent and increasing government spending up to 8 per cent. The financial counterpart of this policy is reflected in the increase of the real stock of government debt by 80 per cent. In contrast, in the Euro area, the interest rate decline was slower and less sharp and the monetary expansion was milder, with an increase in M1 of 50 per cent. The responses to the crisis on the fiscal side look ambiguous. On one hand, receipts collected by the government were roughly constant. Despite the GDP drop during the crisis, governments increased tax rates as they were concerned by the impact of sovereign spreads. On the other hand, an increase in government spending occurred that was smaller but more persistent than that in the United States.

The real interest rates behaved similarly in the few first quarters of 2007 but quickly diverged. While the real interest rate became negative in the United States, it was slow to decline in Europe and only reached negative values by the end of the sample. This is in line with the hypothesis that

Figure 1: The anatomy of the recession



Note: Data is from St. Louis FED FRED dataset, IMF and Eurostat. Details about sources and additional figures are in Appendix A.

the two economic areas implemented different policy mixes. To further support this argument, we estimate a monetary and fiscal rule for the United States and the Euro area as in Leeper (1991) using a post-2007 sample. The monetary rule is given by

$$r_t = \bar{r} + \psi_\pi \pi_t + \varepsilon_t^r,$$

where r_t denotes the policy interest rate, π_t is the inflation rate, and ε_t^r is an autocorrelated process, that is, $\varepsilon_t^r = \rho^r \varepsilon_{t-1}^r + \epsilon_t^r$ with ϵ_t^r being an i.i.d. shock with standard deviation σ^r. The fiscal policy rule is given by

$$\tau_t = \bar{\tau} + \psi_d d_{t-1} + \varepsilon_t^\tau,$$

where τ_t denotes the tax level and d_t denotes the level of sovereign debt. This policy also has an autocorrelated shock $\varepsilon_t^\tau = \rho^\tau \varepsilon_{t-1}^\tau + \epsilon_t^\tau$, with ϵ_t^τ being an i.i.d. shock with standard deviation σ^τ.

In Leeper (1991), the coefficients ψ_π and ψ_d determine the policy regime. Table 1 presents the estimates of the policy rules. The coefficient of the response to inflation is above 1 for the Euro area and below 1 in the United States. The response of taxes to government debt is almost 10 times higher in the Euro area relative to the United States. Using the taxonomy in Leeper (1991), this evidence points in the direction of active monetary policy/passive fiscal policy in the Euro area as compared to the United States, which exhibits passive monetary policy together with an active fiscal policy.

Table 1: Estimated coefficients of policy rules

Parameter	**Description**	**United States**	**Euro area**
ψ_π	Response of interest rate to inflation	0.782 [2.45]*	1.382 [3.75]**
ρ_r	Autocorrelation of the monetary policy shock	0.764	0.387
σ_r	Standard error of the monetary policy shock	0.002	0.003
ψ_d	Response of taxes to sovereign debt	0.005 [0.25]	0.073 [6.36]**
ρ_τ	Autocorrelation of the tax shock	0.873	0.906
σ_τ	Standard error of the tax shock	0.006	0.002

*Note: This table reports the estimated policy rules for the United States and the Euro area. Newey-West standard errors are used to account for autocorrelation in the shock process. T-statistics are shown in square brackets. * significant at 5 per cent. ** significant at 1 per cent. The autocorrelation and standard error of the shock process are estimated in a second stage using the residuals from the regression. A sample of 32 observations was generated from 2007:1 to 2014:4. Data sources are provided in Appendix A. In the tax rule, the variables are written in terms of GDP.*

The following section develops a simple business cycle model and studies the implications of these different policy arrangements. The role played by financial frictions in the crisis and recovery periods is uncontroversial, and thus, we introduce a simple financial accelerator model to capture the role of financial frictions augmented with fiscal and monetary policies to understand the diverting dynamics conditional on the estimated policies. We use the model to understand the reasons behind the recovery (or the lack thereof). We explicitly consider the case of the ZLB as an extension.[2]

3 A simple model with financial frictions

We design a financial accelerator model that combines ingredients in Leeper (1991) and Fernández-Villaverde (2010). The economy is populated by households, entrepreneurs, firms that produce a final good, intermediate inputs and capital goods, financial intermediaries, the government, and a central bank. The remainder of this section describes each agent, while all the optimality conditions are shown in Appendix B.

3.1 Households

Households choose consumption c_t, hours worked l_t, and financial assets, d_t and a_t. d_t are bonds issued by the government and a_t are deposits in financial intermediaries. Households own firms (and obtain benefits derived from this ownership given by F_t) and pay lump sum taxes, T_t. They maximize the following utility function,

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log(c_t) - \psi \frac{l_t^{1+\varrho}}{1+\varrho} \right\},$$

subject to the following infinite sequence of budget constraints,

$$c_t + \frac{a_t}{p_t} + \frac{d_t}{p_t} = w_t l_t + R_{t-1}\frac{a_{t-1}}{p_t} + R^d_{t-1}\frac{d_{t-1}}{p_t} + T_t + F_t + tre_t,\ t \geq 0$$

[2]We focus on the crisis and post-crisis periods to tackle our question using a parsimonious model that is easily comparable with existing literature. An alternative would be to consider a Markov switching model in the policy rules as in Bianchi (2012) and Bianchi and Ilut (2013). However, such a setup would divert the attention from key dynamics implied by financial frictions and policy mix interaction.

where tre_t is a net transfer from entrepreneurs that is defined later. p_t denotes the price level and w_t the real wage. Two different nominal interest rates exist, one associated with sovereign debt, R_t^d, which is a monetary policy instrument, and the return associated with private assets, R_t.

3.2 Final Good Producer

The consumption good is the unique final good of the economy produced by competitive firms that combine intermediate goods using the following technology:

$$y_t = \left(\int_0^1 y_{it}^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}},$$

where y_{it} are a continuum of intermediate inputs indexed using i whose demand depend on the price of these differentiated goods,

$$y_{it} = \left(\frac{p_{it}}{p_t} \right)^{-\epsilon} y_t.$$

Here, ϵ characterizes the rate of substitution between varieties. This technology implies the following final good price,

$$p_t = \left(\int_0^1 p_{it}^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}.$$

3.3 Intermediate good producers

Intermediate good producers produce differentiated varieties i of the inputs, mixing labour and capital in a Cobb–Douglas production function:

$$y_{it} = e^{z_t} k_{it-1}^{\alpha} l_{it}^{1-\alpha},$$

where k_{it-1} is the capital rented by the firm from entrepreneurs. Productivity z_t follows an AR(1) process.

$$z_t = \rho^z z_{t-1} + \sigma^z \epsilon_t^z, \quad \epsilon_t^z \sim \aleph(0,1).$$

The optimal input choice implies that

$$k_{t-1} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t} l_t$$

and that the marginal cost is given by

$$mc_t = \left(\frac{1}{1-\alpha}\right)^{1-\alpha}\left(\frac{1}{\alpha}\right)^{\alpha}\frac{w_t^{1-\alpha}r_t^{\alpha}}{e^{z_t}}.$$

Additionally, these firms operate as competitive monopolists and are able to fix prices, which can change accordingly to a Calvo lottery with probability θ. In order to fix prices optimally, firms solve the following maximization problem:

$$\max_{p_{it}} \mathbb{E}_t \sum_{\tau=0}^{\infty}(\beta\theta)^{\tau}\frac{\lambda_{t+\tau}}{\lambda_t}\left\{\left(\prod_{s=1}^{\tau}\frac{1}{\Pi_{t+s}}\frac{p_{it}}{p_t} - mc_{t+\tau}\right)y_{it+\tau}\right\}$$

subject to

$$y_{it+\tau} = \left(\prod_{s=1}^{\tau}\frac{1}{\Pi_{t+s}}\frac{p_{it}}{p_t}\right)^{-\epsilon} y_{t+\tau}.$$

Here, λ_t denotes the marginal value of wealth of the households (a Lagrangian multiplier on the household's budget constraint).

3.4 Capital Producers

We assume that there are a set of competitive capital good producers that buy installed capital (x_t) and add new investment i_t to generate installed capital for next period accordingly to the following technology,

$$x_t = x_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t.$$

Here $S[\cdot]$ is an adjustment cost function. They sell their output at a price q_t to entrepreneurs. Consequently, they maximize the following profits function:

$$q_t\left(x_t + \left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t\right) - q_t x_t - i_t = q_t\left(1 - S\left[\frac{i_t}{i_{t-1}}\right]\right) i_t - i_t.$$

3.5 Entrepreneurs

The entrepreneurial section is in line with the costly state verification setup as in Bernanke, Gertler, and Gilchrist (1999). Assume that entrepreneurs use their net worth, n_t, and issue debt to financial intermediates, b_t, to buy new installed capital at price q_t,

$$q_t k_t = n_t + \frac{b_t}{p_t}.$$

Assume a productivity shock ω_{t+1} drawn from a log normal distribution $F(\omega)$ that shifts the rented capital. $F(\omega)$ is such that $E_t(\omega_{t+1}) = 1$, while the dispersion $\varsigma_{\omega,t}$ follows,

$$\varsigma_{\omega,t} = (1-\rho^{\omega})\varsigma_{\omega} + \rho^{\omega}\varsigma_{\omega,t-1} + \sigma^{\omega}\epsilon_t^{\omega}, \quad \epsilon_t^{\omega} \sim \aleph(0,1).$$

Following Christiano, Motto, and Rostagno (2014), we consider the shock to the entrepreneurial-level dispersion as a financial shock. A higher dispersion implies that entrepreneurs default more often, and hence, the external finance premium is higher. The average return of entrepreneur

$$R_{t+1}^k = \frac{p_{t+1}}{p_t}\frac{r_{t+1} + q_{t+1}(1-\delta)}{q_t}.$$

The debt contract determines that the return R_{t+1}^l is a return that gives zero profits to financial intermediaries,

$$[1 - F(\bar{\omega}_{t+1})]R_{t+1}^l b_t + (1-\mu)\int_0^{\bar{\omega}_{t+1}} \omega dF(\omega) R_{t+1}^k P_t q_t k_t = \bar{s} R_t b_t,$$

where $1-\mu$ is the fraction of the return that can be captured by the financial intermediate in case of default. A higher μ implies stronger financial frictions. $\bar{s}$ is an average spread charged by financial intermediates. The problem of the entrepreneur is to pick a leverage ratio and a cut-off for default to maximize its expected net worth given the zero-profit condition of the intermediary.

Given such a contract, the law of motion of entrepreneurial net worth is given by

$$n_t = \gamma^e \frac{1}{\pi_t}\left[R_t^k q_{t-1}k_{t-1} - \bar{s}R_{t-1}b_{t-1} - \mu\int_0^{\bar{\omega}_{t+1}} \omega dF(\omega) R_t^k q_{t-1}k_{t-1}\right] + w^e,$$

where γ^e is the survival rate of entrepreneurs. Exiting entrepreneurs transfer their net worth to households and these fund incoming entrepreneurs. The net of these operations is reflected in the term tre_t observed in the households' budget constraint, which is given by

$$tre_t = (1 - \gamma_t^e) n_t - w^e.$$

3.6 Financial Intermediary

Financial intermediaries operate in a competitive environment and channel resources from households to entrepreneurs. Specifically, the financial intermediaries collect deposits from households and make loans to entrepreneurs.

$$a_t = b_t$$

Given the competitive assumption, these intermediaries obtain zero profits in equilibrium.

3.7 Government

The government is characterized by a monetary policy rule, a fiscal policy rule, a budget constraint, and a government spending shock. Monetary policy follows a simple Taylor rule:

$$R_t^d = R^d + \psi_\pi (\Pi_{t-1} - \bar{\Pi}) + \varepsilon_t^r$$

where $\bar{\Pi}$ is the inflation target and ε_t^r is an autocorrelated monetary policy shock

$$\varepsilon_t^r = \rho^r \varepsilon_{t-1}^r + \epsilon_t^r \quad \epsilon_t^r \sim \aleph(0,1).$$

The fiscal policy rule is instead defined over lump sum taxation,

$$\tau_t = \tau + \psi_d d_{t-1} + \varepsilon_t^\tau$$

with

$$\varepsilon_t^\tau = \rho^\tau \varepsilon_{t-1}^\tau + \epsilon_t^\tau \quad \epsilon_t^\tau \sim \aleph(0,1).$$

Here, government spending is exogenous and follows an AR(1) process.

$$g_t = (1 - \rho^g)\bar{g} + \rho^g g_{t-1} + \epsilon_t^g \quad \epsilon_t^g \sim \aleph(0,1).$$

The path for taxes and government spending imply a path for government debt through the government's budget constraint:

$$d_t = g_t + \frac{R^d_{t-1}}{\pi_t} d_{t-1} - \tau_t.$$

Depending on the coefficients of the monetary and fiscal policy rules, we are in an active/passive regime.

3.8 Aggregation

Market clearing in the goods markets is

$$y_t = c_t + i_t + g_t + \mu G_{t-1}(\bar{\omega}_t)(r_t + q_t(1-\delta))k_{t-1},$$

where $G_t(\bar{\omega}_{t+1}) = \int_0^{\bar{\omega}_{t+1}} \omega dF(\omega)$. Furthermore, the aggregation of production across firms implies that

$$y_t = \frac{1}{v_t} e^{z_t} k^{\alpha}_{t-1} l^{1-\alpha}_{t-1}$$

where $v_t = \int_0^1 \left(\frac{p_{it}}{p_t}\right)^{-\epsilon} di$ is a price dispersion index. Finally, market clearing in the capital market is given by

$$x_t = k_t.$$

3.9 Parametrization

Table 2 lists the parameters of the model along with their descriptions. We calibrate the monetary policy response to inflation, ψ_π, and the fiscal policy response to debt, ψ_d, to the values estimated in Section 2 for the United States and Euro area. We fix most of the remaining parameters to the standard calibration in Fernández-Villaverde (2010), with only two exceptions. We consider bankruptcy costs μ as in Bernanke, Gertler, and Gilchrist (1999) and a discount factor β of 0.99.

For the parametrization of technology, credit, and government spending shocks, we use the estimates by Christiano, Motto, and Rostagno (2010). For the tax and interest rate shocks, we take the volatility and persistence estimated in Section 2. The volatility of the shocks is relevant only for the variance decomposition exercise in Section 4.4.

Table 2: Parametrization

Parameter	Description	Value	
β	Discount factor	0.99	
$\bar{\Pi}$	Target inflation	1.005	
S_0	Adjustment costs of capital	4.75	
ϱ	Frisch elasticity related parameter	0.5	
δ	Capital depreciation rate	0.01	
ς_ω	Average volatility of entrepreneur shock	0.5	
α	Capital share intermediate production	0.22	
θ	Calvo parameter	0.8	
ϵ	Input substitution	10	
$\bar{s}$	Average spread	1.0025	
γ_e	Entrepreneurs exit coefficient	3.67	
B/K	Debt-to-capital ratio	1/3	
d/y	Government debt over annual GDP	0.6	
$\bar{g}/y$	Government consumption over GDP	0.2	
μ	Bankruptcy costs	0.12	
Policies	**Description**	**United States**	**Euro area**
ψ_π	Response of interest rate to inflation	0.782	1.382
ψ_d	Response of taxes to sovereign debt	0.005	0.073
Shock	**Source**	**Autocorrel. (ρ^i)**	**Volatility (σ^i)**
ϵ_ω	Christiano, Motto, and Rostagno (2010)	0.883	0.050
ϵ_z	Christiano, Motto, and Rostagno (2010)	0.821	0.005
ϵ_g	Christiano, Motto, and Rostagno (2010)	0.938	0.021
ϵ_m	Estimated, Section 2	0.764	0.002
ϵ_τ	Estimated, Section 2	0.873	0.006

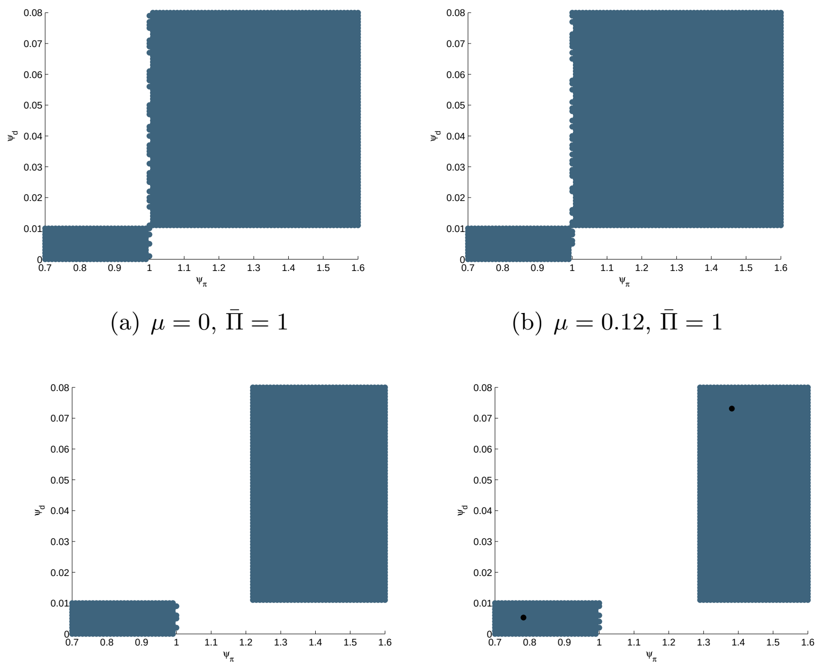
4 Dissecting the model

4.1 Determinacy Regions

We start by examining the conditions for the existence and unicity of equilibrium and how financial frictions affect them. Figure 2 plots determinacy regions for different values of the Taylor rule coefficient, ψ_π, and the fiscal policy rule coefficient, ψ_d, for economies with and without trend inflation and with and without financial frictions. As seen in the figure, determinacy regions are separated into two blocks, one for large values of ψ_π associated with the active monetary policy/passive fiscal policy regime), and one with small ψ_π associated with the active fiscal policy/passive monetary policy regime.

Without trend inflation and financial frictions, the determinacy regions in this model are those of Leeper (1991). However, as discussed in Ascari and Ropele (2009) and Arias (2014), the model with trend inflation (but without financial frictions) requires a more aggressive monetary policy to induce determinacy through active monetary policy. In this model, the determinacy regions also

Figure 2: Determinacy regions



(a) $\mu = 0$, $\bar{\Pi} = 1$ (b) $\mu = 0.12$, $\bar{\Pi} = 1$

(c) $\mu = 0$, $\bar{\Pi} = 1.005$ (d) $\mu = 0.12$, $\bar{\Pi} = 1.005$

Note: Figure (a) plots determinacy regions without financial frictions and trend inflation. Figure (b) plots these regions without trend inflation and with financial frictions from $\mu = 0.12$. Figure (c) plots these regions for the model with trend inflation equal to 2% annually without financial frictions. Figure (d) plots these regions for the case with financial frictions and trend inflation. The black dots in Figure (d) locate the estimated rules for the Euro area and the United States.

depend on the degree of financial frictions, which is measured as the share of the debt that can be recovered from entrepreneurs in the event of default.[3]

As discussed in Ascari and Ropele (2009), the Taylor principle is associated with the long-run properties of the model, and thus, trend inflation is critical. The figure shows that its interaction with the degree of financial frictions is also important. Here, financial frictions exacerbate the failure of the Taylor principle independently of the fiscal policy rule, that is, a more than one-to-one interest rate response to inflation does not guarantee a unique equilibrium. The intuition for our findings about the interaction between trend inflation and financial frictions can be discussed using a standard consumption boom argument. A consumption boom increases prices. The Taylor principle requires that interest rates respond more than one-to-one in order to generate an increase in the real interest rate that negatively affects consumption. With financial frictions, increases in

[3]The baseline model does not include indexation. However, our findings are in line with those of Ascari and Ropele (2009) and Arias (2014), who find that indexation contributes to restoring the Taylor principle, that is, we find that indexation has a similar role in a model with financial frictions.

inflation and consumption reduce the real value of entrepreneur debt, which induce an investment boom, rising marginal costs and inflation. Consequently, an increase in the real interest rate has to be even larger to disincentive consumption and investment. The reduction of the real value of private debt operates on top of the usual channels in the New-Keynesian literature. This implies that when financial frictions are more severe, the determinacy of equilibrium induced through monetary policy generates a costly response to inflation whereas the determinacy induced through active fiscal policy remains the same.

4.2 Mechanism Explanation

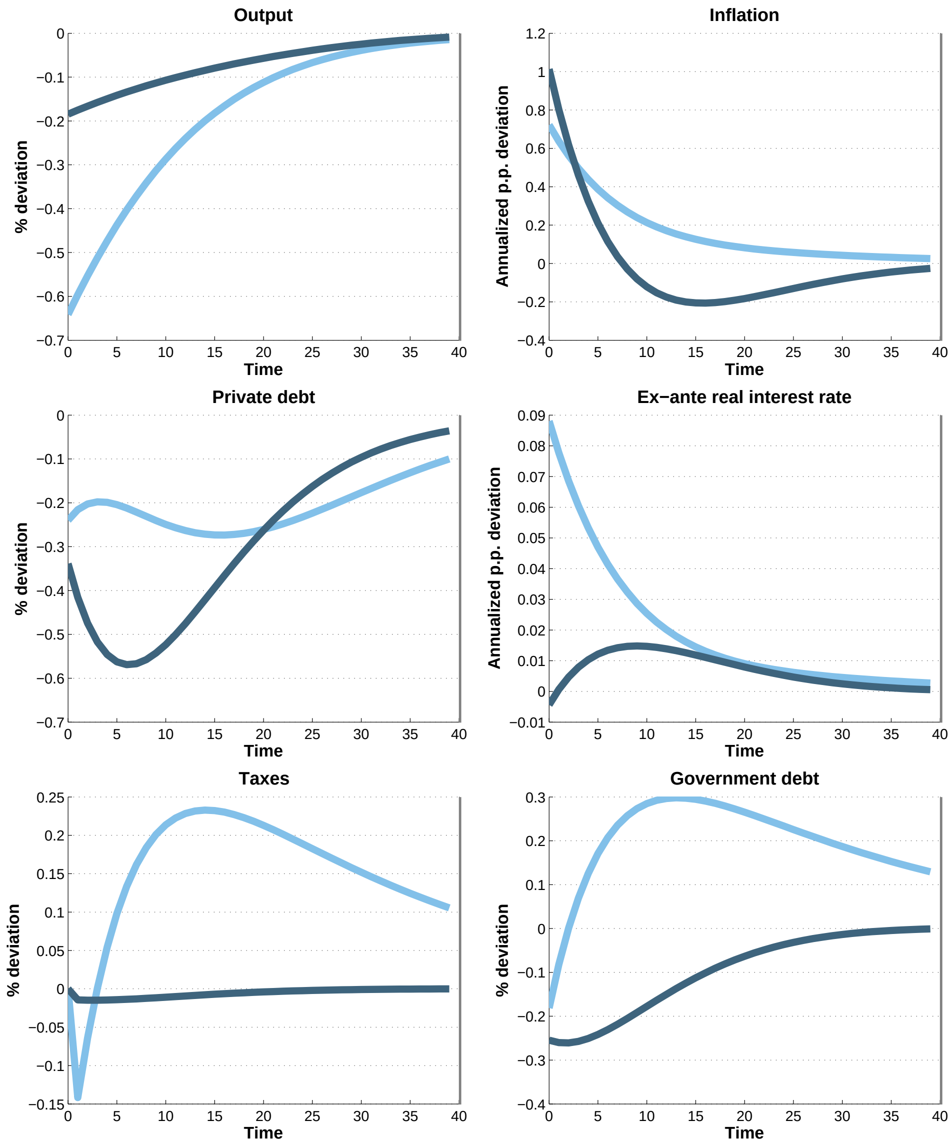
In order to better understand the dynamics under the two regimes, we analyze the impulse response functions to a technology shock under the EA and US policy rules.[4] The two main mechanisms behind the despairing dynamics under fiscal and monetary dominance are related to the changes in the real value of entrepreneurial debt under inflationary regimes and through the real interest rate channel.

Figure 3 shows the response after a negative 1 per cent technology shock. As seen in the figure, the fall of output under monetary dominance is 0.6 per cent, three times larger than that under fiscal dominance. Inflation rises under both regimes, inflating away part of the stock of private and public real debt. Critically, the paths of the ex-ante real interest rate diverge in the two regimes. Under monetary dominance, the real interest rate increases significantly more than under fiscal dominance.

The combination of these two mechanisms—the change in real debt and the change in the real interest rate—are behind the different dynamics under alternative regimes. The lower output fall under fiscal dominance is related to a larger increase in inflation. Higher inflation decreases the real value of entrepreneurial debt, making debt repayment cheaper and ameliorating the fall of investment. Hence, under fiscal dominance, investment and employment fall by less than under monetary dominance. The differences in the evolution of sovereign debt under both regimes are caused by the real interest channel.

[4] We show the response to a credit shock in Figure A2 in the Appendix C.

Figure 3: Response to a 1-per cent negative technology shock

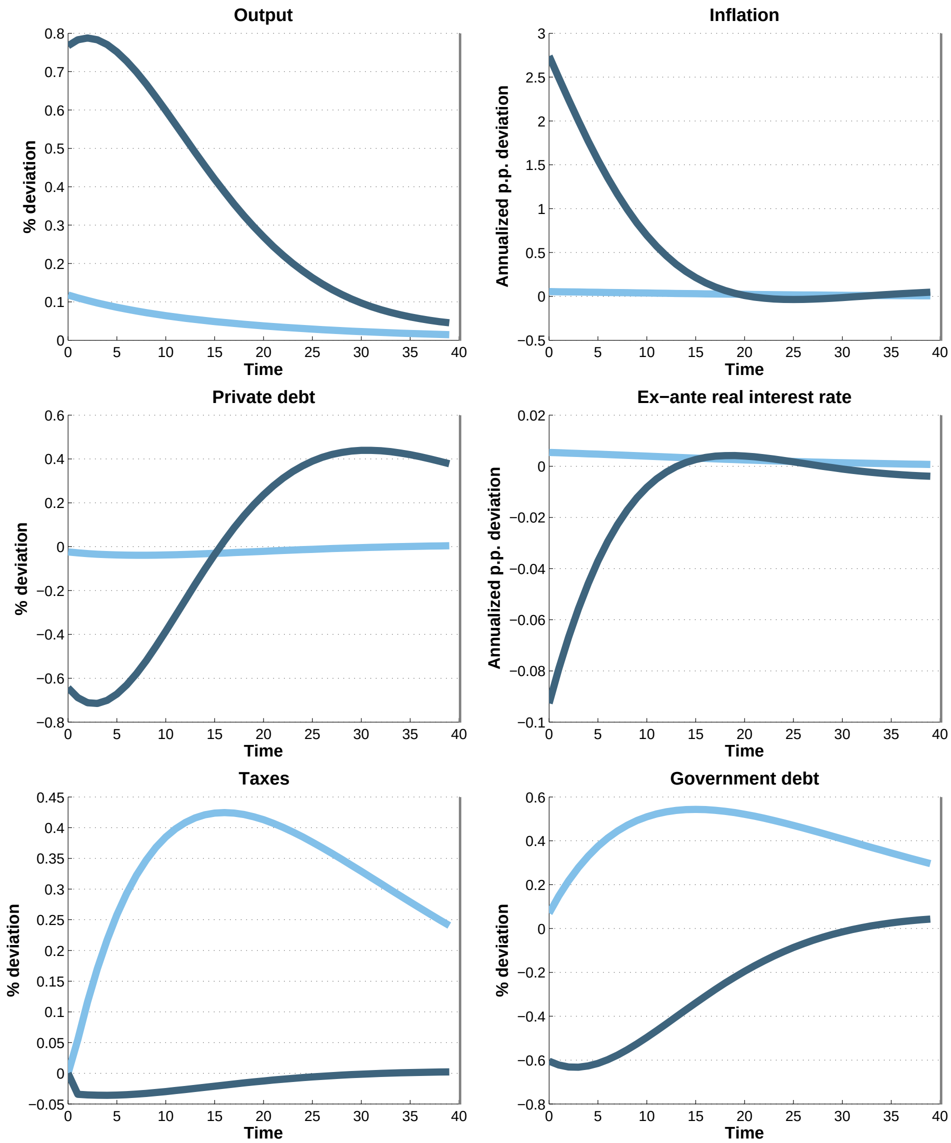


Note: The dark line plots responses under the US calibration and the light blue line does so under the EA calibration.

4.3 Policy Interventions

Figure 4 present the dynamics after a government spending shock. A positive government spending shock is expansionary under the two policy arrangements. However, the increase in government spending is inflationary financed under fiscal dominance (which reduces the real value of interest rate spending), whereas it is covered with debt and the subsequent tax increase under monetary dominance. Under financial frictions and active fiscal policy, the impact of government spend-

Figure 4: Response to a 1 per cent government spending shock



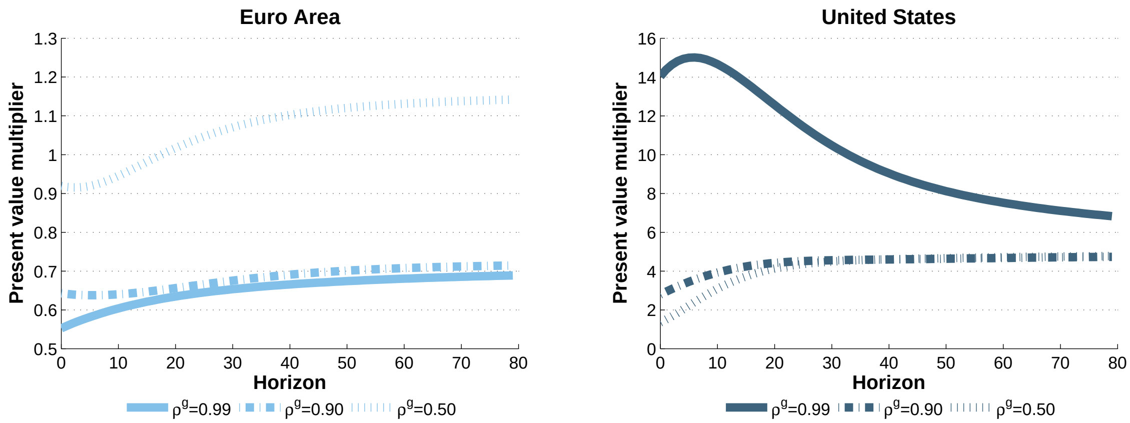
Note: The dark line plots responses under US calibration and the light blue line does so under the EA calibration.

ing is exacerbated as inflation reduces the real value of private debt, which translates to higher investment and lower private debt and spreads. In addition, it lowers the real interest rate, stimulating investment. Instead, under monetary dominance, a higher real interest rate counteracts these dynamics.

To quantify the differences across regimes, we compute the present value multiplier as

$$PVM_k = \frac{E_t \sum_{j=0}^{k} \beta^j (y_{t+k} - \bar{y})}{E_t \sum_{j=0}^{k} \beta^j (g_{t+k} - \bar{g})}.$$

Figure 5: Present value multipliers



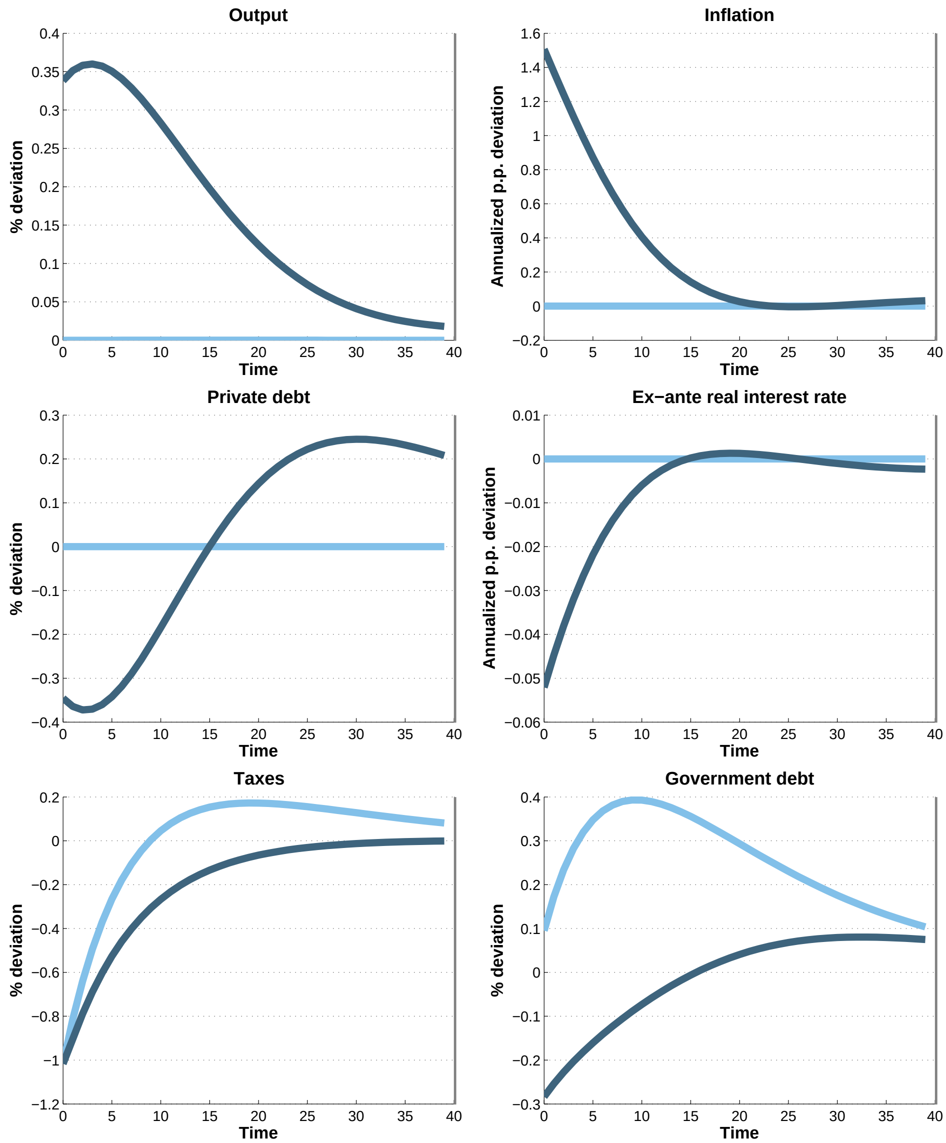
Note: Each curve indicates the degree of PVM_k calculated at different horizons in the horizontal axis for three different degrees of persistence of government spending (0.50, 0.90, and 0.99).

Figure 5 shows the present value multipliers for the two policies under different levels of persistence of the government spending shock. In Appendix C, we report the present value multipliers in the absence of financial or nominal frictions.

The figures depict two main features. First, the present value multipliers are higher under fiscal dominance, and the multipliers tend to converge to 5 in the long run. However, under monetary dominance, they are typically below 1. The intuition behind this result comes from the lack of adjustment of the nominal interest rate under fiscal dominance. As long as the nominal interest rate does not increase, the real interest rate decreases given the response of inflation to government spending discussed before. Here, financial frictions contribute to amplification of the multipliers. This can be seen through a comparison with the figures in the Appendix where we compute multipliers without financial frictions, which are one point below those in Figure 5. This result is consistent with empirical evidence by Canova and Pappa (2011) that shows that government spending multipliers are larger for the subset of episodes that were accompanied by a fall of the real interest rate.

A second interesting and related point is that under fiscal dominance, more persistent government spending processes imply larger multipliers, while the opposite occurs under monetary dominance. This suggests that persistent government spending in the Euro area might have been less effective than temporary spending.

Figure 6: Response to a 1 per cent negative tax shock



Note: The dark line plots responses under the US calibration and the light blue line does so under the EA calibration.

The difference across regimes is also observed following a tax shock, as shown in Figure 6. With an active fiscal policy, a tax cut triggers short-run inflation. Inflationary dynamics reduce the real value of sovereign and private debt. A 1-per cent tax cut raises output by 0.35 per cent. As discussed in the previous paragraph, an active monetary policy neutralizes any real effects of a tax cut.[5]

[5]The interest rate shock is shown in the Appendix. Under active monetary policy, inflation falls after the shock. However, under active fiscal policy rules, inflation increases owing to the impact on the cost of borrowing by the government.

4.4 Volatility and variance decomposition

Table 3 shows the variance decomposition of output and inflation under the EA and US policy rules with and without financial frictions and with and without nominal rigidities. Without friction, the volatility of output is the same across the two policies, 1.3 per cent. This is the case described by Leeper (1991), where the financing decision of the government matters only for nominal variables but does not have real effects. The only two shocks that affect output are technology and government spending shocks, with a 75–25 per cent split. Instead, inflation is largely explained by the monetary policy shock or the tax shock, depending on whether it is under monetary or fiscal dominance, respectively.

On the other hand, in the baseline scenario with both nominal rigidities and financial frictions, the monetary–fiscal policy mix has real effects. Volatility of output is seven times larger under the US policy than under the EA one. Under monetary dominance, 33 per cent of the variance is explained by government spending shocks. Under fiscal dominance, government spending and tax shocks account for 43 per cent and 56 per cent of the variance, respectively. Only 0.7 per cent of the variance is generated by shocks other than fiscal ones.[6]

Most of these differences occur because of nominal rigidities but are amplified by financial frictions. Even in the absence of nominal rigidities, the volatility of output with financial frictions is 50 per cent larger under fiscal dominance. Government spending and tax shocks account for 75 per cent of the variance instead of 32 per cent under monetary dominance. For this calibration, the financial shock matters little for the volatility of output.

The volatility of inflation is 12 times larger under fiscal dominance compared to monetary dominance without nominal financial frictions. By adding frictions, the differences across regimes increase 13–16 times. Under the benchmark case with two frictions, whereas fiscal shocks explain only 8 per cent of the variance of inflation under monetary dominance, they explain 97.4 per cent under fiscal dominance.

[6]We conduct this exercise by keeping the same volatility of policy shocks in both regimes. In Table A2 in the Appendix C, we redo the exercise and set the volatility of the policy shocks to zero, maintaining only the technology and credit shocks. If the economy is subject only to these shocks, the volatility of GDP is lower under the fiscal dominance regime. The large increase in volatility under fiscal dominance occours because the economy becomes more responsive to policy shocks.

Table 3: Volatility and variance decomposition of output and inflation

	No Financial frictions $\mu = 0$		*Financial frictions* $\mu = 0.12$	
	Euro Area	**United States**	**Euro Area**	**United States**
Panel A - Output				
Nominal rigidities $\theta = 0.8$				
Volatility	1.22	6.23	1.28	8.98
Variance decomposition				
ϵ_ω	0.0	0.0	1.2	0.0
ϵ_z	49.6	0.8	41.7	0.1
ϵ_r	19.6	0.9	23.6	0.6
ϵ_τ	0.0	49.0	0.0	56.0
ϵ_g	30.8	49.4	33.6	43.3
No nominal rigidities $\theta = 0.0$				
Volatility	1.30	1.30	1.33	2.03
Variance decomposition				
ϵ_ω	0.0	0.0	0.4	0.2
ϵ_z	75.2	75.2	67.2	24.9
ϵ_r	0.0	0.0	0.4	0.0
ϵ_τ	0.0	0.0	0.0	24.1
ϵ_g	24.8	24.8	32.0	50.8
Panel B - Inflation				
Nominal rigidities $\theta = 0.8$				
Volatility	0.31	5.00	0.35	5.31
Variance decomposition				
ϵ_ω	0.0	0.0	1.4	0.0
ϵ_z	35.3	0.2	30.8	0.2
ϵ_r	58.0	2.8	59.6	2.4
ϵ_τ	0.0	58.5	0.0	63.6
ϵ_g	6.7	38.6	8.3	33.8
No nominal rigidities $\theta = 0.0$				
Volatility	0.58	6.94	0.58	7.63
Variance decomposition				
ϵ_ω	0.0	0.0	0.2	0.0
ϵ_z	24.4	1.0	22.9	0.9
ϵ_r	73.1	1.8	74.0	1.5
ϵ_τ	0.0	57.0	0.0	62.1
ϵ_g	2.5	40.2	2.9	35.5

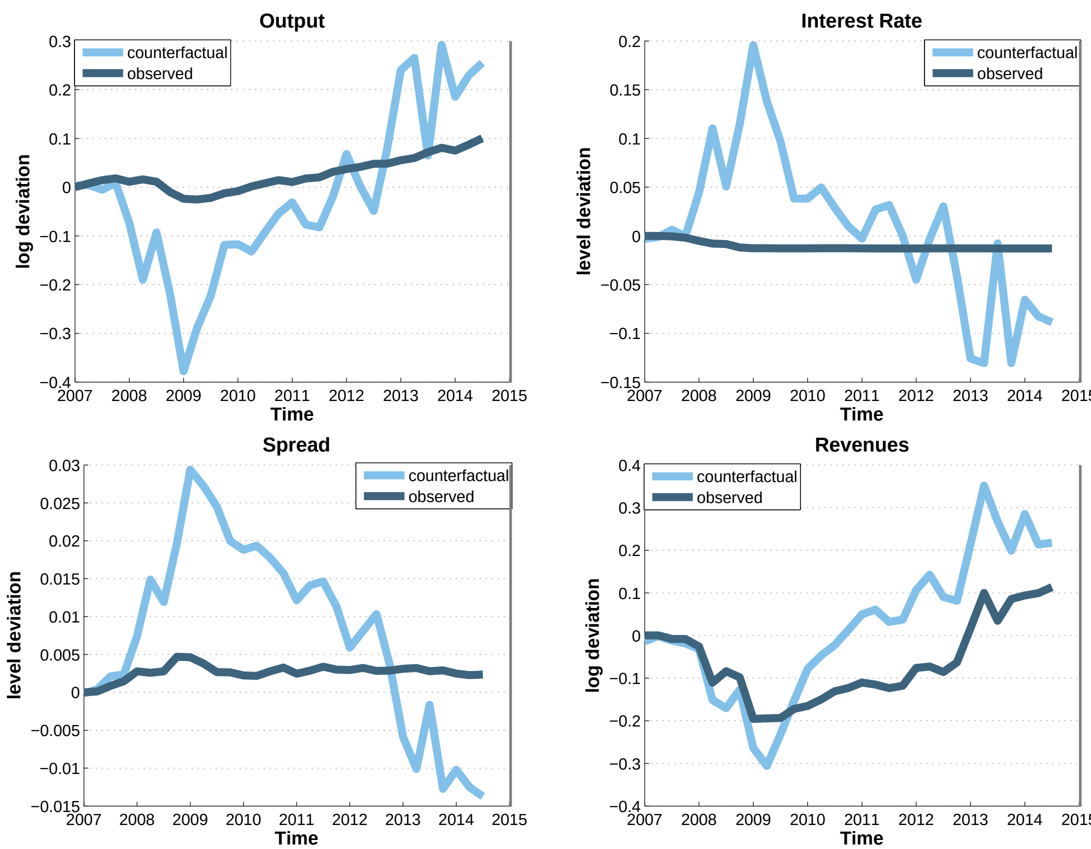
Note: Simulations under baseline calibration. Volatility and the variance explained by each of the shocks are noted in percentages.

5 Counterfactual policies during the crisis

How important are policy regimes in generating the post-crisis recoveries observed in the United States and the Euro area? This section presents the observed dynamics in the United States and the counterfactual dynamics implied by the model that would have been observed had the United States implemented EA estimated policy rules.

The exercise in this section is as follows. After solving the model, we use data on US spreads, output, revenues, interest rates, and government spending, and we use the Kalman Smoother to recover the smoothing estimates of structural shocks for the United States.[7] We consider the economy to have been in the steady state in Q1 2007 and that the United States followed the estimated policy rules. Then, we assume that the fiscal and monetary policy rules used are those of the Euro Area, and we feed the smoothed shocks to simulate a new set of observable variables. Figure 7 presents the observed and counterfactual dynamics using the baseline model.

Figure 7: A counter-factual crisis and recovery



Note: The light line represents actual US data. The dark line shows the counter-factual economy simulated by imposing EA fiscal and monetary policies.

As seen in the figure, under the estimated EA fiscal and monetary policy rules, a higher federal

[7]Details on the data and sources are shown in Appendix A.

funds rate could have been observed for the United States. The higher rates would have driven up private spreads, implying lower output and a more persistent crisis. The nominal interest rate would have been higher for several years, but would hit the zero lower bound by 2012.

Despite that the baseline specification is able to generate some qualitatively interesting counterfactual dynamics, it is clear that this model cannot approximate quantitative results appropriately. These issues can easily be overcome by adding some features. Appendix D presents this same exercise using a model that includes habit formation, persistence in policy rules, and indexation, that performs better in quantitative terms

6 Extension: The zero lower bound

This section studies to what extent the existence of a zero lower bound (ZLB) affects the implications of different fiscal–monetary policy mixes and how this challenges the main findings of this paper. We approach the issue in two complementary ways. First, we study a version of the model in which the gross nominal interest rate is always fixed to 1 and then we analyse a model with occasionally binding ZLB.

6.1 Fixed interest rate at the ZLB

The case of a permanent ZLB is interesting because it has not been considered in the literature. Under monetary dominance, an economy can remain only a few periods at the ZLB. However, in our setting, the ZLB can be permanently sustained if we have an active fiscal policy. Appendix E shows the main results: determinacy regions, the government spending present value multipliers and the volatility and variance decompositions. The results are in line with the baseline model. A small response of taxes to debt guarantees determinacy. The present value multipliers at a long horizon are around 2.5 instead of 5 in the baseline case. With financial frictions, the volatility of GDP under the US policy is four times larger than that under the EA policy, instead of seven times in the baseline case.

6.2 Occasionally Binding ZLB

The previous scenario might be a good approximation if agents expect the ZLB to hold for a long time. We now discuss our findings for the case of an occasionally binding ZLB. We design a version of the model in which the monetary policy rule is given by

$$R_t^d = \max\{R^d + \psi_\pi(\Pi_{t-1} - \bar{\Pi}) + \varepsilon_t^r, 0\}.$$

In this setup, we shock the economy with a monetary policy shock that makes the economy hit the zero lower bound. At that time, we also assume an increase in government consumption. We assume that agents know that when the economy abandons the zero lower bound it will approach the reference regime forever. We study two exercises with occasionally binding ZLB.

In the first exercise, we compare the government spending shocks under the ZLB for two reference regimes: one of fiscal dominance and one of monetary dominance. This is shown in Figure A8 in Appendix F. The case in which the monetary dominance is the reference regime is that discussed in Carrillo and Poilly (2013). The models with ZLB when the reference regime is AFP or AMP share the same features as those studied for the baseline model, but endogenous variables are more responsive when ZLB is explicitly modelled than in the baseline model. However, the co-movement between variables remains the same. Under the zero lower bound, the interest rate channel and the fall in the real value of private debt operate as in the economy where the zero lower bound is not explicitly modelled. In general, the results in Carrillo and Poilly (2013) are exacerbated under an AFP regime.

In the second exercise, we assume that the reference regime is always monetary dominance. When the ZLB binds, we compare a scenario where the fiscal policy becomes temporarily active to one where it remains always passive. This exercise reconciles an active role for monetary policy during normal times with the estimates of the fiscal policy during times of crisis. The interpretation is that the behaviour of the fiscal authority is temporary and limited to the period in which the economy remains in the ZLB. The results are shown in Figure A8 in Appendix F. In this case, and unsurprisingly, there are no differences across the scenarios. Independent of fiscal policy during the ZLB, agents know with certainty that in the short run the economy returns to monetary dominance, so the role of fiscal policy matters only for taxes and debt. Notice that in this case the mechanisms inducing differences between US and Euro area fail to predict differing dynamics. This, highlights the importance of the perceived duration of the AFP regime and suggests future lines of research in the lines of Bianchi (2012) and Bianchi and Ilut (2013) in a financial friction environment.

7 Conclusion

This paper shows that the post-crisis recoveries in the United States and the Euro area can be characterized using different combinations of fiscal and monetary rules. The data suggest that the US policy mix after 2007 can be characterized using a fiscal dominance regime, whereas that of the Euro area is in line with a monetary dominance regime. We present a stylized model to understand whether the differences in dynamics after the financial crisis can be accounted for by the monetary and fiscal policy mix and to isolate the main transmission channels.

We find that dynamics and transmission channels following technology and credit shocks are substantially different depending on whether fiscal policy or monetary policy induces determinacy. Moreover, our model produces a stylized framework to understand why a more solid recovery occurred in the United States rather than in Europe. In the United States, monetary and fiscal policy rules show a larger coordination that boosted the response to expansionary fiscal policies. In Europe, the strict monetary policy neutralized the increase in government spending. There are two key mechanisms behind these findings. The first is associated with the fact that when inflation increases, the real value of entrepreneurs debt decreases, which reduces the cost of investment. This channel becomes important under fiscal dominance. The second is that under fiscal dominance, an increase in inflation also decreases the real interest rate. Our counterfactuals show that if the United States had implemented the estimated rules for the Euro area, the recession would have been deeper and more prolonged with higher interest rates and private spreads.

We provide robustness exercises assuming an explicit ZLB and we find that, in this framework, monetary versus fiscal dominance are likely to induce different dynamics depending on their perceived duration. This last findings open doors for future research on the intersection of financial friction economies with explicit modeling of policy changes as in Bianchi (2012) and Bianchi and Ilut (2013).

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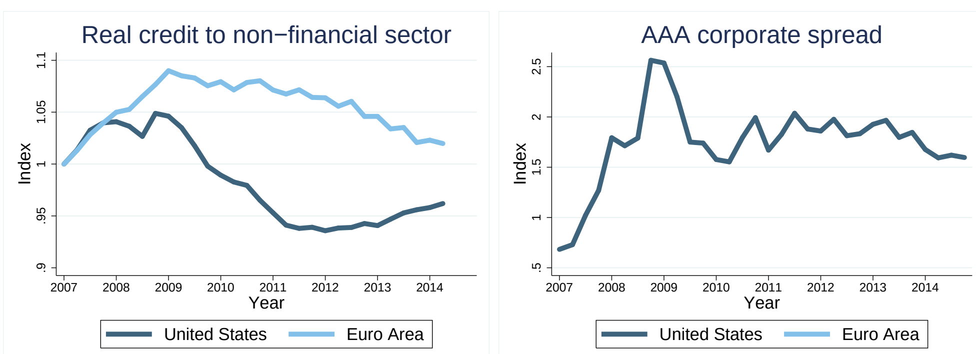
Appendix A: Data

Table A1: Variables and sources

Variable	Area	Description	Source
Interest rate	US	Effective Federal Funds Rate	FRED
	EA	Discount Rate for Euro Area	IMF
Deflator	US	Gross Domestic Product: Implicit Price Deflator	FRED
	EA	Price index (implicit deflator) GDP	Eurostat
GDP	US	Real Gross Domestic Product	FRED
	EA	Gross domestic product (chain linked volume)	Eurostat
M1	US	M1 Money Stock	FRED
	EA	M1 for Euro Area	IMF
Gov. debt	US	Federal Debt: Total Public Debt	FRED
	EA	Quarterly government debt General government)	Eurostat
Gov. consumption	US	Real Government Consumption Expenditures and Gross Investment	FRED
	EA	Final consumption expenditure of general government (Chain linked volumes)	Eurostat
Gov. receipts	US	Federal government total receipts	FRED
	EA	Total general government revenue	Eurostat
Credit	US	Total Credit to Private Non-Financial Sector, Adjusted For Breaks, for United States	BIS
	EA	Credit to Private Non-Financial Sector, Adjusted For Breaks, for Euro area	BIS
Spread	US	Moody's Seasoned Aaa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity	FRED
	EA		

Figure A1: The anatomy of the recession, additional variables



Note: Data is taken from FRED dataset, IMF and Eurostat.

Appendix B: Optimality conditions

FOC households

$$\frac{1}{c_t - hc_{t-1}} - \mathbb{E}\beta\frac{h}{c_{t+1} - hc_t} = \lambda_t$$

$$\lambda_t = \beta\mathbb{E}_t\left\{\lambda_{t+1}\frac{R_t}{\Pi_{t+1}}\right\}$$

$$\lambda_t = \beta\mathbb{E}_t\left\{\lambda_{t+1}\frac{R_t^d}{\Pi_{t+1}}\right\}$$

$$\psi l_t^{\varrho} = w_t \lambda_t$$

FOC intermediate good prod

$$k_{t-1} = \frac{\alpha}{1-\alpha} \frac{w_t}{r_t} l_t$$

$$mc_t = \left(\frac{1}{1-\alpha} \right)^{1-\alpha} \left(\frac{1}{\alpha} \right)^{\alpha} w_t^{1-\alpha} r_t^{\alpha}$$

Price setting IGP

$$\max_{p_{it}} \mathbb{E}_t \sum_{\tau=0}^{\infty} (\beta\theta)^{\tau} \frac{\lambda_{t+\tau}}{\lambda_t} \left\{ \left(\prod_{s=1}^{\tau} \frac{\Pi_{t+s-1}^{\chi}}{\Pi_{t+s}} \frac{p_{it}}{p_t} - mc_{t+\tau} \right) y_{it+\tau} \right\}$$

subject to

$$y_{it+\tau} = \left(\prod_{s=1}^{\tau} \frac{\Pi_{t+s-1}^{\chi}}{\Pi_{t+s}} \frac{p_{it}}{p_t} \right)^{-\epsilon} y_{t+\tau}$$

FOC Price setting IGP

$$\epsilon f_t^1 = (1-\epsilon) f_t^2$$

$$f_t^1 = \lambda_t mc_t y_t + \beta\theta \mathbb{E}_t \left(\frac{\pi_t^{\chi}}{\pi_{t+1}} \right)^{-\epsilon} f_{t+1}^1$$

$$f_t^2 = \lambda_t \pi_t^* y_t + \beta\theta \mathbb{E}_t \left(\frac{\pi_t^{\chi}}{\pi_{t+1}} \right)^{1-\epsilon} \frac{\pi_t^*}{\pi_{t+1}^*} f_{t+1}^2$$

Price dynamics

$$1 = \theta \left(\frac{\pi_{t-1}^{\chi}}{\pi_t} \right)^{1-\epsilon} + (1-\theta) \left(\pi_t^* \right)^{1-\epsilon}$$

FOC Capital good producers

$$q_t \left(1 - S\left[\frac{i_t}{i_{t-1}} \right] - S'\left[\frac{i_t}{i_{t-1}} \right] \frac{i_t}{i_{t-1}} \right) + \beta \mathbb{E}_t \frac{\lambda_{t+1}}{\lambda_t} q_{t+1} S'\left[\frac{i_{t+1}}{i_t} \right] \left(\frac{i_{t+1}}{i_t} \right)^2 = 1$$

$$k_t = k_{t-1} + \left(1 - S\left[\frac{i_t}{i_{t-1}} \right] \right) i_t$$

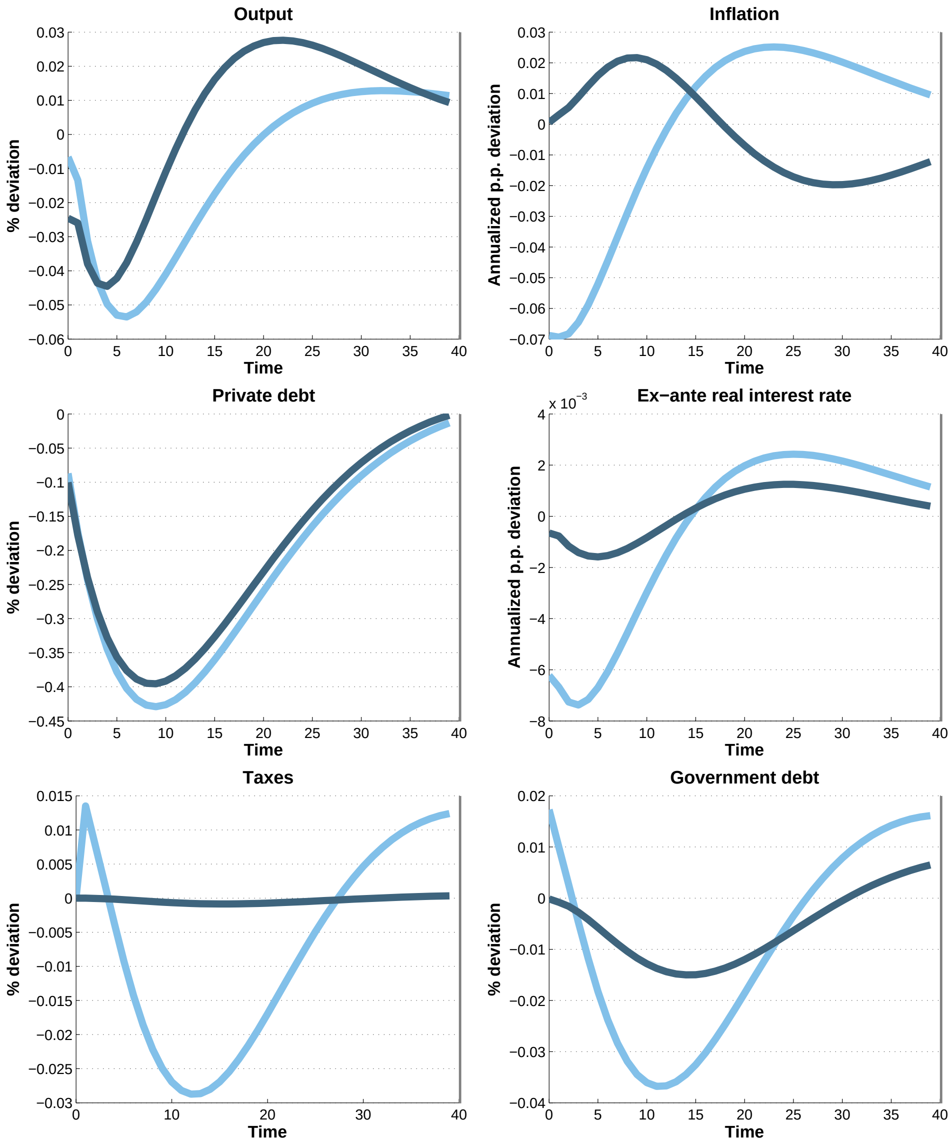
FOC entrepreneurs

$$\mathbb{E}_t \frac{R_{t+1}^k}{s_t R_t} \left(1 - \Gamma_t(\bar{\omega}_{t+1}) \right) = \mathbb{E}_t \eta_t(\bar{\omega}_{t+1}) \frac{n_t}{q_t k_t}$$

$$n_t = \gamma_t^e \frac{1}{\pi_t} \left[(1 - \mu G_{t-1}(\bar{\omega}_t)) R_t^k q_{t-1} k_{t-1} - s_{t-1} R_{t-1} \frac{B_{t-1}}{P_{t-1}} \right] + w^e$$

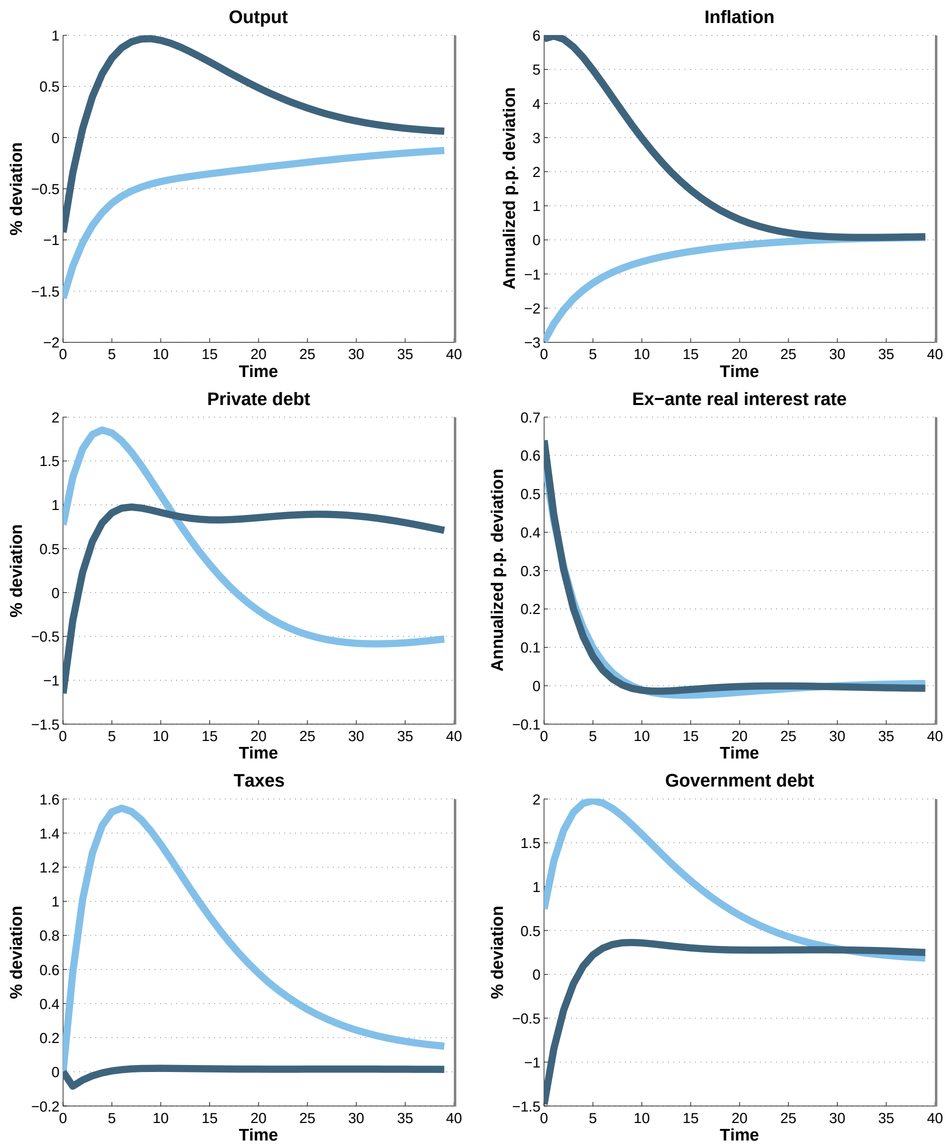
Appendix C: Additional results

Figure A2: Response to a dispersion of projects shock



Note: Dark line plots responses for the US calibration and light blue line under the Euro Area calibration.

Figure A3: Response to a 1 p.p. interest rate shock



Note: Dark line plots responses for the US calibration and light blue line under the Euro Area calibration.

Figure A4: Present value multipliers, different cases

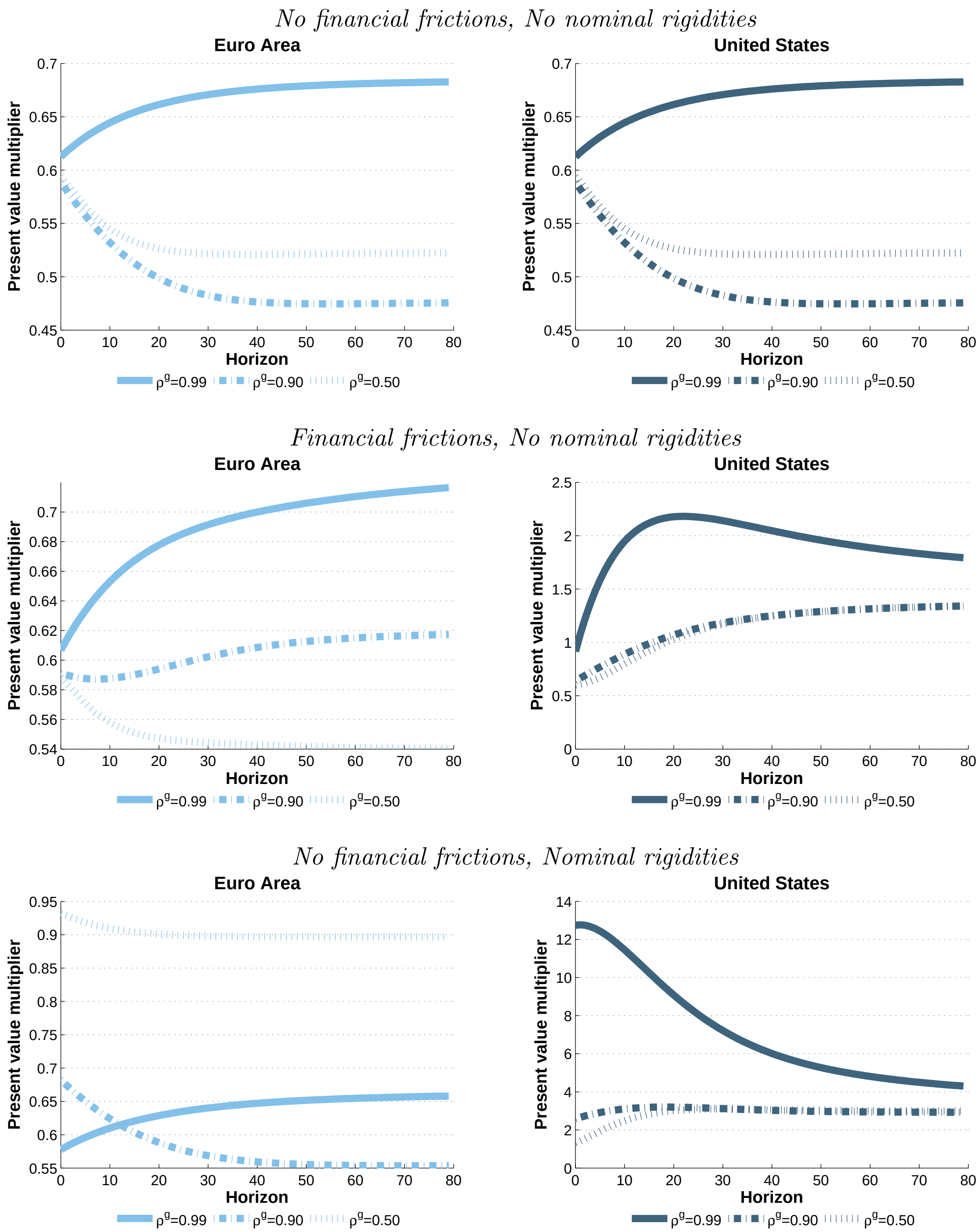


Table A2: Volatility and variance decomposition of output and inflation without policy shocks

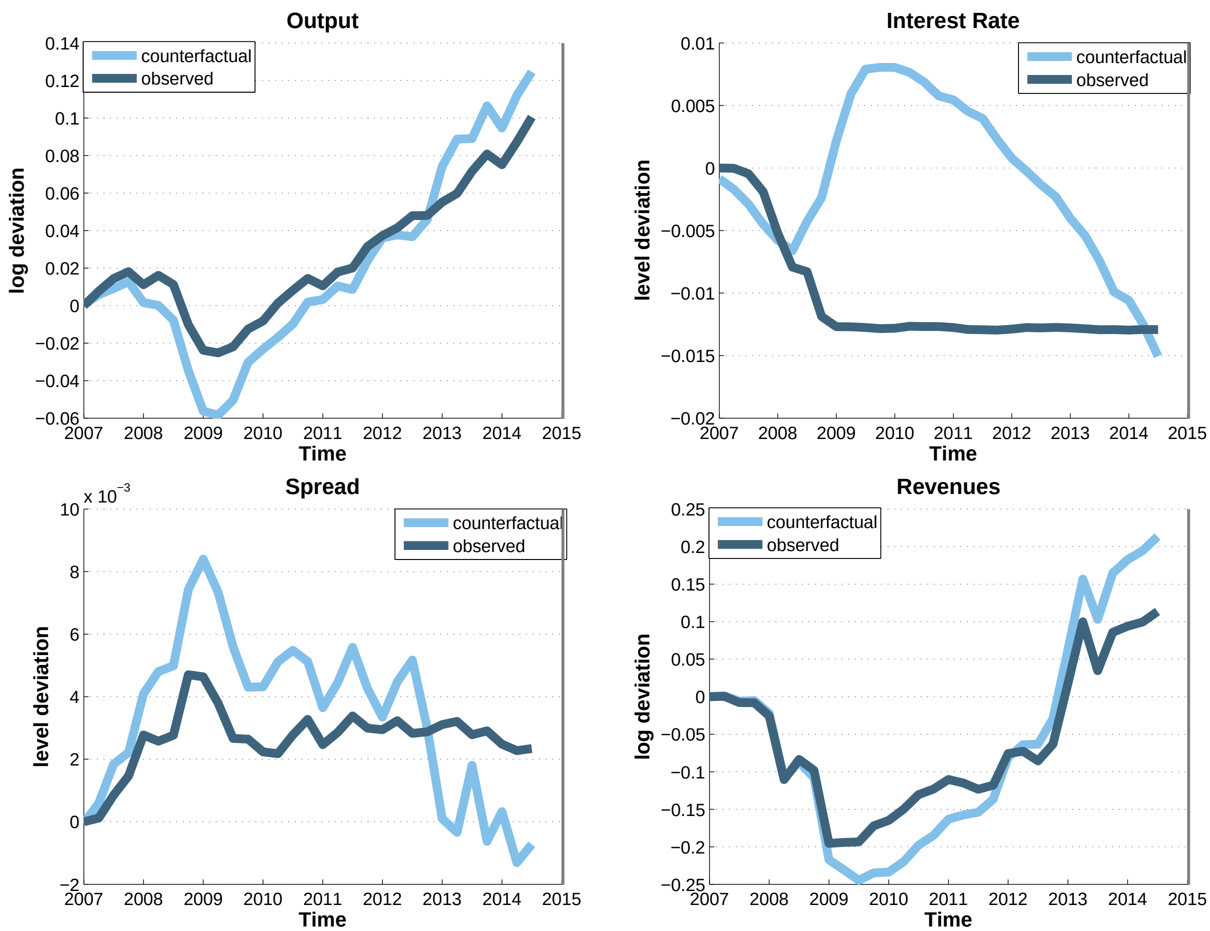
	No Financial frictions $\mu = 0$		*Financial frictions* $\mu = 0.12$	
	Euro Area	**United States**	**Euro Area**	**United States**
Panel A - Output				
Nominal rigidities $\theta = 0.8$				
Volatility	0.86	0.54	0.81	0.31
Variance decomposition				
ϵ_ω	0.0	0.0	2.7	17.0
ϵ_z	100.0	100.0	97.3	83.0
No nominal rigidities $\theta = 0.0$				
Volatility	1.12	1.12	1.09	1.02
Variance decomposition				
ϵ_ω	0.0	0.0	0.6	0.7
ϵ_z	100.0	100.0	99.7	99.3
Panel B - Inflation				
Nominal rigidities $\theta = 0.8$				
Volatility	0.19	0.19	0.20	0.22
Variance decomposition				
ϵ_ω	0.0	0.0	4.2	0.9
ϵ_z	100.0	100.0	95.8	99.1
No nominal rigidities $\theta = 0.0$				
Volatility	0.29	0.71	0.28	0.72
Variance decomposition				
ϵ_ω	0.0	0.0	1.0	0.4
ϵ_z	100.0	100.0	99.0	99.6

Note: Simulations under baseline calibration with only technology and credit shocks. Volatility and the variance explained by each of the shock are in percent.

Appendix D: Counterfactuals

In this simulation we extend the model to include inertia on the two policy rules, habit formation and partly price indexation to inflation, features that are included in models with more quantitative objective. In order to specify the persistence of policy rules, we assume an autocorrelation parameter of 0.9 in each case and we reset the response to endogenous variables such that the implied activism parameters are equal to those in the baseline specification. For example, for the United States, we estimate a monetary policy response to inflation of 0.782. For the counterfactual exercises in the Appendix, we set the smoothing component of monetary policy to 0.9 and the coefficient of the monetary policy response to inflation to 0.0782.

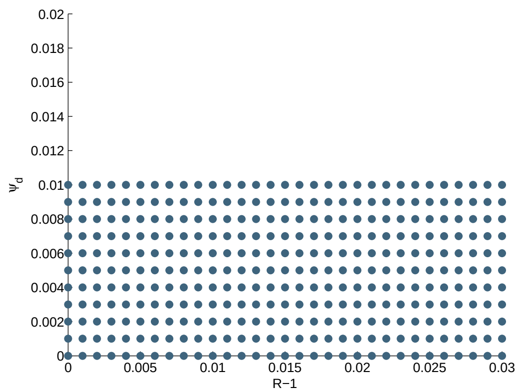
Figure A5: A counter-factual crisis and recovery



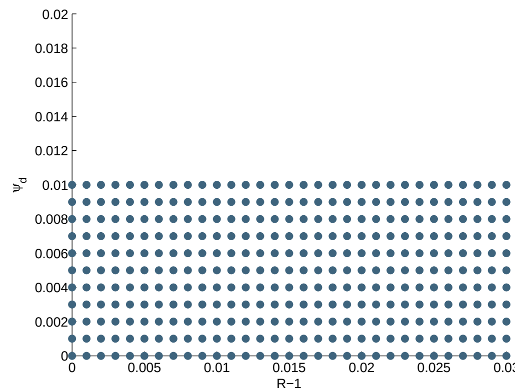
Note: Light line is the actual US data. Dark line is the the counter-factual economy simulated by imposing EU fiscal and monetary policies. In this simulations we further include inertia on the two policy rules, habit formation and partly price indexation to inflation.

Appendix E: Results under fixed interest rate at lower bound

Figure A6: Determinacy under fixed interest rate at lower bound



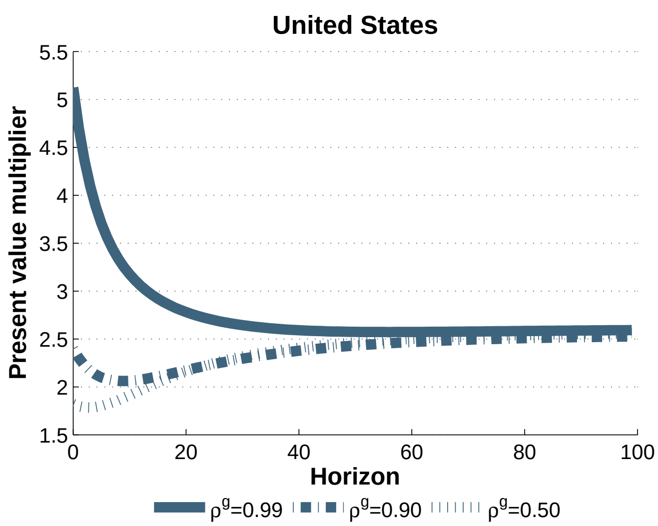
(a) No financial frictions $\mu = 0$



(b) Financial frictions $\mu = 0.12$

Note: Figures plot the determinacy regions with fixed interest rate at the zero lower bound. Figure (a) plots determinacy regions without financial frictions. Figure (b) plots these regions with financial frictions from $\mu = 0.12$.

Figure A7: Present value multipliers under the zero lower bound (US)



Note: Each curve indicates the degree of PVM_k calculated at different horizons in the horizontal axis, for 3 different degrees of persistence of government spending (0.50, 0.90 and 0.99). US monetary policy under the zero lower bound.

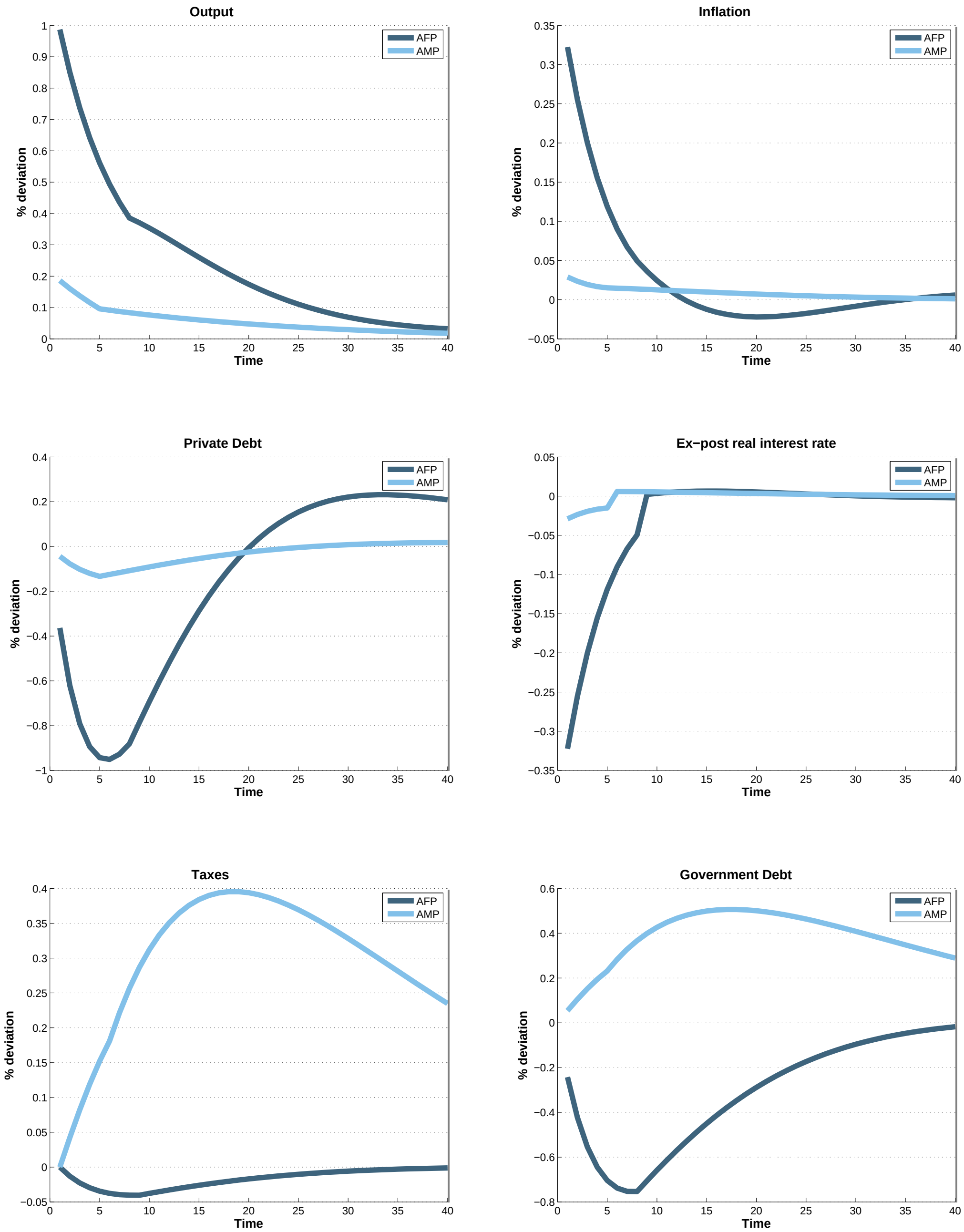
Table A8: Volatility and variance decomposition of output and inflation (US Zero lower bound)

	No Financial frictions $\mu = 0$		*Financial frictions* $\mu = 0.12$	
	Euro Area	**United States**	**Euro Area**	**United States**
		Zero lower bound		**Zero lower bound**
Panel A - Output				
Nominal rigidities $\theta = 0.8$				
Volatility	1.22	4.10	1.28	5.10
Variance decomposition				
ϵ_ω	0.0	0.0	1.2	0.0
ϵ_z	49.6	5.1	41.7	5.1
ϵ_r	19.6	0.0	23.6	0.0
ϵ_τ	0.0	45.2	0.0	45.2
ϵ_g	30.8	49.7	33.6	49.7
No nominal rigidities $\theta = 0.0$				
Volatility	1.30	1.30	1.33	2.03
Variance decomposition				
ϵ_ω	0.0	0.0	0.4	0.2
ϵ_z	75.2	75.2	67.2	24.9
ϵ_r	0.0	0.0	0.4	0.0
ϵ_τ	0.0	0.0	0.0	24.1
ϵ_g	24.8	24.8	32.0	50.8
Panel B - Inflation				
Nominal rigidities $\theta = 0.8$				
Volatility	0.31	1.85	0.35	2.04
Variance decomposition				
ϵ_ω	0.0	0.0	1.4	0.0
ϵ_z	35.3	0.8	30.8	0.7
ϵ_r	58.0	0.0	59.6	0.0
ϵ_τ	0.0	58.7	0.0	51.8
ϵ_g	6.7	40.6	8.3	45.9
No nominal rigidities $\theta = 0.0$				
Volatility	0.58	4.33	0.58	4.71
Variance decomposition				
ϵ_ω	0.0	0.0	0.2	0.0
ϵ_z	24.4	1.6	22.9	1.4
ϵ_r	73.1	0.0	74.0	0.0
ϵ_τ	0.0	56.9	0.0	62.2
ϵ_g	2.5	41.5	2.9	36.4

Note: Simulations for the Euro Area under baseline calibration. For the United States we consider a scenario with a permanent zero lower bound. Volatility and the variance explained by each of the shock are in percent.

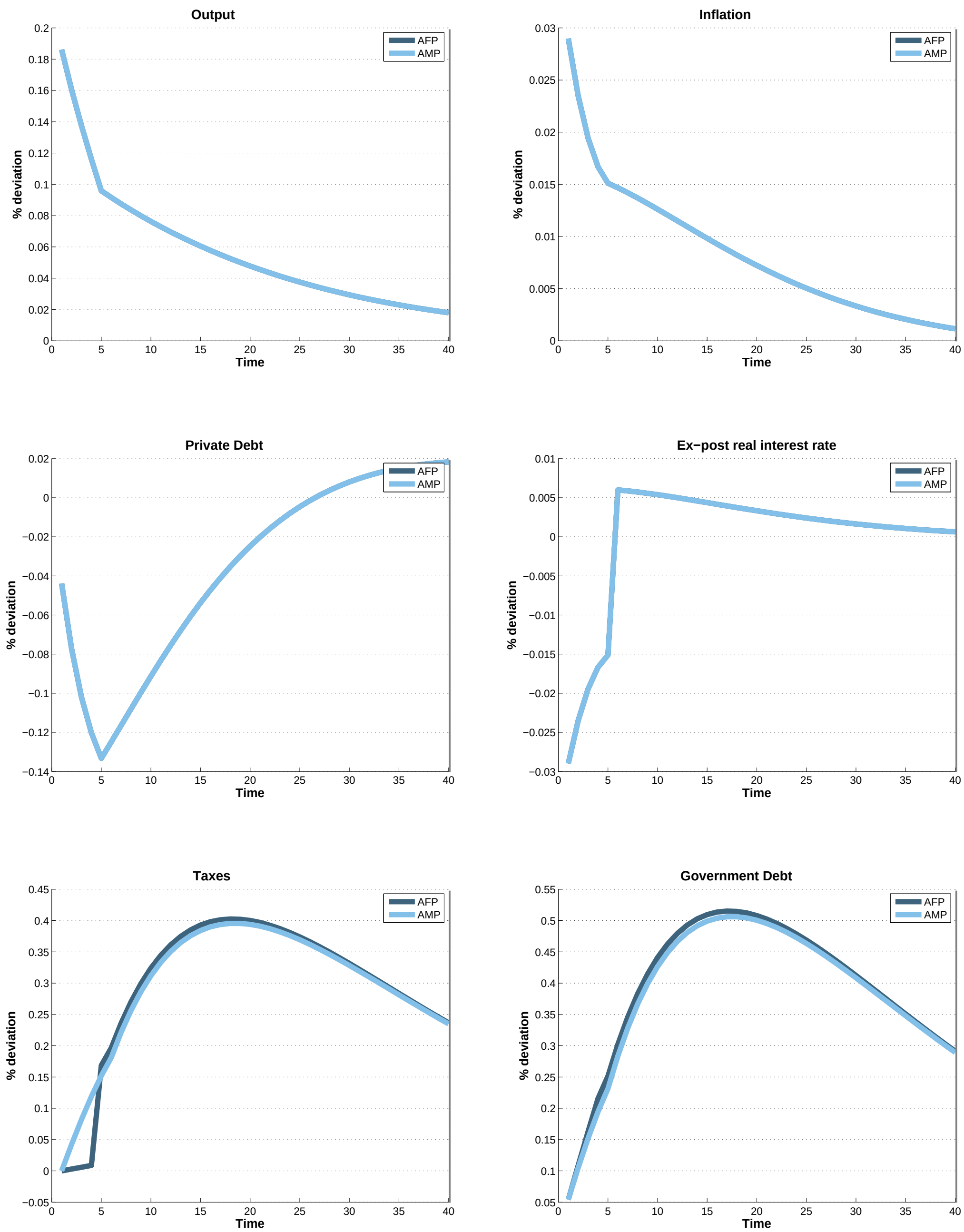
Appendix F: Results under occasionally zero lower bound

Figure A8: Response to a 1 percent increase in Government Spending under the ZLB



Note: Here we plot ZLB hitting for 2 different regimes, the AFP and the AMP regimes.

Figure A8: Response to a 1 percent increase in Government Spending under the ZLB with policy change



Note: Here we plot ZLB hitting when the reference regime is AMP and during the periods in which the ZLB binds there is a policy change to AFP (in the blue line) or not (the light blue line).