On the Interactions between Money Supply and Fiscal Stimulus

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Abstract

In 2020, at the onset of the recent economic crisis, numerous scholars advocated for utilizing money supply issued by the central bank to support expansionary fiscal interventions. This paper aims to further investigate and evaluate this proposal. Specifically, we develop and estimate a New Keynesian model to analyse the effects of a fiscal stimulus that does not result in an increase in public debt, as it is financed by money supply. Through our impulse response analysis, we validate the findings of Galí (2020a), which indicate that an increase in monetary-financed government spending and monetary-financed government transfers have positive economic impacts on consumption and output. Notably, our model also demonstrates similarly positive effects on investment. However, the expansionary impact of monetary-financed fiscal shocks come at a cost: an increase in inflation. The estimation of the model is conducted using US data. The chapter contributes to the existing literature by providing a quantitative counterfactual analysis of the utilization of money supply for financing fiscal stimuli.

Keywords: Fiscal Policy, Money Supply, Fiscal Stimulus

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1 Introduction

Over the past 15 years, the global economy has experienced significant economic and financial changes, which were further exacerbated by the two recent economic crises: the Global Financial Crisis (GFC) and the COVID-19 pandemic. These disruptions affected both aggregate demand and aggregate supply, resulting in adverse global consequences, such as rising unemployment rates and increased income inequalities. Among others, Benigno and Nisticò (2020) highlight the ongoing debate among academics and policymakers, suggesting that cooperation between governments and central banks could lead to effective measures in mitigating the adverse impact of unexpected crises.

Our analysis primarily focuses on periods characterized by high levels of public debt, low inflation, and subdued aggregate demand. In this economic context, our model demonstrates the expansionary economic impact of a monetary-financed fiscal stimulus. We adopt the approach proposed by Benigno and Nisticò (2020), and abstract from central bank balance sheet implications. As highlighted by Benigno and Nisticò (2020), this is possible because the central bank is a unique entity, and its liabilities and reserves are not subject to nominal risks. In our analysis, we investigate the effects of both government transfers and government spending which are monetary-financed, on economic aggregates.

Figure 1 illustrates the evolution of these two time series in the United States since 1960. As discussed in Bianchi et al. (2023), the share of government transfers relative to GDP has been rising in recent decades, while the percentage of government spending with respect to output has been declining. Our model considers both fiscal stimuli and allows for one fiscal stimulus to adjust when the other one is increased.

Additionally, figure 2 depicts the evolution of the M2 monetary aggregate and the public debt-to-GDP over the last six decades. The figures demonstrate a similar pattern of percentage changes in both the M2 and public debt-to-GDP series. Moreover, the aftermath of the

2020-2021 pandemic crisis has contributed to a significant increase in the US public debt, leading to the implementation of President Biden's $1.9 trillion 2021 Stimulus Package. During and in the aftermath of economic crises, particularly over the past 15 years, central banks worldwide have taken measures to address economic challenges. This included reducing interest rates to historically low levels and implementing policies aimed at facilitating lending procedures, both to businesses and financial institutions. Furthermore, central banks have undertaken substantial investments through asset-purchasing programs to support financial markets and stabilize the economy. Concurrently, governments have implemented significant fiscal stimuli, leading to a further increase in sovereign debt levels. Therefore, we find it pertinent to conduct a counterfactual analysis to examine the economic impact of fiscal stimuli combined with money supply from a quantitative perspective.

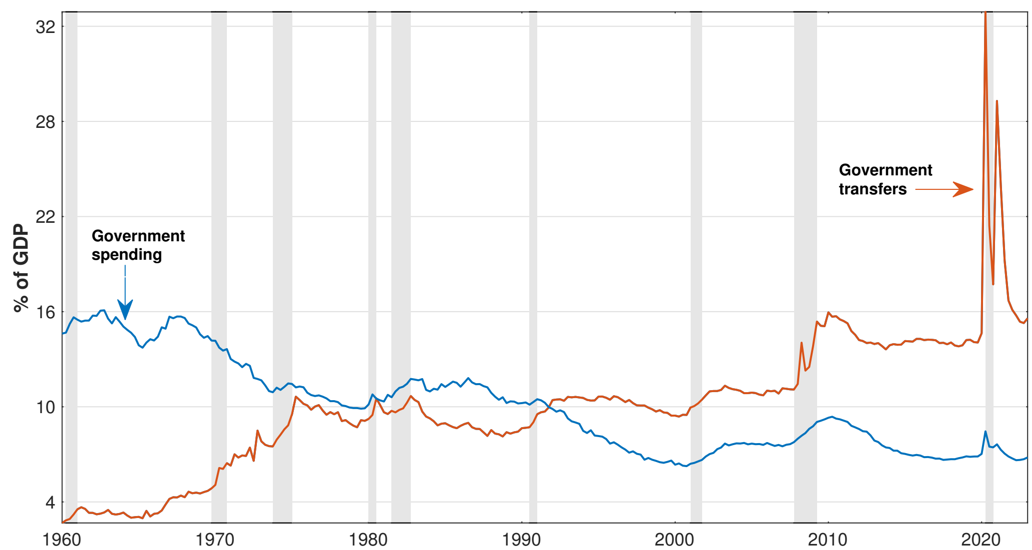
As highlighted in Ng (2021), it is crucial to treat COVID data as exogenous controls in a VAR (Vector Autoregression) setting. The author demonstrated that the response of economic aggregates to general economic shocks differs from their response to COVID shocks. For the same reason, Primiceri and Tambalotti (2020) propose a set of assumptions needed in order to perform forecasting analysis after the pandemic crisis. The authors introduce a "tilting" of the COVID-driven shock to accommodate the extraordinary nature of this period. Therefore, despite the significant impact of the recent economic crisis on the increase in public debt, our sample ends at 2019Q4. This is done because of the uniqueness of this period and the exceptional impact it had on GDP and consumption.

From a theoretical point of view, we use a medium-scale New Keynesian model that includes habits on consumption, nominal rigidities, capital, and investment adjustment costs. Our model features a rich set of shocks, including fiscal shocks. These models have been proven to provide a relatively good fit for US business cycle fluctuations (Del Negro et al., 2007; Smets and Wouters, 2007; Christiano et al., 2011). We estimate the model with Bayesian techniques for the sample period 1960Q1:2019Q4 using US data. We proceed with a counterfactual analysis employing the estimated parameters derived from our model. To conduct this analysis, we extend the same model to incorporate a "monetary-financing" component, wherein the money supply becomes an integral part of the government budget constraint. Within this framework, the central bank accommodates fiscal policy and shifts its emphasis from setting the interest rate to controlling the money supply. This framework is similar to the one proposed by Galí (2020a), in which money supply is determined endogenously and finances the fiscal stimuli. We finally compare the impact on aggregate demand of an increase in government spending and lump-sum transfers financed by money supply, with the same fiscal stimulus financed by debt. Through our impulse response analysis, we validate the expansionary effects associated with this alternative monetary strategy. As expected, the expansionary impact of a monetary-financed fiscal stimulus comes at a cost, which is an increase in inflation.

2 Literature review

The interactions between monetary policy and fiscal policy have been extensively examined in the economic literature. Notably, studies by Sargent et al. (1981), Leeper (1991), Sims (1994), Schmitt-Grohé and Uribe (2000) and Davig and Leeper (2011), among others, investigate the implications of the fiscal-monetary policy mix on various macroeconomic aggregates. Mertens and Ravn (2014) and Bianchi et al. (2020) examine the collaborative nature of monetary and fiscal policies as an effective tool for mitigating the adverse effects of economic and non-economic shocks. In an economic landscape of high levels of public debt, and substantial fiscal stimulus, the concept of a "monetary-financed fiscal stimulus"

Figure 1: Government spending and government transfers as a percent of US GDP, 1960Q1 - 2023Q1

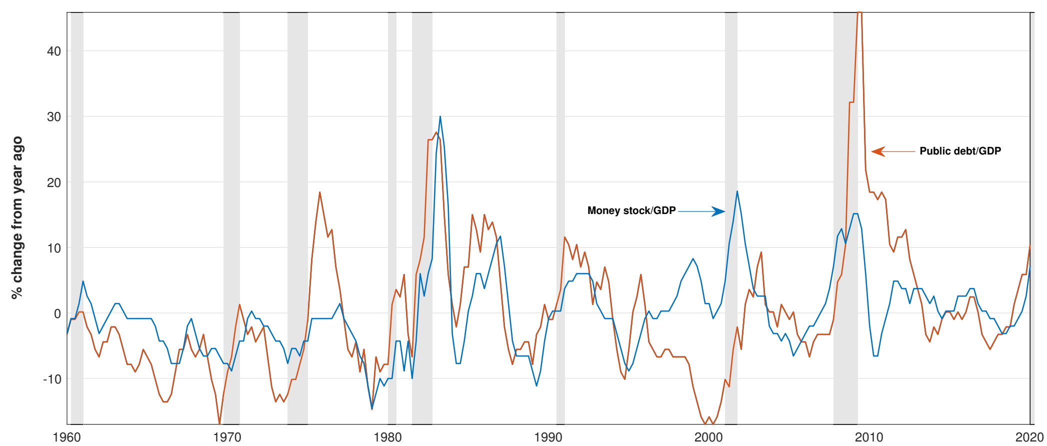


Note: Source of data: Economic Data from the Federal Reserve Bank of St. Louis database. Shaded areas represent NBER recessions.

Galí (2020a) has gained growing consensus among scholars.[1] According to Galí (2020b), in practice, the monetary-financed fiscal stimulus would involve a credit to the government account held at the central bank or the acquisition of non-redeemable government debt from the central bank. Consequently, this debt would be permanently held on the balance sheet of the central bank. Another line of literature, as proposed by Bernanke (2016) suggests the establishment of a new government account at the central bank, exclusively for emergency situations. In all cases, when the central bank engages in monetary financing of the public

[1]Bernanke (2003) refers to this concept using Milton Friedman's terminology "Helicopter money", which refers to lump-sum transfers to households financed by newly printed money. Andolfatto et al. (2013) analyses the monetization of public debt, which involves the permanent purchase of government bonds from the central bank. Giavazzi and Tabellini (2014) propose the issuance of long-term maturity debt, such as 30 years, which would be bought by the central bank. Cukierman (2020) and Galí (2020a) discuss about seigniorage, which is defined as the purchasing power of increased money supply used by the central bank to directly purchase newly issued government debt. In this case, the central bank would buy government debt and the government would not have to repay the debt, nor the interest on it.

Figure 2: Money supply and public debt-to-GDP ratio in the US, 1960Q1 - 2019Q4



Note: Money supply aggregate is represented by the M2 money stock. The public debt is represented by the market value of marketable treasury debt, and GDP is the Gross Domestic Product. Source of data: Economic Data from the Federal Reserve Bank of St. Louis database. Shaded areas represent NBER recessions.

debt, the money supply experiences a permanent increase.[2] The use of monetary-financing is typically reserved for extreme circumstances when public debt levels are already high and interest rates are too low to provide an effective tool for economic recovery and combating low inflation. During times of aggregate demand disruptions, Woodford (2012) and Turner (2015) demonstrate that monetary-financing would stimulate aggregate demand to a greater extent compared to debt-financing. Turner (2015) further argues that monetary-financing is more desirable and optimal compared to alternative policies measures.

In the context of providing fiscal stimulus through a tax cut or an increase in government spending backed by money creation Bernanke (2003) emphasizes the importance of making sure that "much or all of the increase in the money stock is viewed as permanent" (Bernanke (2003, p.7). By utilizing money supply to finance a fiscal stimulus through a permanent increase in the monetary base, it becomes possible to address the issue of Ricardian equivalence

[2]It is worth noting that this distinguishes monetary-financed fiscal stimuli from quantitative easing, which has only a temporary impact on the monetary base.

that undermines the efficiency of fiscal stimuli.

A policy measure involving the cooperation between the central bank and the government to achieve monetary-financing of public debt has raised concerns regarding the potential consequences of hyperinflation (Sargent and Wallace, 1973). However, our analysis focuses on a counterfactual scenario involving monetary-financed fiscal stimuli during a period when the central bank has limited scope to implement expansionary monetary policy due to low interest rates. This economic setting differs substantially from a high inflation period in which central banks raise policy rates to combat inflation and manage inflation expectations. Given the persistent low inflation and well-anchored inflation expectations observed over the past decade, as well as the recognition of the credibility and independence of central banks in developed countries by the market, Cukierman (2020) argues that the risk of hyperinflation may be of lesser concern. Lawson and Feldberg (2020) explain that when central banks are characterized by independence and credibility, there may be scope for monetisation without the need to give up their credibility. Furthermore, past instances of hyperinflation resulting from the monetisation of public spending occurred during periods when central banks and governments were not separate entities. The Zimbabwe hyperinflation and the Weimar Republic episode in the 1920s are two examples.

Another criticism refers to the political sphere, as highlighted by Giavazzi and Tabellini (2014) and Turner (2015). They argue that the use of the money-financing policy may be misleading and lead to its excessive and unwarranted utilisation. Turner (2015) further contends that the monetary-financing policy is desirable under all circumstances, and the only obstacle lies in addressing limitations from a policy perspective. Once these limitations are overcome, the money-financing policy becomes the optimal approach to stimulate aggregate demand.

As assessed in previous literature and corroborated in our analysis, a monetary-financed fiscal policy that does not increase public debt has the potential to increase inflation levels. As mentioned earlier, the focus of this paper is to evaluate the macroeconomic impact of a monetary-financed fiscal stimulus during periods of low aggregate demand and when interest rates are constrained by the effective lower bound. Given the limited scope for expansionary monetary policy in such a liquidity trap scenario, it becomes pertinent to quantitatively investigate this alternative proposal. In this particular setting, characterized by persistently low inflation levels (as observed in the US over the past decade), an inflationary effect resulting from monetary-financed fiscal stimuli can serve to mitigate a portion of the government debt burden through the process of "inflating-away". Bianchi et al. (2023) develop a theoretical framework that allows for partially unfunded fiscal shocks. Similar to the monetary financing scheme, unfunded fiscal shocks have a positive impact on real variables. In their model, the central bank controls monetary policy while the government controls fiscal policy. However, the central bank accommodates the necessary increase in inflation to support the unfunded fiscal shocks. Our quantitative analysis contributes to the existing literature on monetary-financed fiscal stimuli, specifically in the context of US data. By conducting an analysis of the utilisation of money supply to finance fiscal stimuli, we provide insights into the potential implications and outcomes of such a policy approach.

The rest of the paper is structured as follows. Section 3 describes the theoretical model. Section 4 discusses the estimation results. Section 4.3 shows simulation results comparing a scenario in which fiscal stimulus is monetary-financed and a scenario in which fiscal stimulus is debt-financed. Section 6 describes robustness analysis, and section 7 concludes.

3 Theoretical model

In this section the theoretical model is described. The structure of the model is similar to medium-scale new Keynesian models present in the literature (Smets and Wouters, 2007;

Christiano et al., 2005; Del Negro and Schorfheide, 2008; Leeper et al., 2017).

The economy is populated by a continuum of agents, intermediate good firms, a final good firm, a government and a central bank. Intermediate firms are monopolistically competitive, rent capital from households, produce goods by setting prices à la Calvo (Calvo, 1983). The final good is produced and packed by a final good firm and is then sold to households. The wage is set on a frictional labour market. The households in turn provide labour to intermediate firms, obtain dividends from the firms, and utility from consumption, real balances, labour and fiscal policies. For the fiscal policy side, we focus on two instruments: transfers and government spending. The government issuing (expansionary) fiscal policies faces a scenario in which additional public debt emerging from the expansionary fiscal policy is debt-financed through issuance of government bonds. This is the traditional "debt-financed scenario". In the counterfactual scenario, the government finances the increase in public debt through an increase in money supply. This is the "monetary-financed scenario".

Henceforth, upper case variables with a time subscript are variables in levels, steady state variables are letters without a time subscript and lower case variables with a hat are linearized variables. Linearization is made in terms of log deviations of a variable from its steady state value.

3.1 Households

The household derives utility from consumption, real money balances and labour maximising the following utility function:

$$\max_{C_t(j), \frac{M_t(j)}{P_t}, L_t(j)} E_t \left\{ \sum_{t=0}^{\infty} \beta^s b_{t+s} \left[\left(ln\left(C_{t+s}(j) - hC_{t+s-1}(j)\right) + \frac{\chi_t}{1-\nu_m} \left(\frac{M_{t+s}(j)}{P_{t+s}} \right)^{1-\nu_m} \right) - \frac{\phi_t}{1+\nu_l} L_{t+s}(j)^{1+\nu_l} \right] \right\} \tag{1}$$

where C_t, $\frac{M_t}{P_t}$, L_t represent respectively consumption, real money balances and labour. β_t is the discount factor, b_t represents a preference shifter to the household's utility function and h is a parameter representing habits. ϕ_t and χ_t are two preference shifters affecting the marginal utility of leisure and money holdings. The preference shifters follow AR(1) processes as follows:

$$ln\,\phi_t = (1-\rho_\phi)\,ln\,\phi + \rho_\phi\,ln\,\phi_{t-1} + \sigma_{\phi,t}\,\epsilon_{\phi,t}, \text{with}\,\epsilon_{\phi,t} \sim N(0,1) \tag{2}$$

$$ln\,b_t = (1-\rho_b)\,ln\,b + \rho_b\,ln\,b_{t-1} + \sigma_{b,t}\,\epsilon_{b,t}, \text{with}\,\epsilon_{b,t} \sim N(0,1) \tag{3}$$

$$ln\,\chi_t = (1-\rho_\chi)\,ln\,\chi + \rho_\chi\,ln\,\chi_{t-1} + \sigma_{\chi,t}\,\epsilon_{\chi,t}, \text{with}\,\epsilon_{\chi,t} \sim N(0,1) \tag{4}$$

In our model, consumption and real money balances enter the household's objective function in a separable way, following Del Negro and Schorfheide (2008) and Punzo and Rossi (2022).

The budget constraint faced by the household is given by:

$$\begin{aligned} &P_{t+s}C_{t+s}(j) + P_{t+s}I_{t+s}(j) + B_{t+s}(j) + M_{t+s}(j) \\ &= R_{t+s-1}B_{t+s-1}(j) + M_{t+s-1}(j) + R^k_{t+s}(j)K_{t+s-1}(j) \\ &+ W_{t+s}(j)N_{t+s}(j) + P_{t+s}D_{t+s}(j) + P_{t+s}T_{t+s}(j) \end{aligned} \tag{5}$$

where I_t is investment, K_t is capital and R^k_t is the rate of return on capital. Bonds B_t pay a price of $R_t = 1 + i_t$. Households receive T_t transfers from the government and D_t represent dividends obtained from firms. W_t is the nominal wage obtained by the households. The equation for capital accumulation is given by:

$$K_t(j) = (1-\delta)\,K_{t-1}(j) + \mu_t\left(1 - S\left(\frac{I_t(j)}{I_{t-1}(j)}\right)\right)I_t(j) \tag{6}$$

$S(\cdot)$ is a function representing the investment adjustment costs, with $S''(\cdot) > 0$. δ is the depreciation rate of capital. μ_t represents a shock to investment, and follows an AR(1) process:

$$ln\,\mu_t = (1-\rho_\mu)\,ln\,\mu + \rho_\mu\,ln\,\mu_{t-1} + \sigma_\mu\,\epsilon_{\mu,t}, \text{with}\,\epsilon_{\mu,t} \sim N(0,1) \tag{7}$$

3.2 Labour packers

The economy is populated by labour packers, which hire households providing labour, combine it into labour services, L_t, and provide it to intermediate firms.

$$L_t = \left[\int_0^1 L_t(j)^{1/(1+\lambda_w)} di\right]^{1+\lambda_w} \tag{8}$$

where λ_w is a parameter. We obtain a labour demand function and the price of aggregated labour L_t:

$$L_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-(1+\lambda_w)/\lambda_w} L_t \tag{9}$$

and

$$W_t = \left[\int_0^1 W_t(j)^{-1/\lambda_w} di\right]^{-\lambda_w} \tag{10}$$

The wage setting is subject to nominal rigidities following Calvo (1983). Each period a fraction ξ of households cannot optimize nor change their wage. For these households, the wage increases at the geometrically weighted average of the steady state rate of inflation $\pi^\star$ and of last period's inflation π_{t-1} with weights $1-\iota_w$ and ι_w. The problem for the households that can adjust their wages is:

$$\begin{aligned}
&\max_{\tilde{W}_t} E_t \sum_{t=0}^{\infty} \zeta_w^s \beta^s b_t \left[-\frac{\phi_t}{1+\nu_l} L_t(j)^{1+\nu_l}\right] \\
&\text{s.t. } L_t(j) = \left(\frac{W_t(j)}{W_t}\right)^{-\frac{1+\lambda_w}{\lambda_w}} L_t \\
&\text{eq. (5) and}
\end{aligned} \tag{11}$$

$$W_{t+s}(j) = \left(\prod_{l=1}^{s} (\pi^*)^{1-\iota_w} (\pi_{t+l-1})^{\iota_w} \right) \tilde{W}_t(j)$$

The first order condition of the problem above is:

$$W_t = \left[(1-\zeta_w)\, \tilde{W}_t^{-1/\lambda_w} + \zeta_w \left((\pi^*)^{1-\iota_w} (\pi_{t-1})^{\iota_w} W_{t-1} \right)^{-1/\lambda_w} \right]^{-\lambda_w} \tag{12}$$

3.3 Final good firms

Final good firms operate in a perfectly competitive market and produce an homogeneous good Y_t. The final good firms buy intermediate goods from intermediate firms and pack and sell the final good Y_t to consumers. Thus, Y_t is an index represented by a continuum of intermediate goods $Y_t(i)$:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{1}{1+\lambda_t^p}}\, di \right]^{1+\lambda_t^p} \tag{13}$$

where λ_t^p is the mark-up shock and follows an AR (1) process:

$$ln\lambda_t^p = (1-\lambda_t^p)\, ln\lambda^p + \rho_{\lambda^p}\, ln\lambda_{t-1}^p + \sigma_{\lambda^p}\, \epsilon_{\lambda_t^p}, \text{with}\, \epsilon_{\lambda_t^p} \sim N(0,1) \tag{14}$$

We obtain that

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\frac{1+\lambda_t^p}{\lambda_t^p}} Y_t$$

and the price of the final goods firm is:

$$P_t = \left[\int_0^1 P_t(i)^{\frac{1}{\lambda_t^p}}\, di \right]^{-\lambda_t^p}$$

where the price of the final good is P_t and the price of the intermediate good (i) is $P_t(i)$.

3.4 Intermediate good firms

The representative intermediate goods firm follows a Cobb Douglas technology that makes use of capital K_t and labour L_t through the following relation:

$$Y_t(i) = A_t^{1-\alpha} K_t(i)^{\alpha} L_t(i)^{1-\alpha} \tag{15}$$

where Y_t is the output produced in period t and A_t represents fixed technology across all firms. A_t follows an AR(1) process:

$$lnA_t = \rho_a lnA_{t-1} + \sigma_a \epsilon_t^a,\ \epsilon_t^a \sim N(0,1)$$

The intermediate firm decides on the quantity of capital stock to rent from households and on the quantity of labour to employ. Capital and labour represent costs for the firms, and as a consequence the firm's problem is to maximize its profits, that are equal to:

$$\Pi_{it} = P_{it} Y_{it} - W_t N_{it} + R_t^k K_t$$

that results in a capital-labour ratio which is equal for all firms:

$$\frac{K_t(i)}{L_t(i)} = \frac{\alpha}{1-\alpha} \frac{W_t}{R_t^k} \tag{16}$$

Intermediate goods firms set their prices à la Calvo (1983), thus similar to the wage setters. Calvo price setting allows a number $1-\theta$ of firms to reset their prices in period t, while the remaining θ fraction of firms keep their prices indexed to the inflation rate in period $t-1$. Those firms that cannot adjust their prices will have a price increasing with the steady state inflation π and the inflation in period $t-1$, π_{t-1}. Firms that may change their price, choose a price P_t^* today taking into consideration the impact of P_t^* on future profits. The price P_t^* is the same across all firms readjusting it. The price setting for intermediate good firms follows the same process as for wages. A fraction of firms $1-\zeta^p$ adjust their prices, while a fraction ζ^p cannot adjust them. Prices for the non-adjusting firms follow:

$$P_t(i) = (\pi_{t-1})^{\iota^p} (\pi^*)^{1-\iota^p} \tag{17}$$

and the firms able to adjust their prices, follow the optimal price equation:

$$\max_{\tilde{P^*}_t} \sum_{s=0}^{\infty} \zeta_p^s \beta^s \Xi_{t+s}^p \left(\tilde{P}_t(i) \left(\prod_{l=1}^{s} \pi_{t+l-1}^{\iota^p} {\pi^*}^{1-\iota^p} \right) - MC_{t+s} \right) Y_{t+s}(i) \tag{18}$$

where $\tilde{P}_t(i)$ is the newly set price and MC_{t+s} is the marginal cost. ι^p represents the price indexation parameter and Ξ_{t+s}^p is the Lagrange multiplier.

Aggregate price dynamics, considering the Calvo pricing parameter is given by:

$$P_t = \left[(1-\zeta_p)\, \tilde{P}_t(i)^{-\frac{1}{\lambda_{f,t}}} + \zeta_p \left(\pi_{t-1}^{\iota_p} \pi_\star^{1-\iota_p} P_{t-1} \right)^{-\frac{1}{\lambda_{f,t}}} \right]^{-\lambda_{f,t}}$$

The aggregate price is thus given by a weighted average of the price set by the firms that adjust it and the price of firms that keep it indexed to last period's inflation, with a weight given by ζ_p.

3.5 Monetary policy

The central bank sets up the nominal interest rate r_t according to changes in inflation and the difference between output and potential output (Taylor, 1993)

$$\frac{R_t}{R^*} = \left(\frac{R_{t-1}}{R^*} \right)^{\rho_m} \left[\left(\frac{\pi_t}{\pi^*} \right)^{\phi_\pi} \left(\frac{Y_t}{Y^*} \right)^{\phi_y} \right]^{1-\rho_m} e^{\epsilon_t^m} \tag{19}$$

where R^* and Y^* are the target level of interest rate and output set by the central bank, π^* is the inflation target, and ρ_m captures the degree of interest rate smoothing. ϕ_π is the weight of inflation on the interest rate and ϕ_y is the weight of output gap on the interest rate. ϵ_t^m is a monetary policy exogenous shock and it is assumed to follow an AR (1) process:

$$ln\, \epsilon_t^m = \rho_m ln\, \epsilon_{t-1}^m + \mu_t^m,\, \mu_t^m \sim N(0,1)$$

3.6 Fiscal policy

The government budget constraint is:

$$P_t G_t + B_{t-1}(1 + i_{t-1}) = P_t T_t + B_t + \Delta M_t \tag{20}$$

where G_t represents government expenditures and $\Delta M_t = M_t - M_{t-1}$.

Transfers follow a fiscal rule, that we construct based on Leeper et al. (2010). In linearized form, the fiscal rule is the following:

$$T_t = -\frac{{B_{t-1}}^{\psi_{bt}}}{{Y_t}^{\psi_{yt}}}\, e^{t_t^*} \tag{21}$$

where t_t^* is a shock to taxes and it is assumed to follow the AR process:

$$ln\, t_t^* = \rho^t ln\, t_{t-1}^* + \sigma^t \epsilon_t^t,\, \epsilon_t^t \sim N(0,1) \tag{22}$$

The government spending shock follows an AR process:

$$ln\, g_t = \rho^g ln\, g_{t-1} + \sigma^g \epsilon_t^g,\, \epsilon_t^g \sim N(0,1) \tag{23}$$

4 Estimation results

4.1 Data and estimation technique

We use quarterly data publicly available on the Economic Data website of the Federal Reserve Bank of St. Louis. All observable variables except the fiscal observables are constructed as in Smets and Wouters (2007). Fiscal observable variables are computed following the methodology described in Leeper et al. (2010). A more detailed description of the data time series and data transformation is in Appendix B.

We use quarterly data and nine time series. The time series used match the variables in our model of consumption, investment, hours worked, real wage, inflation, the nominal interest rate, government spending and government transfers and money supply. The observable equation for each observable matching the model variable is:

$$X_t = X_{obs} \tag{24}$$

where X_t represents the model variable and X_{obs} is the observable variable.

We employ Bayesian estimation techniques, which enable us to specify prior probability distributions for model parameters and subsequently combine these with likelihood functions derived from the data. This method is well-suited for our analysis, as we can draw upon extensive literature on DSGE modeling to inform our choice of priors.

We estimate the model using 1 million draws. The acceptance rate il approximately 23%

4.2 Fixed parameters and prior distributions

Table 1 describes calibrated values for the fixed parameters. We fix the household's discount factor to 0.99 to match a 4% annual real interest rate. We obtain an average annual inflation rate that closely matches the one in our sample, equal to approximatively 4%. The labour share in our production function is calibrated to be 0.33 and the capital depreciation rate is set at 0.025 as in Del Negro et al. (2007) and Bianchi et al. (2023).

Table 1: Calibrated parameters and source

Parameter	**Value**	**Source**
β Household's discount factor	0.99	to match 1% real annual int.rate
α Labour share in Cobb Douglas function	0.33	Del Negro et al. (2007)
δ Capital depreciation rate	0.025	Del Negro et al. (2007)
ν Inverse elasticity of substitution consumption to money	1	Galí (2015)
λ_w Steady state wage markup	0.3	Del Negro et al. (2007)
χ Steady state inverse velocity of money supply	0.52	Our sample
$\frac{G}{Y}$ Share of government spending on GDP	0.22	Our sample
$\frac{T}{Y}$ Share of government transfers on GDP	0.26	Our sample
$\frac{B}{Y}$ Share of public debt on GDP annualized	2.4	Galí (2020a)

We follow Galí (2015) to calibrate the inverse elasticity of substitution between money and consumption, and set the parameter to 1. The inverse velocity of money supply in steady state and the shares of government spending and transfers are set equal to our sample averages. We finally calibrate the share of public debt to GDP as in Galí (2020b).

4.3 Estimation results

Table 2, 3, 4 show results for parameters estimated with Bayesian estimation.

Table 2: Standard errors of shocks

Parameter	Prior			Posterior		
	Distribution	*Mean*	*St. Dev*	*Mean*	10%	90%
σ_z Productivity shock standard error	Inv. gamma	0.1	2	1.19	1.09	1.28
σ_b Risk premium shock standard error	Inv. gamma	0.1	2	2.80	2.35	4.14
σ_g Government spending shock standard error	Inv. gamma	0.1	2	2.61	2.42	2.82
σ_i Investment shock standard error	Inv. gamma	0.1	2	13.98	8.69	19.29
σ_r Monetary policy shock standard error	Inv. gamma	0.1	2	0.26	0.24	0.28
σ_π Inflation shock standard error	Inv. gamma	0.1	2	9.44	5.58	14.38
σ_t Transfers shock standard error	Inv. gamma	0.1	2	4.46	4.12	4.80
σ_m Money supply shock standard error	Inv. gamma	0.1	2	24.48	55.45	64.63
σ_l labour supply shock standard error	Inv. gamma	0.1	2	57.75	36.78	84.84

Table 3: Persistence parameters

Parameter	Prior			Posterior		
	Distribution	*Mean*	*St. Dev*	*Mean*	10%	90%
ρ_z Productivity persistence parameter	Beta	0.7	0.2	0.63	0.56	0.69
ρ_b Risk premium persistence parameter	Beta	0.7	0.2	0.36	0.25	0.48
ρ_g Government spending persistence parameter	Beta	0.7	0.2	0.63	0.55	0.71
ρ_μ Investment persistence parameter	Beta	0.7	0.2	0.34	0.24	0.44
ρ_r Monetary policy persistence parameter	Beta	0.7	0.2	0.21	0.11	0.31
ρ_π Inflation persistence parameter	Beta	0.7	0.2	0.64	0.55	0.74
ρ_t Transfers persistence parameter	Beta	0.7	0.2	0.35	0.26	0.45
ρ_m Money supply persistence parameter	Beta	0.7	0.2	0.77	0.70	0.84
ρ_l labour supply persistence parameter	Beta	0.7	0.2	0.09	0.02	0.16

Prior distributions and values, and standard deviations of the standard errors of shocks are set as in Smets and Wouters (2007). Priors of persistence parameters are set following Leeper et al. (2010), while we follow Bianchi et al. (2023) for the transfer parameter referring to debt and output, for the Taylor rule parameters and for the parameters regarding price and wage rigidities. We set priors for the investment adjustment costs and for habits as in

Del Negro et al. (2007). Graphs for prior and posterior distributions, together with other estimation output can be found in Appendix C.

Table 4: Structural parameters

	Prior			**Posterior**		
Parameter	*Distribution*	*Mean*	*St. Dev*	*Mean*	10%	90%
h Consumption habits	Beta	0.7	0.1	0.82	0.80	0.89
ρ_r Interest rate smoothing parameter	Beta	0.75	0.1	0.74	0.71	0.80
ϕ_π Weight of inflation on the interest rate	Normal	2.00	0.1	0.84	1.70	2.04
ϕ_y Weight of output on the interest rate	Normal	0.5	0.1	0.04	0.00	0.07
Γ Investment adjustment costs	Normal	4.00	1.5	4.59	2.95	6.31
ψ_{bt} Transfers parameter for debt	Gamma	0.25	0.1	0.36	0.14	0.47
ψ_{yt} Transfers parameter for output	Gamma	0.1	0.05	0.11	0.03	0.20
ζ_w Wage stickiness	Beta	0.5	0.1	0.68	0.64	0.74
ι_w Wage indexation	Beta	0.5	0.2	0.13	0.01	0.23
ζ_p Price stickiness	Beta	0.5	0.1	0.85	0.83	0.88
ι_p Price indexation	Beta	0.5	0.2	0.07	0.01	0.14

5 Effects of monetary-financed fiscal stimuli

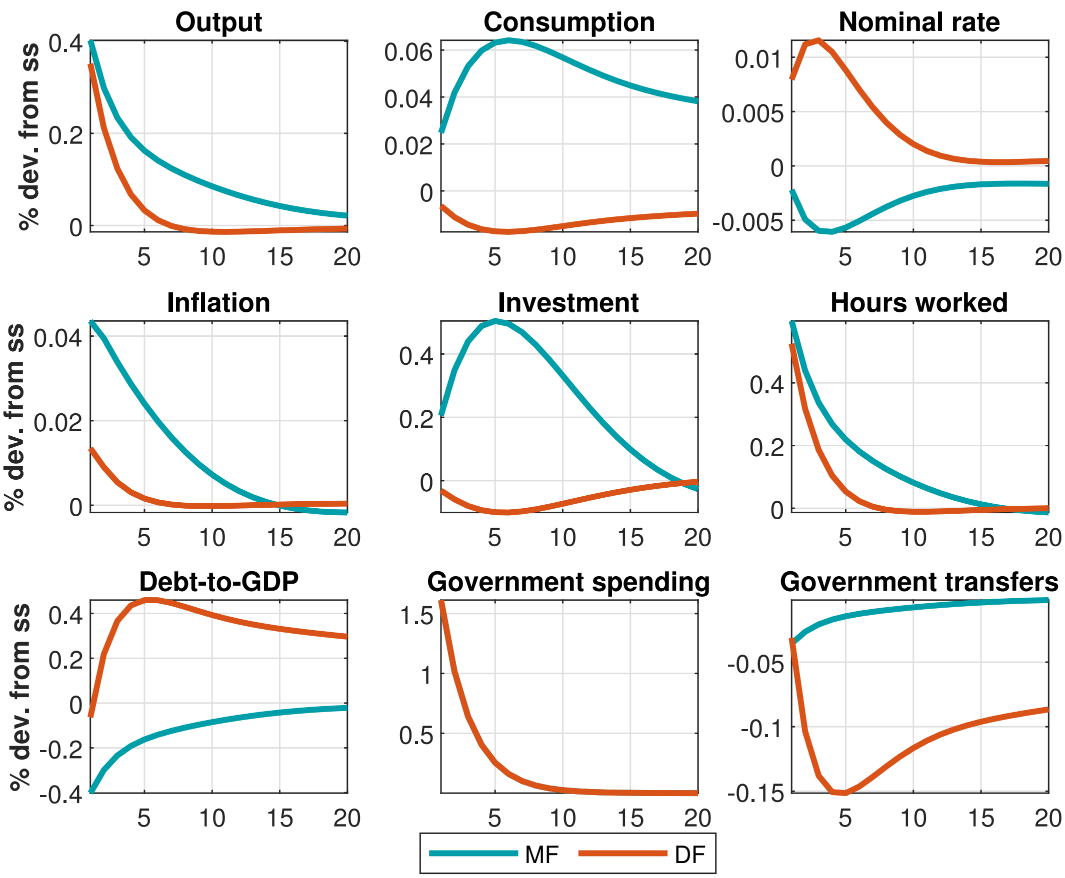
In this section we analyse two scenarios in which the government and the central bank work together to issue expansionary fiscal policies through fiscal stimuli. Two types of fiscal stimuli are analysed: an increase in government transfers to households and an increase in government spending. We divide our analysis into two scenarios. We call the first scenario the "debt-financed fiscal stimuli" scenario. In this setting, the central bank pursues a monetary policy based on inflation targeting, and focuses on controlling the policy rate. We estimate the model representing this scenario, and the estimation results are shown in the previous section. Rhe second scenario is called "monetary-financed fiscal stimuli". Here, the central bank gives up of the control on the policy rate and focuses on the money supply. We adapt the second scenario to include the "monetary-financing" part and simulate the model with the parameters calibrated with the values of estimated parameters obtained from the "debt-financed fiscal stimuli" scenario.

In the "debt-financed fiscal stimuli" scenarios, the model features a Taylor rule, as described by equation (19). On the other hand, when the fiscal stimulus is financed by money supply, the fiscal and monetary authorities increase the money growth together with the fiscal stimuli in order to keep the public debt constant. Having constant debt implies that the deviation of the debt from its steady state value has to be equal to zero: $\hat{b}_t = 0$. In this case, the linearized version of equation (20) becomes:

$$\Delta m_t = \frac{1}{\chi} \left[\frac{g}{y} g_t + \frac{t}{y} t_t + \frac{b}{y} \frac{r}{\pi} \left(i_{t-1} - \pi_t \right) \right] \tag{25}$$

Figure 3 shows the impact of an increase in government spending on the main economic aggregates in the two scenarios: when the government spending increase is financed by debt and when the government spending increase is financed by money supply. The magnitude of the shock is equal to its estimated value in the "debt-financed fiscal stimuli" scenario. Output increases in both scenarios, though the increase is much more persistent in the monetary-financing scenario. After an increase in government spending and the increase in inflation due to the positive demand shock, inflation needs to be stabilized. The monetary authority increases the nominal interest rate, decreases the money supply and the government increases future taxes to finance the current expansionary government spending. As a result, real rates increase, driving consumption down. A monetary-financed government spending increase leaves public debt unchanged, while increasing inflation and lowering the real interest rate. The real interest rate here decreases as a consequence of the central bank's control of the money supply, and not of the nominal interest rate. Therefore the positive shift in the consumption response is driven by the nominal interest rate, which combined with the increase in inflation brings about a decrease in the real interest rate. The nominal interest rate

Figure 3: Government spending increase: debt vs monetary-financing

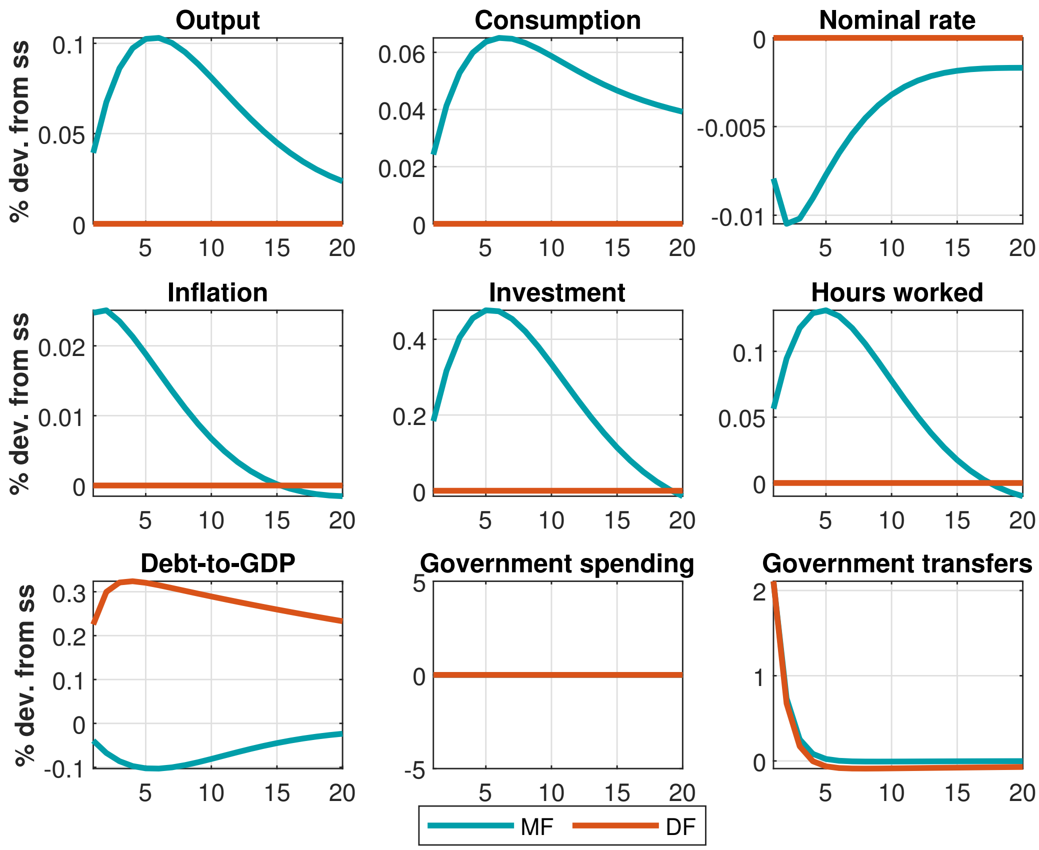


Note: The blue line represents the monetary-financed government spending, while the orange line is the debt-financed government spending.

increases only in response to an adjustment process inside the government budget constraint, thus by a smaller amount, as the government spending is not financed by debt. This is key for our analysis, as consumption is no longer crowded-out. Thus, monetary-financing represents one of the channels through which consumption increases after an increase in government spending (Coenen and Straub, 2005; Galí et al., 2007; Asimakopoulos et al., 2020).

Figure 4 shows the impact of an increase in transfers on the main economic variables in the two scenarios: when the increase in transfers is financed by debt and when the increase in transfers is financed by money supply. The magnitude of the shock is again set to its

Figure 4: Transfers increase: debt vs monetary-financing

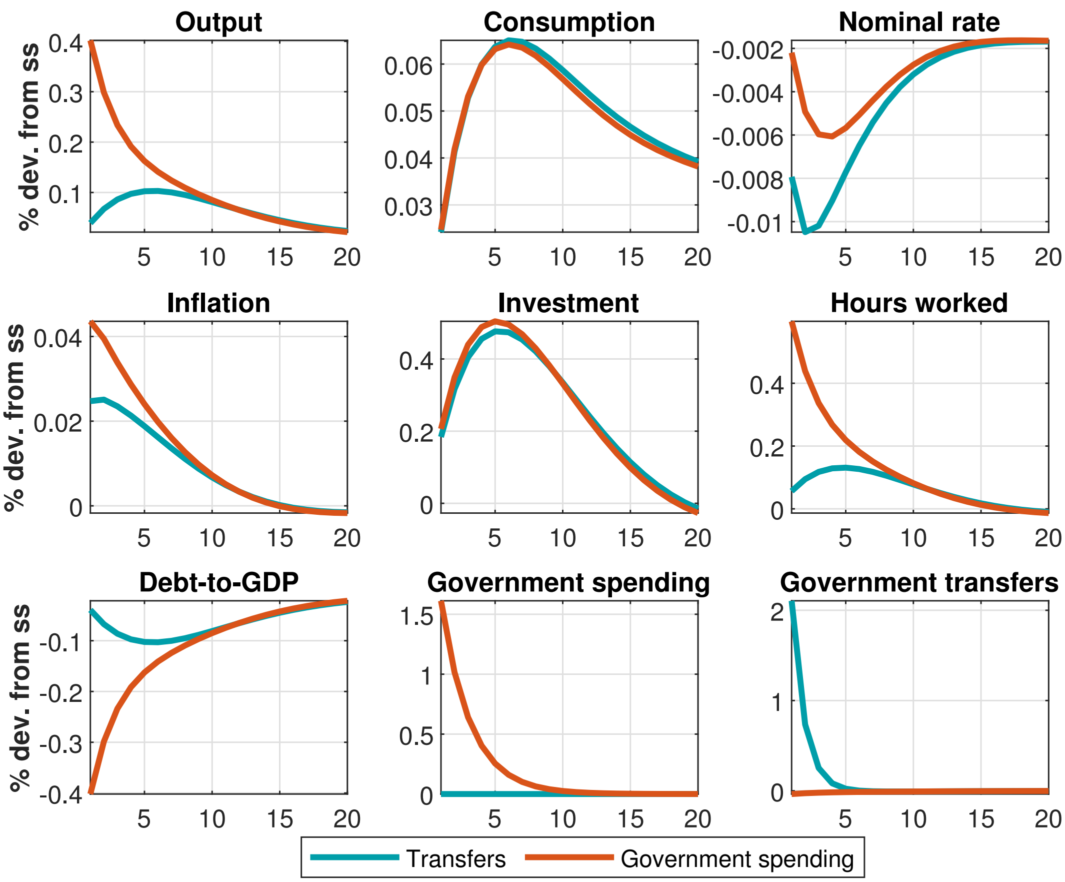


Note: The blu line represents the monetary-financed government transfers, while the orange line represents the debt-financed government transfers.

estimated value.

In the first scenario, the lack of impact on economic variables is explained by the effect of the Ricardian equivalence. A debt-financed increase in transfers has no impact on economic variables, as consumers understand that a transfer increase today is payed back by higher future taxes. When the fiscal stimulus is debt-financed, the monetary authority pursues an inflation targeting strategy to control inflation through a response to inflation in the nominal interest rate rule. This causes output, consumption, and inflation to remain unchanged. Furthermore, neither money supply nor interest rates are adjusted. On the other hand, the increase in transfers financed by money supply has an expansionary impact on output

Figure 5: Monetary financing: government spending and transfers increase



Note: The blue line shows the response to a transfers increase in a monetary-financing scenario. The orange line shows the response to a government spending increase in the same scenario.

and consumption, as the increase in transfers to households counts as a direct increase in disposable income. After the increase in money supply, the nominal interest rate adjusts downwards. Given the increase in inflation, the real interest rate decreases. This has a positive impact on consumption and investment, which brings about an increase in output. The increase in output together with a constant debt level lowers the debt-to-output ratio. Inflation expectations increase, which leads to an increase in inflation. The monetary-financed transfers shock explains the transmission mechanism of the expectations channel. Consumers understand that an increase in transfers in time t, that leaves public debt unchanged in time

$t + k$ does not imply a taxes increase in the future. The result is that, without the Ricardian effect, the economy experiences an expansionary impact on nominal GDP and consumption. Inflation expectations rise, bringing about an increase in inflation and, since the increase in interest rates is near to zero, real interest rates remain low or decrease. Moreover, a higher inflation rate has an additional positive impact on levels of pre-existing debt, because it removes part of its value.

Figure 5 shows the difference between the two fiscal stimuli when the financing occurs through money supply. The blue line shows the impact of a money-financed increase in government transfers, while the orange line shows the impact of a money-financed increase in government spending. As described in the previous figures, the case in which the fiscal stimulus (either increase in transfers or increase in government spending) is financed through money supply has an expansionary impact on the main economic variables. The response of consumption to an increase in government spending is lower compared to the impact of an increase in transfers. For output, the opposite holds: our model predicts a higher increase in output after an increase in government spending than after an increase in transfers.

6 Robustness analysis

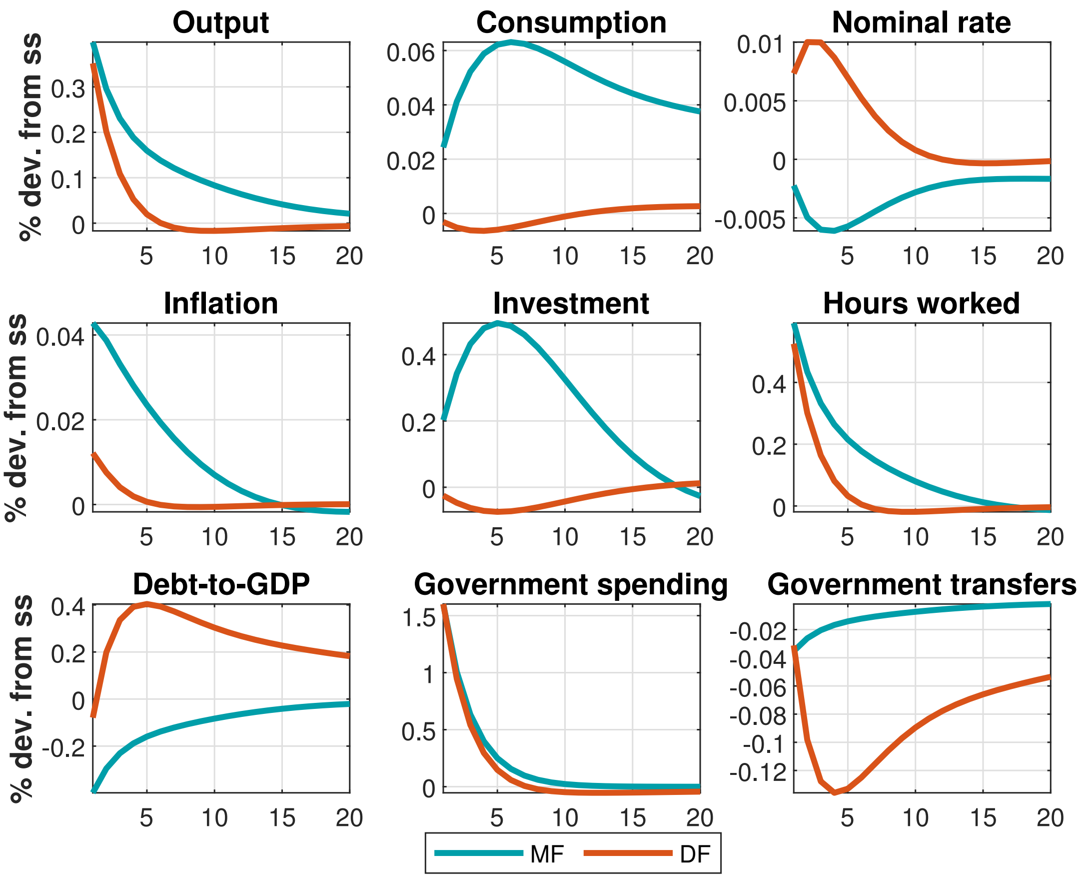
In the previous section, we conducted a counterfactual analysis for a model where transfers follow a fiscal rule, as described in Galí (2020a), and government spending follows an AR process. In this section, we incorporate a fiscal rule for government spending as well.

The fiscal rule for government spending will be similar to the fiscal rule applied to transfers.

$$G_t = -\frac{{B_{t-1}}^{\psi_{bg}}}{Y_t^{\psi_{yb}}} e^{g_t^*} \tag{26}$$

where g_t^* is an exogenous component, following an AR(1) process. The results are shown in Figure 6 and 7. When employing two fiscal rules, the results closely resemble those of the main analysis.

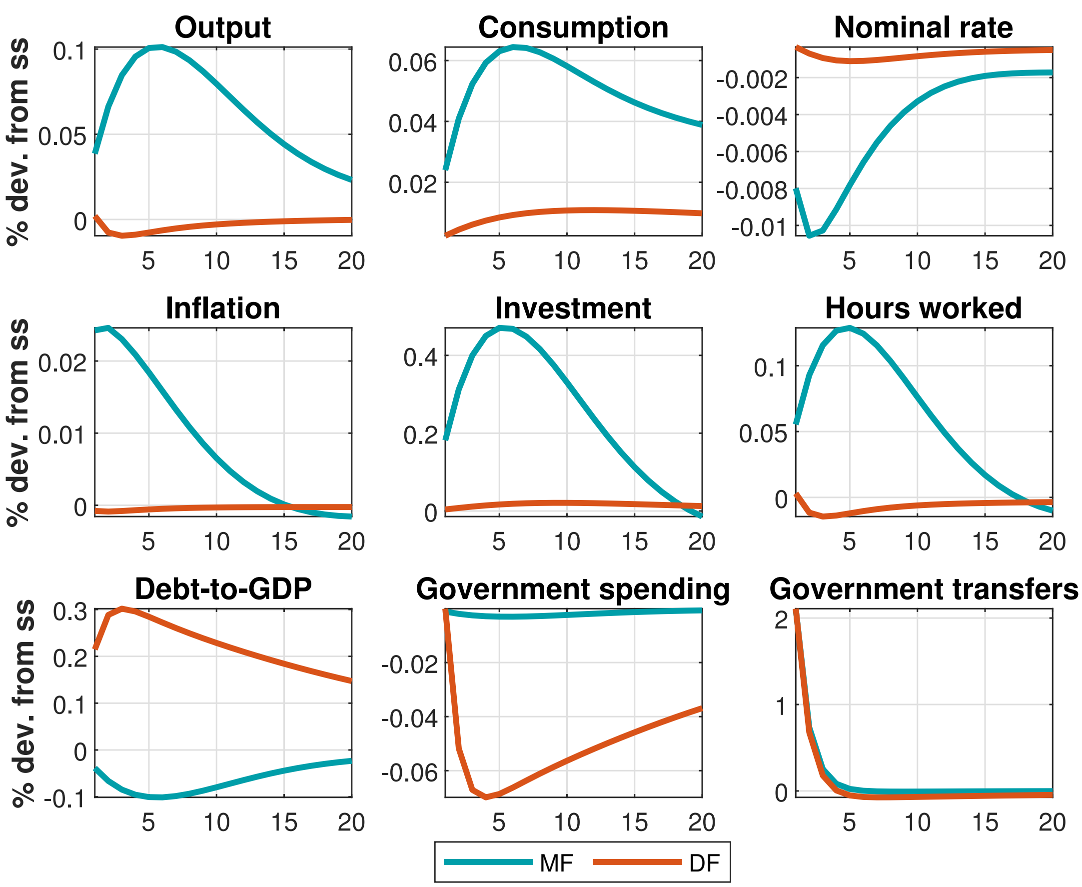
Figure 6: First robustness check: government spending increase



Note: This figure shows IRFs in a model where both fiscal stimuli follow fiscal rules. The blue line represents the monetary-financed government spending, while the orange line represents the debt-financed government spending.

As a second robustness check, we allow for one instrument to remain unchanged while the other one is utilised for a fiscal stimulus in the monetary financed scenario. Therefore, we “shut down” transfers when implementing a positive shock to government spending, and likewise, we “shut down” government spending in the presence of a positive shock to transfers. The fiscal instruments once again adapt to the level of output and public debt, thereby following the same two fiscal rules as in the previous exercise. Results for this analysis are shown in figures 8 and 9.

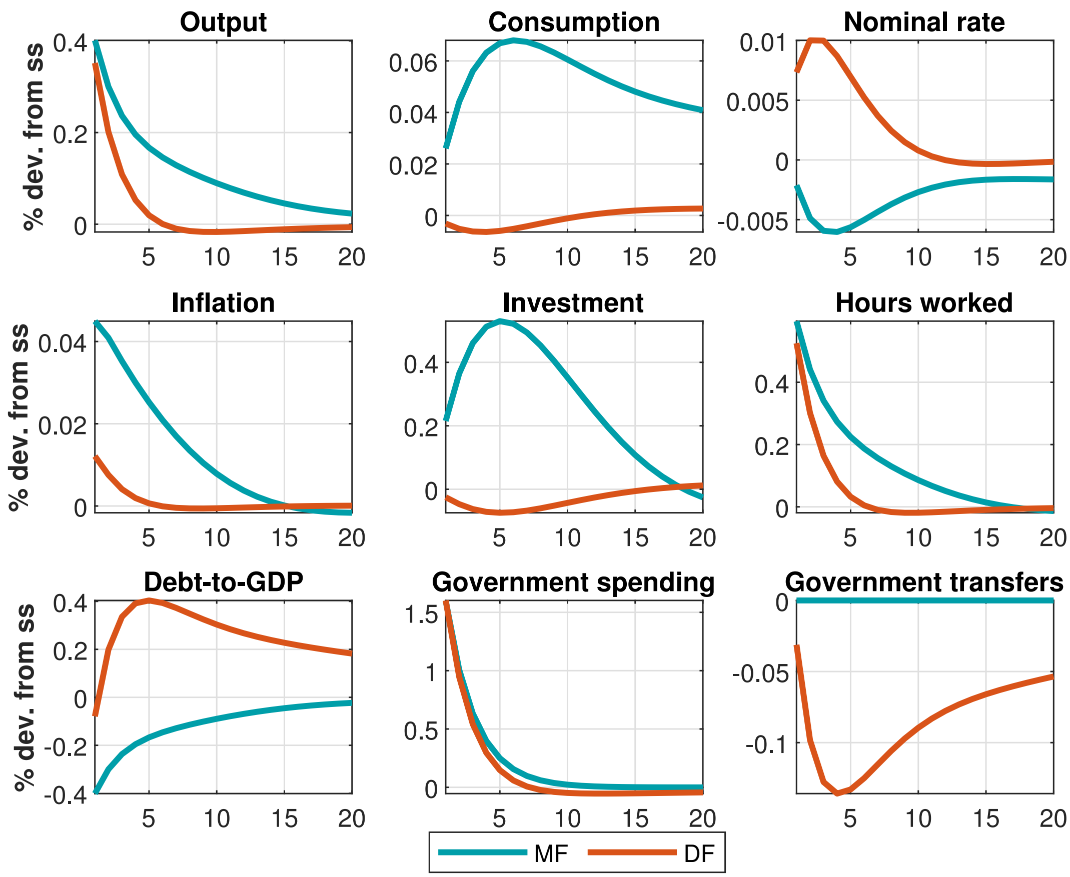
Figure 7: First robustness check: transfers increase



Note: This figure shows IRFs in a model where both fiscal stimuli follow fiscal rules. The blue line represents the monetary-financed government transfers, while the orange line represents the debt-financed transfers.

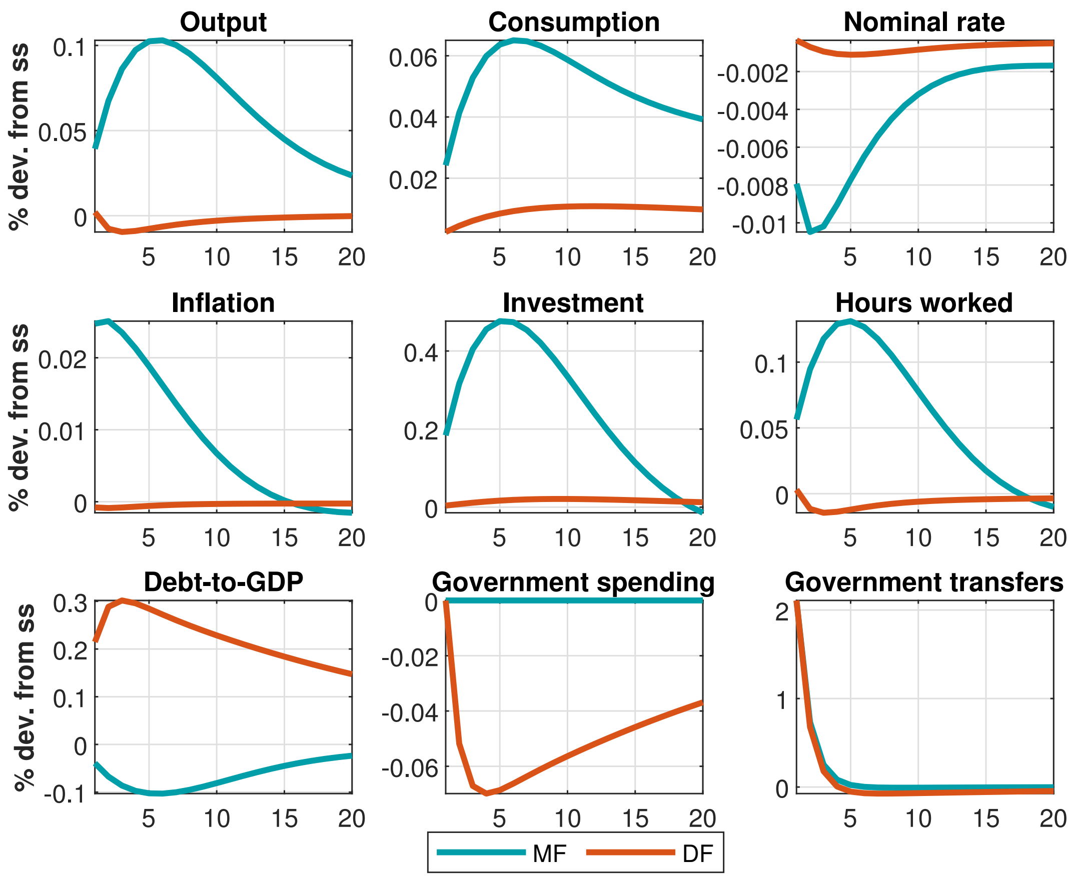
The robustness analysis demonstrate that the impact on economic aggregates of fiscal shocks in the monetary-financed scenario remains robust to the inclusion of the second fiscal rule, and to fixing one fiscal instrument, when the second instrument increases. There is however one difference when two fiscal rules are employed. In this case, Ricardian equivalence does not hold anymore in the debt-financed scenario with a transfers increase.

Figure 8: Second robustness check: government spending increase



Note: This figure shows IRFs in a model where government transfers do not adjust to an increase in government spending in the monetary financed scenario. The blu line represents the monetary-financed government spending, while the orange line represents the debt-financed government spending.

Figure 9: Second robustness check: transfers increase



Note: This figure shows IRFs in a model where government spending does not adjusts to an increase in government transfers in the monetary-financed scenario. The blue line represents the monetary-financed government transfers, while the orange line represents the debt-financed transfers.

7 Conclusions

The collaboration between monetary policy and fiscal policy has proven to be an effective tool in mitigating the negative consequences of both economic and non-economic shocks. Given the rising levels of US government debt, the need for implementation of stimulus packages such as ARPA, and the prolonged period of low inflation observe in the US over the past years, we consider it pertinent to conduct a counterfactual analysis of monetary-financed fiscal stimuli. To carry out this analysis, we develop a New Keynesian model that incorporates fiscal policy, and employ Bayesian methods to estimate its parameters using US data. Subsequently, we conduct a simulation analysis by augmenting the model with a model part representing a monetary-financed fiscal stimulus, using the previously estimated parameters. This allows us to quantitatively evaluate the expansionary impact of this alternative method of financing fiscal stimuli. We demonstrate that a monetary financing scheme for fiscal stimuli has positive impacts on all economic variables. However, this comes at a cost: an increase in inflation. A caveat of our model is worth noting. Our model does not incorporate financial frictions and the implications for central bank balance sheets. If monetary financing is to be the focus of policy advice, it would be useful to include these features in the analysis.

Appendices

Appendix A Log-linearized equations

Euler equation

$$
\begin{aligned}
&(1-h\beta)(1-h)\ \xi_t = \\
&(1-h)\ b_t - \left(\beta\, h^2\right) c_t + h\, c_{t-1} - \beta h\,(1-h)\,\mathbb{E}_t\left[b_{t+1}\right] + \beta h\,\mathbb{E}_t\left[c_{t+1}\right]
\end{aligned}
\tag{27}
$$

where $\quad \xi_t = r_t - \mathbb{E}_t\left[\pi_{t+1}\right] + \mathbb{E}_t\left[\xi_{t+1}\right]$

Money demand

$$
\nu_m m_t = \chi_t + b_t - \frac{1}{R-1} r_t - \xi_t \tag{28}
$$

Investment FOC

$$
i_t - \frac{\beta}{1+\beta}\,\mathbb{E}_t\left[i_{t+1}\right] = \frac{1}{1+\beta} i_{t-1} + \frac{1}{\omega\,(1+\beta)} q_t - \frac{1}{\omega\,(1+\beta)} \xi_t + \frac{1}{\omega\,(1+\beta)} \epsilon_t^i \tag{29}
$$

Law of motion of capital

$$
k_t = \left(1 - \frac{i}{k}\right) k_{t-1} + \frac{i}{k} i_t + \frac{i}{k} \epsilon_t^i \tag{30}
$$

Production function

$$
y_t = a_t + \alpha k_t + (1-\alpha)\, n_t \tag{31}
$$

Capital-labour relation

$$
r_t^k = w_t + n_t - k_t \tag{32}
$$

Household's FOC for capital

$$q_t = \frac{r^k}{r^k + (1-\delta)}\,\mathbb{E}_t\left[r_{t+1}^k\right] + \frac{(1-\delta)}{r^k + (1-\delta)}\,\mathbb{E}_t\left[q_{t+1}\right] + \frac{r^k}{r^k + (1-\delta)}\,\mathbb{E}_t\left[\xi_{t+1}\right] \tag{33}$$

Marginal cost

$$\Lambda_t = \alpha r_t^k + (1-\alpha)\,w_t - a_t \tag{34}$$

Wages

$$\begin{aligned} & w_t - w_{t-1} + \pi_t - \iota^w \pi_{t-1} = \\ & \frac{1-\omega^w}{\omega^w}\frac{1-\beta\omega^w}{1+\nu_l\frac{1+\lambda^w}{\lambda^w}}\left(b_t + \phi_l + \nu_l n_t - \xi_t - w_t\right) + \beta\,\mathbb{E}_t\left(w_{t+1} - w_t + \pi_{t+1} - \iota^w \pi_t\right) \end{aligned} \tag{35}$$

New Keynesian Phillips curve

$$\pi_t = \frac{(1-\omega^p\,\beta)\,(1-\omega^p)}{(1+\beta\,\iota^p)\;\omega^p}\left(\Lambda_t + \frac{\lambda^p}{1+\lambda^p}\epsilon_{\lambda_t^p}\right) + \frac{\iota^p}{1+\iota^p\beta}\,\pi_{t-1} + \frac{\beta}{1+\beta\,\iota^p}\;\mathbb{E}_t\left[\pi_{t+1}\right] \tag{36}$$

Aggregate economy

$$y_t = \frac{c}{y}\,c_t + \frac{i}{y}\,i_t + \frac{g}{y}\,g_t \tag{37}$$

Monetary policy

$$r_t = (1-\rho_m)\left(\phi_\pi \pi_t + \phi_y y_t\right) + \rho_m r_{t-1} + \lambda_t^m \tag{38}$$

Government budget constraint

$$\frac{b}{y}\frac{r}{\pi}\left(b_{t-1} + r_{t-1} - \pi_t\right) + \frac{g}{y}g_t + \frac{t}{y}t_t = \frac{b}{y}b_t + \chi_m \Delta m_t \tag{39}$$

Fiscal rules

$$t_t = -\psi_{yt} y_t - \psi_{bt} b_{t-1} + t_t^*$$

$$g_t = -\psi_{yg} y_t - \psi_{bg} b_{t-1} + g_t^*$$

Law of motion of money

$$m_{t-1} = m_t + \pi_t - \Delta m_t \tag{40}$$

Exogenous processes

Cost push: $\lambda_t^p = \rho_p \, \lambda_{t-1}^p + \epsilon_t^p$

Investment: $\lambda_t^i = \rho_i \, \lambda_{t-1}^i + \epsilon_t^i$

Monetary policy: $\lambda_t^m = \rho_m \, \lambda_{t-1}^m + \epsilon_t^m$

Equity premium: $\lambda_t^b = \rho_b \, \lambda_{t-1}^b + \epsilon_t^b$

Technoglogy: $a_t = \rho_a \, a_{t-1} + \epsilon_t^a$

Money demand: $\chi_t = \rho_\chi \, \chi_{t-1} + \epsilon_t^\chi$

labour: $\phi_t^l = \rho_l \, \phi_{t-1}^l + \epsilon_t^l$

Transfers: $t_t^* = \rho_t^t t_{t-1}^* + \epsilon_t^t$

Gov. spending: $g_t^* = \rho_t^g g_{t-1}^* + \epsilon_t^g$

Appendix B Data construction

In this section we describe the data construction. In what follows, the following FRED data series are used: GDPDEF is the implicit price deflator that is seasonally adjusted, with 2012=100. POPINDEX is a population index such that population in 1992Q3=1. CNP16OV is the civil non institutional population 16 year and older. The series is non seasonally adjusted, and it is expressed in thousands. The variables are constructed as follows:

1. Consumption:

$$100\text{*LN}\left(\frac{\text{Non durable goods and services/GDPDEF}}{\text{POPINDEX}}\right) \tag{41}$$

2. Investment:

$$100\text{*LN}\left(\frac{\text{Fixed Private Investment(FPI)}}{\text{POPINDEX}}\right) \tag{42}$$

3. Hours worked:

$$100\text{*LN}\left(\frac{\text{Nonfarm Business: Average Weekly Hours(PRS85006023)*Employment(CE16OV)}}{\text{POPINDEX}}\right) \tag{43}$$

4. Real wage:

$$100\text{*LN}\left(\frac{\text{Nonfarm Business Sector: Real Hourly Compensation (COMPRNFB)}}{\text{GDPDEF}}\right) \tag{44}$$

5. Inflation:

$$100\text{*LN}\left(\Delta\text{GDPDEF}\right) \tag{45}$$

For a first analysis, considering the prolonged period with interest rates hitting their effective lower bound, we use the Shadow rate as in Wu and Xia (2016)[3]. However, we also estimated our model with the short term nominal interest rate. Estimation results are robust to both interest rate time series. Shadow rates and short term interest rates are constructed as:

[3] The series are available here: https://www.atlantafed.org/cqer/research/wu-xia-shadow-federal-funds-rate.

6. Shadow rate and nominal interest rate:

$$\frac{\text{Shadow rate}}{4} \tag{46}$$

$$\frac{\text{Effective federal funds rate (FEDFUNDS)}}{4} \tag{47}$$

Fiscal variables are available on the Bureau of Economic Analysis website, and are retrieved from the NIPA tables available at https://www.bea.gov/data/government/receipts-and-expenditures.

7. Government spending:

$$100{*}\text{LN}\left(\frac{\text{GS/GDPDEF}}{\text{POPINDEX}}\right) \tag{48}$$

where GS = (Government consumption expenditure + government gross investment + government net purchases of non-produced assets) - consumption of fixed capital

8. Transfers:

$$100{*}\text{LN}\left(\frac{\text{T/GDPDEF}}{\text{POPINDEX}}\right) \tag{49}$$

where T = [(current transfer payments - current transfer receipts) + (capital transfer payments - capital transfer receipts) + subsidies] (table 3.2, lines 26, 19, 46, 42, 36) - [(current tax receipts + contributions for government social insurance + income receipts on assets + current surplus of government enterprises) (table 3.2, lines 2, 10, 13, 23) - *total tax revenues*]

and:

total tax revenues = consumption tax revenues + labour tax revenues + capital tax revenues

with:

consumption tax revenues = excise taxes + custom duties

labour tax revenues = average labour income tax rate * tax base

capital tax revenues = average capital income tax rate * tax base

9. Money supply:

$$100^{*}\mathrm{LN}\left(\frac{\mathrm{M2(M2SL)/GDPDEF}}{\mathrm{POPINDEX}}\right) \tag{50}$$

Appendix C Additional figures

Figure 1: Multivariate convergence diagnostics

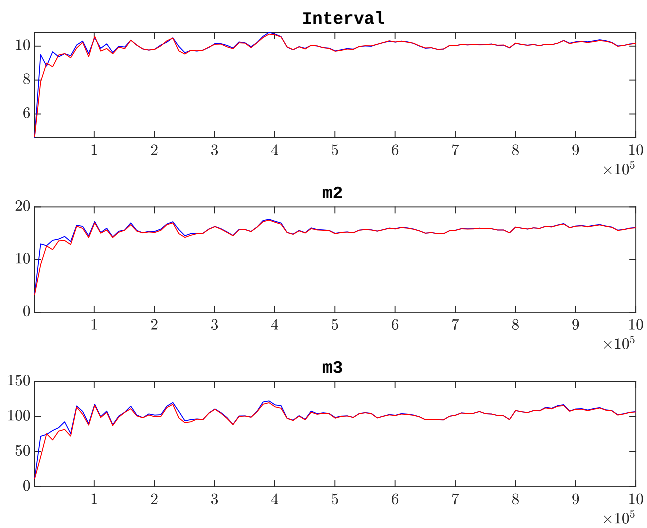
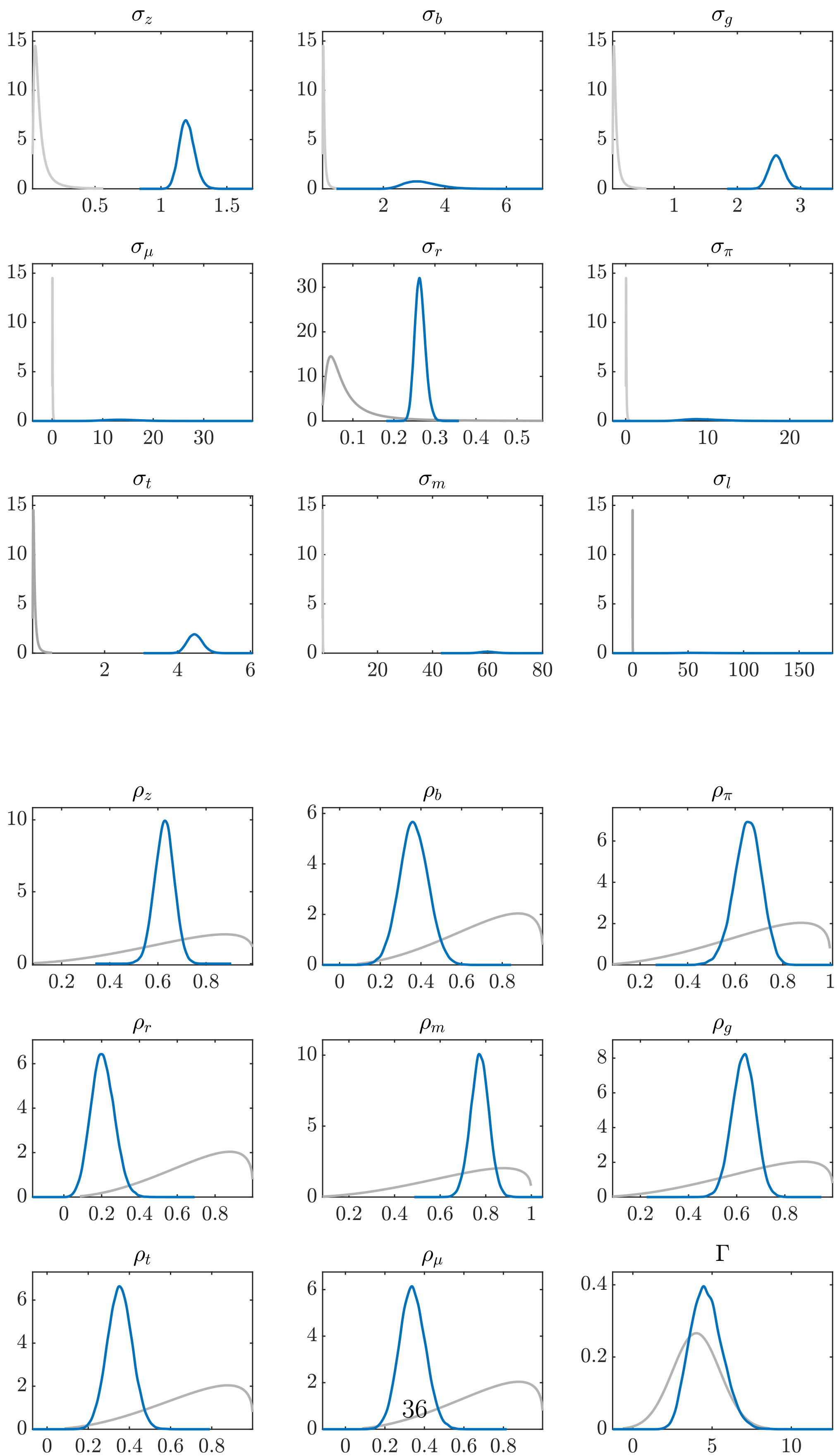
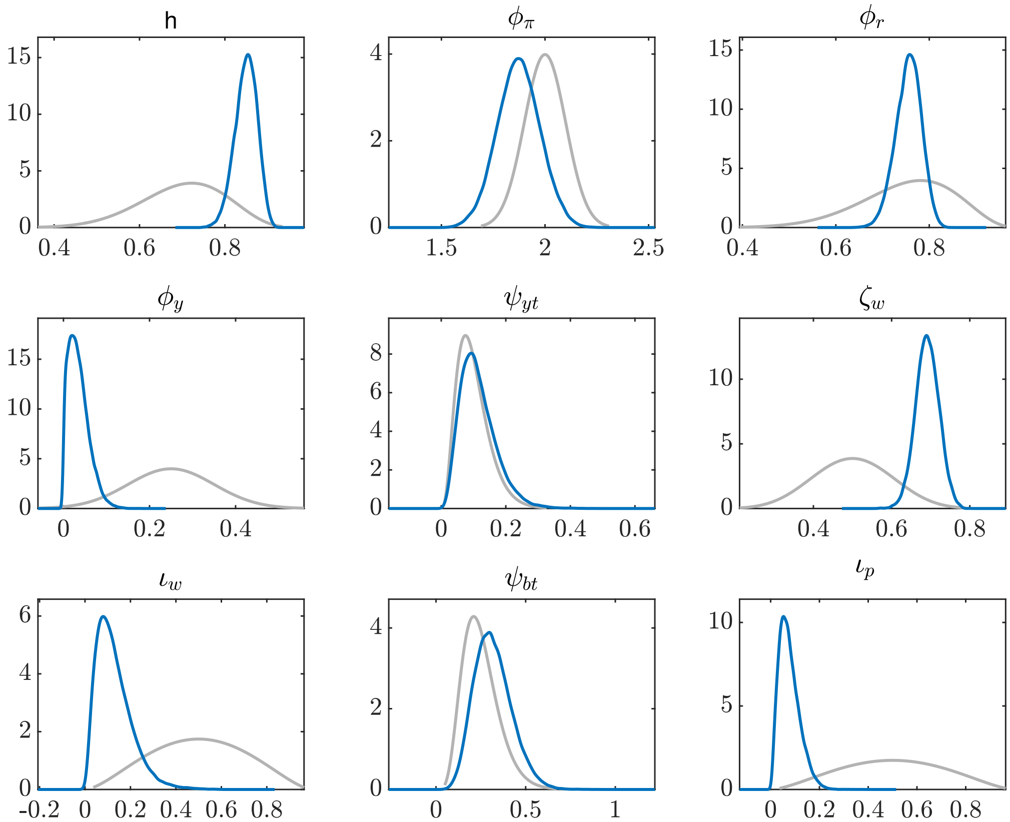


Figure 2: Priors and posteriors plots




h
ϕ_π
ϕ_r
ϕ_y
ψ_{yt}
ζ_w
ι_w
ψ_{bt}
ι_p

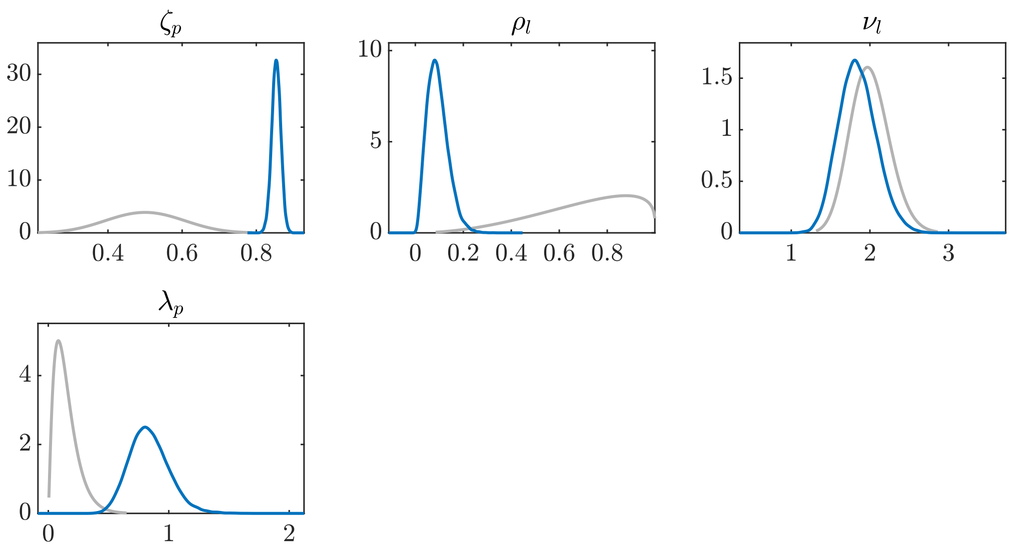

ζ_p
ρ_l
ν_l
λ_p

Figure 3: Smoothed shocks

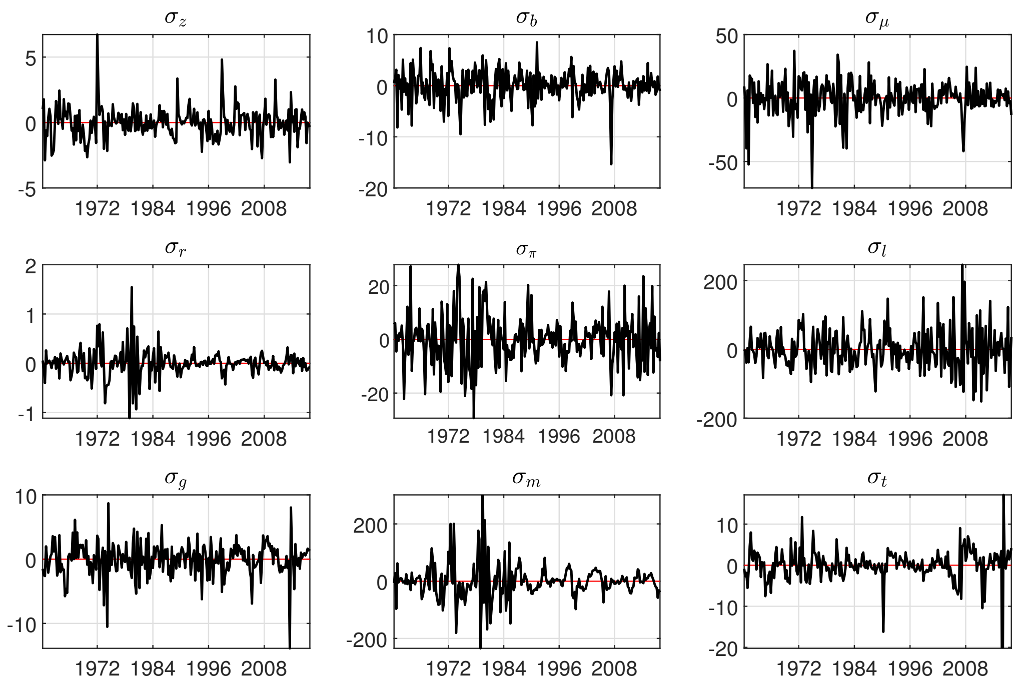
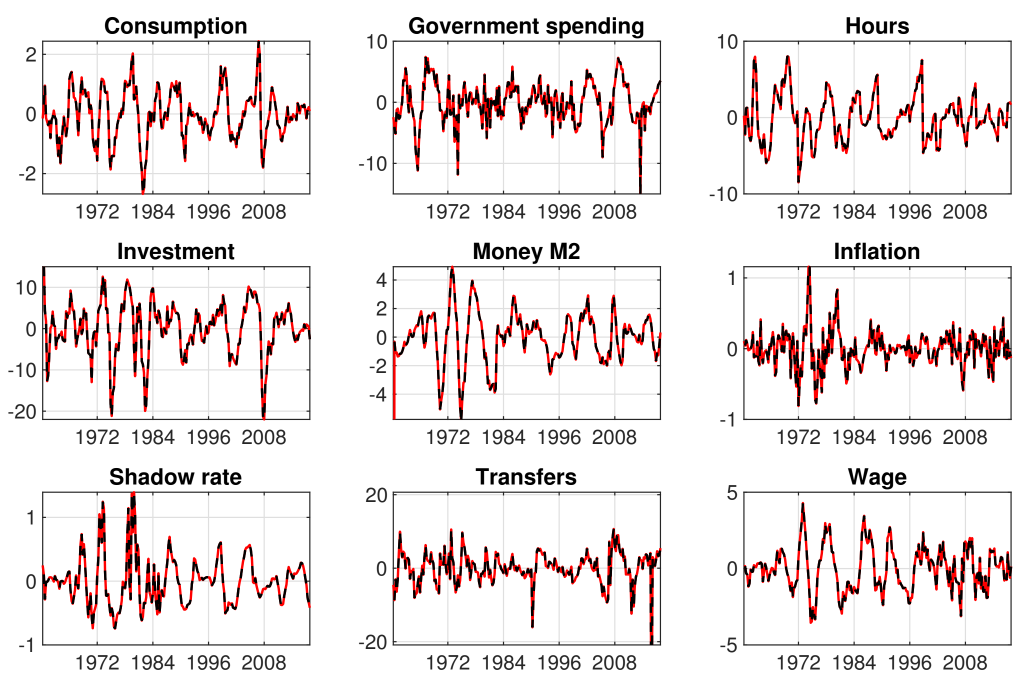


Figure 4: Historical and smoothed variables



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