The Effects of a Money-Financed Fiscal Stimulus*

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Abstract

I analyze the effects of a fiscal stimulus financed through money creation. I study the effects of both a tax cut and an increase in government purchases, and compare them with those resulting from a conventional debt-financed stimulus, with and without a binding zero lower bound (ZLB) on the nominal interest rate. When the ZLB is not binding, a money-financed fiscal stimulus is shown to have much larger multipliers than a debt-financed fiscal stimulus. That difference in effectiveness persists, but is much smaller, under a binding ZLB. The analysis points to the key role of nominal rigidities in shaping those effects.

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"*The prohibition of money financed deficits has gained within our political economy the status of a taboo, as a policy characterised not merely as –in many circumstances and on balance– undesirable, but as something we should not even think about let alone propose.*" Lord Turner (2013)

1 Introduction

The recent economic and financial crisis has acted as a powerful reminder of the limits to conventional countercyclical policies. The initial response of monetary and fiscal authorities to the decline of economic activity, through rapid reductions in interest rates and substantial increases in structural deficits, left policymakers out of conventional ammunition well before the economy had recovered. Policy rates hit their zero lower bound (ZLB) at a relatively early stage of the crisis, while large and rising debt ratios forced widespread fiscal consolidations –still underway in some countries– that likely delayed the recovery and added to the economic pain. While the adoption of unconventional monetary policies by the Federal Reserve, the ECB and other major central banks may have helped support the economy over the past few years, such policies failed to provide a sufficiently large boost to aggregate demand to quickly bring output and employment back to their potential levels, and inflation closer to its target level.

Against that background, and looking ahead, there is a clear need to think of policies that may help stimulate a depressed economy without relying on lower nominal interest rates (which are unfeasible when the zero lower bound is binding) or further rises in the stock of government debt (given the high debt ratios, and the consequent risks of debt crisis, that often characterize depressed economies). In that regard, proposals focusing on labor cost reductions or structural reforms, repeatedly put forward by the IMF and other international organizations, have been recently called into question by several authors on the grounds that their effectiveness at raising output hinges on a simultaneous loosening of monetary policy, an option no longer available under a binding ZLB.[1]

In the present paper I analyze the effectiveness of an alternative policy: a fiscal stimulus *financed through money creation*, requiring neither an increase in the stock of government debt nor higher taxes, current or future. I study separately two types of money-financed fiscal stimuli: a reduction in (lump-sum) taxes and an increase in government purchases. For each of these interventions, I analyze its effects on

[1] See Galí (2013), Galí and Monacelli (2016) and Eggertsson, Ferrero and Raffo (2014), among others.

several macro variables, and compare them to the corresponding effects from a more conventional debt-financed stimulus, with monetary policy independently pursuing a price stability mandate.

Each of these policy interventions and their effects is analyzed in the context of two alternative environments. In the baseline environment (which I refer to below as "normal times"), the fiscal stimulus is exogenous, and the ZLB on the nominal interest rate is assumed not to be binding. In the alternative environment (labeled as "liquidity trap"), the money-financed fiscal stimulus is assumed to take place in response to an adverse demand shock that brings the natural interest rate into negative territory, thus preventing monetary policy from fully stabilizing output and inflation, due to the ZLB.

The goal of the present paper is not so much to offer a realistic quantitative analysis of the effects of a money-financed fiscal stimulus, but to get a better understanding of its qualitative implications –especially in comparison to a fiscal stimulus financed through more orthodox arrangements– and of the consequences of its implementation under a binding ZLB. With this in mind, I conduct the analysis below using a textbook New Keynesian model with monopolistic competition and sticky prices. For simplicity I restrict the analysis to a closed economy with no endogenous capital accumulation.

The main findings of the paper can be summarized as follows. In normal times, when the ZLB is not binding, a money-financed fiscal stimulus is shown to have much larger output multipliers than a debt-financed fiscal stimulus. The main reason for that difference lies in the monetary accommodation associated with the former type of intervention, which leads to a large positive response of (private) consumption. Under debt financing, on the other hand, a fiscal stimulus has either no effect on activity (in the case of a tax cut) or a much smaller effect than under money-financing (in the case of an increase in government purchases), due to the endogenous tightening of monetary policy that accompanies it. Conditional on money-financing, an increase in government purchases is shown to have a larger output multiplier, but a smaller consumption multiplier, than a tax cut. My analysis stresses the key role of nominal rigidities in generating the previous findings.

A money-financed fiscal stimulus, whether a tax cut or an increase in government purchases, is also shown to dominate its debt-financed counterpart from a welfare viewpoint. Thus, both in normal times and under a liquidity trap, a money-financed tax cut is shown to be generally welfare enhancing. A money-financed increase in (wasteful) government purchases, on the other hand, generally lowers utility, but the implied welfare loss is generally smaller than its corresponding debt-financed counterpart. Under a liquidity trap, however, an increase in government purchases may be welfare enhancing if the economy suffers from large distortions, with the welfare gains larger if financed by money creation.

1.1 Related Literature

Milton Friedman's celebrated "monetary and fiscal framework" article (Friedman (1948)) is, as far as I know, the earliest reference where a case for money-financed budget deficits is made. In Friedman's view, the ideal policy framework would require that governments maintain a balanced budget in structural terms (i.e. under full employment), but that they let automatic stabilizers operate in the usual way, with the deficits generated during recessions being financed by money creation (and, symmetrically, with surpluses in boom times used to reduce the money stock). Such a "rule" would be a most effective countercyclical tool for, in the words of Friedman, *"...in a period of unemployment [issuing interest-earning securities] is less deflationary than to levy taxes. This is true. But it is still less deflationary to issue money."*

A similar argument can be found in Haberler (1952), who emphasizes how the effectiveness of such a policy would be amplified through the Pigou effect channel. Friedman (1969), in the context of his analysis of optimal policy, represents the earliest known reference to "helicopter money," a term often used to refer to money-financed fiscal transfers. More specifically, Friedman sought to trace the effects of a thought experiment whereby *"one day a helicopter flies over this community and drops an additional $1,000 in bills from the sky...,"* though no endorsement of that policy was intended.

More recently, Bernanke (2003) refers to the potential desirability of a money-financed fiscal stimulus, in the context of a discussion of the options left to Japanese policy makers. The same motivation was shared in the subsequent work by Auerbach and Obstfeld (2005), using an analytical approach closer to the present paper. More specifically, that paper studies the effectiveness of open market operations in raising inflation and output when the economy is at the zero lower bound, as a result of some temporary adverse shock. That effectiveness is shown to be strongly dependent on whether the increase in liquidity is permanent and expected to be so by agents. Their analysis and some of the qualitative findings are related to those of the intervention considered in section 5 below, namely, a tax cut funded by money creation under a binding ZLB. A related, more recent contribution can be found in Buiter (2014), who analyzes the impact of a money-financed transfer to households (a "helicopter drop") in a relatively general setting, emphasizing the importance of "irredeemability" of money as the ultimate source of the expansionary effect on consumption of a such a policy. The present paper can be viewed as extending the analyses in Auerbach and Obstfeld (2005) and Buiter (2014) by providing a *comparison* of (i) the effects of money-financed vs. debt-financed tax cuts, as well as (ii) the differential effects of money-financed tax cuts vs. increases in government purchases.[2]

Other recent discussions include Turner (2013, 2016) who points to the potential virtues of monetary financing of fiscal deficits. See also Reichlin, Turner and Woodford (2013) and Giavazzi and Tabellini (2014) for related discussions. Their analysis is not based, however, on a formal model.

The present paper is related to the large literature on the effects of changes in government purchases.[3] Much of that literature has tended to focus on the size of the government spending multiplier under alternative assumptions. That multiplier is predicted to be below or close to unity in the context of standard RBC or New Keynesian models, but it can rise substantially in the presence of non-Ricardian households (see, e.g., Galí, López-Salido and Vallés (2007)) or when the ZLB constraint is binding (Christiano, Eichenbaum and Rebelo (2011), Eggertsson (2011)). The present paper shows that large multipliers also arise when the increase in government purchases is financed through money creation, even in the absence of non-Ricardian households or a binding ZLB constraint.

The remainder of the paper is organized as follows. Section 2 describes formally the fiscal and monetary framework used in the subsequent analysis, as well as the specific experiments undertaken. Section 3 describes the (standard) nonpolicy blocks of the model. Section 4 derives the (approximate) equilibrium conditions in a neighborhood of the perfect foresight steady state. Section 5 analyzes the effect of an exogenous tax cut and an exogenous increase in government purchases, in the absence of a binding ZLB constraint, and under the two financing regimes considered. Section 6 evaluates the effects of identical fiscal interventions when the economy is hit by an adverse shock that makes the ZLB temporarily binding. Section 7 summarizes the main findings and concludes.

[2] The papers also differ in terms of modelling choices. Thus, Auerbach and Obstfeld (2005) use a flexible price model as their baseline framework, turning to a model with Taylor contracts as their sticky price model. They generate a demand for money by assuming a cash-in-advance constraint, thus implying a constant velocity. Finally they introduce taxation in the form of (distortionary) consumption taxes. By contrast, I adopt as a reference framework a textbook New Keynesian model with Calvo pricing, money in the utility function, and lump-sum taxes. With the exception of the treatment of the financing of fiscal stimulus, my framework corresponds to the workhorse model generally used in the recent monetary policy literature.

[3] Woodford (2011) uses a framework identical to the one used in the present paper to analyze the effects of increases in government purchases and the role played by monetary policy in shaping those effects. See Ramey (2011) for a broad survey of the theoretical and empirical literature on the subject.

2 The Fiscal and Monetary Policy Framework

Next I describe the fiscal and monetary policy framework assumed in subsequent sections. I start by introducing the budget constraints of the fiscal and monetary authorities, and then move on to describe the fiscal interventions that are the focus of my analysis. Throughout I consider a fully *unanticipated* intervention which is announced at a given point in time (period 0). No other news or shocks occur after that, so the environment is modeled as a deterministic one.

2.1 Budget Constraints

The fiscal authority's period budget constraint is given by

$$P_t G_t + B_{t-1}^F (1 + i_{t-1}) = P_t (T_t + S_t) + B_t^F \tag{1}$$

where G_t and T_t denote government purchases and lump-sum taxes (both in real terms). B_t^F is the stock of one-period nominally riskless bonds issued by the fiscal authority in period t and yielding a nominal return i_t. S_t denotes a (real) transfer from the central bank to the fiscal authority.

The corresponding budget constraint for the monetary authority is given by

$$B_t^M + P_t S_t = B_{t-1}^M (1 + i_{t-1}) + \Delta M_t \tag{2}$$

where B_t^M denotes the central bank's holdings of government bonds at the end of period t, and M_t is the quantity of money in circulation.[4]

One can combine (1) and (2) to obtain the government's *consolidated* budget constraint:

$$P_t G_t + B_{t-1} (1 + i_{t-1}) = P_t T_t + B_t + \Delta M_t \tag{3}$$

where $B_t \equiv B_t^F - B_t^M$ denotes government debt held by households (henceforth, government debt, for short).

Equivalently, and after letting $\mathcal{B}_t \equiv B_t / P_t$ and $\mathcal{R}_t \equiv (1 + i_t)(P_t / P_{t+1})$, one can write:

$$G_t + \mathcal{B}_{t-1} \mathcal{R}_{t-1} = T_t + \mathcal{B}_t + \Delta M_t / P_t \tag{4}$$

[4] Note that the (stylized) balance sheet of the central bank is given by

$$B_t^M = M_t + K_t$$

where K_t is the central bank's capital, which evolves according to:

$$K_t = K_{t-1} + B_{t-1}^M i_{t-1} - P_t S_t$$

where $\Delta M_t/P_t$ represents period t's seignorage, i.e. the purchasing power of newly created money.

In much of the analysis below I consider equilibria near a *steady state* with zero inflation, no trend growth, and constant government purchases G, taxes T and government debt $\mathcal{B}$. Constancy of real balances requires that $\Delta M = 0$ and, hence, zero seignorage in that steady state. It follows from (4) that

$$T = G + \rho \mathcal{B} \tag{5}$$

must hold in that steady state, using the fact that, as shown below, $\mathcal{R} = 1 + \rho$, where ρ is the household's discount rate.[5]

In a neighborhood of the zero inflation steady state, the level of seignorage, expressed as a fraction of steady state output, can be approximated as

$$\begin{aligned} (\Delta M_t/P_t)(1/Y) &= (\Delta M_t/M_{t-1})(P_{t-1}/P_t)L_{t-1}/Y \\ &\simeq \varkappa \Delta m_t \end{aligned} \tag{6}$$

where $L_t \equiv M_t/P_t$ denotes real balances, $m_t \equiv \log M_t$, and $\varkappa \equiv L/Y$ is the steady state *inverse* income velocity of money. In other words, up to a first order approximation, the level of seignorage is proportional to money growth .

Let $\widehat{b}_t \equiv (\mathcal{B}_t - \mathcal{B})/Y$, $\widehat{g}_t \equiv (G_t - G)/Y$, and $\widehat{t}_t \equiv (T_t - T)/Y$ denote, respectively, deviations of government debt, government purchases, and taxes from their steady state values, expressed as a fraction of steady state output. In what follows I interpret $\mathcal{B}$ as an exogenously given long run debt target.

A first order approximation of the consolidated budget constraint (4) around the zero inflation steady state yields the following difference equation describing the evolution of government debt, expressed as a share of steady state output Y:

$$\widehat{b}_t = (1+\rho)\widehat{b}_{t-1} + b(1+\rho)(\widehat{i}_{t-1} - \pi_t) + \widehat{g}_t - \widehat{t}_t - \varkappa \Delta m_t \tag{7}$$

where $\widehat{i}_t \equiv \log((1+i_t)/(1+\rho))$ and $\pi_t \equiv p_t - p_{t-1}$.

Throughout I assume a simple tax rule of the form

$$\widehat{t}_t = \psi_b \widehat{b}_{t-1} + \widehat{t}_t^* \tag{8}$$

[5] Note that under the additional assumption that the central bank's real holdings of government debt, $\mathcal{B}_t^M \equiv B_t^M/P_t$, are constant in the steady state, (2) implies

$$S = \rho \mathcal{B}^M$$

i.e. the central bank's steady state transfer to the fiscal authority equals the interest generated by its government debt holdings.

Thus, tax variations have two components. The first component, $\psi_b \widehat{b}_{t-1}$, is endogenous and varies in response to deviations of the debt ratio from its long run target. The second component, $\widehat{t}_t^*$, is independent of the debt ratio and should be interpreted as the exogenous component of the tax rule.

Combining (7) and (8) we obtain

$$\widehat{b}_t = (1 + \rho - \psi_b)\widehat{b}_{t-1} + b(1 + \rho)(\widehat{i}_{t-1} - \pi_t) + \widehat{g}_t - \widehat{t}_t^* - \varkappa \Delta m_t \tag{9}$$

Henceforth I assume $\psi_b > \rho$, which combined with $\lim_{T\to\infty} \widehat{x}_T = 0$ for $x \in \{g, t^*, \Delta m, i, \pi\}$ (as is the case below) guarantees that $\lim_{T\to\infty} E_t\{\widehat{b}_t\} = 0$, i.e. the debt ratio converges to its long run target. Accordingly, the government's transversality condition $\lim_{T\to\infty} \Lambda_{0,T}\mathcal{B}_T = 0$ will be satisfied *for any price level path*, as long as the discount factor $\Lambda_{0,T} \equiv \prod_{j=0}^{T-1} \mathcal{R}_j^{-1}$ converges to zero, which will be the case in all the experiments considered below. The previous property is often referred to in the literature as fiscal policy being Ricardian (or passive).

2.2 Experiments

Below I analyze two stylized fiscal interventions, using the basic New Keynesian model as a reference framework. The first experiment consists of an exogenous *tax cut*, while the second one takes the form of an exogenous *increase in government purchases*. Both interventions are announced and implemented in period 0, and assumed to be fully unanticipated before that time. For concreteness, I assume

$$\widehat{t}_t^* = -\delta^t < 0$$

for $t = 0, 1, 2, ...$where $\delta \in [0, 1)$ measures the intervention persistence. Symmetrically, in the case of an increase in government purchases I assume

$$\widehat{g}_t = \delta^t > 0$$

for $t = 0, 1, 2, ...$Notice that in both cases the size of the stimulus is normalized to be 1 percent of steady state output in period 0.

The effects of each type of fiscal intervention are analyzed under two alternative financing schemes. The first financing scheme, which I refer to as *money financing* (or *MF*, for short) is the main focus of the present paper. Specifically, I consider a regime in which seignorage is adjusted in order to keep *real debt* $\mathcal{B}_t$ unchanged. In terms of the notation above, this requires $\widehat{b}_t = 0$ and hence

$$\Delta m_t = (1/\varkappa)\left[\delta^t + b(1 + \rho)(\widehat{i}_{t-1} - \pi_t)\right] \tag{10}$$

for $t = 0, 1, 2, ...$ Note that the previous assumptions, combined with (*8*), imply (i) that under the *MF* regime taxes are *not raised* as a result of the fiscal stimulus, either in the short run or in the long run, relative to their initial level, and (ii) that they are temporarily *lowered* in the case of a tax cut.

Under the second financing scheme considered, which I refer to as *debt financing* (or *DF,* for short), the fiscal authority issues debt in order to finance the fiscal stimulus, eventually adjusting the path of taxes in order to attain the long run debt target $\mathcal{B}$, as implied by rule (8)). The monetary authority, on the other hand, is assumed to pursue an independent price stability mandate. For concreteness I assume that, as long as feasible, it conducts policy so that $\pi_t = 0$ for all t. The money supply –and, as a result, seignorage– then adjusts endogenously in order to bring about the interest rate required to stabilize prices, given money demand. I interpret the debt financing regime as a stylized representation of the one prevailing in most advanced economies, and the one generally assumed in the theoretical literature on the effects of fiscal policy shocks, with or without a binding ZLB.[6]

In the baseline scenario described above, the fiscal stimuli analyzed are exogenous, and undertaken in the absence of any other disturbance. Furthermore, the nominal interest rate is assumed to remain positive at all times, i.e. the ZLB is assumed not to be binding. In Section 6, by contrast, and as discussed there in more detail, I study the effects of a fiscal stimulus that is triggered as a response to an adverse demand shock that pulls the natural rate of interest temporarily into negative territory. In that context, the ZLB prevents the monetary authority from attaining its price stability objective. I refer to that scenario as a *liquidity trap.* I compare the economy's response to the adverse shock with and without a fiscal response in the form of a tax cut or an increase in government purchases. In the case of a fiscal response, I consider both a money financing and a debt financing regime (as described above), and compare their respective outcomes.

3 Non-Policy Blocks

Next I describe the non-policy blocks of the model, which I keep as simple as possible, using the basic New Keynesian model as a reference framework.[7]

[6] The assumed monetary policy can be seen as the limiting case of an interest rate rule of the form $\widehat{i}_t = \phi_\pi \pi_t$ as $\phi_\pi \to \infty$.

[7] See e.g. Woodford (2003) or Galí (2015) for a textbook exposition.

3.1 Households

The economy is inhabited by a large number of identical households. Household preferences are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t \mathcal{U}(C_t, L_t, N_t; Z_t) \tag{11}$$

where $C_t \equiv \left(\int_0^1 C_t(i)^{1-\frac{1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}}$ is a consumption index, N_t is employment, $L_t \equiv M_t/P_t$ denotes household's holdings of real balances, and Z_t is an exogenous demand shifter.[8] $\beta \equiv 1/(1+\rho) \in (0,1)$ is the discount factor. As usual it is assumed that $C_t \geq 0$, $N_t \geq 0$ and $L_t \geq 0$ for all t.

The household maximizes (11) subject to a sequence of budget constraints

$$P_t C_t + B_t + M_t = B_{t-1}(1 + i_{t-1}) + M_{t-1} + W_t N_t + D_t - P_t T_t$$

for $t = 0, 1, 2, ...$where W_t is the nominal wage and D_t are dividends paid by firms.[9] A standard solvency constraint ruling out Ponzi schemes is assumed:

$$\lim_{T \to \infty} \Lambda_{0,T} \mathcal{A}_t \geq 0 \tag{12}$$

where $\mathcal{A}_t \equiv (B_{t-1}(1 + i_{t-1}) + M_{t-1})/P_t$ denotes the representative household's real financial wealth at the beginning of period t.

In the analysis below, period utility $\mathcal{U}(\cdot)$ is assumed to take the form

$$\mathcal{U}(C, L, N; Z) = (U(C, L) - V(N))\, Z$$

with $V(\cdot)$ increasing and convex, $U(\cdot)$ increasing and concave, and $U_l/U_c = h(L/C)$ with $h(\cdot)$ being a continuous and decreasing function satisfying $h(\overline{\varkappa}) = 0$ for some $0 < \overline{\varkappa} < \infty$. The last assumption, combined with (14), guarantees that the demand for real balances remains bounded as the interest rate approaches zero, with a satiation point attained at $L = C\overline{\varkappa}$.

The optimality conditions for the household problem are given by:

$$U_{c,t} = \beta(1 + i_t)(P_t/P_{t+1})U_{c,t+1} \tag{13}$$

$$\mathcal{U}_{l,t}/\mathcal{U}_{c,t} = h(L_t/C_t) = i_t/\,(1 + i_t) \tag{14}$$

[8] The preference shifter Z_t is used to generate a reduction in the natural rate of interest in the "liquidity trap" scenario analyzed in section 6.

[9] Optimal allocation of expenditures across goods implies that total consumption expenditures $\int_0^1 P_t(i)C_t(i)di$ can be written as $P_t C_t$, where $P_t \equiv \left(\int_0^1 P_t(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$ is the relevant price index.

for $t = 0, 1, 2, ...$ Equation (13) is the consumption Euler equation. Equation (14) is a money demand schedule. Such optimality conditions must be complemented with the transversality condition $\lim_{T\to\infty} \Lambda_{0,T}\mathcal{A}_t = 0$.

Each household is specialized in a differentiated labor service. The corresponding wage is set optimally by a "union" representing all workers with a given specialization, subject to a demand schedule resulting from firms' cost minimization, and taking aggregate variables as given. Employment is then determined by firms' demand. In that context, the optimal wage setting rule is given by

$$W_t/P_t = \mathcal{M}_w(V_{n,t}/U_{c,t}) \tag{15}$$

where $\mathcal{M}_w \equiv \epsilon_w/(\epsilon_w - 1)$ is the desired wage markup. Thus, I introduce a markup distortion in the labor market while maintaining the assumption of wage flexibility for simplicity. The combination of market power in the goods market and in the labor market leads to an inefficient steady state, which is relevant for the determination of the welfare effects of the policy interventions considered here, as discussed below.

3.2 Firms

A representative firm produces the single final good with a constant returns technology

$$Y_t \equiv \left(\int_0^1 X_t(i)^{1-\frac{1}{\epsilon}} di\right)^{\frac{\epsilon}{\epsilon-1}}$$

where $X_t(i)$ denotes the quantity of intermediate good i, for $i \in [0,1]$. Profit maximization under perfect competition leads to the set of demand conditions:

$$X_t(i) = (P_t(i)/P_t)^{-\epsilon} Y_t \quad all\ i \in [0,1] \tag{16}$$

Intermediate goods are produced by a continuum of monopolistically competitive firms, indexed by $i \in [0,1]$. Each firm produces a differentiated intermediate good with a technology

$$X_t(i) = N_t(i)^{1-\alpha}$$

where $N_t(i) \equiv \left(\int_0^1 N_t(i,j)^{1-\frac{1}{\epsilon_w}} dj\right)^{\frac{\epsilon_w}{\epsilon_w-1}}$ denotes the effective labor input hired by firm i, with $N_t(i,j)$ denoting the amount of labor of type j, for $j \in [0,1]$. Each firm in the intermediate goods sector can reset the price of its good with probability $1-\theta$ in any given period, as in Calvo (1983), subject to the isoelastic demand schedule (16).

In that case, aggregation of the optimal price setting decisions leads to dynamics of inflation around a zero inflation steady state described by the difference equation:

$$\pi_t = \beta \pi_{t+1} - \lambda(\mu_t - \mu)$$

where $\mu_t \equiv \log \frac{(1-\alpha)P_t}{W_t N_t^{\alpha}}$ is the (log) average price markup, $\mu \equiv \log \mathcal{M}_p = \log \frac{\epsilon_p}{\epsilon_p - 1} > 0$ is the (log) desired price markup, and $\lambda \equiv \frac{(1-\theta)(1-\beta\theta)(1-\alpha)}{\theta(1-\alpha+\alpha\epsilon_p)}$.[10] I interpret $\theta \in [0, 1]$, the fraction of firms keeping their price constant in any given period, as an index of price rigidities.

4 Steady State and Equilibrium Dynamics

The analysis below considers equilibria in a neighborhood of a steady state with zero inflation and zero government purchases.[11] Note that at the zero inflation steady state price markups must be at their desired level. Combining that result with (15), (14) and the goods market equilibrium condition, $Y_t = C_t + G_t$, all evaluated at the steady state (with $G = 0$), and letting $\mathcal{M} \equiv \mathcal{M}_w \mathcal{M}_p$ denote the "composite" markup, one can derive the conditions jointly determining steady state output and real balances, which are given by the system

$$(1-\alpha)U_c(N^{1-\alpha}, L) = \mathcal{M} V_n(N) N^{\alpha}$$

$$h(L/N^{1-\alpha}) = \rho/(1+\rho)$$

which is assumed to have a unique solution.[12]

Letting $\widehat{y}_t \equiv \log(Y_t/Y)$, $\widehat{c}_t \equiv \log(C_t/C)$, $\widehat{l}_t \equiv \log(L_t/L)$, $\widehat{\xi}_t \equiv \log(U_{c,t}/U_c)$, $\widehat{i}_t \equiv \log((1+i_t)/(1+\rho))$, and $\widehat{\rho}_t \equiv -\log(Z_{t+1}/Z_t)$, the equilibrium around the steady state can be approximated by the following system (ignoring the ZLB constraint at this point):

$$\widehat{y}_t = \widehat{c}_t + \widehat{g}_t \tag{17}$$

$$\widehat{\xi}_t = \widehat{\xi}_{t+1} + (\widehat{i}_t - \pi_{t+1} - \widehat{\rho}_t) \tag{18}$$

$$\widehat{\xi}_t = -\sigma \widehat{c}_t + \upsilon \widehat{l}_t \tag{19}$$

$$\pi_t = \beta \pi_{t+1} - \lambda \widehat{\mu}_t \tag{20}$$

[10] See, e.g. Galí (2015, chapter 3) for a derivation.

[11] Given my objectives, that choice of steady state carries little loss of generality but simplifies the algebra considerably.

[12] A sufficient condition for a unique steady state is given by $U_c(C, \varkappa C)$ being non-increasing in C, with $\varkappa \equiv h^{-1}(\rho/(1+\rho))$ denoting the steady state inverse velocity.

$$\widehat{\mu}_t = \widehat{\xi}_t - \left(\frac{\alpha + \varphi}{1 - \alpha}\right) \widehat{y}_t \tag{21}$$

$$\widehat{l}_t = \widehat{c}_t - \eta \widehat{i}_t \tag{22}$$

$$\widehat{l}_{t-1} \equiv \widehat{l}_t + \pi_t - \Delta m_t \tag{23}$$

$$\widehat{b}_t = (1 + \rho - \psi_b)\widehat{b}_{t-1} + b(1 + \rho)(\widehat{i}_{t-1} - \pi_t) + \widehat{g}_t - \widehat{t}_t^* - \varkappa \Delta m_t \tag{24}$$

where $\varphi \equiv NV_{nn}/V_n$, $\sigma \equiv -CU_{cc}/U_c$, $\upsilon \equiv LU_{cl}/U_c$ and $\eta \equiv \epsilon_{lc}/\rho$, with $\epsilon_{lc} \equiv -(1/h')(\rho/(1+\rho))V$ denoting the elasticity of substitution between consumption and real balances, with all terms evaluated at the steady state.[13] As discussed above, $\widehat{t}_t^* = -\delta^t$ for $t = 0, 1, 2, ...$in the case of a tax cut, and $\widehat{g}_t = \delta^t$ for $t = 0, 1, 2, ...$ when an increase in government purchases is assumed instead.

In order to close the model, the above equilibrium conditions must be supplemented with an equation describing the financing regime. In the case of money financing, that equation is given by:

$$\Delta m_t = (1/\varkappa)\left(\delta^t + b(1 + \rho)(\widehat{i}_{t-1} - \pi_t)\right) \tag{25}$$

Under debt financing and inflation targeting, (25) must be replaced with

$$\pi_t = 0 \tag{26}$$

for all t. In the latter case money growth adjusts endogenously in order to support the interest rate required to stabilize inflation, as determined by (22) and (23).

The previous model is, of course, a highly stylized one, but it contains the key ingredients for a meaningful analysis of the issue at hand. In particular, the presence of nominal rigidities makes room for monetary policy to affect real outcomes in addition to nominal ones.

4.1 Calibration

Unless noted otherwise, the simulations below assume the following baseline parameter settings. The discount factor is set at $\beta = 0.995$, which implies a steady state (annualized) real interest rate of about 2 percent. I assume $\varphi = 5$ (corresponding to a Frisch elasticity of labor supply of 0.2). Parameter α is set to 0.25. These are values broadly similar to those found in the literature.

[13] Note that $\epsilon_{lc} = 1/(\sigma_l + \upsilon)$ with $\sigma_l \equiv -LU_{ll}/U_l$.

The model's main frictions are given by price stickiness and market power in both goods and labor markets. I assume a baseline setting of $\theta = 3/4$, i.e. an average price duration of four quarters, a value consistent with much of the empirical micro and macro evidence. Below I also report some results using $\theta = 1/4$ as an alternative calibration, characterized by a lesser degree of price stickiness, and which I refer to as "flexible prices."

As in Galí (2015), the baseline calibration from the price and wage markups is $\mathcal{M}_p = 1.125$ and $\mathcal{M}_w = 1.28$. The former implies a 12.5 percent steady state price markup, while the latter is consistent with a steady state unemployment rate of 5 percent, roughly the average unemployment rate in the postwar U.S. economy.[14] Below I also consider an alternative calibration, following Galí and Monacelli (2016), which I refer to as "large distortions," with $\mathcal{M}_p = 1.35$ and $\mathcal{M}_w = 1.82$. The former setting is consistent with OECD estimates of average price markups in the European Union, while the latter implies a steady state unemployment rate of 12 percent, roughly the average unemployment rate among southern European countries over the 1999-2014 period.

In calibrating the steady state inverse velocity ($\varkappa$) and the interest semi-elasticity of money demand (η) I must take a stand on the appropriate empirical counterpart to the model's money stock variable. The focus on direct financing of the fiscal stimulus through money creation by the central bank calls for choosing the monetary base (M0) as that empirical counterpart. Average (quarterly) M0 income velocity in the U.S. over the 1960-2015 period is 3.6. The corresponding value for the euro area over the period 1999-2015 is 2.7. I take a middle ground and set $\varkappa = 1/3$ as the steady state inverse velocity in the baseline calibration. In order to calibrate interest semi-elasticity of money demand, I rely on the evidence in Ireland (2009) using quarterly U.S. data for the period 1980-2006. Implied estimates for η in the latter paper range between 6 and 8 (once scaled to be consistent with a *quarterly* interest rate), so I adopt a baseline setting of 7. Finally, in my baseline calibration I assume separability of real balances, which implies $\upsilon = 0$.

I calibrate the tax adjustment parameter, ψ_b, so that one-twentieth of the deviation from target in the debt ratio is corrected over four periods (i.e. one year), in the absence of further deficits.[15] This requires setting ψ_b equal to 0.02. That calibration can be seen as a rough approximation to the fiscal adjustment speed required for euro area countries, as established by the so-called "fiscal compact" adopted in 2012.

[14] See Galí (2015, chapter 7) for a derivation of the relation between the unemployment rate and the wage markup.

[15] Given $\rho = 0.005$, as implied by the baseline calibration, ψ_b is determined by the condition $(1.005 - \psi_b)^4 = 0.95$.

With regard to the target/steady state debt ratio b, I assume a baseline setting of 2.4, which is consistent with the 60 percent reference value specified in EU agreements (after suitable scaling to quarterly output). Finally, with regard to the persistence parameter δ, I choose 0.5 as a baseline setting. Results for alternative values of many of the parameters are reported in the sensitivity analysis section.

5 The Effects of a Money-Financed Fiscal Stimulus in Normal Times

In the present section I use the basic New Keynesian model as a framework for the analysis of the effects of a tax cut and an increase in government purchases under the two financing schemes introduced above, i.e. debt and money financing.

Before undertaking that analysis, I state an irrelevance proposition which holds in the special case of fully flexible prices and separability of real balances in the utility function.

Proposition [Irrelevance of the Financing Method in a Special Case]: Under fully flexible prices ($\theta = 0$) *and* separable real balances ($\upsilon = 0$) the effects of a fiscal stimulus on real variables (other than real balances) is independent of the financing method.

The previous result is an illustration of *Ricardian equivalence* (Barro (1974)), which applies to the model economy above under the conditions that guarantee money neutrality ($\theta = \upsilon = 0$), and given the assumption of lump-sum taxes. Its proof is straightforward. Under flexible prices, all firms set prices as a constant markup over marginal cost, implying $\widehat{\mu}_t = 0$ for all t, which combined with (17), (19) and (21) yields:

$$\widehat{y}_t = \left(\frac{1-\alpha}{\alpha + \varphi + \sigma(1-\alpha)} \right) \left(\sigma \widehat{g}_t + \upsilon \widehat{l}_t \right) \tag{27}$$

for $t = 0, 1, 2, ...$Note that under separable real balances ($\upsilon = 0$) the equilibrium level of output (and, as a result, employment) is increasing in government purchases, but independent of the tax level. Furthermore, and conditional on any given path of taxes, output is not affected by the path of government debt or the money supply in that case. This is also the case for consumption (given (17)) and the real interest rate $\widehat{r}_t \equiv \widehat{i}_t - \pi_{t+1}$ (given (18) and (19)).[16]

[16] Not surprisingly, the equilibrium price level (and other nominal variables) is not invariant to the financing method even in the particular case of flexible prices and separable real balances. Note

The above irrelevance proposition no longer holds when prices are sticky and/or utility is not separable in real balances. The analysis and simulations below focus on the consequences of departing from the assumption of price flexibility for the effects of a money-financed fiscal stimulus, relative to the case of debt financing. Thus, when prices are sticky, aggregate demand and output are a function of current and expected real interest rates, which in turn are affected by the paths for the money supply and nominal interest rates, which differ across financing methods. The analysis below aims at assessing whether a money-financed fiscal stimulus can have non-negligible effects on economic activity, when a realistic degree of price stickiness is assumed.[17]

5.1 A Money-Financed Tax Cut

Figure 1 displays the response over time of output, inflation, debt and other macroeconomic variables of interest to an exogenous tax cut, under the baseline calibration described above.[18] The red lines with circles display the responses under the money financing (MF) scheme, while the blue lines with diamonds show the response under debt financing (DF). For inflation, I show both the annualized quarterly rate and the year-on-year rate. For debt, I display the percent response of real debt as well as that of the debt-output ratio.

As Figure 1 makes clear, a debt-financed tax cut has no effect on any variable, other than debt and taxes. That neutrality result is, of course, well known and a consequence of Ricardian equivalence, given my assumption of lump-sum taxes (Barro (1974)): the short-run tax reduction would be matched by future tax increases, leaving their present discounted value unchanged, and the household's intertemporal budget constraint unaffected. See the Appendix for a formal derivation. Since no

that in the latter case, the equilibrium price level is the solution to the difference equation

$$p_t = \frac{\eta}{1+\eta} p_{t+1} + \frac{1}{1+\eta} m_t + u_t \tag{28}$$

While $u_t \equiv (1+\eta)^{-1}(\eta \widehat{r}_t - \widehat{c}_t - l)$ is independent of the financing method in that particular case, this is not true for m_t, and hence for the price level.

[17] Nonseparability of real balances ($\upsilon \neq 0$) also breaks the irrelevance proposition, even when prices are fully flexible. In the latter case (27) holds, and the fact that different financing methods will have different effects on the path of money, inflation and nominal interest rates implies that real balances (given (22)) and, hence, output (given (27)) will also be affected by how the fiscal stimulus is financed. As discussed in Woodford (2003) and Galí (2015), among others, the non-neutralities that rely exclusively on nonseparable real balances tend to be quantitatively small and to have counterfactual implications.

[18] As discussed above, in the present section the ZLB constraint has been ignored in solving for the equilibrium responses.

other equilibrium condition is affected by the tax cut and the increase in government debt (see (17)-(23)), all variables (other than $\widehat{t}_t$ and $\widehat{b}_t$), both nominal and real, remain unchanged in response to the debt-financed tax cut. Since output and consumption are not altered, neither is inflation. The central bank does not have to adjust the interest rate or the money supply in order to stabilize inflation.[19]

By way of contrast, when the tax cut is financed by money creation it has a substantial expansionary effect on the level of economic activity, as reflected in the persistent rise in output displayed in Figure 1 (see red lines with circles). That increase is driven by the rise in consumption resulting from lower real interest rates. Output rises by about half a percentage point on impact. Inflation also rises, with the response of the year-on-year rate reaching a peak of about 0.4 percentage points four quarters after the start of the intervention. Note that by construction real debt remains unchanged under money financing, while the debt-output ratio declines somewhat due to the increase in output. Interestingly, while the money supply increases in the short run as a result of the policy intervention, it decreases later during the adjustment process, in order to offset the reduction in real rates, given the assumed rule that seeks to stabilize real debt.

Why doesn't Ricardian equivalence apply to the money-financed tax cut? As shown formally in the Appendix, to the extent that the policy intervention raises the discounted sum of real seignorage and current prices do not jump to offset that increase (due to the assumed price stickiness), current tax cuts will be perceived as net worth by each individual household, inducing and increase in its consumption, given output, prices and interest rates (which the household takes as given). The resulting increase in aggregate consumption, combined with the assumed stickiness of prices, will then trigger several general equilibrium effects, including an increase in output, inflation and interest rates, as shown in Figure 1. The household's perceived increase in net worth that triggered such equilibrium response will prove correct ex-post, thus justifying the initial increase in consumption.

There is a sense in which the previous non-neutrality result should not be surprising: it is a variation on a policy intervention often analyzed in the literature, namely, an increase in the money supply in an environment in which monetary policy is not neutral due to the presence of sticky prices.[20] The money financing rule assumed here implies a specific path for the money supply, given by (10), shaped by the objective to keeping real debt unchanged in the face of a tax cut and the induced

[19] This result does not hinge on the assumption of strict inflation targeting. In fact, it is independent of the exact monetary policy rule, as long as the latter doesn't respond to taxes or the debt ratio themselves.

[20] See, e.g. Galí (2015, chapter3).

changes in interest rates.

5.2 A Money-Financed Increase in Government Purchases

Figure 2 displays the dynamic response of the same set of macroeconomic variables to an exogenous increase in government purchases, under the baseline calibration and ignoring the ZLB constraint. Again, the red lines with circles display the responses under the money financing (MF) scheme, while the blue lines with diamonds show the response under debt financing (DF).

Under debt financing, the expansionary effects of government purchases are strongly subdued, as reflected in the tiny increase in output resulting from the policy intervention. In fact, equation (27) provides an analytical expression for the size of the output response in this case since the equilibrium under strict inflation targeting is equivalent to that under flexible prices. Note that the multiplier is always smaller than one, since consumption unambiguously goes down as a result of higher real interest rates. Debt and, as a result, taxes increase moderately, returning to their initial value only asymptotically.

Under money financing, by contrast, the expansionary effects on output are much larger, with the multiplier remaining above unity throughout the adjustment. The key difference is that consumption now increases due to the decline in real rates brought about by the increase in liquidity. The expansion in output and consumption, with the consequent increase in real wages (not shown) leads to a frontloaded increase in inflation, which reinforces the expansion in aggregate demand by lowering the real rate.

Figure 3 provides a comparison of the effects of an increase in government purchases to those resulting from a tax cut, both under money financing. Most noticeably, the rise of output (and inflation) is seen to be larger in the case of an increase in spending, but the opposite is true for consumption.

The above finding of a small government spending multiplier on output under tax or debt financing and an inflation targeting central bank is well known from the literature on fiscal policy in the New Keynesian model.[21] As Woodford (2011) emphasizes, the property of a small multiplier is not an inherent one, but hinges critically on the nature of the monetary policy response to the increase in government purchases. Under the money financing scheme, monetary policy provides ample

[21] See Ramey (2011) for a survey of that literature. See also the discussion in Galí et al. (2007), who introduce hand-to-mouth consumers in an otherwise standard New Keynesian model in order to boost the spending multiplier.

accommodation to the fiscal expansion, reinforcing the latter's effects on output through a reduction in real interest rates.

5.3 Welfare

Next I analyze the welfare effects of the fiscal interventions discussed above, restricting myself to first order changes. Up to a first order approximation, the change in household utility is given by

$$
\begin{aligned}
\widehat{\mathcal{U}}_t &= U_c C \widehat{c}_t + U_l L \widehat{l}_t - V_n N \widehat{n}_t \\
&= U_c C \left[\widehat{c}_t - \left(\frac{1-\alpha}{\mathcal{M}} \right) \widehat{n}_t + \varkappa (1-\beta) \widehat{l}_t \right] \\
&= U_c C \left[\left(1 - \frac{1}{\mathcal{M}} \right) \widehat{y}_t - \widehat{g}_t + \varkappa (1-\beta) \widehat{l}_t \right]
\end{aligned}
$$

for $t = 0, 1, 2, ...$ where $\mathcal{M} \equiv \mathcal{M}_p \mathcal{M}_w$ is the "composite" markup, and where I have made use of the fact that in the steady state $(1-\alpha)(Y_t/N_t) = \mathcal{M}(V_{n,t}/U_{c,t})$. Note that the presence of market power in goods and/or labor markets ($\mathcal{M} > 1$) makes the level of economic activity inefficiently low, by implying a marginal product of labor, $(1-\alpha)(Y_t/N_t)$, above the marginal rate of substitution, V_n/U_c. In that context, any policy that generates an increase a employment and output will raise utility, unless it diverts a sufficiently large fraction of the resulting increase in output away from consumption (e.g. towards government purchases), or it implies a sufficiently large decline in real balances.

Figure 4 shows the response of utility to a tax cut and to an increase in government purchases, under the two financing regimes, for the baseline calibration of the model above.

Note first that under a utility-based criterion there are no gains or losses from a debt-financed tax cut, since the latter is fully neutral (due to Ricardian equivalence, as discussed above). On the other hand, utility rises in response to a tax cut when the latter is financed by money creation. In that case, and due to an inefficiently low initial level of activity, the gains from the implied increase in consumption more than offset the disutility from higher employment, and are enhanced by higher real balances (though the latter has a tiny effect quantitatively in all the experiments considered).

On the other hand, and as shown on the right hand panel of Figure 4, an increase in government purchases generates utility losses independently of the financing method used. In the case of a debt-financed stimulus this is unambiguous since the decline in consumption and real balances, together with the increase in employment, they all contribute to a loss in utility. In the case of a money-financed increase in government purchases, the loss in utility is smaller, largely due to the increase in consumption enjoyed by households in this case.

More generally, one cannot rule out the possibility that a money-financed increase in government purchases raises utility, even under the assumption of purely wasteful government purchases. Ignoring the utility effect of real balances (typically small, quantitatively), this will be the case if the following condition is satisfied:

$$\left(1-\frac{1}{\mathcal{M}}\right)\frac{\Delta\widehat{y}_t}{\Delta\widehat{g}_t}>1$$

i.e. if the government spending multiplier is sufficiently greater than unity ($\Delta\widehat{y}_t/\Delta\widehat{g}_t >> 1$), and/or the initial level of activity is sufficiently inefficient ($\mathcal{M} >> 1$), though this is not the case under the baseline calibration considered here.

5.4 Sensitivity Analysis

Next I briefly discuss the sensitivity of some of the qualitative findings above regarding the effectiveness of fiscal policy. I focus on two parameters, those measuring the degree of price stickiness and the persistence of the shock. I use the cumulative output multiplier, $(1-\delta)\sum_{t=0}^{\infty}\widehat{y}_t$, as a measure of the effectiveness of the policy intervention.

Figure 5a displays the cumulative output multipliers for a tax cut and an increase in government purchases as a function of θ, the index of price stickiness. The big dots correspond to the baseline calibration. Three observations are worth making. Firstly, the multipliers are invariant to θ in the case of a debt-financed fiscal stimulus, but strongly increasing in the case of a money-financed stimulus, both for a tax cut and an increase in government purchases.[22] Secondly, the size of the multiplier for a money-financed stimulus remains above that for a debt-financed stimulus and converges to it only as prices become fully flexible. And thirdly, the size of the multiplier for a money-financed increase in government purchases is larger than that of an equally-sized money-financed tax cut, for any given degree of price stickiness.

Figure 5b displays identical multipliers as a function of δ, the parameter indexing the persistence of the shock. Again, the output multiplier is independent of δ in the case of a debt-financed stimulus. In the case of a money-financed tax cut the

[22] In the case of government purchases, the finding of "full" invariance is due to the assumption of strict inflation targeting. In the presence of a more flexible rule, the multiplier would be increasing in the degree of price stickiness.

relationship appears to be non-monotonic: the multiplier is increasing for values of δ below 0.8, but decreasing for larger values of that parameter. In the case of an increase in government purchases, the multiplier also decreases with the persistence of the shock, particularly so at high values of δ. Most importantly, however, the Figure confirms the robustness to changes in the degree of shock persistence of two of the findings above: that money-financed fiscal stimuli are more effective than their debt-financed counterparts, and that the output multipliers for a money-financed increase in government purchases are larger than that of a money-financed tax cut. The robustness of the previous findings extents to alternative calibrations of other parameters, including the money demand semi-elasticity η or the size of the steady state debt ratio b (results not shown).

6 The Effects of a Money-Financed Fiscal Stimulus in a Liquidity Trap

In this section I explore the effectiveness of a money-financed fiscal stimulus in stabilizing the economy in the face of an adverse demand shock. The shock is assumed to be large enough to prevent the central bank from fully stabilizing output and inflation, due to the ZLB constraint on the nominal rate. Note that under the notation introduced above the latter constraint takes the form $\widehat{i}_t \geq \log \beta$ for all t.

In particular, the baseline experiment assumes that $\widehat{\rho}_t = -\gamma < \log \beta$ for $t = 0, 1, 2, ...T$ and $\widehat{\rho}_t = 0$ for $t = T+1, .T+2, ..$ i.e. a temporary adverse demand shock is assumed that brings the natural rate into negative territory. The shock is assumed to be fully unanticipated and, once it is realized, the trajectory of $\{\widehat{\rho}_t\}$ and the corresponding policy responses are known with certainty.

The ZLB constraint can be incorporated formally in the set of equilibrium conditions above by replacing (22) with

$$(\widehat{i}_t - \log \beta)(\widehat{l}_t - \widehat{c}_t + \eta \widehat{i}_t) = 0 \tag{29}$$

for all t, where

$$\widehat{i}_t \geq \log \beta \tag{30}$$

is the ZLB constraint and

$$\widehat{l}_t \geq \widehat{c}_t + \eta \widehat{i}_t \tag{31}$$

represents the demand for real balances.

In addition, in the case of debt financing, condition (26) must be replaced with:

$$(\widehat{i}_t - \log \beta)\pi_t = 0 \tag{32}$$

for all t, which guarantees that the zero inflation target is met as long as the ZLB constraint is not binding.

Next I analyze several scenarios, each defined by a specific combination of monetary and fiscal policy responses to the demand shock described above. I assume $\gamma = -0.01$ and $T = 5$. Thus, and given $\beta = 0.995$, the experiment considered corresponds to a natural interest rate dropping to -2% for six quarters, and reverting back to an initial value of $+2\%$ after that (both in annualized terms).

I start by considering the *benchmark* case of *no fiscal response* to the shock ($\widehat{g}_t = \widehat{t}_t^* = 0$, for $t = 0, 1, 2, ...$) with the central bank implementing the optimal discretionary policy subject to the ZLB constraint. As discussed in Galí (2015, chapter 5), that policy has the central bank lowering the nominal rate to zero for the duration of the shock (i.e. up to T), while reverting back to a simple inflation stabilizing rule.[23] Formally,

$$\widehat{i}_t = \max(\log \beta, \widehat{\rho}_t + \phi_\pi \pi_t) \tag{33}$$

where $\phi_\pi > 1$.

The solid black line (with crosses) in Figure 6 shows the economy's response to the adverse demand shock in the absence of a fiscal response. The ZLB constraint prevents the central bank from lowering the nominal rate to match the decline in the natural rate. As a result, the adverse demand shock triggers a significant drop in output and inflation during its duration. Note also that real debt increases considerably due to the rise in real interest rates. Once the natural rate returns to its usual value, inflation and the output gap are immediately stabilized at their zero target value, given the policy rule (33), with debt gradually returning to its initial value through the (endogenous) increase in taxes.

The blue line (with diamonds) and red line (with circles) shows the corresponding effects when the fiscal authority responds to the adverse demand shock by cutting taxes, and financing the resulting deficit through debt issuance or money creation, respectively. In either case the size of the tax cut is 1 percent of steady state output, and lasts for the duration of the shock. In the case of a debt financed tax cut we see once again Ricardian equivalence at work, with no effects on any variable (other than taxes and debt themselves) relative to the case of no fiscal response.[24] By contrast,

[23] The central bank could attain a better outcome under an optimal policy with commitment. See, e.g. Eggertsson and Woodford (2003), Jung et al. (2005), and Galí (2015). My goal here is to characterize the effect of different fiscal interventions. The case of optimal discretionary monetary policy in the absence of fiscal response is just a useful benchmark with respect to which I measure the effectiveness of different fiscal interventions.

[24] Formally, we can see this by noting that no equilibrium condition other than (24) is affected by

when the tax cut is financed by money creation the impact on output and inflation is substantial, with the decline in those variables more than halved relative to the case of no fiscal response, despite the moderate size of the tax cut. The key factor behind the high effectiveness of the money-financed tax cut lies in the persistently lower real interest rates it generates. That decline in real rates is, in turn, brought about through two mechanisms: a persistently lower nominal rate once the adverse shock is gone, and higher expected inflation, both resulting from the permanent increase in liquidity injected into the system in order to finance the tax cut. Note that the previous mechanism is reminiscent of forward guidance policies that promise to keep interest rates low once the adverse shock is gone (see, e.g. Eggertsson and Woodford (2013)). From that perspective, the money financing rule can be interpreted as a way of "formalizing" the commitment to keep interest rates low.

Figure 7 shows the corresponding effects when the fiscal authority increases government purchases by 1 per cent of steady state output in response to the adverse shock. Again, the black line with crosses displays the effects of the shock in the absence of a fiscal response. In contrast with the tax cut case, we see that a debt-financed increase in government purchases, whose effects are represented by the blue line (with diamonds), is very effective at dampening the negative effects of the natural rate shock on output and inflation. That finding is consistent with the conclusions of Christiano et al (2011) and Eggertsson (2011), which point to the existence of very large government spending multipliers when the ZLB is binding. The main reason for the high effectiveness of government purchases in a liquidity trap (relative to normal times) lies in the absence of a dampening response of monetary policy, in the form of higher real rates required to stabilize inflation. Note also that when the increase in government purchases (of the same size) is money-financed (see red line with circles) its impact on output and inflation is only slightly larger than under the debt-financed case, a finding which contrasts with the results obtained under "normal times." (recall Figure 2). The greater effectiveness of money-financing in this case can be traced to the slightly lower nominal rate path it induces, once the adverse shock is gone, due to the accumulated liquidity.

Finally, Figure 8 compares the effects of a money-financed increase in government purchases to those of a money-financed tax cut, with the case of no fiscal response also shown as a benchmark. Interestingly, the difference between the two are much smaller than under "normal times," with the effects of an increase in government purchases on output being only marginally larger than those of a tax cut, with the larger direct effect on aggregate demand in the case of an increase in government

the tax cut and the resulting increase in government debt. This remains true when (29) and (32) replace (22) and (32), as it is the case in a liquidity trap.

purchases being largely offset by the larger decline in consumption.

Figure 9a displays the (first-order) effects on utility of the adverse natural rate shock, under the baseline calibration, with and without a fiscal response and, under the two financing regimes. Note that, relative to the cases of no fiscal response or of a debt-financed tax cut (which lead to identical large utility losses), a money-financed tax cut of 1 percent of output limits substantially the utility losses from the shock. The welfare effects are much less favorable when the fiscal authority raises instead government purchases (by the same size), with utility remaining persistently below that in the case of no fiscal response after two quarters, independently of the financing method used.

Figure 9b illustrates the important role played by the size of the initial distortions in determining the welfare gains from alternative policies, by showing the utility effects of the same interventions analyzed in Figure 9a, under the "large distortion" calibration introduced above. Most significantly, the large inefficiency in the initial allocation and the resulting large losses resulting from the adverse demand shock in the absence of a fiscal response, makes it desirable from a welfare viewpoint to boost economic activity by increasing government purchases, even if the latter are entirely *wasteful*, as assumed here. This is true independently of the financing mechanism, though utility losses appear to be smaller when the stimulus is financed through money creation.

7 Concluding remarks

In the present paper I have analyzed the effects of a fiscal stimulus financed through money creation, and compared them with those resulting from a conventional debt-financed stimulus, with and without a binding zero lower bound on the nominal interest rate.

A number of results from that analysis are worth stressing. First and foremost, a fiscal stimulus, in the form of a tax cut or an increase in government purchases financed through money creation provides a way to boost economic activity effectively, as long as prices are reasonably sticky. Such a policy has no major adverse side effects, other than a temporary mild rise in inflation. In particular, it can be designed such that debt and taxes do not need to rise, either in the short run or the long run. Furthermore, such money-financed fiscal stimuli appears to be more effective than their debt-financed counterpart, and has better welfare properties.

Secondly, a money-financed increase in government purchases has a larger output multiplier than a money-financed tax cut, but the latter has better welfare properties.

Thirdly, money-financed tax cuts also appear to be more effective countercyclical policies than their debt-financed counterparts when the ZLB is binding, though in that environment the financing regime is not so important in the case of an increase in government purchases.

Finally, when the economy's initial distortions are large, an increase in government purchases in response to an adverse shock to the natural rate may be welfare enhancing, even if involves purely wasteful government spending. The desirability of such a stimulus is greater if financed with money creation.

The money-financed fiscal stimuli analyzed in the present paper are likely to be considered illegal in many jurisdictions. In particular, the fact that monetary policy is (at least temporarily) driven by the requirements of the fiscal authority may be perceived as an outright violation of the principle of central bank independence.[25] Legal issues aside, it is clear that a *recurrent* use of such policies would likely be a source of an inflation bias and may bring about changes in individual behavior likely to undermine their effectiveness (e.g. indexation or greater price flexibility). Those considerations notwithstanding, the possibility of a fiscal stimulus financed through money creation remains a powerful tool that policymakers may resort to in an emergency, when all other options have failed.

[25] Though this would arguably not be the case if the intervention was designed and called for by the central bank itself...

APPENDIX

Recall the household's period budget constraint:

$$P_t C_t + M_t + B_t = B_{t-1}(1 + i_{t-1}) + M_{t-1} + W_t N_t + D_t - P_t T_t \tag{34}$$

Letting $Y_t \equiv (W_t N_t + D_t)/P_t$ denote real income, and defining $\mathcal{A}_t \equiv (B_{t-1}(1 + i_{t-1}) + M_{t-1})/P_t$, the previous constraint can be written as:

$$C_t + \frac{i_t}{1+i_t} L_t + \frac{1}{\mathcal{R}_t} \mathcal{A}_{t+1} = \mathcal{A}_t + Y_t - T_t \tag{35}$$

Solving (35) forward from period zero onward and using the transversality condition $\lim_{T\to\infty} \Lambda_{0,T} \mathcal{A}_T = 0$ yields

$$\sum_{t=0}^{\infty} \Lambda_{0,t} \left(C_t + \frac{i_t}{1+i_t} L_t \right) = \mathcal{A}_0 + \sum_{t=0}^{\infty} \Lambda_{0,t} \left(Y_t - T_t \right) \tag{36}$$

where $\Lambda_{0,t} \equiv \mathcal{R}_0^{-1} \mathcal{R}_1^{-1} ... \mathcal{R}_{t-1}^{-1}$.

On the other hand, solving the consolidated government budget constraint (4) forward from period 0 onwards yields:

$$\sum_{t=0}^{\infty} \Lambda_{0,t} G_t + \frac{B_{-1}(1+i_{-1})}{P_0} = \sum_{t=0}^{\infty} \Lambda_{0,t} \left(T_t + \frac{\Delta M_t}{P_t} \right) \tag{37}$$

where $\Lambda_{0,t} \equiv (\mathcal{R}_0 \mathcal{R}_1 ... \mathcal{R}_{t-1})^{-1}$ and where the transversality condition $\lim_{T\to\infty} \Lambda_{0,T} \mathcal{B}_T = 0$ has been imposed, as implied by $\lim_{T\to\infty} \Lambda_{0,T} \mathcal{A}_T = 0$ combined with the non-negativity constraint on money holdings.

Combining (37) and (36), we obtain:

$$\sum_{t=0}^{\infty} \Lambda_{0,t} \left(C_t + \frac{i_t}{1+i_t} L_t \right) = \frac{M_{-1}}{P_0} + \sum_{t=0}^{\infty} \Lambda_{0,t} \left(Y_t - G_t + \frac{\Delta M_t}{P_t} \right) \tag{38}$$

Note that each individual household takes as given the path of $\Lambda_{0,t}$, Y_t, G_t, M_t, i_t and P_t, while choosing C_t and L_t for $t = 0, 1, 2, ...$[26] Equation (38) makes clear that a

[26] In equilibrium, $C_t = Y_t$ and

$$\begin{aligned}
\frac{M_{-1}}{P_0} + \sum_{t=0}^{\infty} \Lambda_{0,t} \frac{\Delta M_t}{P_t} &= \sum_{t=0}^{\infty} \left(\Lambda_{0,t} - \Lambda_{0,t+1} \frac{P_t}{P_{t+1}} \right) \frac{M_t}{P_t} \\
&= \sum_{t=0}^{\infty} \Lambda_{0,t} \left(1 - \mathcal{R}_t^{-1} \frac{P_t}{P_{t+1}} \right) \frac{M_t}{P_t} \\
&= \sum_{t=0}^{\infty} \Lambda_{0,t} \left(\frac{i_t}{1+i_t} \right) \frac{M_t}{P_t}
\end{aligned}$$

tax reduction financed by the issuance of debt will be matched by future tax increases, leaving their present discounted value unchanged, and the household's intertemporal budget constraint unaffected. As a result, there is no change in consumption or money demand, with no change in $\Lambda_{0,t}$, Y_t, M_t, i_t or P_t being required to satisfy any equilibrium condition, only the path of taxes and debt.

On the other hand, when the tax cut is financed through money creation, with the consequent increase in the discounted sum of seignorage, $\sum_{t=0}^{\infty} \Lambda_{0,t}(\Delta M_t/P_t)$, that policy intervention is perceived as net worth by each individual household, inducing and increase in its consumption, given output, prices and interest rates (which it takes as given). The resulting increase in aggregate consumption, combined with the assumed stickiness of prices, will then trigger a variety of general equilibrium effects, including an increase in output, inflation and interest rates.

To further illustrate the channel through which the money financed tax cut end up raising consumption, assume for simplicity $U(C, L) \equiv \log C + \chi \log L$. In that case money demand satisfies $\chi C_t = \frac{i_t}{1+i_t} L_t$ and we can rewrite (38) as

$$\sum_{t=0}^{\infty} \Lambda_{0,t} C_t = \frac{1}{1+\chi} \left(\frac{M_{-1}^H}{P_0} + \sum_{t=0}^{\infty} \Lambda_{0,t} \left(Y_t - G_t + \frac{\Delta M_t}{P_t} \right) \right)$$

Furthermore, and ignoring preference shocks, the household's Euler equation implies $\Lambda_{0,t} = \beta^t (C_0/C_t)$ for $t = 0, 1, 2, ...$thus yielding the consumption function:

$$C_0 = \frac{1-\beta}{\chi} \left(\frac{M_{-1}}{P_0} + \sum_{t=0}^{\infty} \Lambda_{0,t} \left(Y_t - G_t + \frac{\Delta M_t}{P_t} \right) \right)$$

which makes clear how an increase in current and future seignorage $\{\Delta M_t/P_t\}$ that is not fully offset by an increase in the current price level, P_0, expands the individual household's perceived resources, leading to an increase in current consumption, given the path of output, prices, interest rates, and government purchases. Given price stickiness the resulting increase in demand is reflected in an increase in output, which may further the initial increase in consumption.

That equality, however, will obtain ex-post. Ex-ante each household perceives an increase in its available resources (given by the right hand side of (38)), inducing an increase in consumption and real balances (given output, prices and interest rates).

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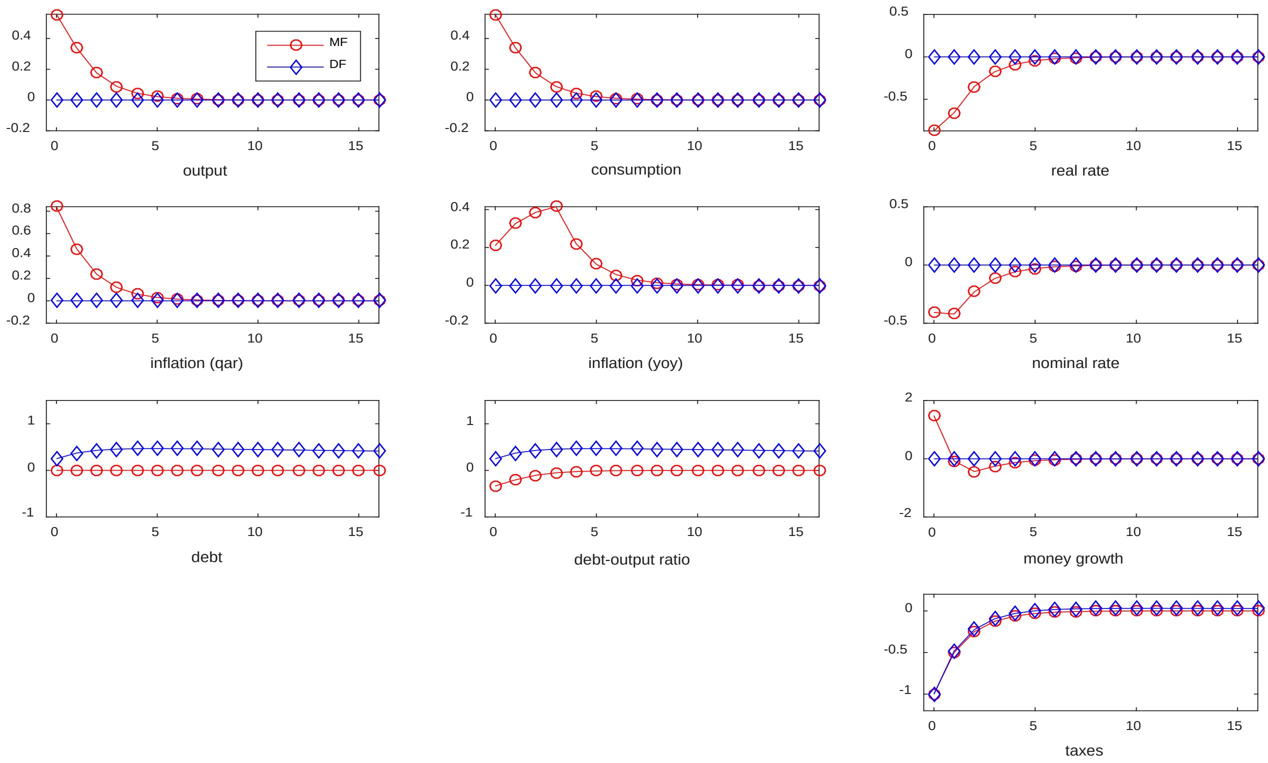

Figure 1. Dynamic Effects of a Tax Cut: Debt vs. Money Financing

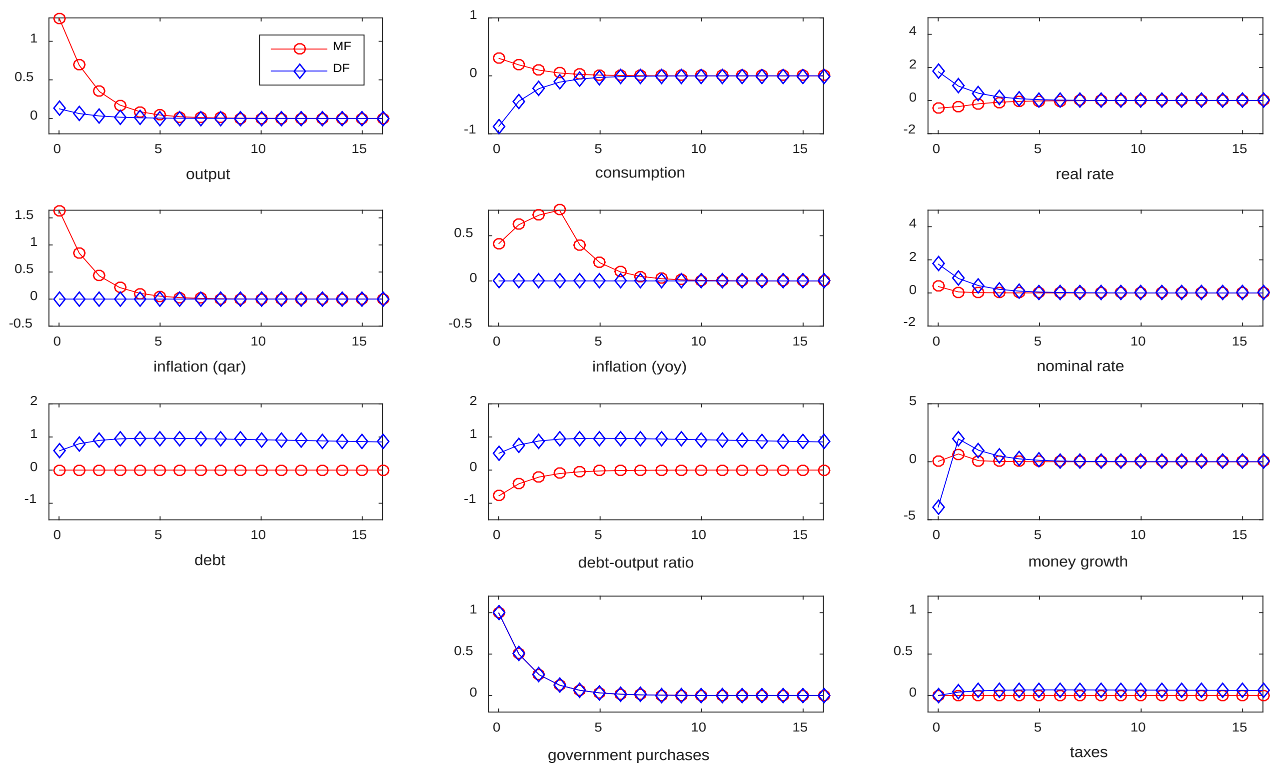

Figure 2. Dynamic Effects of an Increase in Government Purchases:
Debt vs. Money Financing

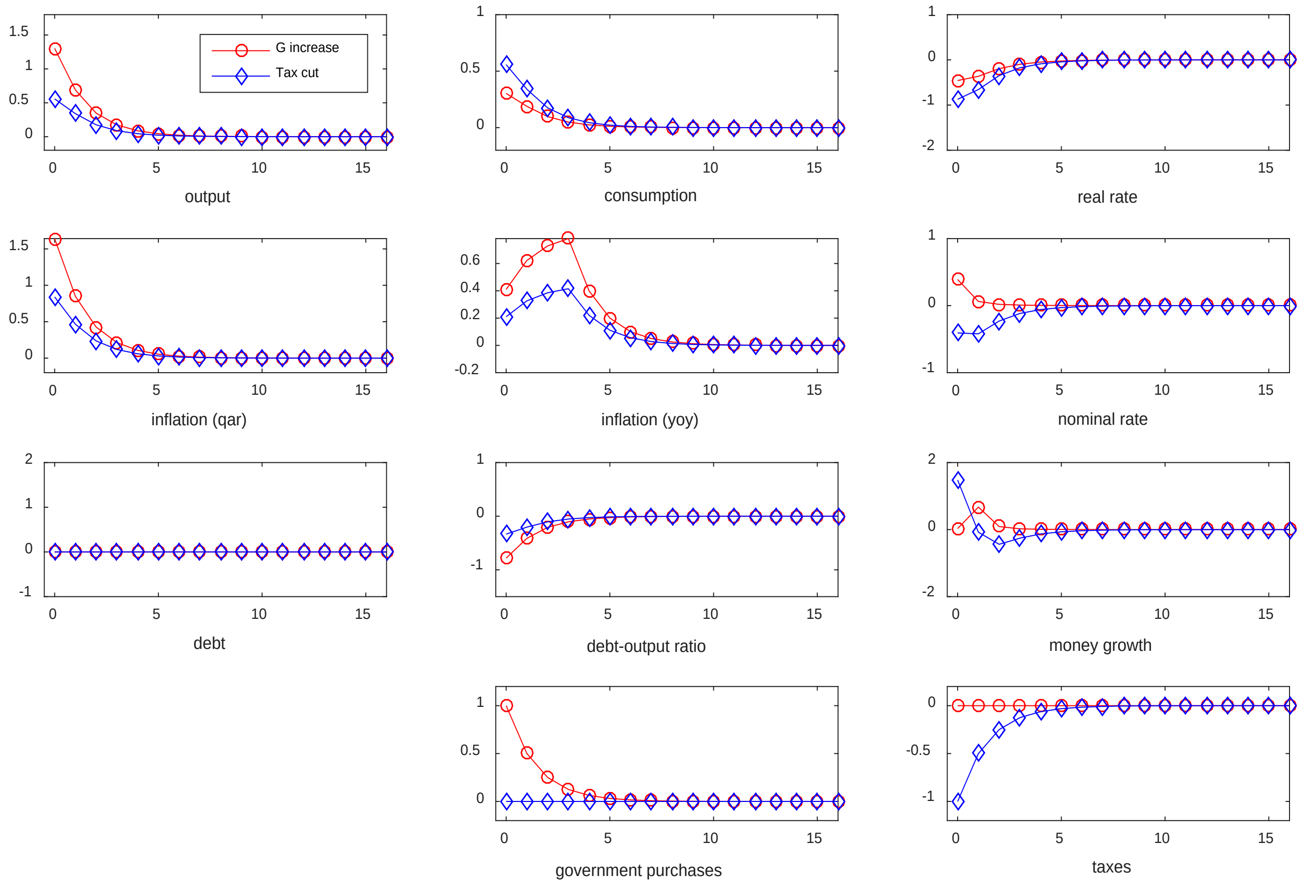

Figure 3. Dynamic Effects of Money-Financed Fiscal Stimuli:
Tax cut vs. Increase in Government Purchases

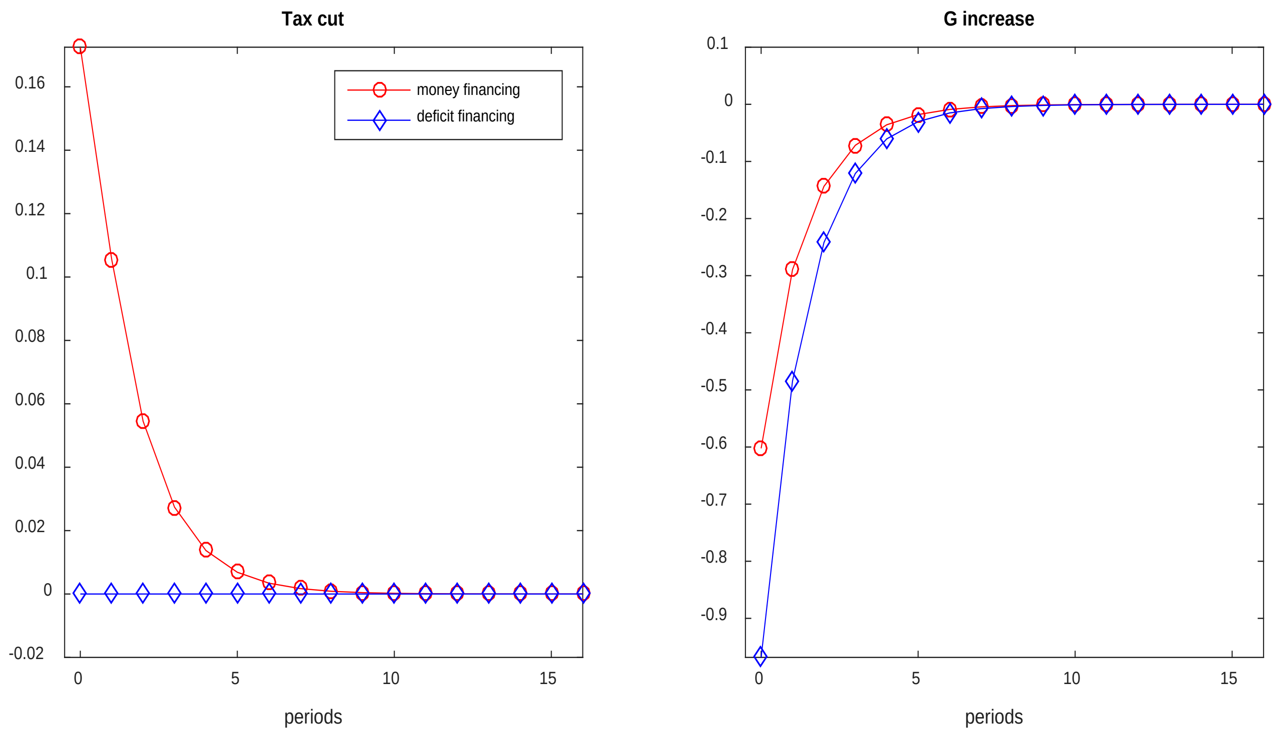

Figure 4. Welfare Effects

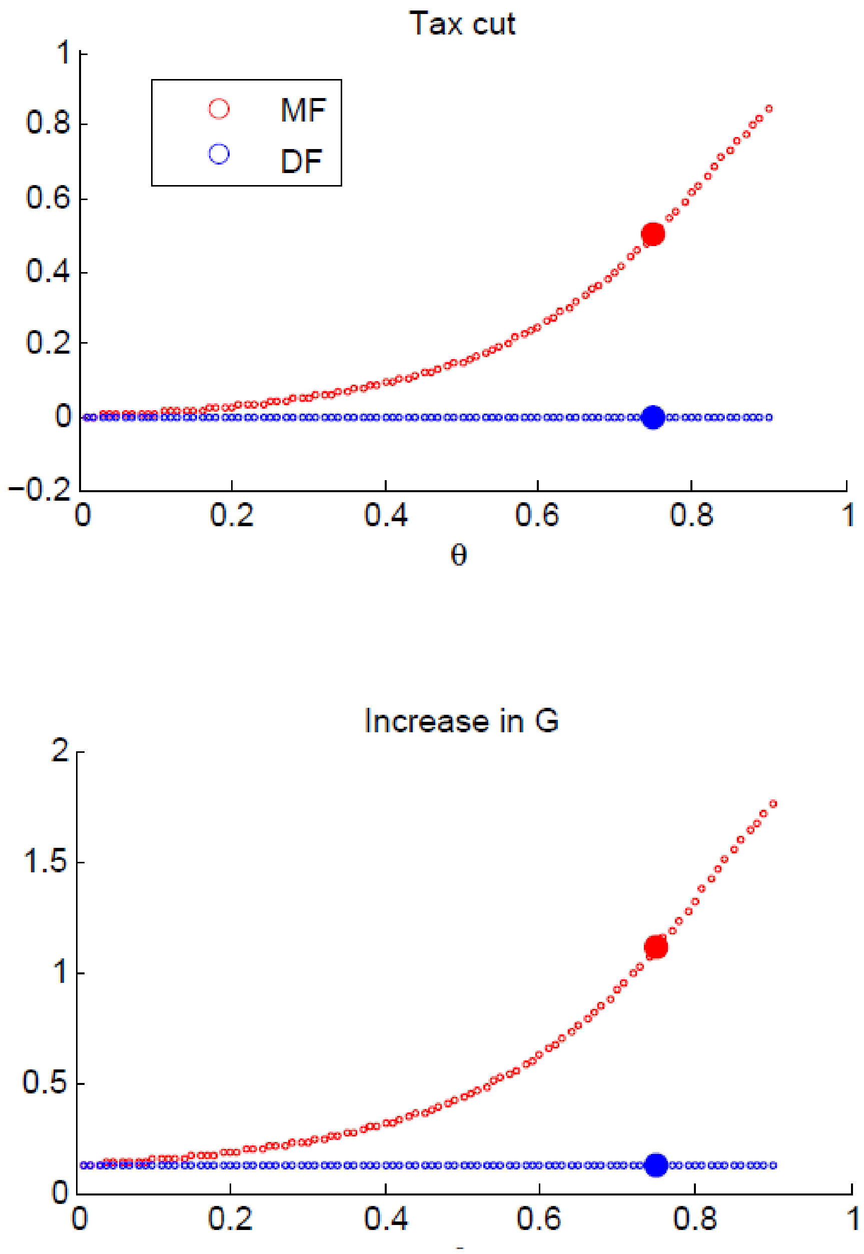

Figure 5a. Fiscal Multipliers: The Role of Price Stickiness

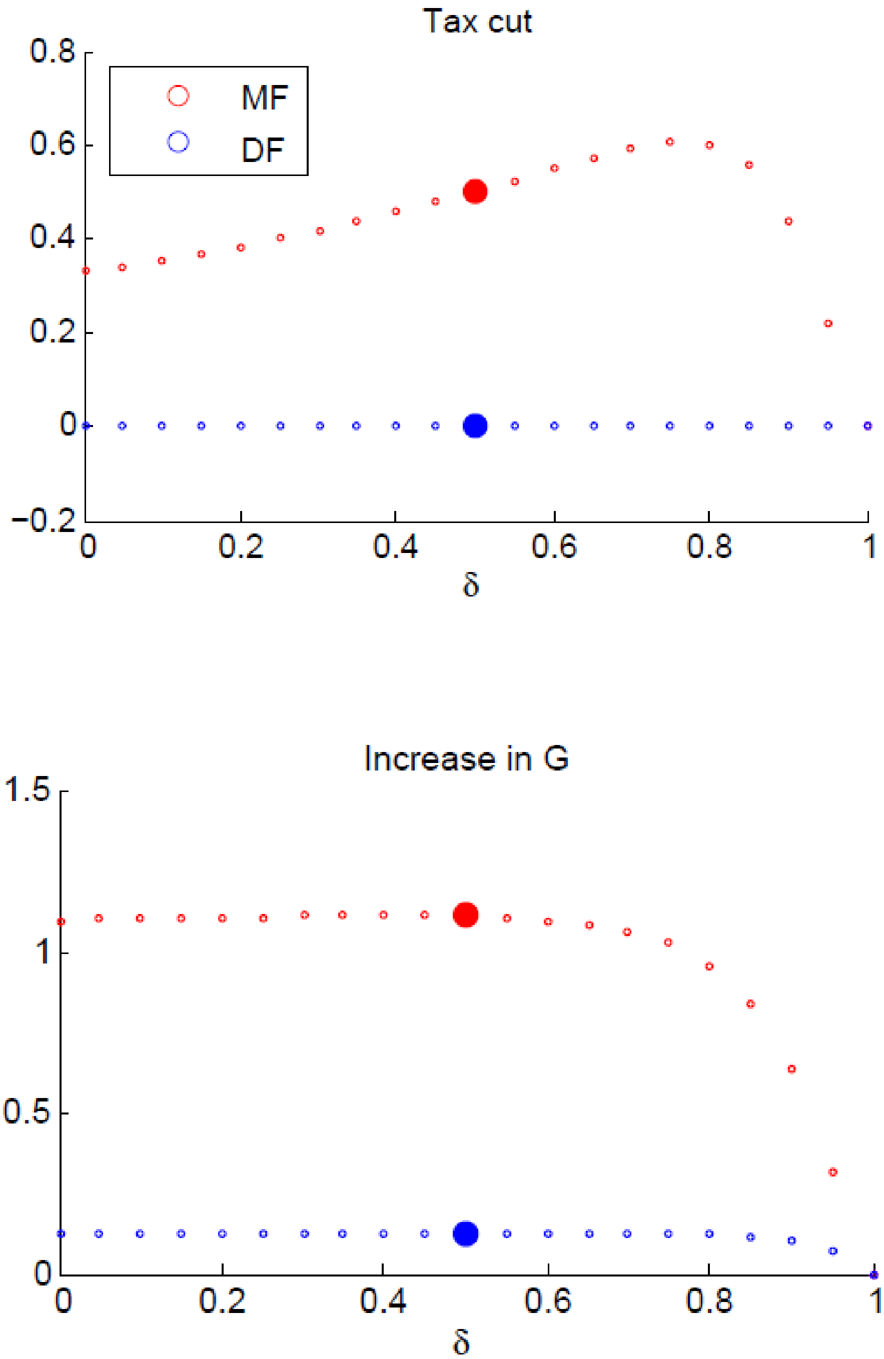

Figure 5b. Fiscal Multipliers: The Role of Shock Persistence

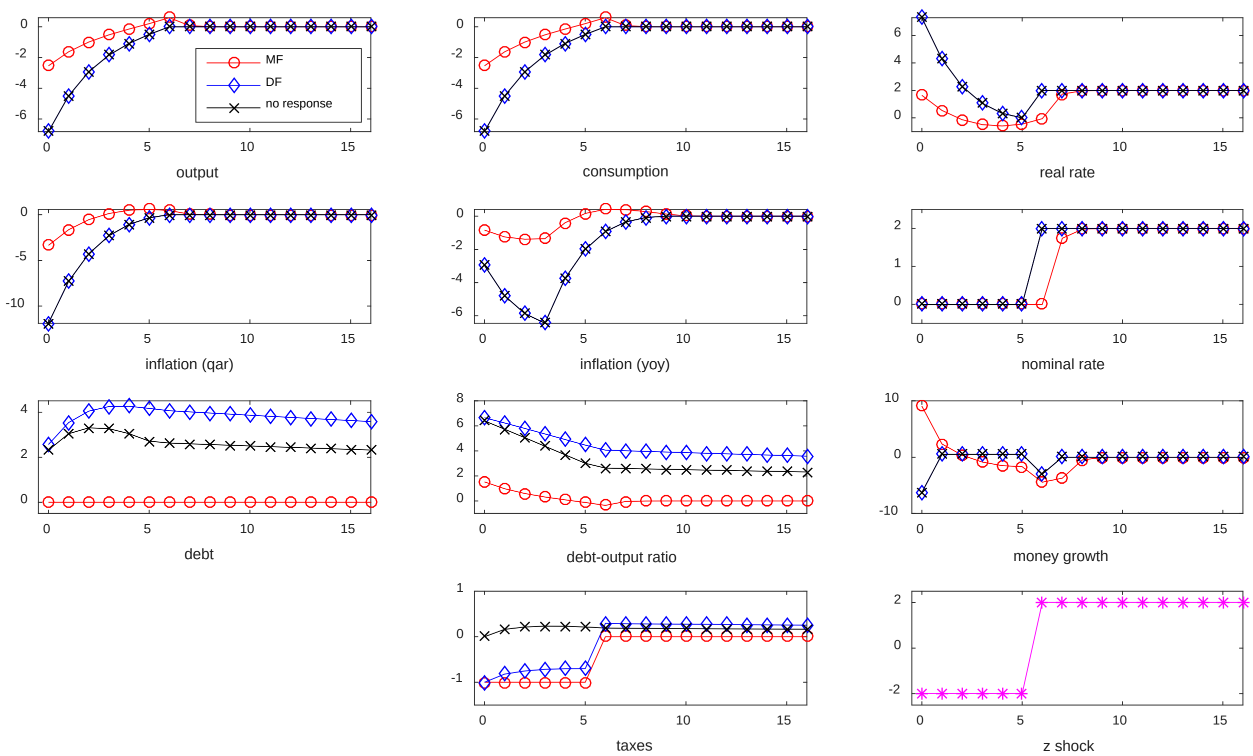

Figure 6. Dynamic Effects of a Tax Cut in a Liquidity Trap

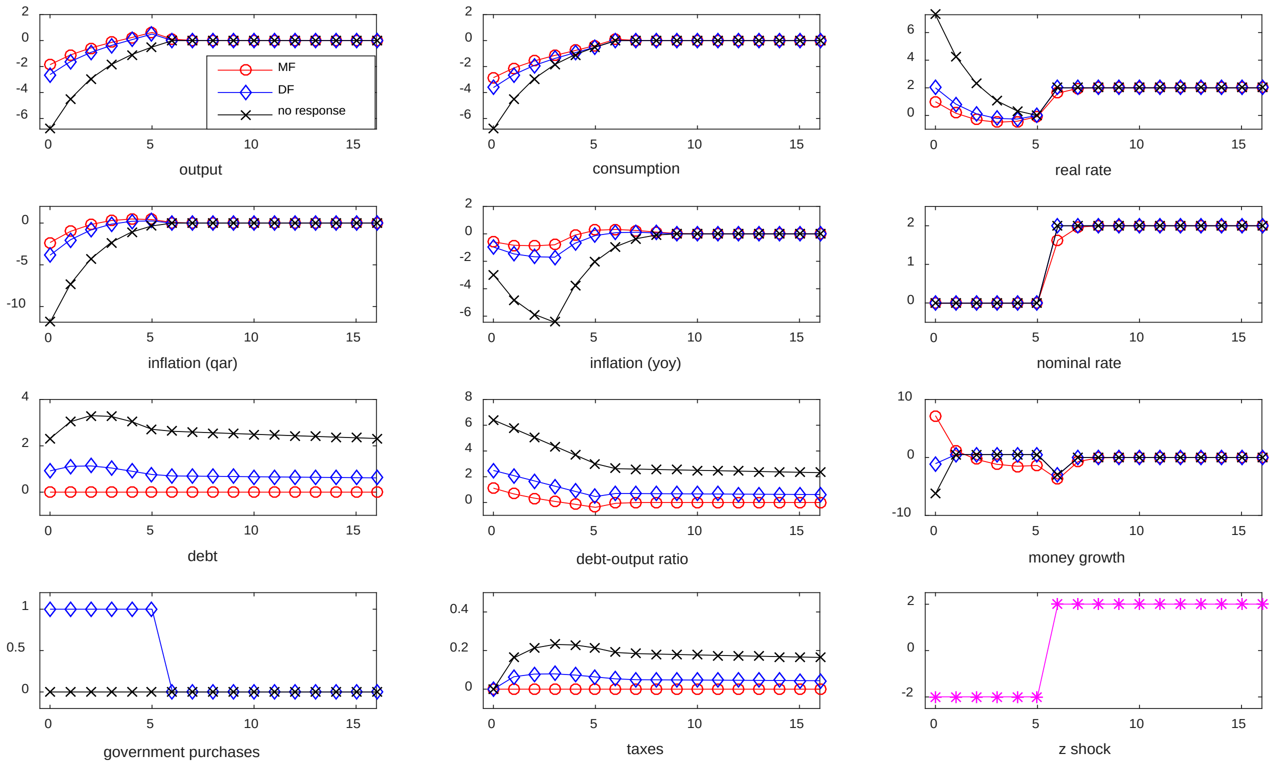

Figure 7. Dynamic Effects of an Increase in Government Purchases in a Liquidity Trap

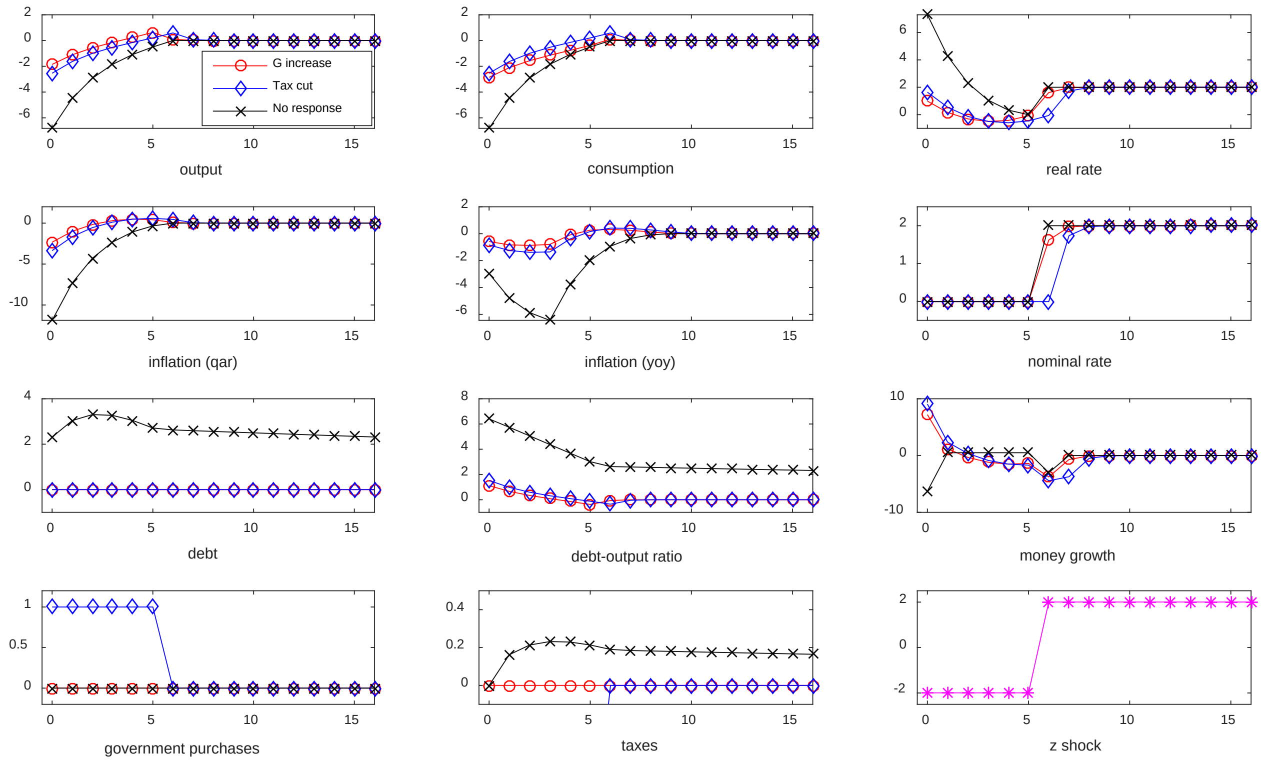

Figure 8. Dynamic Effects of Money-Financed Fiscal Stimuli in a Liquidity Trap

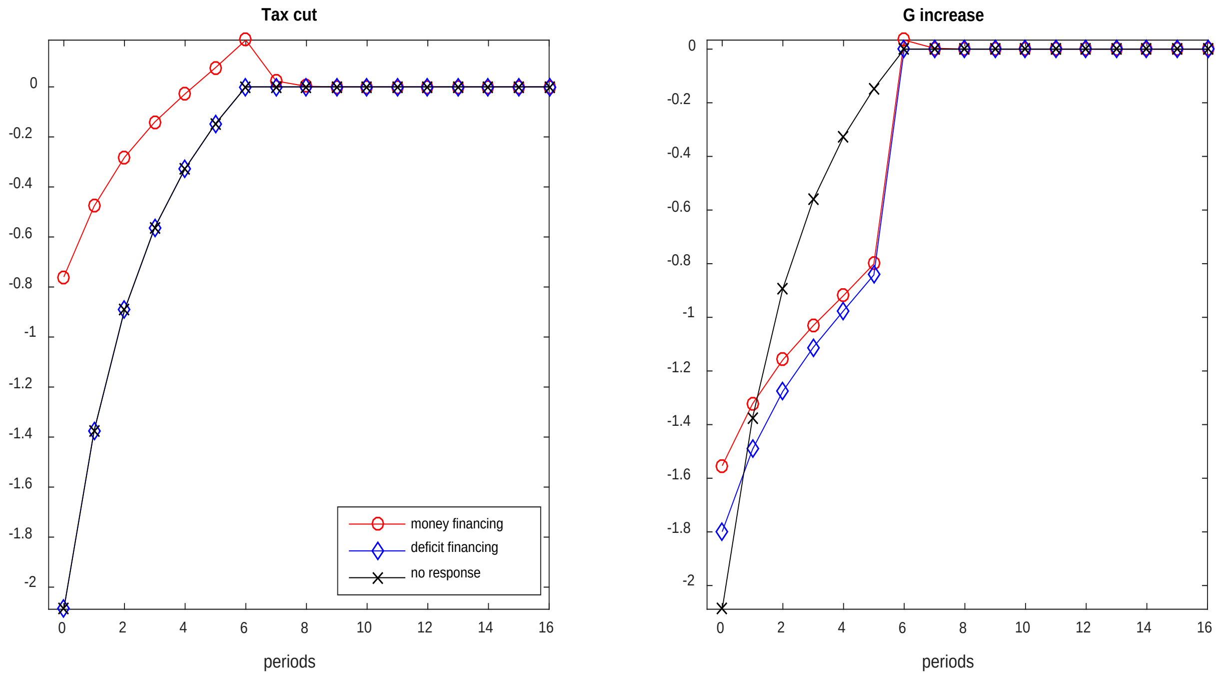

Figure 9a. Fiscal Stimuli and Welfare in a Liquidity Trap
The Case of Small Distortions

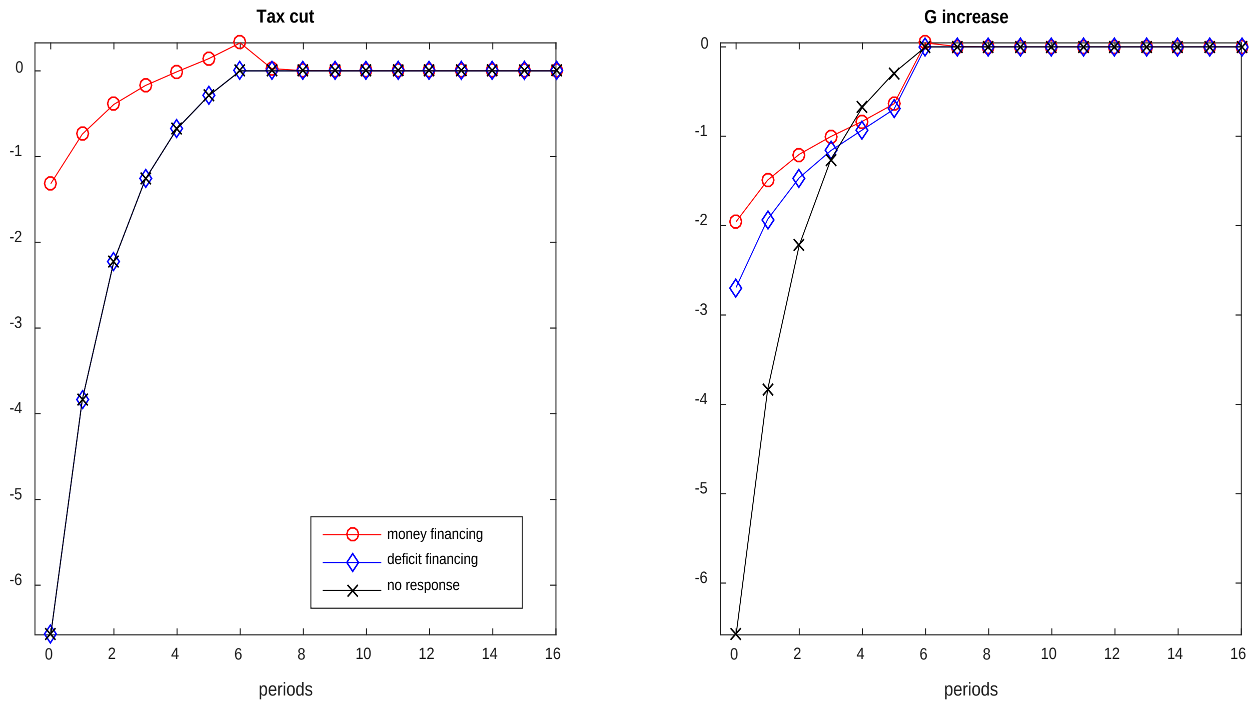

Figure 9b. Fiscal Stimuli and Welfare in a Liquidity Trap
The Case of Large Distortions