Is monetary-financing a valuable alternative to debt-financing in response to fiscal stimuli?

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Abstract

The unprecedented increase in US sovereign debt has drawn attention among policymakers. In this paper, we investigate the use of the money supply issued by the central bank to support expansionary fiscal interventions. To do so, we develop and estimate a New Keynesian model using US data for the sample period 1960:Q1-2019:Q4. Then, we run a quantitative counterfactual analysis to assess the effects of a fiscal stimulus that does not result in an increase in public debt, as it is financed by money supply. Our impulse response analysis indicates that increases both in monetary-financed government spending and monetary-financed transfers have positive economic impacts on private consumption, investment, and output. However, the expansionary impact of monetary-financed fiscal shocks comes at a cost: an increase in inflation. We also find that the higher the debt-to-GDP ratio, the lower the positive effects of a monetary-financed fiscal stimulus. Lastly, we divide the sample into two sub-periods and find that the impact of a monetary-financed fiscal stimulus stays positive, but varies according to the estimation sub-period.

Keywords: Fiscal Policy, Monetary Policy, Bayesian Estimation

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1 Introduction

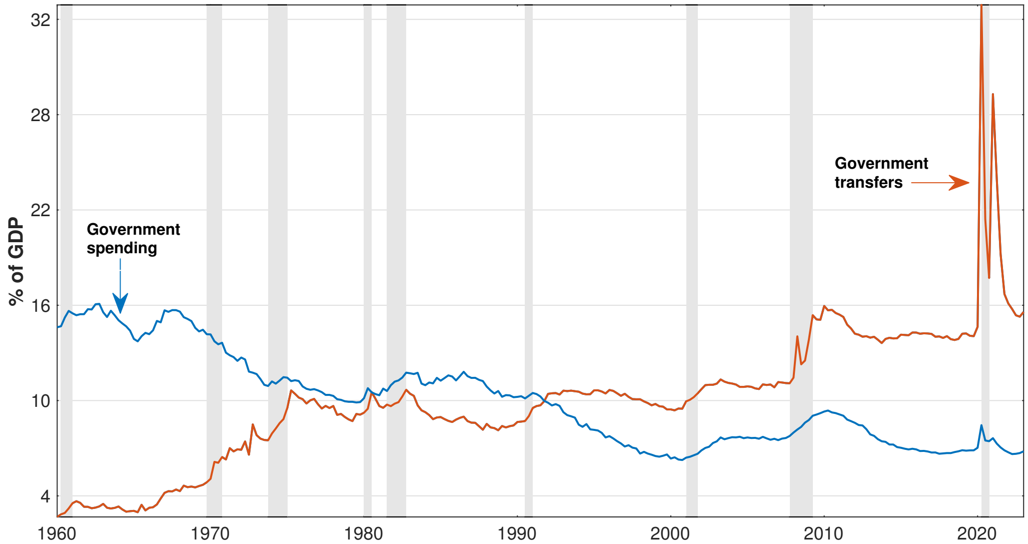
Over the past 15 years, the global economy has experienced significant economic and financial changes, which were further exacerbated by the two recent economic crises: the Global Financial Crisis (GFC) and the COVID-19 pandemic. These disruptions affected both aggregate demand and aggregate supply, 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. Benigno and Nisticò (2020) highlight that 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 monetary-financed government transfers and government spending 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. We consider transfers because of the increasing trend it experienced, which indicates the constant need for the government to intervene in the economy. We also consider government spending, because of its relevance as a share of GDP and of government public debt.

Figure 2 shows the evolution of the M2 monetary aggregate and the public debt-to-GDP over the past six decades. The figure demonstrates a correlated evolution of the changes in M2 and in the public debt-to-GDP series. Moreover, the public debt-to-GDP ratio increased from 2008Q1 until 2019Q4 by 40 percentage points, rising from approximately 64% to 105%.

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

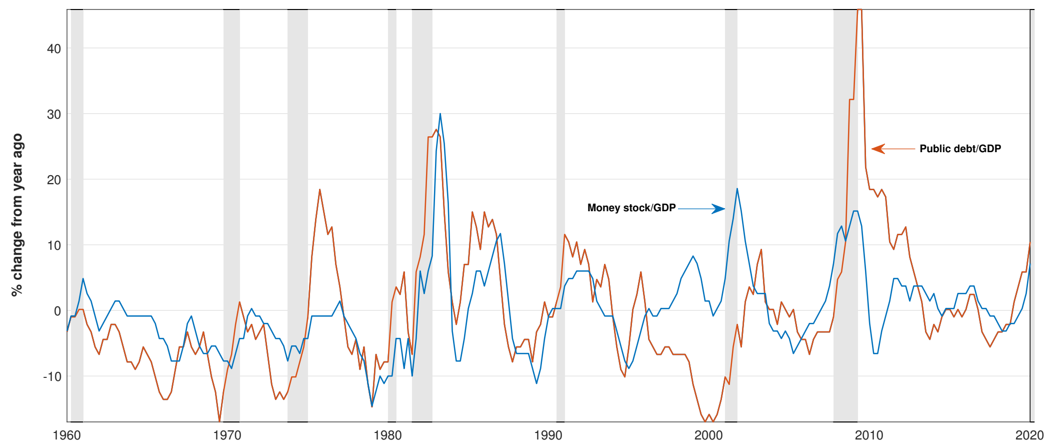


Notes: Source of data: Economic Data from the Federal Reserve Bank of St. Louis database. Shaded areas represent NBER recessions.

In particular, over the past 15 years, central banks worldwide have undertaken various 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 financed through money supply from a quantitative perspective.

As highlighted in Ng (2021), it is crucial to treat COVID data as exogenous controls in a Vector Autoregressive 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 with 2019Q4. This is done because of the uniqueness of this period and the exceptional impact the period had on output and consumption.

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



Notes: 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.

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 macroeconomic aggregate 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 amplified increase in inflation compared to the scenario in which the fiscal stimulus is debt-financed.

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" 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

[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 monetisation 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 the seigniorage, which is 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.

engages in monetary financing of the public 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). The use of money supply to finance a fiscal stimulus through a permanent increase in the monetary base, makes it possible to address the issue of Ricardian equivalence 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

[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.

banks and governments were not separate entities. The Zimbabwe hyperinflation and the Weimar Republic episode in the 1920s are two examples.

Giavazzi and Tabellini (2014) and Turner (2015) criticise the use of money to finance the government debt from a political point of view. They argue that the use of the money-financing policy may be misleading and lead to its excessive and unwarranted utilisation. Turner (2015) further argues 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 can become 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 the level of public debt has the potential to increase inflation levels. As mentioned earlier, the focus of this chapter 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) recently added to the literature about the fiscal theory of the price level by developing 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 7 concludes.

3 Theoretical model

In this section the theoretical model is presented. Its structure is in line with standard medium-scale new Keynesian models (see, for example, 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 households that provide labour and capital services to intermediate firms and obtain dividends from them. The representative household makes consumption decisions as well as capital accumulation decisions. We assume that it trades a riskless one period government bond. Labour is differentiated over households, so that there is some monopoly power over wages that results in an explicit wage equation and allows for the introduction of sticky nominal wages à la Calvo (Calvo, 1983). The representative household receives lump-sum transfers from the government.

Moreover, we include intermediate firms that are monopolistically competitive. These firms hire labour and rent capital from households and they 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. We also assume partial indexation of prices and wages to past inflation rates.

In addition, we consider a central bank that sets its policy rate following a Taylor-type interest-rate rule (Taylor, 1993). Moreover, the central bank supplies the money demanded by the household to support the desired nominal interest rate.

Since the focus of our work is on the alternative ways of financing fiscal stimuli, we consider two different scenarios. In the traditional debt-financed scenario, the expansionary fiscal policy is financed through the issuance of government bonds. In the monetary-financed scenario, an increase in government spending and transfers is financed through a rise in money supply. We estimate the model including the debt-financed scenario, and with the estimated parameter values we run a simulation of the model including the monetary-financed scenario.

This allows us to provide a counterfactual analysis of a monetary-financed fiscal stimulus and compare the impulse response functions derived from both scenarii.

3.1 Households

The utility of the representative household depends positively on consumption and real money balances, whereas it depends negatively on labour supply. The objective function for household $j \in [0,1]$ is given by:

$$\max_{C_t(j), \frac{M_t(j)}{P_t}, L_t(j)} \mathbb{E}_t \left\{ \sum_{t=0}^{\infty} \beta^t b_t \left[\left(ln\,(C_t(j) - hC_{t-1}(j)) + \frac{\chi_t}{1-\nu_m} \left(\frac{M_t(j)}{P_t} \right)^{1-\nu_m} \right) - \frac{\phi_t}{1+\nu_l} L_t(j)^{1+\nu_l} \right] \right\} \tag{1}$$

where C_t, $\frac{M_t}{P_t}$, L_t represent consumption, real money balances and labour, respectively. β_t is the discount factor, b_t represents a preference shock to the household's utility function and h is a parameter that measures the degree of external habit formation in consumption. Moreover, ϕ_t indicates a shock to the labour supply, whereas χ_t is preference shock that affects money holdings. We assume that b_t, ϕ_t and χ_t follow exogenous AR(1) processes:

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

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

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

Following Del Negro and Schorfheide (2008) and Punzo and Rossi (2022), we assume that consumption and real money balances enter the household's objective function in a separable way.

The budget constraint faced by the representative household is given by:

$$\begin{aligned} & P_tC_t(j) + P_tI_t(j) + B_t(j) + M_t(j) \\ & = R_{t-1}B_{t-1}(j) + M_{t-1}(j) + R_t^k K_{t-1}(j) + W_tL_t(j) + P_tD_t + P_tT_t(j) \end{aligned} \tag{5}$$

where P_t indicates the price level, while R_t is the gross nominal return of government bonds denoted by B_t. Moreover, I_t represents the private investment and K_t is capital. W_t denotes the wage rate while R_t^k is the rental rate and D_t are the firm's dividends. We also assume that households receive transfers T_t from the government.

The equation for capital accumulation is given by:

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

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

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

Additionally, each household supplies a differentiated form of labour, $L(j)$ to labour packers. Labour packers are perfectly competitive firms that hire labour from the households and combine it into labour services, L_t, that are offered to the intermediate firms.

3.2 Final good firms

Final good firms operate in a perfectly competitive market and produce an homogeneous good, Y_t. These firms buy goods from intermediate firms, $Y_t(i)$, and pack and sell the final good to households. The aggregation technology of the final production good firm is given by:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{1}{1+\lambda_t^p}}\, di\right]^{1+\lambda_t^p} \tag{8}$$

where λ_t^p is a markup shock and follows an AR (1) process:

$$ln\lambda_t^p = (1-\rho_\pi) ln\lambda^p + \rho_\pi \lambda_{t-1}^p + \sigma_\pi\, \epsilon_t^{\lambda^p}, \text{with}\, \epsilon_t^{\lambda^p} \sim N(0,1) \tag{9}$$

The cost minimisation problem yields the downward-sloping demand for each intermediate input:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\frac{1+\lambda_t^p}{\lambda_t^p}} Y_t \tag{10}$$

where $P_t(i)$ is the price of the intermediate production good i, while P_t indicates the price of the final good. Perfect competition in the final production goods sector implies that P_t is given by:

$$P_t = \left[\int_0^1 P_t(i)^{-\frac{1}{\lambda_t^p}}\, di\right]^{-\lambda_t^p} \tag{11}$$

3.3 Intermediate good firms

Each intermediate good i is produced by a firm i combining capital K_t and labour L_t through the following technology:

$$Y_t(i) = A_t^{1-\alpha} K_t(i)^{\alpha} L_t(i)^{1-\alpha} \tag{12}$$

where A_t indicates the exogenous shock to total factor productivity following a first order autoregressive process:

$$lnA_t = (1-\rho_z)lnA + \rho_z lnA_{t-1} + \sigma_z \epsilon_{z,t},\ \epsilon_{z,t} \sim N(0,1)$$

All firms face the same prices for their labour and capital inputs. Therefore, profit maximization implies that the capital-to-labour ratio is the same for all firms:

$$\frac{K_t(i)}{L_t(i)} = \frac{\alpha}{1-\alpha}\frac{W_t}{R_t^k} \tag{13}$$

We also assume that, for intermediate goods firms, there is a sticky price adjustment due to staggered prices à la Calvo (Calvo, 1983). Finally, we allow for partial indexation to the past inflation rate.

3.4 Monetary policy

As mentioned above, the monetary authority sets up the nominal interest rate R_t following a Taylor-type interest-rate rule (Taylor, 1993). As in Del Negro et al. (2007) this implies that the policy rate is adjusted according to changes in inflation and output.

$$\frac{R_t}{R^*} = \left(\frac{R_{t-1}}{R^*}\right)^{\phi_r} \left[\left(\frac{\pi_t}{\pi^*}\right)^{\phi_\pi} \left(\frac{Y_t}{Y^*}\right)^{\phi_y}\right]^{1-\phi_r} e^{\lambda_t^r} \tag{14}$$

where R^* is the steady state level for the interest rate, π^* is the steady state inflation, and ϕ_r 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 on the interest rate. Finally, ϵ_t^r is a monetary policy exogenous shock and it is assumed to follow an AR (1) process:

$$ln\, \lambda_t^r = (1-\rho_r) ln \lambda^r + \rho_r \lambda_{t-1}^r + \sigma_r \epsilon_{r,t},\, \epsilon_{r,t} \sim N(0,1)$$

3.5 Fiscal policy

The government budget constraint is:

$$P_t G_t + B_{t-1}(1 + i_{t-1}) = P_t T_t + B_t + \Delta M_t \tag{15}$$

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). The fiscal rule is the following:

$$T_t = -\frac{{B_{t-1}}^{\psi_{bt}}}{Y_t^{\psi_{yt}}} e^{t_t} \tag{16}$$

where t_t is a shock to transfers and it is assumed to follow the AR(1) process:

$$ln\, t_t = (1-\rho_t) g + ln\, t_{t-1} + \sigma_t \epsilon_{t,t},\, \epsilon_{t,t} \sim N(0,1) \tag{17}$$

The government spending shock follows an AR process:

$$ln\, g_t = (1-\rho_g) g + ln\, g_{t-1} + \sigma_g \epsilon_{g,t},\, \epsilon_{g,t} \sim N(0,1) \tag{18}$$

We estimate our model assuming the fiscal policy as outlined above. In section 5 we will use the estimated parameters to calibrate a modified version of the model, in which the increase in transfers and government spending are monetary-financed. This is the monetary-financed scenario.

3.6 Market equilibrium

The final goods market is in equilibrium if the production of firms equals the demand by households for consumption and investment and government expenditure:

$$Y_t = C_t + I_t + G_t \tag{19}$$

4 Estimation results

In this section, we describe the data and the estimation technique used in order to assess the theoretical model. Then, we discuss how we estimate the endogenous parameters and the exogenous processes related to the structural shocks. Finally, we present the main estimation results.

4.1 Data and estimation technique

We use quarterly data for nine time series publicly available on the Economic Data website of the Federal Reserve Bank of St. Louis over the sample period 1960:Q1 - 2019:Q4.[3] The observed variables are real output, real private consumption, real private investment, real wage, inflation, the shadow rate, real government spending, real government transfers and money supply. Accordingly, the model features nine shocks for nine observed variables. Following Leeper et al. (2010) and Pfeifer (2014), we detrend the logarithm of each real

[3]We remove from the dataset the period starting from 2019Q4 due to the significant volatility and uncertainty it brought to macroeconomic aggregates. Ng (2021), among others discuss the peculiarity of the COVID data. The author notes the necessity to incorporate these data as exogenous controls in a time series setting. To avoid introducing this additional complexity/feature to the model, we limit the sample to 2019Q4.

variable separately,[4] while we demean the inflation rate and nominal interest rate.[5]

The measurement equations for the observables matching the model variables is:

$$
\begin{aligned}
\text{Output} &= 100 \times y_t \\
\text{Consumption} &= 100 \times c_t \\
\text{Investment} &= 100 \times i_t \\
\text{Real wage} &= 100 \times w_t \\
\text{Inflation} &= 100 \times \pi_t \\
\text{Shadow rate} &= 100 \times r_t \\
\text{Government spending} &= 100 \times g_t \\
\text{Transfers} &= 100 \times t_t \\
\text{Money supply} &= 100 \times m_t
\end{aligned}
$$

where the left-hand side of the equation is the observable variable and the right-hand side represents the log-linearized model variable multiplied by 100. For a detailed description of data construction, please see the Online Appendix.

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 modelling to inform our choice of priors. We use multiple optimisation algorithms to find the mode. We employ Monte Carlo Markov Chain (MCMC) methods and the Metropolis Hastings (MH) algorithm. The model is estimated using 3,000,000 draws from the posterior distributions. We run two parallel chains in the MCMC MH algoritm,

[4]In particular, we use the HP filter with a smoothing parameter equal to 1,600.

[5]Some studies (see, for example, Greenwood et al., 1997, Greenwood et al., 2000, Altig et al., 2011, Schmitt-Grohé and Uribe, 2012) have estimated DSGE models including one or two common stochastic trends. This strategy is feasible when the number of trends is limited to one or two, but it becomes non-trivial in the presence of a larger number of trends. In this regard, Leeper et al. (2010) argued that, in models analysing fiscal policy, the number of trends is often larger than two because several fiscal variables display their own trends. Moreover, some of these variables, such as transfers, show upward trends, and this requires specific modelling assumptions in order to guarantee fiscal sustainability. Indeed, online Appendix XX shows that the fiscal series included in our analysis clearly display different trends in the sample period considered. Accordingly, as an estimation strategy, we prefer to follow the treatment of observed variables used by Leeper et al. (2010).

and the acceptance rate of each of the chains is approximately 24%.[6]

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). Finally, we follow Leeper et al. (2017) and Bianchi et al. (2023) and calibrate both steady state markup values for wages and prices equal to 0.14.

Table 1: Fixed parameters according to quarterly data

Param.	**Description**	**Value**	**Source**
β	Discount factor	0.99	to match 4% real annual int.rate
α	Labour share in the Cobb Douglas function	0.33	Del Negro et al. (2007)
δ	Capital depreciation rate	0.025	Del Negro et al. (2007)
ν_m	Inv. elast. of substitution btw money & consumption	1	Galí (2015)
λ_w	Wage markup	0.14	Bianchi et al. (2023)
λ_p	Price markup	0.14	Bianchi et al. (2023)
$\frac{B}{Y}$	Share of public debt on GDP	0.6	Galí (2020a)
χ	Steady state inverse velocity of money supply	0.52	From our data sample
$\frac{G}{Y}$	Share of government spending on GDP	0.22	From our data sample
$\frac{T}{Y}$	Share of government transfers on GDP	0.26	From our data sample

Notes: The table shows the name and the description of the fixed parameters, their calibrated values and the target or the source.

We follow Galí (2015) to calibrate the inverse elasticity of substitution between money and consumption, and set this parameter equal 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).

[6] All our estimations are done with Dynare (http://www.dynare.org/).

Priors for the mean and the standard deviation of exogenous and persistence parameters are selected based on previous related literature. The priors for the exogenous processes align with Smets and Wouters (2007) and Leeper et al. (2010) and are presented in table 2. The first three columns of table 3 show priors for the structural parameters. Consumption habits and investment adjustment costs are set as in Smets and Wouters (2007). Taylor rule parameters ϕ_r, ϕ_π and ϕ_y, as well as wage and price stickiness parameters ζ_w and ζ_p, wage and price indexation parameters, ι_w and ι_p, and the priors for fiscal policy parameters, ψ_{bt} and ψ_{yt} are in line with Bianchi et al. (2023).

4.3 Posterior estimates

Tables 2 and 3 display results for the estimated parameters. The first three columns of each table present information about the priors, as explained in the previous section. The last three columns show the posterior mean estimates and their 10% and 90% credible sets.

Identification tests based on Qu and Tkachenko (2012) and Iskrev (2010) show that the jacobian matrices of the first two moments and of the spectral density have full rank. Therefore, the parameters are all identified. Moreover, trace plots for each of the estimated parameters display no trend, implying that the Metropolis Hastings algorithm converges to a stable distribution.

As it becomes evident from table 2, we obtain higher standard deviations for more volatile aggregates, such as inflation, investment, and money supply, than for other variables. Table 2 shows that the AR processes for the shocks that appear to be most persistent are money supply and monetary policy, with persistence parameters of 0.8175 and 0.9950 respectively. Structural parameters are mostly in line with literature, except the wage indexation and the price indexation parameters, which are estimated to be lower than other estimates, such as Smets and Wouters (2007) and Del Negro et al. (2007), but higher than others (e.g. Leeper et al., 2017). Graphs for prior and posterior distributions, together with other estimation output can be found in the appendix.

Table 2: Priors and posteriors for the exogenous processes parameters

		Prior			Posterior		
Param.	**Description**	*Distribution*	*Mean*	*St. Dev*	*Mean*	10%	90%
ρ_z	Productivity persistence parameter	Beta	0.7	0.2	0.3042	0.2011	0.4034
ρ_b	Risk premium persistence parameter	Beta	0.7	0.2	0.4531	0.3269	0.5799
ρ_g	Government spending persistence parameter	Beta	0.7	0.2	0.7484	0.6900	0.8085
ρ_μ	Investment persistence parameter	Beta	0.7	0.2	0.2978	0.2040	0.3883
ρ_r	Monetary policy persistence parameter	Beta	0.7	0.2	0.9950	0.9904	0.9998
ρ_π	Cost push persistence parameter	Beta	0.7	0.2	0.6536	0.5618	0.7417
ρ_t	Transfers persistence parameter	Beta	0.7	0.2	0.4821	0.3864	0.5784
ρ_m	Money supply persistence parameter	Beta	0.7	0.2	0.8175	0.7584	0.8795
σ_z	Productivity shock standard error	Inv. gamma	0.1	2	0.1276	0.0848	0.1696
σ_b	Risk premium shock standard error	Inv. gamma	0.1	2	0.0223	0.0173	0.0271
σ_g	Government spending shock standard error	Inv. gamma	0.1	2	0.0250	0.0232	0.0268
σ_μ	Investment shock standard error	Inv. gamma	0.1	2	0.1699	0.1410	0.1983
σ_r	Monetary policy shock standard error	Inv. gamma	0.1	2	0.0084	0.0076	0.0093
σ_π	Cost push shock standard error	Inv. gamma	0.1	2	1.2758	0.7803	1.7616
σ_t	Transfers shock standard error	Inv. gamma	0.1	2	0.0423	0.0391	0.0455
σ_m	Money supply shock standard error	Inv. gamma	0.1	2	0.2180	0.2014	0.2343

Notes: The table shows the name and the description, the prior distributions, means and standard deviations as well as the posterior means and credible sets for the 10th and 90th percentiles of the parameters for the exogenous processes.

Table 3: Priors and posteriors for the structural parameters

		Prior			Posterior		
Param.	**Description**	*Distribution*	*Mean*	*St. Dev*	*Mean*	10%	90%
ν_l	Inverse Frisch elasticity	Gamma	2	0.25	1.6537	1.3291	1.9655
h	Consumption habits	Beta	0.7	0.1	0.7993	0.7481	0.8483
ϕ_r	Interest rate smoothing parameter	Beta	0.5	0.1	0.1849	0.1242	0.2490
ϕ_π	Weight of inflation on the interest rate	Gamma	2.00	0.2	3.3500	3.1560	3.9019
ϕ_y	Weight of output on the interest rate	Gamma	0.125	0.1	0.1769	0.1360	0.2178
Γ	Investment adjustment costs	Normal	6.00	0.5	6.1313	5.3633	6.9388
ψ_{bt}	Transfers parameter for debt	Gamma	0.25	0.1	0.2658	0.1421	0.3803
ψ_{yt}	Transfers parameter for output	Gamma	0.1	0.05	0.1213	0.0306	0.2082
ζ_w	Wage stickiness	Beta	0.5	0.1	0.4794	0.4195	0.5389
ι_w	Wage indexation	Beta	0.5	0.2	0.4542	0.1547	0.7397
ζ_p	Price stickiness	Beta	0.5	0.1	0.9620	0.9555	0.9683
ι_p	Price indexation	Beta	0.5	0.2	0.1127	0.0575	0.1659

Notes: The table shows the name and the description, the prior distributions, means and standard deviations, as well as the posterior means and credible sets for the 10th and 90th percentiles of the structural parameters.

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 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. The second scenario is called monetary-financed scenario. 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 scenario.

In the debt-financed scenarios, the model features a Taylor rule, as described by equation

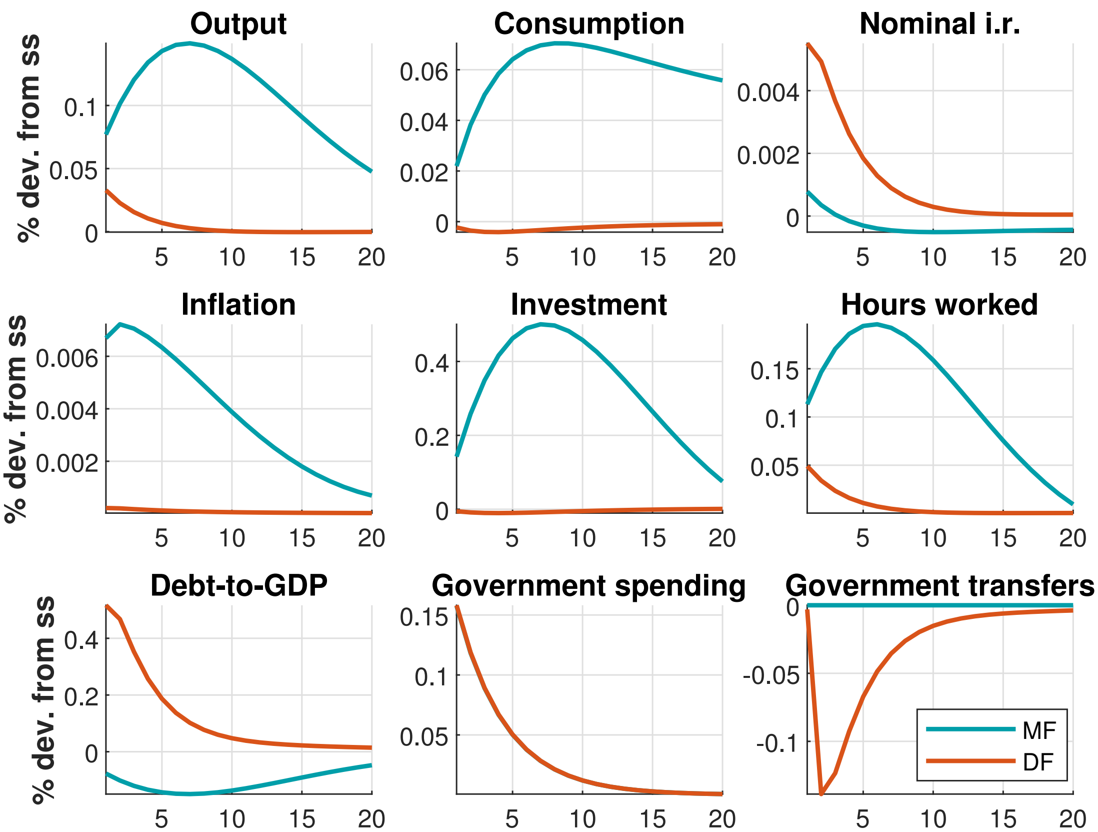
(14). On the other hand, when the fiscal stimulus is financed by money supply, the fiscal and monetary authorities increase the money growth together with the fiscal stimuli in order to keep the public debt constant. Having constant debt implies that the deviation of the debt from its steady state value has to be equal to zero: $\hat{b}_t = 0$. In this case, the linearized version of equation (15) becomes:

$$\Delta m_t = \frac{1}{\chi}\left[\frac{g}{y}g_t + \frac{t}{y}t_t + \frac{b}{y}\frac{r}{\pi}\left(i_{t-1} - \pi_t\right)\right] \tag{20}$$

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 scenario. Output increases in both scenarios, though the increase is much more persistent in the monetary-financing scenario. In the debt-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 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 reacts positively to 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

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

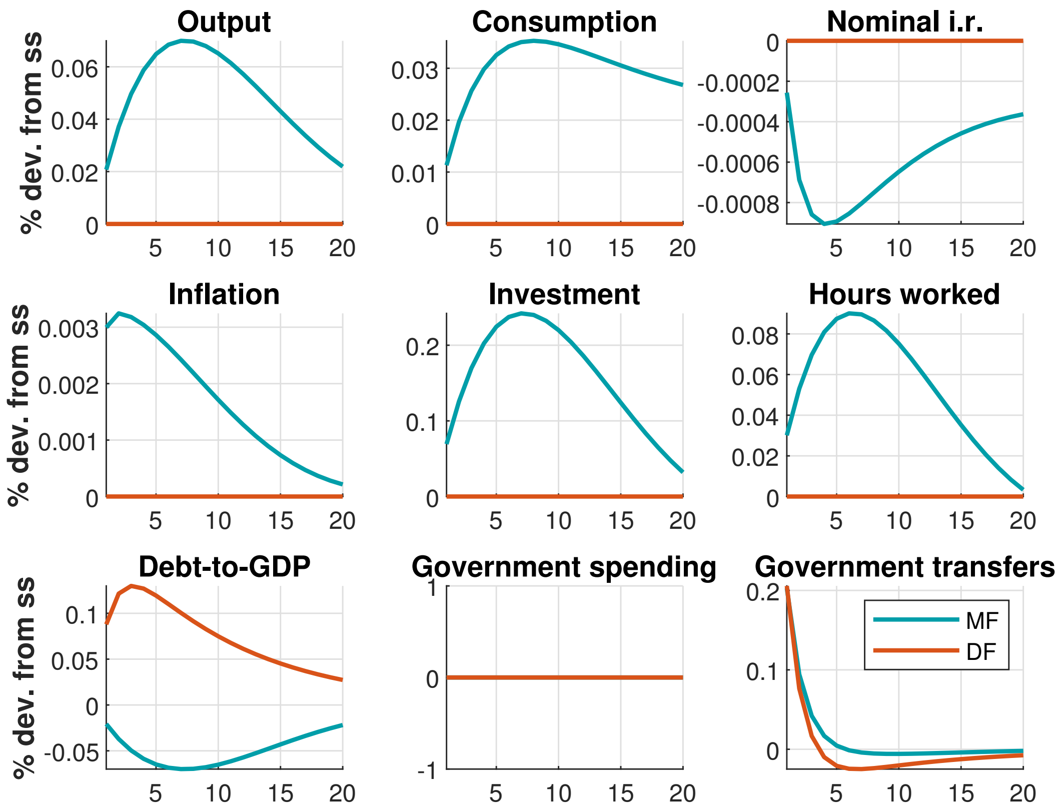


Note: The blue line represents the monetary-financed government spending, while the orange line is the debt-financed government spending.

in transfers is financed by money supply. The magnitude of the shock is again set to its 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 paid 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

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.

increase in transfers financed by money supply has an expansionary impact on output and consumption, as the increase in transfers is perceived by households as a direct increase in their 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.

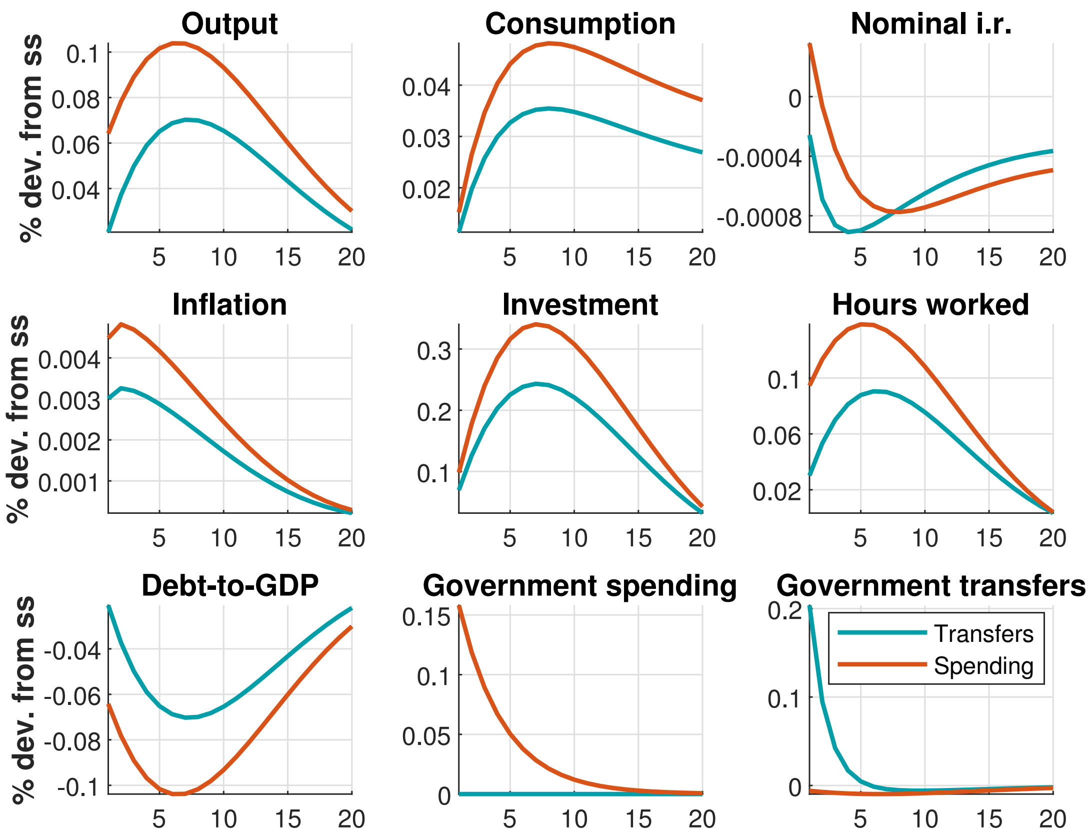
The monetary-financed transfers shock explains the transmission mechanism of the expectations channel. Consumers understand that an increase in transfers in time t, that leaves public debt unchanged in time $t + k$ does not imply a taxes increase in the future.

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 nominal interest rate decreases, 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.

The reason why Ricardian equivalence holds in the case of a debt-financed increase in government transfers and not of a monetary-financed increase lies in the anticipation of households. In the first scenario, households anticipate that a future decrease in transfers (or increase in lump-sum taxes) will offset current increase in transfers. In the second case, an increase in money supply issued to fund the expansionary fiscal policy results in a corresponding increase in real balances. Since real balances contribute to consumers' wealth, the improvement in wealth translates into an increase in consumption and 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.

6 Robustness analysis

In this section we provide additional results for robustness analysis. In section 7.1 we split the entire data sample into two sub-periods, 1960Q1 - 1979Q2, also called the Great Inflation and 1984Q1 - 2007Q2, known as the Great Moderation. As explained in Ascari et al. (2023), the two sub-samples match well two periods that in the literature on the monetary-fiscal interactions are know as, respectively, a fiscally-led and a monetary-led regime. We estimate the debt-financed scenario model over the two subsamples and compare the estimated parameters with those for the entire sample. We then run the same counterfactual analysis conducted in the main analysis, for the two subsamples, and compare the IRFs obtained in the monetary-financed scenario with those for the entire sample.

Previous literature has analyse the importance of different levels of fiscal stress for the impact of fiscal shocks on macroeconomic aggregates, or for the magnitude of fiscal multipliers (Born et al., 2020; Huidrom et al., 2020). In section 7.2 we provide robustness results for different debt-to-GDP levels. Specifically, we compare the IRFs obtained for monetary-financed fiscal shocks in cases of public debt-to-GDP ratios equal to 60% (used in the benckmark model), 30% and 120%.

6.1 Sub-samples

Table 4 and 5 present the posterior means of the estimated parameters for the entire sample and the two sub-samples. The priors used for the two sub-periods align with those employed for the entire sample (please see table 3), except for ϕ_y, for which the prior used to estimate the model over the period 1960Q1 - 1979Q2 is set to 0.2. Standard errors magnitudes associated with exogenous processes are mostly consistent across time periods. Exceptions are with the cost-push shock, which is significantly higher over the entire sample compared to the two sub-periods, and with the money supply shock, displaying nearly half the value for the second sub-sample in contrast to both the entire sample and the first sub-sample. To achieve convergence, measurement error for the cost push shock was introduced over the entire sample. The productivity exogenous process demonstrates greater persistence over the entire sample, and when considering the sub-periods, with lower persistence observed during the Great Inflation compared to the Great Moderation. The same results are obtained for the monetary policy persistence parameter. Although the government spending exogenous process shows similar persistence across the three periods, transfers persistence parameters are higher when estimating across both sub-samples. Lastly, the cost-push persistence parameter exhibits greater magnitude during the Great Inflation.

Table 5 presents differences among estimated structural parameters across the three periods. For instance, the parameter that relates transfers to output ψ_{yt} is lower during the Great Moderation, and ψ_{bt}, that relates transfers to public debt is higher during this sub-sample, compared to the other two periods. The weight of inflation on the interest rate in the Taylor rule, is equal to 2.2243 during the Great Inflation, in contrast to values exceeding 3 for the other two periods. Furthermore, wage indexation and price stickiness exhibit lower values in the first sub-sample compared to the other two periods. On the contrary, the interest rate smoothing parameter equal to 0.7938 during the Great Inflation, is four times higher compared to the ones estimated over the other two periods.

Table 4: Priors and posteriors for the exogenous processes parameters - sub-samples

		Posterior mean		
Param.	**Description**	1960Q1:2019Q4	1960Q1:1979Q2	1984Q1:2007Q2
σ_z	Productivity shock standard error	0.1265	0.0686	0.0745
σ_b	Risk premium shock standard error	0.0222	0.0381	0.0245
σ_g	Government spending shock standard error	0.0250	0.0273	0.0214
σ_μ	Investment shock standard error	0.1689	0.1943	0.1303
σ_r	Monetary policy shock standard error	0.0085	0.0094	0.0089
σ_π	Cost push shock standard error	1.2591	0.3768	0.5097
σ_t	Transfers shock standard error	0.0422	0.0319	0.0226
σ_m	Money supply shock standard error	0.2181	0.2472	0.1360
ME_π	Measurement error cost push shock	0.0593	-	-
ρ_z	Productivity persistence parameter	0.3026	0.1940	0.2693
ρ_b	Risk premium persistence parameter	0.4542	0.3891	0.2819
ρ_π	Cost push persistence parameter	0.6535	0.8201	0.7454
ρ_m	Money supply persistence parameter	0.8153	0.7954	0.8880
ρ_g	Government spending persistence parameter	0.7490	0.7451	0.7510
ρ_μ	Investment persistence parameter	0.3013	0.2613	0.2392
ρ_t	Transfers persistence parameter	0.4796	0.7248	0.7073
ρ_r	Monetary policy persistence parameter	0.9955	0.2328	0.9825

Notes: The table shows the name and the description of the parameters for the exogenous processes, as well as their posterior means. The first column shows the posterior means for the entire sample, while the second and the third columns show the posterior means for the first and the second sub-samples respectively.

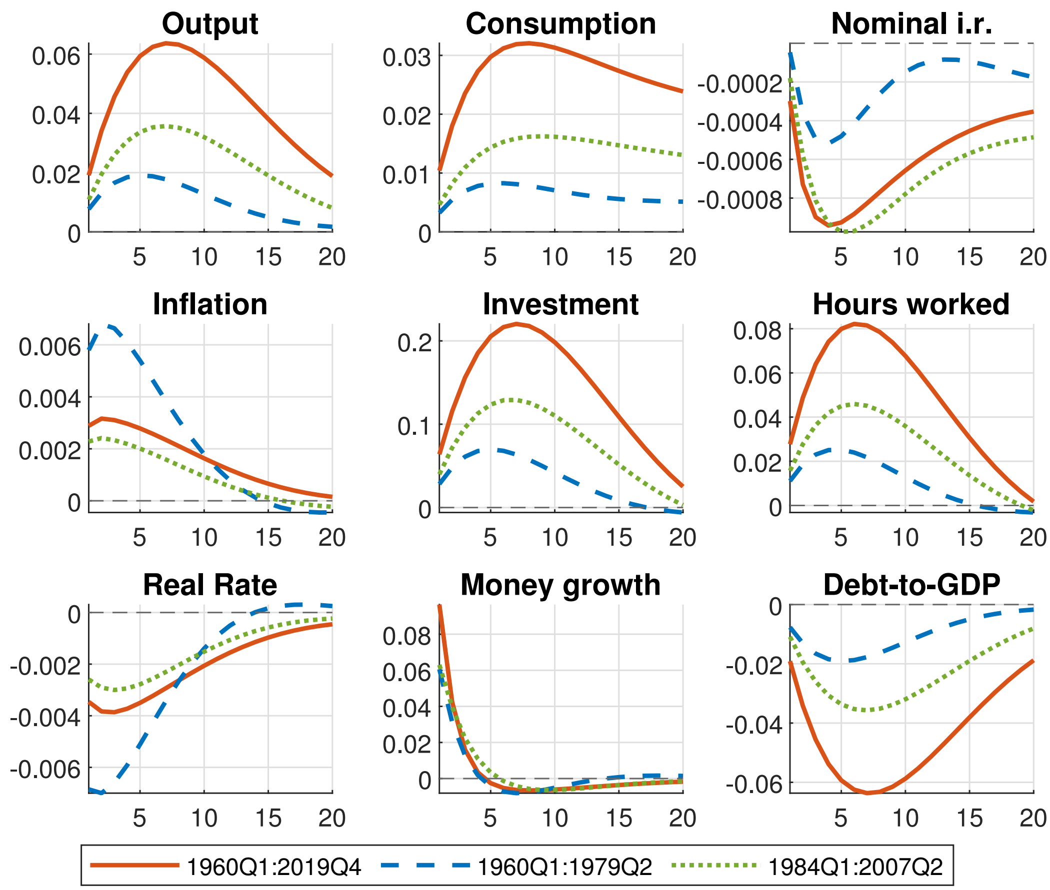
Table 5: Structural parameters - sub-samples

		Posterior mean		
Param.	**Description**	1960Q1:2019Q4	1960Q1:1979Q2	1984Q1:2007Q2
ν_l	Inverse Frisch elasticity	1.6537	2.0728	1.8319
Γ	Investment adjustment costs	6.1163	5.8614	6.0796
h	Consumption habits	0.7990	0.8687	0.8501
ϕ_π	Weight of inflation on the interest rate	3.5292	2.2243	3.1951
ψ_{yt}	Transfers parameter for output	0.1209	0.1097	0.0880
ψ_{bt}	Transfers parameter for debt	0.2657	0.2424	0.2994
ι_w	Wage indexation	0.4644	0.3564	0.4684
ζ_p	Price stickiness	0.9619	0.8738	0.9542
ι_p	Price indexation	0.1082	0.2056	0.0761
ζ_w	Wage stickiness	0.4731	0.4400	0.3887
ϕ_r	Interest rate smoothing parameter	0.1835	0.7938	0.1922
ϕ_y	Weight of output on the interest rate	0.1763	0.1660	0.1965

Notes: The table shows the name and the description of the structural parameters, as well as their posterior means. The first column shows the posterior means for the entire sample, while the second and the third columns show the posterior means for the first and the second sub-samples respectively.

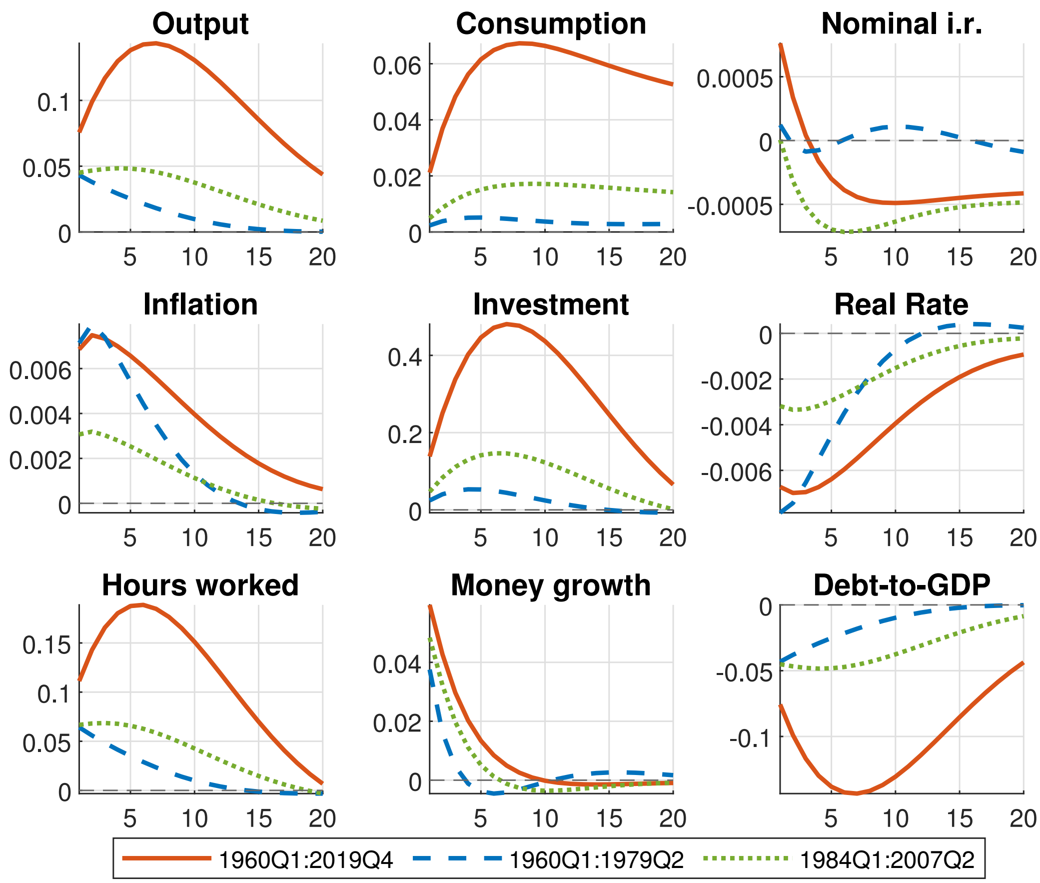
Figure 6 and 7 display the different impact of fiscal policy shocks on macroeconomic aggregates. Figure 6 focuses on an increase in monetary-financed transfers. Using data from the Great Inflation, after an increase in transfers, inflation rises (blue dashed line) twice as much as during the other two periods. This has a downward pressure on the real interest rate, causing it to decrease twice as much as for the other two periods. However, the real rate transmission channel to output, consumption, investment and hours worked shows weaker, but still positive effects during this sub-sample. Figure 7 focuses on an increase in monetary-financed government spending. Once more, the IRFs obtained for the Great Inflation show lower, yet still positive effects on output, consumption, investment and hours worked. The lower increase in output also results in a lesser positive impact on the public debt-to-GDP ratio for both fiscal shocks.

Figure 6: Monetary-financed transfers increase - sub-samples



Note: The figure shows the IRFs for a monetary-financed transfers increase. The orange line refers to the entire sample from 1960Q1 until 2019Q4. The blue dashed line refers to the first sub-sample, from 1960Q1 until 1979Q2. The green line refers to the second sub-sample, from 1984Q1 until 2007Q2.

Figure 7: Monetary-financed government spending increase - sub-samples

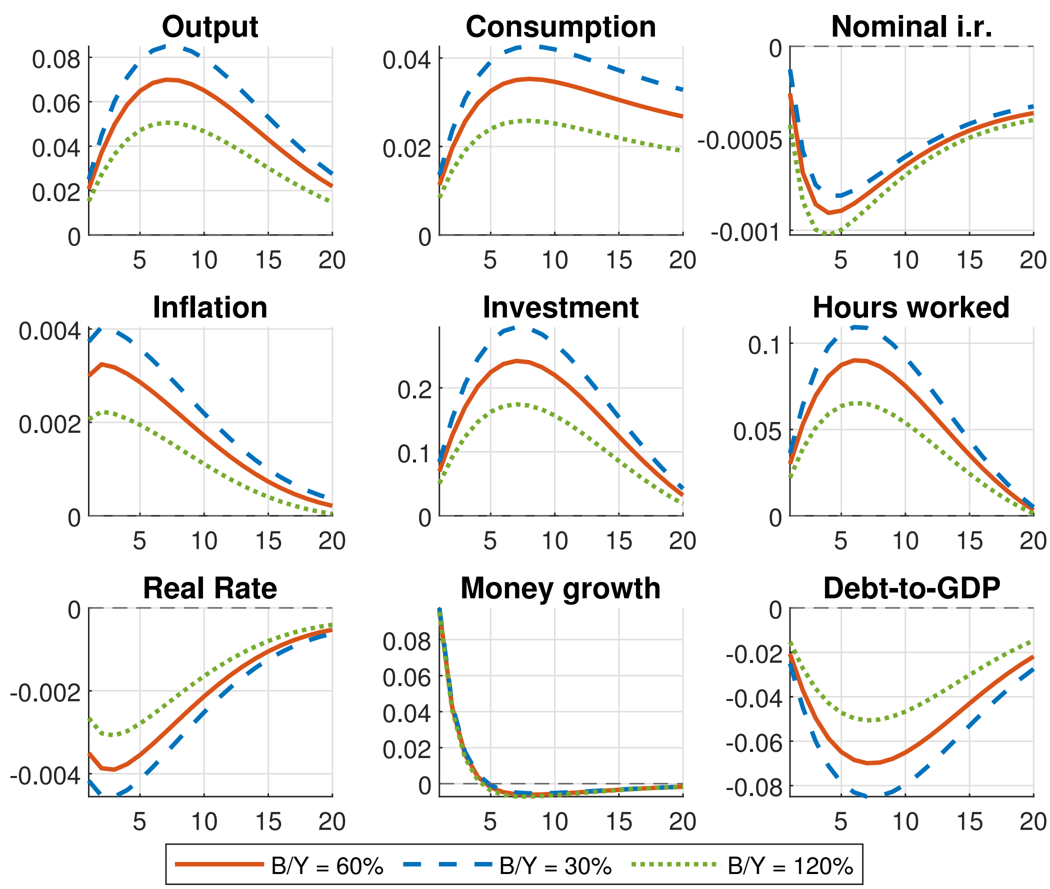


Note: The figure shows the IRFs for a monetary-financed government spending increase. The orange line refers to the entire sample from 1960Q1 until 2019Q4. The blue dashed line refers to the first sub-sample, from 1960Q1 until 1979Q2. The green line refers to the second sub-sample, from 1984Q1 until 2007Q2.

6.2 Debt-to-GDP level

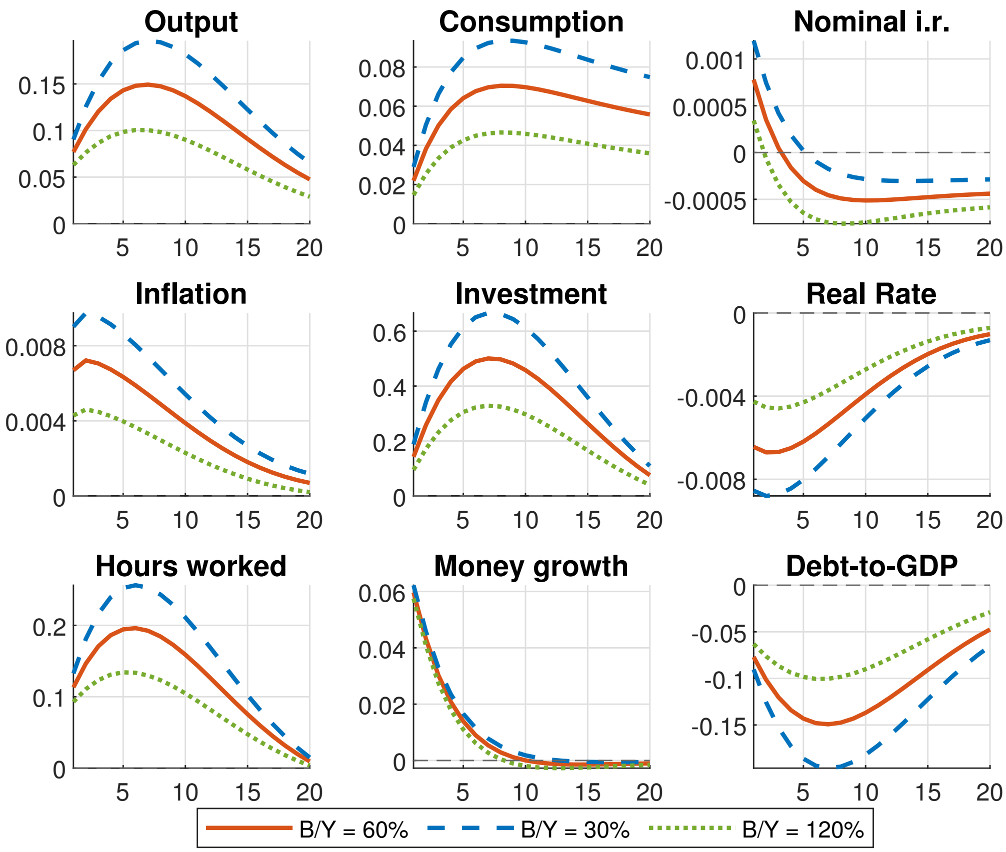
In this section two additional analysis are presented. Figure 8 displays IRFs for the monetary-financed scenario simulated with the estimated parameters over the entire sample setting different public debt-to-GDP ratios. It appears evident that fiscal shocks exert a higher positive impact on the economy in the presence of a lower debt-to-GDP ratio. This result holds for both monetary-financed increase in transfers and government spending.

Figure 8: Monetary-financed transfers increase: debt-to-GDP level



Note: The figure shows the IRFs for a monetary-financed transfers increase. The orange line refers to a model with a level of debt-to-GDP of 60%. The blue dashed line refers to a model with a level of debt-to-GDP of 30%. The green line refers to a model with a level of debt-to-GDP of 120%

Figure 9: Monetary-financed government spending increase: debt-to-GDP level



Note: The figure shows the IRFs for a monetary-financed government spending increase. The orange line refers to a model with a level of debt-to-GDP of 60%. The blue dashed line refers to a model with a level of debt-to-GDP of 30%. The green line refers to a model with a level of debt-to-GDP of 120%

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 fiscal stimulus packages, and the prolonged period of low inflation observed 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. We employ Bayesian methods to estimate the model parameters using US data. Subsequently, we conduct a simulation analysis by augmenting the model with a feature 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 a fiscal stimulus. We demonstrate that a monetary financing scheme for fiscal stimuli has positive impacts on economic aggregates. However, this comes at a cost: a higher increase in inflation compared to the alternative debt-financing method. Additional analysis shows that the impact of a monetary-financed fiscal stimulus remains positive, but varies according to the estimation sub-period, when the sample is split into two. Lastly, we show that the higher the level of the public debt-to-GDP ratio, the lower are the positive effects of a monetary-financed fiscal stimulus on the economy. 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.

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