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Abstract

I analyze the effects of an increase in government purchases financed entirely through seignorage, in both a classical and a New Keynesian framework, and compare them with those resulting from a more conventional debt-financed stimulus. My findings point to the importance of nominal rigidities in shaping those effects. Under a realistic calibration of such rigidities, a money-financed fiscal stimulus is shown to have very strong effects on economic activity, with relatively mild inflationary consequences. If the steady state is sufficiently inefficient, an increase in government purchases may increase welfare even if such spending is wasteful.

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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 ammunition well before the economy had recovered. Policy rates hit the zero lower bound at a relatively early stage of the crisis, while large and rising debt-GDP ratios have forced widespread fiscal consolidations–still underway in many countries–that have 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, it is clear that such policies have failed to provide a sufficient boost to aggregate demand to bring output and employment back to their potential levels.

Against that background, there is a clear need to think of policies that help stimulate the recovery without relying on lower nominal interest rates (which are unfeasible) or further rises in the stock of government debt (which are viewed as undesirable, given the historically high–and growing– debt ratios, and the associated fears of triggering a debt crisis). The option of a fiscal stimulus in the form of a larger government spending financed through higher taxes is generally viewed as politically undesirable (given the high tax rates prevailing in many countries), as well as potentially ineffective (given the likely offsetting effects of higher taxes). On the other hand, 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.[1]

[1] See Galí (2013), Galí and Monacelli (2014) and Eggertsson, Ferrero and Raffo (2013),

In the present paper I analyze the effects of an alternative policy to revive the economy: a fiscal stimulus, in the form of a temporary increase in government purchases, *financed entirely through money creation*. In contrast with the unconventional monetary measures undertaken by the Fed and other central banks (e.g. quantitative easing), such a policy has a *direct effect on aggregate demand*, and hence on output and employment.[2] Thus, its success is not contingent on a hoped-for response of the private sector materializing. Furthermore, and as shown below, that intervention does not require a reduction in nominal interest rates, an increase in the stock of government debt and/or higher taxes, current or future.

Of course, the main concern about that policy, and the likely reason why it is seldom discussed as an option, lies in the fears of high inflation resulting from the associated monetary expansion.[3] Though the link between money supply and inflation in actual economies is likely to be more nuanced than is implied by a simplistic quantity-theoretical framework, the prediction that the cumulative increase in prices will *eventually* match the cumulative increase in the money supply is hard to avoid, on theory grounds.[4] Yet, the timing and overall pattern of price increases of a money-financed fiscal stimulus, as well as the latter's effect on economic activity, is likely to depend on a number of factors. The main goal of the present paper is to evaluate the likely effects, under a variety of assumptions, of a money-financed fiscal stimulus on output, inflation and other macro variables, and to shed light on the role played by different factors in shaping those effects and the associated tradeoffs.

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among others.

[2] Similarly, a "helicopter drop" that raised households' money holdings would not necessarily result in a higher aggregate demand if households chose not to spend that windfall. Buiter (2014) argues in the context of a rather general model of household optimization that a consumption boost is a robust prediction of a helicopter drop.

[3] There are exceptions. Buiter (2014) analyzes the impact of 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. Bernanke (2003) and Turner (2013) also discuss the potential virtues of monetary financing of fiscal deficits. Their analysis is not based, however, on a formal model. See also Reichlin, Turner and Woodford (2013) and Giavazzi and Tabellini (2014) for related discussions.

[4] This is so in the presence of a money demand function with conventional properties, and the assumption of no permanent effect of the temporary fiscal stimulus on economic activity, inflation and/or nominal rates.

With that objective in mind I develop and analyze two different models. The first one consists of a simple classical monetary framework, characterized by perfect competition and fully flexible prices and wages. The second model is a standard New Keynesian framework with monopolistic competition in goods and labor markets and staggered nominal wage and price setting. I also consider an extension of the latter allowing for a fraction of households that have no access to financial markets. I use plausible calibrations of both frameworks to analyze and compare the effects of an exogenous increase in government purchases under two alternative financing regimes: (i) monetary financing and (ii) debt financing, with the central bank's decisions bound by an interest rate rule in the latter case.

A key finding from my analysis lies in the importance of nominal rigidities in shaping the effects of a money-financed fiscal stimulus. In the presence of fully flexible prices and wages, such a fiscal intervention has a very small effect on economic activity, and a huge, heavily frontloaded impact on inflation. The effect on welfare is unambiguously negative. By contrast, in a model economy allowing for a realistic calibration of such rigidities, a money-financed fiscal stimulus has very strong effects on economic activity, with relatively mild inflationary consequences. The large multipliers implied by such an intervention contrast with the much smaller ones generally found in the literature, associated with a more conventional fiscal stimulus, financed by the issuance of debt, in an environment in which the central bank follows a simple inflation-based interest rate rule. Furthermore, if output is sufficiently below its efficient level, a money-financed fiscal stimulus may raise welfare even if based on purely wasteful government spending.

This paper is related to the large literature on the effects of government spending.[5] 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 zero lower bound on the nominal interest rate is binding (Christiano, Eichenbaum and Rebelo (2011), Eggertsson (2011)). The present paper shows that large multipliers also arise when the increase in government spending is financed through money creation, enven in the absence of non-Ricardian households or a binding zero lower bound constraint.

[5] See Ramey (2011) for a recent survey of that literature.

The remainder of the paper is organized as follows. Section 2 describes the fiscal and monetary framework used in the subsequent analysis, and discusses some basic analytics of money-financed government spending. Section 3 analyzes the effect of a money-financed fiscal stimulus in a classical model. Section 4 carries out an identical exercise using a New Keynesian model as a reference framework, including an extension which allows for a fraction of non-Ricardian households. Section 5 summarizes the main findings and concludes.

2 Fiscal and Monetary Policy Framework

In the present section I describe the fiscal and monetary policy framework that is common to the different model economies analyzed below. I start by introducing the budget constraints of the fiscal and monetary authorities, and then move on to describe formally the fiscal intervention that is the focus of my analysis.

2.1 Budget Constraints

The fiscal authority's period budget constraint is given by

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

where G_t and T_t denote government purchases and lump-sum taxes (both in real terms), B_t is the stock of one-period nominally riskless government debt issued in period t and yielding a nominal return i_t, and S_t^G denotes a real transfer from the central bank to the fiscal authority. Equivalently, and after letting $\mathcal{B}_t \equiv B_t/P_t$ and $\mathcal{R}_t = (1 + i_t)(P_t/P_{t+1})$ we can write:

$$G_t + \mathcal{B}_{t-1}\mathcal{R}_{t-1} = T_t + S_t^G + \mathcal{B}_t \tag{1}$$

The central bank's budget constraint is given by

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

where B_t^M denotes the central bank's holdings of government debt at the end of period t, and M_t is the quantity of money in circulation.[6] Equivalently, in

[6] The balance sheet of the central bank is given by

$$B_t^M = M_t + K_t^M$$

real terms

$$\mathcal{B}_t^M + S_t^G = \mathcal{B}_{t-1}^M \mathcal{R}_{t-1} + \Delta M_t/P_t \tag{2}$$

where $\mathcal{B}_t^M \equiv B_t^M/P_t$ and $\Delta M_t/P_t$ is the amount of seignorage generated in period t.

The amount of government debt held by households (expressed in real terms), and denoted by $\mathcal{B}_t^H \equiv B_t^H/P_t$, is given by

$$\mathcal{B}_t^H = \mathcal{B}_t - \mathcal{B}_t^M \tag{3}$$

In what follows I often refer to $\mathcal{B}_t^H$ as *net* government debt, for short. Combining (1), (2), and (3) one can derive the government's *consolidated* budget constraint

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

which may also be interpreted as a difference equation describing the evolution of net government debt over time.

Below I consider equilibria near a steady state with zero inflation, no trend growth, and constant net government debt $\mathcal{B}^H$, government purchases G, and taxes T.[7] On the other hand, constancy of real balances requires that $\Delta M = 0$ in that steady state. It follows from (4) that

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

where ρ is the household's time discount rate, which in the zero inflation steady state must equal the interest rate $i = \mathcal{R} - 1$ (as shown below). Note that (2) implies

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

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

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

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

[7] The constancy of the net government debt in the steady state implicitly assumes a tax rule designed to stabilize that variable about some target $\mathcal{B}^H$

Note that 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

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

where $m_t \equiv \log M_t$ and $V \equiv PY/M$ is the steady state income velocity of money. In words, the level of seignorage is proportional to money growth.

Let $\widehat{b}_t^H \equiv (\mathcal{B}_t^H - \mathcal{B}^H)/Y$, $\widehat{g}_t \equiv (G_t - G)/Y$ and $\widehat{t}_t \equiv (T_t - T)/Y$ denote, respectively, deviations of net government debt, government purchases and taxes from their steady state values, expressed as a fraction of output. A first order approximation of the consolidated budget constraint (4) around the zero inflation steady state yields the following difference equation describing the evolution over time of net government debt, expressed as a share of steady state output Y:

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

where $\widehat{i}_t \equiv \log((1+i_t)/(1+\rho))$, $\pi_t \equiv p_t - p_{t-1}$ and $b^H \equiv \mathcal{B}^H/Y$ is the steady state ratio of net government debt to output (the steady state *debt ratio,* for short).

2.2 Money-Financed vs. Debt-Financed Fiscal Stimulus

In "normal" times government purchases are assumed to be constant and equal to G. The objective of the analysis below is to determine the consequences of deviations of government purchases from that "normal" level, i.e. $\widehat{G}_t \equiv G_t - G$. I refer to those deviations as "fiscal stimulus" (or "fiscal contraction," if negative). Below I assume that such fiscal stimulus, expressed as a fraction of steady state output and denoted by $\widehat{g}_t \equiv (G_t - G)/Y$, follows the exogenous process

$$\widehat{g}_t = \rho_g \widehat{g}_{t-1} + \varepsilon_t^g$$

where $\rho_g \in [0,1)$ indexes the "persistence" of the fiscal intervention.

The baseline policy experiment analyzed below consists of an increase in government purchases financed entirely through seignorage, i.e. with no changes in taxes *over the relevant horizon examined* ($\widehat{t}_t = 0$).[8] Formally,

$$\Delta M_t / P_t = \widehat{G}_t \tag{8}$$

or, equivalently, using (6),

$$\Delta m_t = V \widehat{g}_t \tag{9}$$

i.e., the growth rate of the money supply is proportional to the fiscal stimulus, inheriting the latter's exogeneity. Furthermore, as implied by (7), and as long as taxes remain unchanged, the debt ratio evolves under this regime according to the difference equation:

$$\widehat{b}_t^H = (1+\rho)\widehat{b}_{t-1}^H + b^H(1+\rho)(\widehat{i}_{t-1} - \pi_t) \tag{10}$$

Note that whether the central bank transfer to the fiscal authority takes the form of a direct transfer of seignorage (with no counterpart) or a permanent increase in the central bank's holdings of government debt has no bearing on the macroeconomic effects of the fiscal stimulus and is only relevant from an accounting viewpoint.

Below, a standard money demand equation of the form

$$m_t - p_t = c_t - \eta i_t \tag{11}$$

is derived as one of the household's problem optimality conditions. In most macro models (including the two analyzed below), the (transitory) fiscal stimulus of the kind considered here has no permanent effect on consumption or the nominal rate. Combined with (9) and (11) that assumption implies

[8] I make this assumption in order not to introduce an additional degree of freedom in the analysis, given by the choice of tax rule. Given that Ricardian equivalence holds, the timing of taxes does not have any impact on the equilibrium response of any variable other than the stock of government debt itself. Thus, I implicitly assume that, starting at some future period after the fiscal stimulus, taxes are adjusted endogenously in order to guarantee that the steady state debt ratio reverts back to a target level b^H. For instance, one may assume that the fiscal authority implements a rule

$$\widehat{t}_{t+k} = \phi_\tau \widehat{b}_{t+k}^H$$

for $k = T_\tau, T_\tau + 1, T_\tau + 2, ...$after a fiscal stimulus initiated in period t, and where $\phi_\tau > \rho$. The previous assumption guarantees that the households' transversality condition is satisfied independently of the path of the price level. In other words, the implied fiscal regime is Ricardian (or "passive"). See, e.g. Leeper (1991) and Woodford (1996) for a discussion.

a permanent increase in the price level resulting from the money-financed fiscal stimulus given by:

$$\begin{aligned}
\lim_{k\to\infty} \frac{\partial p_{t+k}}{\varepsilon_t^g} &= \lim_{k\to\infty} \frac{\partial m_{t+k}}{\varepsilon_t^g} \\
&= \frac{V}{1-\rho_g}
\end{aligned}$$

While the latter long-run effect is robust under a variety of models, the short run effect on inflation and the timing of the eventual price adjustment, as well as the companion effects on output and employment, will generally differ across economic environments. The objective of the analysis below is to help understand those differences, the key factors that underlie them, and the resulting tradeoffs.

As an alternative to the fiscal-monetary regime described above, and with the purpose of having a comparison benchmark, I also analyze the effects of a debt-financed fiscal stimulus in a (more conventional) environment in which the central bank follows a simple interest rate rule given by

$$\widehat{i}_t = \phi_\pi \pi_t \tag{12}$$

where $\phi_\pi > 1$ determines the strength of the central bank's response of inflation deviations from the zero long-term target.

Once again, I assume that taxes remain unchanged over the relevant horizon of analysis, with the deficits incurred as a result of the fiscal stimulus being financed by the issuance of new debt.[9] Under this alternative policy regime, and while taxes remain unchanged, the debt ratio evolves according to the difference equation (7), with $\widehat{t}_t$ set to zero:

$$\widehat{b}_t^H = (1+\rho)\widehat{b}_{t-1}^H + b^H(1+\rho)(\widehat{i}_{t-1} - \pi_t) + \widehat{g}_t - (1/V)\Delta m_t \tag{13}$$

In contrast with the money-financing regime, Δm_t is no longer determined by $\widehat{g}_t$. Instead it is indirectly pinned down by the interest rate rule (12), which requires that the central bank injects or withdraws money from circulation

[9] As in the case of a money-financed fiscal stimulus I assume that the fiscal authority eventually adjusts taxes in order to guarantee that the debt ratio reverts back to its target level, independently of the evolution of prices and quantities. In other words, fiscal policy is "passive" or "Ricardian".

by means of open market operations (in exchange for government debt) in order to accommodate whatever money is demanded by households at the targeted interest rate.

As discussed below, an interest rate rule like (12) gives the central bank a tight control over inflation in response to a fiscal stimulus, through its choice of coefficient ϕ_π. Yet, that tighter control comes at the price of a smaller impact of the fiscal stimulus on economic activity (i.e. a smaller "fiscal multiplier") as well as a more adverse evolution of the debt ratio in the short run. Below I analyze quantitatively such differential implications.

As a measure of the effectiveness of an increase in government spending in stimulating economic activity under the alternative environments described above I compute the *dynamic government spending multiplier*

$$\Phi(k) \equiv \frac{\sum_{j=0}^{k} \partial y_{t+j} / \partial \varepsilon_t^g}{\sum_{j=0}^{k} \partial g_{t+j} / \partial \varepsilon_t^g}$$

for $k = 0, 1, 2, ...$. In addition, and in order to quantify the implied output-inflation tradeoff associated with a fiscal stimulus I compute the statistic

$$\Psi(k) \equiv \frac{\sum_{j=0}^{k} \partial y_{t+j} / \partial \varepsilon_t^g}{\sum_{j=0}^{k} \partial \pi_{t+j} / \partial \varepsilon_t^g}$$

for $k = 0, 1, 2, ...$, which I henceforth refer to as the *tradeoff ratio.* Note that a higher value for that ratio represents a larger impact on output per percent increase in the price level of a given fiscal stimulus, and can thus be viewed as representing a more favorable policy tradeoff.

3 The Effects of a Money-Financed Fiscal Stimulus in a Classical Monetary Model

Next I lay out a model of a classical monetary economy in which the above fiscal and monetary policy framework is embedded. Both goods and labor markets are perfectly competitive, and prices and wages are fully flexible. Assumptions on preferences and technology facilitate the derivation of a closed-form expression for the approximate equilibrium responses of quantities and prices to a fiscal stimulus.

3.1 Households/Preferences

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

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t, M_t/P_t) \tag{14}$$

where C_t is consumption, N_t is employment, M_t/P_t denotes real balances, and $\beta \equiv 1/(1+\rho)$ is the discount factor. Period utility $U(\cdot)$ is assumed to take the functional form

$$U(C, M/P, N) = \log C - \frac{N^{1+\varphi}}{1+\varphi} + \chi \log \frac{M}{P}$$

The household maximizes (14) subject to a sequence of budget constraints

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

for $t = 0, 1, 2, ...$where P_t is the price of the final good, W_t is the nominal wage, B_t^H denotes households' holdings of nominally riskless one-period government bonds (paying an interest i_t), T_t denotes lump-sum taxes, and D_t are dividends. The last two variables are expressed in real terms, and taken as given by the household.

In addition the household must satisfy a no-Ponzi game condition:

$$\lim_{T \to \infty} E_t\{\Lambda_{t,t+T}(1/P_{t+T})(M_{t+T} + B_{t+T}^H\} \geq 0$$

where $\Lambda_{t,t+k} \equiv \beta^k (C_t/C_{t+k})$ is the stochastic discount factor.

The corresponding optimality conditions are given by

$$W_t/P_t = C_t N_t^{\varphi}$$

$$1 = \beta(1 + i_t) E_t\{(C_t/C_{t+1})(P_t/P_{t+1})\}$$

$$M_t/P_t = \chi C_t (1 + 1/i_t)$$

Using lower case letters to denote the naturals logs of the original variable, we can write the log-linear approximations to the above conditions in a neighborhood of the zero inflation steady state as (ignoring constants):

$$w_t - p_t = c_t + \varphi n_t \tag{15}$$

$$c_t = E_t\{c_{t+1}\} - (\widehat{i}_t - E_t\{\pi_{t+1}\}) \tag{16}$$

$$l_t \equiv m_t - p_t = c_t - \eta \widehat{i}_t \tag{17}$$

where $\eta \equiv 1/\rho$.

3.2 Firms/Technology

The single good is produced by a large number of identical, perfectly competitive firms with a technology

$$Y_t = N_t$$

Profit maximization requires that in equilibrium

$$W_t/P_t = 1$$

or, equivalently,

$$w_t - p_t = 0$$

3.3 Equilibrium

To determine the equilibrium allocation note that goods market clearing requires

$$Y_t = C_t + G_t$$

On the other hand, labor market clearing, implies

$$1 = C_t N_t^{\varphi}$$

Combining the two equilibrium conditions with the production function $Y_t = N_t$ we obtain an equation (implicitly) determining output as a function of government purchases

$$1 = (Y_t - G_t)Y_t^{\varphi} \tag{18}$$

I assume that government purchases account for a fraction γ of output in the steady state, i.e. $G/Y = \gamma$. A first-order approximation of (18) around the steady state yields:

$$\widehat{y}_t = \Theta \widehat{g}_t \tag{19}$$

where $\Theta \equiv 1/[1 + \varphi(1-\gamma)] \in (0,1)$ is the government spending multiplier on output and $\widehat{y}_t \equiv \log(Y_t/Y)$. Thus, a fiscal stimulus has an unambiguous expansionary effect on output (and employment), as intended.

Combining the previous result with the goods market clearing condition we get:

$$\widehat{c}_t = -\varphi \Theta \widehat{g}_t \tag{20}$$

where $\widehat{c}_t \equiv \log(C_t/C)$.

The (ex-ante) real interest rate, $\widehat{r}_t \equiv \widehat{i}_t - E_t\{\pi_{t+1}\}$, can be determined by combining (20) with the household's (log-linearized) Euler equation (16) to yield

$$\widehat{r}_t = (1-\rho_g)\varphi\Theta\widehat{g}_t \tag{21}$$

Note, thus, that the "real block" of the model's equilibrium can be solved for independently of how the fiscal stimulus is financed. This is a consequence of both monetary policy neutrality and Ricardian equivalence holding in the above model.

On the other hand, the response of the price level and other nominal variables to the fiscal stimulus, depends on the monetary policy rule in place and, hence, on how the fiscal stimulus is financed. Our interest is in determining the price response to the fiscal stimulus and how the latter is shaped by the particular policy regime in place.

In order to solve for the "nominal block" of the model's equilibrium, we combine money demand (17) with the equilibrium expressions for consumption and the real interest rate, (20) and (21), together with the Fisherian equation $\widehat{i}_t \equiv \widehat{r}_t + E_t\{\pi_{t+1}\}$ to obtain the following expressions for the equilibrium price level and nominal interest rate (ignoring constant terms):

$$p_t = m_t + \sum_{k=1}^{\infty}\left(\frac{\eta}{1+\eta}\right)^k E_t\{\Delta m_{t+k}\} + \varphi\Theta\widehat{g}_t \tag{22}$$

and

$$\widehat{i}_t = \frac{1}{\eta}\sum_{k=1}^{\infty}\left(\frac{\eta}{1+\eta}\right)^k E_t\{\Delta m_{t+k}\} \tag{23}$$

which hold independently of how the fiscal stimulus is financed. Thus, the price level is positively related to government purchases (since the latter decrease consumption, thus reducing the demand for real balances), expected future growth rates of money (since they raise the nominal rate, thus decreasing the demand real balances) and the current money supply. Since government purchases are taken as exogenous, the difference in the response of the price level and the nominal rate across regimes necessarily depends on their implied money supply path. Next we analyze the regimes associated with money and debt financing in turn.

3.4 The Effects of a Money-Financed Fiscal Stimulus

In the case of government purchases financed through seignorage, $\Delta m_t = V\widehat{g}_t$ holds (as shown in (9)), where $V \equiv \rho/(1+\rho)\chi(1-\gamma)$ is steady state velocity, thus implying

$$p_t = m_t + \left(\frac{\eta V \rho_g}{1+\eta(1-\rho_g)} + \varphi\Theta \right) \widehat{g}_t$$

and

$$\widehat{i}_t = \left(\frac{V \rho_g}{1+\eta(1-\rho_g)} \right) \widehat{g}_t$$

Note that the dynamic response of the price level to the fiscal stimulus can be written as

$$\frac{\partial p_{t+k}}{\partial \varepsilon_t^g} = \frac{V(1-\rho_g^{k+1})}{1-\rho_g} + \left(\frac{\eta V \rho_g}{1+\eta(1-\rho_g)} + \varphi\Theta \right) \rho_g^k$$

Two results are worth emphasizing. Firstly, the adjustment of the aggregate price level to the money-financed fiscal stimulus is strongly frontloaded, with the price level increasing *more than proportionally* to the money supply in the short-run. This is a consequence of the decline in the demand for real balances induced by lower consumption and a higher nominal rate. In fact, if the increase in government spending is not too persistent (low ρ_g) it can be easily checked that the price level will overshoot its long run level, with a bout of very high inflation in the short run followed by persistent (albeit mild) deflation. Secondly, the money-financed fiscal stimulus unambiguously lowers welfare in the simple classical monetary economy, due to a simultaneous reduction in consumption and real balances, and an increase in work hours.

Before I start showing some quantitative results, I briefly describe the baseline calibration of the model's parameters. That calibration, summarized in the top panel of Table 1, assumes the following settings for the household related parameters: $\beta = 0.99$ (which implies a steady state real return on financial assets of about 4 percent), $\varphi = 5$ (implying a Frisch elasticity of labor supply of 0.2), $\eta = 4$ and $V = 4$ (both consistent with empirical evidence for the U.S. economy).[10] In addition I assume the following fiscal

[10] The calibration of η is based on the estimates of an OLS regression of (log) M2 inverse velocity on the 3 month Treasury Bill rate (quarterly rate, per unit), using quarterly data over the period 1960:1-1988:1. The focus is on that period because it is characterized by

policy settings: $\gamma = 0.2$ (steady state share of government purchases in output), $b^H = 2.4$ (corresponding to a 60 percent ratio of debt to *annual* output), and $\rho_g = 0.5$ (with an alternative "high persistence" calibration of 0.9, with some results reported for the full support of that parameter). Finally, the size of the fiscal stimulus is normalized to one percent of (steady state) quarterly output.

Figure 1 displays the dynamic responses of output, inflation, and a number of other macroeconomic variables to a money-financed fiscal stimulus in the classical economy under the baseline calibration with $\rho_g = 0.5$. The top panel of Table 2 reports some associated statistics, including the effects on output and inflation and the tradeoff ratio at three different horizons ($k = 0, 4, 12$), as well as the 12-quarter impact on the (annualized) debt ratio. The top panel of Table 3 shows analogous results obtained under the "high persistence" calibration ($\rho_g = 0.9$). Finally, Figure 2 displays the government spending multiplier and the tradeoff ratio for $k = 0, 4, 12$ as a function of the persistence of the fiscal stimulus (ρ_g). In all cases, reported inflation, interest rates, money growth rates and debt ratios are annualized.

Note that in the classical economy under the present calibration the effect of the fiscal stimulus on economic activity is very small: the government spending multiplier is only 0.2, independently of the persistence of the stimulus. While a larger multiplier can always be obtained by assuming a smaller setting for φ (i.e. more elastic labor supply), I stick to a conservative value $\varphi = 5$ throughout the analysis, while emphasizing the deviations from the 0.2 benchmark rather than its absolute value.[11]

In addition to the low multiplier, several results are worth highlighting:

- The effects of the money-financed fiscal stimulus on inflation are very large (almost 30 percent on impact under $\rho_g = 0.5$), and increasing in the persistence of the shock. They are, however, extremely short-lived, and concentrated in the first quarter.

- The tradeoff ratio takes a extremely low value: close to or less than 0.05 for the three horizons considered, i.e. the cumulative increase in

a highly stable relationship between velocity and the nominal rate, which is consistent with the model. Note that such a calibration corresponding to a unit semi-elasticity with respect to the annualized interest rate.

[11] A larger multiplier could be obtained by assuming a more elastic labor supply. Thus, if $\varphi = 1$ the multiplier is $\Theta = 1/1.8 = 0.56$

output is significantly less than one-tenth of the corresponding increase in the price level, a highly unfavorable tradeoff. The simulations also suggest that the output-inflation tradeoff worsens with the persistence of the fiscal stimulus.

- Welfare is unambiguously reduced as a result of the fiscal stimulus: consumption and real balances decline, and work hours increase.

- The only "positive" outcome of the intervention considered pertains to the substantial decrease in the debt ratio (more than 4 percentage points), resulting from erosion of the real value of government debt outstanding at the time the stimulus is initiated, due to the high unanticipated inflation.

3.5 Money-Financed vs. Debt-Financed Fiscal Stimulus

Consider next the alternative regime of a debt-financed fiscal stimulus, accompanied by a monetary policy described by the simple interest rate rule (12). Combining that rule with the Fisherian equation and (21) yields the difference equation:

$$\phi_\pi \pi_t = (1-\rho_g)\varphi\Theta\widehat{g}_t + E_t\{\pi_{t+1}\} \tag{24}$$

Under the assumption $\phi_\pi > 1$ the unique stationary solution to (24) is given by:

$$\pi_t = \frac{(1-\rho_g)\varphi\Theta}{\phi_\pi - \rho_g}\,\widehat{g}_t$$

The corresponding dynamic response of the price level is given by

$$\frac{\partial p_{t+k}}{\partial \varepsilon_t^g} = \frac{\varphi\Theta(1-\rho_g^{k+1})}{\phi_\pi - \rho_g} \tag{25}$$

with an implied long run response

$$\lim_{k\to\infty}\frac{\partial p_{t+k}}{\partial \varepsilon_t^g} = \frac{\varphi\Theta}{\phi_\pi - \rho_g} > 0$$

Thus we see that, in response to the fiscal stimulus, the price level rises on impact and keeps increasing over time (as long as $\rho_g > 0$) until it stabilizes at a permanently higher level. Most importantly, however, the previous finding suggests that a central bank that follows a simple rule like (12) can "control", through an appropriate choice of coefficient ϕ_π, the extent of the inflationary impact of the fiscal stimulus. In particular, that impact can be made arbitrarily small by having the central bank respond to inflationary pressures sufficiently aggressively, i.e. by choosing a sufficiently large value for ϕ_π. Furthermore, and as made clear by (25), the inflationary impact of the fiscal stimulus is, perhaps counterintuitively, decreasing in the persistence of the latter. The reason is that, a more persistent increase in government purchases has a smaller impact on the real rate, which in turn requires a smaller inflation to be brought about, given the interest rate rule in place, and for any given ϕ_π.

The potential benefits of a strong anti-inflationary stance by the monetary authority come with a cost: its implementation may require a large sale of central bank holdings of government debt in the short run and, hence, a temporary increase in the size of the corresponding household holdings above and beyond the newly issued debt required to finance the fiscal stimulus. To see this, note that the (endogenous) response of the money supply to the fiscal stimulus under the present regime can be derived by combining (12), (17), (20) and (25), is given by:

$$\frac{\partial m_{t+k}}{\partial \varepsilon_t^g} = \frac{\varphi\Theta\ (1 - \rho_g^k \phi_\pi (1 + \eta(1 - \rho_g)))}{\phi_\pi - \rho_g} \tag{26}$$

A comparison of the limits of (25) and (26) as $k \to \infty$ makes clear that the long run response of the money supply coincides with that of the price level (i.e. both variables are cointegrated). However, the paths of the two variables *can differ substantially in the short run.* In particular, the money supply declines on impact, as can be checked by setting $k = 0$ in (26):

$$\frac{\partial m_t}{\partial \varepsilon_t^g} = \frac{\varphi\Theta\ (1 - \phi_\pi (1 + \eta(1 - \rho_g)))}{\phi_\pi - \rho_g} < 0$$

It is east to check that $\partial^2 m_t / \partial \varepsilon_t^g \partial \phi_\pi < 0$, i.e. the size of the money supply *decline* is increasing in the strength of its anti-inflationary stance, as measured by ϕ_π. Note also that the negative response of the money supply may persist for several periods, as (26) makes clear. As a counterpart to the change in the money supply the central bank adjusts its holdings of government debt, which impinges on the evolution of the debt ratio, as shown in (13). In particular, the central bank's need to sell government debt (or issue its own debt) in the short run in order to bring down the money supply leads to an increase in the debt ratio larger than what would be strictly required in order to finance the budget deficit, which I take to be politically undesirable or unfeasible.

The intuition for the short run contraction in the money supply can be understood by considering the money demand equation

$$m_t = p_t + c_t - \eta i_t$$

Thus, both a nominal rate rise in response to higher inflation, and a decline in nominal consumption, $p_t + c_t$, in response to the fiscal stimulus (or a small increase, relative to the rise in the nominal rate), lead to a decline in money demand. The latter must be fully accommodated by the central bank, which is thus forced to sell part of its government debt holdings, increasing further the amount of debt held by households.

Figure 3 displays the implied dynamic responses of several macro variables to the fiscal stimulus under a debt-financing regime, for two different values of the inflation coefficient in rule (12): $\phi_\pi = 1.5$ and $\phi_\pi = 100$. The first setting corresponds to the value of the inflation coefficient in Taylor's (1993) celebrated rule, and is meant to capture (in a highly stylized way) an empirically plausible policy response. The second setting implies a negligible response of inflation in response to the fiscal stimulus thus capturing an extreme (and admittedly unrealistic) anti-inflationary stance. I refer to the two previous calibrations of the policy rule as "Taylor" and "inflation targeting" (or IT, for short). For the sake of comparability, Figure 3 also displays the dynamic responses obtained under a monetary-financing fiscal stimulus. As discussed above the responses of the real variables are invariant to the financing strategy and hence deserve no further comment. The difference in the responses of inflation are, however, stark: even a moderate inflation coefficient of 1.5 is enough to bring down the increase in inflation to 2.1 percentage point on impact, a value an order of magnitude smaller than implied by the money-financed fiscal stimulus. The increase in inflation is even smaller (0.7 percent) under $\rho_g = 0.9$, for the reasons exposed above. The other side of the coin can be found in the response of the debt ratio, which is now positive and increasing (more so under the IT calibration), largely due to the large open market sales of government debt, which more than offset the negative (albeit small) impact of inflation on the real value of debt. The implied increase in the debt ratio after 12 quarters is less than 1.1 percent under $\rho_g = 0.5$, less than 2.4 percent under $\rho_g = 0.9$.

Finally, we see that the response of the nominal interest rate (and hence of real balances held by households, one of the determinants of utility) is very similar across the three regimes. The reason is simple: the response of the real rate is identical in the three cases, so the only difference hinges on the response of expected inflation which is almost identical (and close to zero) under the three regimes. Yet, the increase in the nominal rate appears to be slightly smaller under the IT calibration, given the implied zero expected inflation. The difference across regimes is starker under the assumption of $\rho_g = 0.9$, as shown in Table 3, for expected inflation is much more persistent under monetary financing in that case.

Not surprisingly, and as shown in Figure 4, the tradeoff ratio is larger under the debt financing cum Taylor rule regime, than under monetary financing, due to the smaller denominator. Furthermore, and in contrast with the monetary financing case, we see that the tradeoff improves as the persistence of the shock increases, due to the smaller effect on inflation. In any event, the value of the tradeoff ratio is seen to remain below 2 for the entire range of ρ_g settings (by construction it is always infinity under strict inflation targeting, and it is thus not plotted for that case).

All things considered, our analysis of the effects of a money-financed fiscal stimulus in a classical monetary economy does not support a strong case for that intervention, due to its limited effectiveness in stimulating output and employment and its large inflationary consequences, even though the latter are restricted to the very short run. While its impact on activity is equally small, a debt-financed fiscal stimulus, accompanied by a simple interest rate rule, has the advantage of a very limited impact on inflation, especially if the fiscal stimulus is highly persistent. The only evident cost of a debt-financed stimulus relative to the money-financed one appears to lie in its larger implied debt ratio, though the size of the increase in the latter even in the more adverse cases considered remains "acceptable".

As discussed next, many of these conclusions change substantially when the fiscal stimulus is embedded in a very different economic environment, one characterized by the presence of nominal rigidities, as shown and discussed in the next section.

4 The Effects of a Money-Financed Fiscal Stimulus in a New Keynesian Model

Some of the key findings of the previous section regarding the effects of a fiscal stimulus under alternative financing schemes are likely to hinge critically on the assumption of flexible prices and wages, an assumption at odds with the empirical micro evidence.[12] In particular, the finding of a strong frontloading (and possible overshooting) of the price level in response to the fiscal stimulus is unlikely to carry over to an environment in which prices are set by firms in a staggered fashion, and marginal costs adjust sluggishly due to nominal wage rigidities. The assumption of flexible prices and wages, with its implied monetary neutrality, is also likely to be central to the finding of invariance in the response of real variables to alternative schemes for the financing of the fiscal stimulus (with their implied differences in monetary policy rules).

In the present section I relax the assumption of fully flexible prices and wages underlying the analysis above. More specifically, I embed the fiscal-monetary framework introduced in Section 2 into a New Keynesian model with monopolistic competition in goods and labor markets, staggered nominal wage and price setting, and endogenous capital accumulation with convex adjustment costs. At the end of the section I also consider an extension of the New Keynesian model allowing for a fraction of non-Ricardian households, as in Galí, López-Salido and Vallés (2007).

The focus of the present section goes beyond showing that neither the *frontloading* nor the *invariance* results can survive the introduction of nominal rigidities. My objective is also to get a sense of the quantitative effects of a money-financed fiscal stimulus on different macro variables, and their differences with those obtained under a more conventional debt-financing scheme, in a model with a *realistic* degree of price and wage rigidities.

Next I describe the key features of the model.

[12] See e.g. Nakamura and Steinsson (2008) for recent micro evidence on price setting, and Barattieri, Basu and Gottschalk (2014) for analogous evidence regarding wages.

4.1 Households

The representative household's preferences are given by

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, M_t/P_t, N_t) \tag{27}$$

where

$$U\left(C, M/P, N\right) = \frac{X(C, M/P)^{1-\sigma} - 1}{1-\sigma} - \int_0^1 \frac{N(z)^{1+\varphi}}{1+\varphi} dz \tag{28}$$

and where $X(C, M/P)$ is defined by

$$\begin{aligned} X(C, M/P) &\equiv \left((1-\vartheta)C_t^{1-\upsilon} + \vartheta\left(\frac{M_t}{P_t}\right)^{1-\upsilon}\right)^{\frac{1}{1-\upsilon}} \qquad for\ \upsilon \neq 1 \qquad (29) \\ &\equiv C_t^{1-\vartheta}\left(\frac{M_t}{P_t}\right)^{\vartheta} \qquad for\ \upsilon = 1 \end{aligned}$$

with υ denoting the (inverse) elasticity of substitution between consumption and real balances, and ϑ the relative weight of real balances in utility. Each household has a continuum of members, indexed by $z \in [0, 1]$, each specialized in a given type of labor service. $N_t(z)$ denotes employment (or work hours) of type z labor in period t. Irrespective of their wage and work hours, all household members are assumed to consume the same amount of goods, C_t, and enjoy the same level of real balances, M_t/P_t.

Households have access to three different assets: money (M_t), one-period nominally riskless bonds (B_t) and productive capital (K_t). Their period budget constraint is given by

$$P_t(C_t+I_t)+B_t+M_t = B_{t-1}(1+i_{t-1})+M_{t-1}+R_t^k K_t+\int_0^1 W_t(z)N_t(z)dz+P_tD_t-P_tT_t$$

with the capital stock K_t evolving according to

$$K_{t+1} = (1-\delta)K_t + \phi\left(I_t/K_t\right)K_t$$

and where R_t^k is the rental price of capital. Capital adjustment costs are introduced through the term $\phi\left(I_t/K_t\right)K_t$, which determines the change in the capital stock (gross of depreciation) induced by investment I_t. I assume

$\phi' > 0$, and $\phi'' \leq 0$, with $\phi'(\delta) = 1$, and $\phi(\delta) = \delta$, where δ is the depreciation rate. The remaining variables are defined as in the classical model of the previous section.

Households choose optimally their level of consumption and their portfolio allocation, but take employment as given, since the latter is determined by firms.

Wages are set by unions. Each union represents all workers specialized in a given type of labor. Each period, a typical union faces a probability $1-\theta_w$ of resetting the nominal wage for its members, independently of other unions and the time elapsed since the last resetting. Thus, each period a fraction $1-\theta_w$ of workers see their nominal wages reset, while a fraction θ_p keep their wages unchanged. A union setting its members' wage in period t seeks to maximize the objective function

$$\max_{W_t^*} \sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \left\{ U_{c,t+k} \frac{W_t^*}{P_{t+k}} N_{t+k|t} - \frac{N_{t+k|t}^{1+\varphi}}{1+\varphi} \right\}$$

subject to a labor demand schedule

$$N_{t+k|t} = \left(\frac{W_t^*}{W_{t+k}} \right)^{-\epsilon_w} N_{t+k} \tag{30}$$

where W_t^* is the nominal wage newly set in period t, $W_t \equiv \left(\int_0^1 W_t(z)^{1-\epsilon_w} dz \right)^{\frac{1}{1-\epsilon_w}}$ is a nominal wage index, and $N_{t+k|t}$ denotes employment in period $t+k$ for workers who had their wage last reset in period t. Note that such behavior is, from the viewpoint of each union and its members, consistent with maximization of their respective households' utilities, taking as given the wages set by other unions and all aggregate variables.

4.2 Firms

There is a single final good produced by a representative, perfectly competitive firm with a constant returns technology:

$$Y_t = \left(\int_0^1 X_t(j)^{\frac{\epsilon_p - 1}{\epsilon_p}} dj \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}$$

where $X_t(j)$ is the quantity of intermediate good j used as an input, and $\epsilon_p > 1$ is the elasticity of substitution among different intermediate goods.

The production function for a typical intermediate goods firm is given by:

$$Y_t(j) = K_t(j)^{\alpha} N_t(j)^{1-\alpha} \tag{31}$$

where $K_t(j)$ and $N_t(j)$ represent the capital and labor services hired, and where

$$N_t(j) \equiv \left(\int_0^1 N_t(j,z)^{\frac{\epsilon_w - 1}{\epsilon_w}} dz \right)^{\frac{\epsilon_w}{\epsilon_w - 1}}$$

is an effective labor input index with $N_t(j,z)$ denoting employment of type z labor and and $\epsilon_w > 1$ is the elasticity of substitution among different types of labor.

Intermediate goods firms are assumed to set prices in a staggered fashion, in a way analogous to wage setting. Each firm resets its price with probability $1 - \theta_p$ each period, independently of the time elapsed since the last adjustment. Thus, each period a fraction $1 - \theta_p$ of producers reset their prices, while a fraction θ_p keep their prices unchanged. A firm resetting its price in period t will seek to maximize

$$\max_{P_t^*} \; E_t \sum_{k=0}^{\infty} \theta_p^k E_t \left\{ \Lambda_{t,t+k} (1/P_{t+k}) Y_{t+k|t} \left(P_t^* - \Psi_{t+k} \right) \right\}$$

subject to the sequence of demand constraints $Y_{t+k|t} = \left(P_t^*/P_{t+k}\right)^{-\epsilon_p} Y_{t+k}$, where P_t^* represents the price chosen by firms resetting prices at time t, $Y_{t+k|t}$ is the level of output in period $t+k$ for a firm that last reset its price in period t, Ψ_{t+k} is the marginal cost, and $\Lambda_{t,t+1} \equiv \beta \left(C_{t+1}/C_t\right)^{-\upsilon} \left(X_{t+1}/X_t\right)^{\upsilon - \sigma}$ is the relevant stochastic discount factor.

4.3 Equilibrium

The optimality conditions of the households' and firms' problems, as well as the model's equilibrium conditions is familiar from the existing literature and is thus relegated to the Appendix. Next I list the corresponding approximate equilibrium conditions, based on a log-linearization of the original ones around a zero inflation steady state.

Output and aggregate demand components:

$$\widehat{y}_t = (1 - \gamma_i - \gamma_g)\widehat{c}_t + \gamma_i \widehat{\mathrm{i}}_t + \widehat{g}_t \tag{32}$$

$$\widehat{c}_t = E_t\{\widehat{c}_{t+1}\} - (1/\sigma)(\widehat{i}_t - E_t\{\pi_{t+1}\} - \varpi E_t\{\Delta \widehat{i}_{t+1}\}) \tag{33}$$

$$\widehat{\mathfrak{i}}_t - \widehat{k}_t = \varsigma q_t \tag{34}$$

$$q_t = \beta E_t\{q_{t+1}\} + (1-\beta(1-\delta))E_t\{\widehat{r}^k_{t+1} - p_{t+1}\} - (\widehat{i}_t - E_t\{\pi_{t+1}\}) \tag{35}$$

$$\widehat{g}_t = \rho_g \widehat{g}_{t-1} + \varepsilon^g_t \tag{36}$$

where $\widehat{\mathfrak{i}}_t \equiv \log(I_t/I)$, $\gamma_i \equiv \frac{\alpha\delta}{\mathcal{M}_p(\rho+\delta)}$ is the steady state investment share, $q_t \equiv \log Q_t$ is the log of the shadow value of installed capital (Tobin's Q), $\varsigma \equiv -1/\phi''(\delta)\delta$, and $\varpi \equiv (1-\frac{\sigma}{\upsilon})\beta/(V_c + (1-\beta))$, with $V_c \equiv \left(\frac{(1-\vartheta)(1-\beta)}{\vartheta}\right)^{\frac{1}{\upsilon}}$ denoting consumption velocity.

Price and wage inflation equations:

$$\pi^p_t = \beta E_t\{\pi^p_{t+1}\} - \lambda_p \widehat{\mu}^p_t \tag{37}$$

$$\pi^w_t = \beta E_t\{\pi^w_{t+1}\} - \lambda_w \widehat{\mu}^w_t \tag{38}$$

$$\widehat{\mu}^p_t = -\widehat{\omega} + \alpha(\widehat{k}_t - \widehat{n}_t) \tag{39}$$

$$\widehat{\mu}^w_t = \widehat{\omega} - (\sigma\widehat{c}_t + \varphi\widehat{n}_t + \varpi\widehat{i}_t) \tag{40}$$

where $\pi^p_t \equiv p_t - p_{t-1}$ and $\pi^w_t \equiv w_t - w_{t-1}$ denotes price and wage inflation, $\omega_t \equiv w_t - p_t$ denotes the (log) real wage, $\lambda_p \equiv \frac{(1-\theta_p)(1-\beta\theta_p)}{\theta_p}$, and $\lambda_w \equiv \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\epsilon_w\varphi)}$.

Factor prices and quantities:

$$\widehat{\omega}_t = \widehat{\omega}_{t-1} + \pi^w_t - \pi^p_t \tag{41}$$

$$\widehat{\mathfrak{r}}^k = \widehat{\omega}_t + \widehat{n}_t - \widehat{k}_t \tag{42}$$

$$\widehat{k}_{t+1} = \delta\widehat{\mathfrak{i}}_t + (1-\delta)\widehat{k}_t \tag{43}$$

$$(1-\alpha)\widehat{n}_t = \widehat{y}_t - \alpha\widehat{k}_t \tag{44}$$

where $\mathfrak{r}^k \equiv r^k_t - p_t$ is the (log) real rental cost of capital.

Money demand:

$$\widehat{l}_t = \widehat{c}_t - \eta\widehat{\mathfrak{i}}_t \tag{45}$$

where $l_t \equiv m_t - p_t$ and $\eta \equiv 1/\rho\upsilon$

Debt dynamics:

$$\widehat{b}^H_t = (1+\rho)\widehat{b}^H_{t-1} + b^H(1+\rho)(\widehat{i}_{t-1} - \pi_t) + \widehat{g}_t - (1/V)\Delta m_t \tag{46}$$

Monetary policy rule:

In the case of monetary financing regime it is given by:

$$\Delta m_t = V\widehat{g}_t \tag{47}$$

where $V = V_c/(1 - \gamma_i - \gamma_g)$ is the steady state income velocity of money.

In the case of a debt financing regime monetary policy is described by the interest rate rule:

$$\widehat{i}_t = \phi_\pi \pi_t \tag{48}$$

4.4 Money-Financed Fiscal Stimulus: Main Findings

Next I report the predictions of the New Keynesian model regarding the effects of a money-financed fiscal stimulus identical to the one analyzed in the previous section in the context of a classical economy.

The New Keynesian model contains additional parameters whose baseline settings are summarized in the second panel of Table 1. Most of those settings are relatively uncontroversial. I set the elasticity of output with respect to capital, α, equal to 1/4. The (quarterly) depreciation rate δ is set to 0.025. Parameter ς is the elasticity of investment with respec to Tobin's Q, and is set to 0.1, consistently with some empirical evidence on aggregate investment.[13] The elasticity of substitution among goods, ϵ_p, is set to 6, which implies a 20 percent net markup in the steady state. The corresponding elasticity of substitution among different types of labor, ϵ_w, is set to equal 4.5. As shown in Galí (2011), that value is consistent with a steady state unemployment rate of 5 percent, under an interpretation of the model which introduces unemployment explicitly. I set the two parameters indexing the degree of nominal rigidities, θ_p and θ_w, equal to 0.75, implying an average duration of prices and wages of four quarters.

Figure 5 displays selected impulse responses to a one percent money-financed fiscal stimulus, under the assumption of $\rho_g = 0.5$. Key statistics are reported in the second panel of Table 2. The effect of the fiscal intervention on output (and employment) is an order of magnitude larger than in the classical economy, with a multiplier of 4.5 on impact. That spending multiplier is also

[13] See e.g. Hassett and Hubbard (1996)

significantly larger than is generally found in the literature.[14] The effect on inflation is, on the other hand, an order of magnitude smaller than in the classical model, with an impact on (annualized) inflation of 3.8 per cent (in contrast with close to 30 percent in the classical model). The effect on inflation goes down to 2.2 percent a year after the shock, and 0.7 percent three years after. As reported in Table 3, the effects of the money-financed fiscal stimulus on both output and inflation are even larger when I set $\rho_g = 0.9$.

As a comparison of Figures 1 and 5 makes clear, a key qualitative difference between the classical and New Keynesian economies lies in the responses of consumption and the real interest rate. In contrast with the classical economy, in the New Keynesian model the real interest rate declines persistently in response to the monetary injection that accompanies the fiscal stimulus. That reduction in the real interest rate induces a large expansion of consumption (more than 5 percent on impact), which contrasts with the crowding out of that variable observed in the classical economy. It is that expansion in consumption (and also in investment, not shown in the Figure) which is behind the large multiplier associated with that fiscal intervention in the New Keynesian economy. Interestingly, the decline in the real interest rate observed in the New Keynesian model in response to the money-financed fiscal stimulus coexists with an increase in the nominal rate, which is brought about a large expansion of money demand due to higher prices and consumption. The gap between the two is, of course, due to a persistently higher rate of inflation, resulting from the gradual adjustment of prices (in contrast with the very large, one-off jump in the price level in the classical model). Gradualism in the price response, implied by staggered price setting, thus seems to play a key role in the transmission mechanism of the money-financed fiscal stimulus in the New Keynesian model. Importantly, the upward response of the nominal rate suggests that the the existence of a zero lower bound on that variable (whether currently binding or not) should not be an impediment to the implementation and success of a fiscal intervention of the kind considered here.

Some additional results are highlighted next:

[14] See the surveys by Hall (2009) and Ramey (2011) for a discussion of the mulpliers uncovered in the literature, both theoretical and empirical. Needless to say, the fact that the multiplier associated with a money-financed fiscal stimulus is well above empirical estimates of that multiplier doesn't have any bearing on the validity of the model since the kind of fiscal stimulus analyzed here doesn't have an empirical counterpart in the U.S. postwar period.

- As shown in Figure 6, the size of the dynamic multiplier increases with the horizon, except for values of ρ_g close to unity. This points to a highly persistent endogenous response of the components of aggregate demand other than government spending itself. On the other hand, the Figure makes clear there is no simple relation between the dynamic multiplier and the persistence of the shock: that relation is increasing on impact and at short horizons, but it becomes decreasing at longer horizons.

- The tradeoff ratio is shown to decrease with the persistence of the fiscal stimulus, pointing to a proportionally larger impact of that persistence on prices than on output, possibly due to the forward looking nature of inflation in the New Keynesian model.

- The debt ratio declines substantially, though more gradually than in the classical economy. This is due to the smaller inflation surprise on impact (and hence a smaller erosion of the real value of outstanding debt), followed by persistently lower real interest rates (which reduce the government's interest payments and hence the debt issuance requirements).

4.5 Money-Financed vs. Debt-Financed Fiscal Stimulus: Main Findings

Figure 7 allows one to compare the effects of a money-financed fiscal stimulus to those resulting from a more conventional debt-financed stimulus combined with a monetary policy described by a simple interest rate rule.

As in the case of the classical economy, the response of inflation to the fiscal stimulus is much more muted under debt financing, since the central bank has its hands free to counteract the incipient inflation with a more restrictive monetary policy, leading to a rise in the real interest rate (instead of the decline observed under money financing). Not surprisingly, the rise in both the real and nominal rates is larger in the IT case, compared with the less extreme Taylor calibration. Note also the difference in the pattern of money growth, which increases sharply under money financing (by construction), but declines instead under debt financing (with a much larger decline under IT than under Taylor), as needed in order to support the higher nominal rates required by the policy rule, without the boost to money demand resulting from higher consumption or much higher prices.

The persistent increase in the real interest rate under the debt financing scenario is responsible for the decline in consumption and investment (the latter not shown in the Figure) and, as a result, a much smaller impact on output and employment. That gap in the impact on economic activity is clearly illustrated in Figure 8 which displays the dynamic multiplier at a 4-quarter horizon as a function of ρ_g under the three environments considered (money financing, Taylor and IT). Clearly, and as shown earlier, a money-financed fiscal stimulus is much more effective than a debt-financed one at stimulating economic activity. But the right hand panel of Figure 8 suggests it may not do so efficiently: the tradeoff ratio appears to be much larger in the case of a debt-financed stimulus and a Taylor rule (again, by construction it is infinite in the IT case and is thus not plotted).

That previous finding suggests that by adjusting the size of the fiscal stimulus adequately, a policymaker would be able attain the same impact on output under debt financing as observed under money financing, but with a smaller effect on prices. Such a policy would, however, involve a large decline in consumption (in contrast to the large increase observed under monetary financing), and a large increase in the debt ratio (in contrast to the decline under money financing).

The increase in the debt ratio under a debt financing regime is a consequence of three factors: (i) the need to issue debt to finance the fiscal stimulus, (ii) the higher real interest rates (and thus larger interest payments), and (iii) the large short run contraction of the money supply, which has as a counterpart a sale of government debt by the central bank). Those three factors are offset, to a limited very degree, by the initial inflation surprise and the consequent erosion of the real value of debt, but–as discussed above–that surprise is small in the Taylor case and plainly inexistent under strict inflation targeting.

The last column of Tables 2 and 3, under the $12ADJ$ heading, reports the increase in the debt ratio (after 12 quarters) when the size of the fiscal stimulus is *adjusted* in order to match the impact on output resulting from a one percent money-financed fiscal stimulus. Note that for $\rho_g = 0.5$ the adjusted increase in the debt ratio is of 2.4 percent in the Taylor case, and as high as 195 percent in the IT case. When $\rho_g = 0.9$ is assumed instead the previous values rise to 28 percent and 587 percent (!), respectively. The previous exercise suggests that replicating the impact of a money-financed fiscal stimulus on economic activity through a more conventional debt-financed fiscal stimulus may require a fiscal expansion too large to be politically feasible, given its likely impact on the debt ratio (as well as the adverse effect on consumption!), especially if that stimulus is highly persistent or the central bank adopts a strong anti-inflationary stance.

The finding of a much larger multiplier in the case of a money-financed increase in government spending (relative to the case of a debt-financed stimulus combined with a Taylor rule) is related to some of the findings in the resent literature on government spending under a (temporarily) binding zero lower bound constraint (see, e.g., Eggertsson (2011) and Christiano, Eichenbaum and Rebelo (2011)). Thus, in both cases the real interest rate declines in response to the fiscal stimulus, leading to a crowding-in of consumption and a larger multiplier. Note, however, that there are several (qualitative) differences. In particular, the nominal interest rises in the case of a money-financed fiscal stimulus, while by it remains (temporarily) unchanged in the zero lower bound case. An explicit analysis of differences and similarities between the two cases in the response of several variables is left for future research.[15]

4.6 The Role of Nominal Rigidities

The large differences (quantitative and qualitative) in the response to a money-financed fiscal stimulus between the classical and New Keynesian environments are likely due to the presence of nominal rigidities in the latter. But the existence of those rigidities is not the only difference across models. In particular, the version of the New Keynesian model analyzed above allows for endogenous capital accumulation as well as monetary non-neutralities resulting from the non-separability of real balances in the utility function. In order to assess the importance of nominal rigidities in accounting for the different results I analyze a version of the New Keynesian model developed above, with the modified settings $\theta_p = \theta_w = 0.001$, as an approximation to an environment with fully flexible prices and wages.

Key statistics regarding the response to a fiscal stimulus under the modified calibration can be found in the third panel of Tables 2 and 3. While the predictions differ slightly from those of the classical economy, they are

[15] See also Ascari and Rankin (2013) for an analysis of the dependence of the effects of a fiscal stimulus on the monetary policy rule in place, in a model with overlapping generations and sticky prices.

qualitatively very similar. In particular, the impact on output is very small, independently of the financing scheme, while the effect on inflation is very large (and heavily frontloaded) in the case of money financing. Such findings confirm the critical role played by the presence of nominal rigidities in accounting for the huge difference in the predicted effects of a money-financed fiscal stimulus between the classical and New Keynesian models of Sections 3 and 4, respectively.

4.7 An Extension with non-Ricardian Households

Some recent empirical research on the effects of government spending, typically using vector autoregressive methods, has uncovered a positive response of consumption in response to an identified exogenous increase in government purchases.[16] Galí, López-Salido and Vallés (2007; GLV, henceforth) have argued that such empirical finding is generally at odds with the predictions of conventional macro models, classical or New Keynesian, that are built on the assumption of a financially unconstrained, infinitely-lived representative household. They show, however, that an extension of the New Keynesian model that allows for a (sufficiently large) fraction of non-Ricardian households, i.e. household that do not have access to financial markets and just consume their labor income, can account for the observed consumption response.

In the present subsection I revisit the analysis of the effects of a money-financed fiscal stimulus using an extension of the New Keynesian model that allows for a fraction of non-Ricardian households. Following GLV I assume the presence of two types of households in the economy. The preferences of both are identical and given by (27)-(29). The main difference between the two types lies in their unequal access to financial markets. The first type, referred to as Ricardian and representing a fraction of $1-\lambda$ of all households, have access to three different assets: money, one-period nominally riskless bonds and productive capital. Their budget constraints and behavior thus correspond to those of the representative household of the standard New Keynesian model above.

In addition to Ricardian households, I assume the existence of a second type, accounting for a fraction λ of all households. They do not have access to financial markets and can only use monetary holdings to transfer resources

[16] Add references

intertemporally. For simplicity I assume they are not taxed. I refer to those households as *Keynesian*. Their period budget constraint is given by:

$$P_t C_t^K + M_t^K = M_{t-1}^K + \int_0^1 W_t(z) N_t^K(z) dz$$

where employment, N_t^K, determined by firms, is also taken as given. Details regarding the optimality conditions of the Keynesian households can be found in the Appendix.

Wage setting proceeds as in the model of the previous section, with nominal wages reset in a staggered fashion by unions representing workers specialized in different types of labor. The only difference is that among a given union's members, both Ricardian and Keynesian types are represented, in the same proportions as in the economy as a whole. The objective function for a union resetting the nominal wage of its members is thus:

$$\max_{W_t^*} \sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \left\{ \left((1-\lambda)U_{c,t+k}^R + \lambda U_{c,t+k}^K\right) \frac{W_t^*}{P_{t+k}} N_{t+k|t} - \frac{N_{t+k|t}^{1+\varphi}}{1+\varphi} \right\}$$

subject to (30), and where the superscript R or K denotes the household type The previous objective function recognizes that the marginal utilities of both types of households will generally differ. Note, however, that no distinction is made regarding employment across types of households, in other words, it is assumed that $N_{t+k|t}^K = N_{t+k|t}^R$ for all t, k. which is assumed to depend only on the wage (in other words, firms are blind to the type of household a worker belongs to when making its hiring decisions). In the Appendix I derive the wage inflation equation generated by the modified wage setting problem.

Firms' optimization problem is not affected by the presence of two types of households. The log-linearized equilibrium conditions of the extended model can be found in the Appendix.

Parameter λ, denoting the share of Keynesian consumers, is set to 0.5, a value suggested by earlier empirical evidence. The remaining parameters are kept at their baseline values.[17]The bottom panel of Tables 2 and 3 show some summary statistics regarding the effects of a money-financed and debt-financed fiscal stimulus in that model.

[17]See, e.g. Campbell and Mankiw

The effects of a money-financed fiscal stimulus on output and inflation (as well as on most other macro variables) appear not be affected by the presence of non-Ricardian households. This is the case even though the response of consumption and real balance holdings differs across the two types (not shown). In other words, the presence of a fraction of non-Ricardian households does not alter the conclusions regarding the large multipliers and relatively mild and spread-out over time impact on inflation of that fiscal intervention.

That invariance result no longer holds in the case of a debt-financed fiscal stimulus. Thus, under a Taylor rule, the presence of Keynesian consumers enhances the impact of that fiscal intervention on output: the multiplier is now greater than one and the effect on aggregate consumption positive (not shown), but that impact on activity remains well below the one observed under monetary financing.[18] The counterpart to the larger effect on activity is a stronger effect on inflation.

The presence of Keynesian consumers also amplifies the impact of the debt-financed stimulus under the IT regime, though the differential effect seems rather small, with the multiplier remaining close to zero due to the strong crowding out of consumption

Overall, I conclude that the potential presence of a significant share of non-Ricardian households does not alter the basic qualitative findings obtained above regarding the effects of a money-financed fiscal stimulus.

4.8 Welfare

Next I briefly discuss the likely impact on welfare of the fiscal stimulus analyzed above. In doing so I restrict myself to first order effects and, for simplicity, I assume that real balances have a negligible weight in utility, relative to consumption or employment.

In a neighborhood of the steady state, the household's period utility can

[18] That "amplification" effect of the presence non-Ricardian households under a Taylor is precisely the one emphasized in the GLV paper.

be approximated to a first order by:

$$
\begin{aligned}
\widehat{U}_t &= U_c C \widehat{c}_t + U_n N \widehat{n}_t + U_m (M/P) \widehat{l}_t \\
&= U_c C \left[\widehat{c}_t - MRS \left(\frac{N}{C} \right) \widehat{n}_t + \frac{U_m}{U_c} \left(\frac{M/P}{C} \right) \widehat{l}_t \right] \\
&= U_c C \left[\widehat{c}_t - \left(\frac{MRS}{MPN} \right) \left(\frac{1-\alpha}{\gamma_c} \right) \widehat{n}_t + \left(\frac{1-\beta}{V_c} \right) \widehat{l}_t \right] \\
&= U_c C \left[\widehat{c}_t - \left(\frac{1-\alpha}{\mathcal{M}\gamma_c} \right) \widehat{n}_t + \left(\frac{1-\beta}{V_c} \right) \widehat{l}_t \right]
\end{aligned}
$$

where $\mathcal{M} \equiv \mathcal{M}_p \mathcal{M}_w$ is the steady state "composite" gross markup. Thus the change in period utility in response to a fiscal stimulus corresponding to one percent of steady state output, and measured as a fraction of steady state consumption is given by:

$$
\frac{\partial \widehat{\mathbb{U}}_{t+k}}{\partial \varepsilon_t^g} = \frac{\partial \widehat{c}_{t+k}}{\partial \varepsilon_t^g} - \left(\frac{1-\alpha}{\mathcal{M}\gamma_c} \right) \frac{\partial \widehat{n}_{t+k}}{\partial \varepsilon_t^g} + \left(\frac{1-\beta}{V_c} \right) \frac{\partial \widehat{l}_{t+k}}{\partial \varepsilon_t^g} \tag{49}
$$

As discussed above, in the classical economy the response of utility to a fiscal stimulus is unambiguously negative, independently of the financing method, given that $\partial \widehat{c}_{t+k}/\partial \varepsilon_t^g < 0$, $\partial \widehat{n}_{t+k}/\partial \varepsilon_t^g > 0$ and $\partial \widehat{l}_{t+k}/\partial \varepsilon_t^g < 0$, for $k = 0, 1, 2, ...$holds in all cases. But this is not necessarily the case in the New Keynesian model. This is illustrated in Figure 9, which displays the dynamic response of period utility, expressed in percent consumption equivalent terms, under the baseline calibration of that model and for the three regimes considered above. As the Figure makes clear (and could have been anticipated from looking at the sign of the responses of consumption, employment and the nominal rate in Figure 3), the impact on welfare is unambiguously negative at all horizons under the two debt-financing regimes. But, in the case of a money-financed fiscal stimulus the impact on welfare is positive at all horizons, despite the wasteful nature of government purchases. This is due to the positive effect of both the consumption and real balance components in (49) more than offsetting the adverse effect of higher employment.

5 Concluding Remarks

In the present paper I have analyzed the effects of an increase in government purchases financed entirely through seignorage, in both a classical and a New

Keynesian framework, and compare them with those resulting from a more conventional debt-financed stimulus.

A key finding from my analysis lies in the importance of nominal rigidities in shaping the effects of a money-financed fiscal stimulus. In the presence of fully flexible prices and wages, such a fiscal intervention has a very small effect on economic activity, and a huge, heavily frontloaded impact on inflation. The effect on welfare is unambiguously negative. By contrast, in a model economy allowing for a realistic calibration of such rigidities, a money-financed fiscal stimulus has very strong effects on economic activity, with relatively mild inflationary consequences. The large multipliers implied by such an intervention contrast with the much smaller ones generally found in the literature, associated with a more conventional fiscal stimulus, financed by the issuance of debt, in an environment in which the central bank follows a simple inflation-based interest rate rule. Furthermore, if output is sufficiently below its efficient level, a money-financed fiscal stimulus may raise welfare even if based on purely wasteful government spending.

APPENDIX

A.1. The New Keynesian Model: Optimality and Equilibrium Conditions

The household's optimality conditions are:

$$1 = (1 + i_t)E_t \left\{\Lambda_{t,t+1}(P_t/P_{t+1})\right\}$$

$$M_t/P_t = (\vartheta/(1-\vartheta))^{\frac{1}{\upsilon}}\, C_t(1+1/i_t)^{\frac{1}{\upsilon}}$$

$$Q_t = E_t \left\{\Lambda_{t,t+1}[(R^k_{t+1}/P_{t+1}) + Q_{t+1}\left((1-\delta) + \phi_{t+1} - (I_t/K_t)\,\phi'_{t+1}\right)]\right\}$$

$$Q_t = 1/\phi'\,(I_t/K_t)$$

where $\Lambda_{t,t+1} \equiv \beta\,(C_{t+1}/C_t)^{-\upsilon}\,(X_{t+1}/X_t)^{\upsilon-\sigma}$, Q_t is the (real) shadow value of installed capital in place (i.e. Tobin's Q). Under the assumptions made on function ϕ, the elasticity of the investment-capital ratio with respect to Q is given by $-1/\phi''(\delta)\delta \equiv \varsigma$.

Note that in the steady state $Q_t = 1$, $i = \rho \equiv \beta^{-1} - 1$ and income velocity is given by

$$V \equiv \frac{Y}{M/P} = \frac{Y}{C}\left(\frac{(1-\vartheta)(1-\beta)}{\vartheta}\right)^{\frac{1}{\upsilon}}$$

The optimality condition for the union's wage setting problem is given by:

$$\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t\left\{U_{c,t+k}\,N_{t+k|t}\left(\frac{W_t^*}{P_{t+k}} - \mathcal{M}_w MRS_{t+k|t}\right)\right\} = 0 \qquad (50)$$

where $MRS_{t+k|t} \equiv (X_{t+k}/C_{t+k})^{\sigma-\upsilon}C_t^{\sigma}N_{t+k|t}^{\varphi}/(1-\vartheta)$ is the relevant marginal rate of substitution in period $t+k$ between household consumption and employment, for workers whose wage has been last set in period t, and $\mathcal{M}_w \equiv \epsilon_w/(\epsilon_w - 1)$. Log-linearization of (50) around the zero inflation steady state yields the approximate optimal wage setting rule

$$w_t^* = \mu^w + (1-\beta\theta_w)\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t\left\{mrs_{t+k|t} + p_{t+k}\right\} \qquad (51)$$

where $w_t^* \equiv \log W_t^*$, $\mu^w \equiv \log \mathcal{M}_w$, and $mrs_{t+k|t} \equiv \sigma c_{t+k} + \varphi n_{t+k|t} + \varpi i_{t+k}$, where $\varpi \equiv (1 - \frac{\sigma}{\upsilon})\beta/(V_c + (1-\beta))$ with $V_c \equiv ((1-\vartheta)(1-\beta)/\vartheta)^{\frac{1}{\upsilon}}$ denoting consumption velocity.

Define the average (log) marginal rate of substitution as $mrs_t \equiv \sigma c_t + \varphi n_t + \varpi i_t$ where $n_t \equiv \int_0^1 n_t(z)dz$ is (log) aggregate employment. Combining (51) with the (approximate) difference equation describing the evolution of the (log) average nominal wage, given by

$$w_t = \theta_w w_{t-1} + (1-\theta_w)w_t^* \tag{52}$$

one can derive the wage inflation equation:

$$\pi_t^w = \beta E_t\{\pi_{t+1}^w\} - \lambda_w(\mu_t^w - \mu^w) \tag{53}$$

where $\pi_t^w \equiv w_t - w_{t-1}$ denotes wage inflation, $\mu_t^w \equiv w_t - p_t - mrs_t$ is the average wage markup, and $\lambda_w \equiv \frac{(1-\theta_w)(1-\beta\theta_w)}{\theta_w(1+\epsilon_w\varphi)}$.

Final goods firms maximize profits taking as given the final goods price P_t and the prices for the intermediate goods $P_t(j)$, all $j \in [0,1]$. This yields the set of demand schedules

$$X_t(j) = (P_t(j)/P_t)^{-\epsilon_p} Y_t$$

as well as the zero profit condition $P_t = \left(\int_0^1 P_t(j)^{1-\epsilon_p}dj\right)^{\frac{1}{1-\epsilon_p}}$.

Cost minimization by intermediate goods firms, taking the wage and the rental cost of capital as given, implies:

$$N_t(z) = (W_t(z)/W_t)^{-\epsilon_w} N_t$$

$$K_t(j)/N_t(j) = (\alpha/(1-\alpha))\left(W_t/R_t^k\right)$$

Marginal cost is common to all firms and given by

$$\Psi_t = \frac{W_t}{(1-\alpha)(K_t/N_t)^\alpha}$$

The first order condition for the intermediate firm's problem is:

$$\sum_{k=0}^{\infty} \theta_p^k E_t\left\{\Lambda_{t,t+k}(1/P_{t+k})Y_{t+k|t}\left(P_t^* - \mathcal{M}_p\Psi_{t+k}\right)\right\} = 0 \tag{54}$$

where $\mathcal{M}_p \equiv \epsilon_p/(\epsilon_p - 1)$. Log-linearization of the previous price setting condition around a zero inflation state yields:

$$p_t^* = \mu^p + \sum_{k=0}^{\infty}(\beta\theta_p)^k E_t\{\psi_{t+k}\} \tag{55}$$

where $p_t^* \equiv \log P_t^*$, $\psi_t \equiv \log \Psi_t$, and $\mu^p \equiv \log \mathcal{M}_p$. Combining (55) with the equation describing the evolution of the (log) aggregate price level

$$p_t = \theta_p p_{t-1} + (1-\theta_p) p_t^*$$

yields the price inflation equation

$$\pi_t^p = \beta E_t\{\pi_{t+1}^p\} - \lambda_p(\mu_t^p - \mu^p)$$

where $\pi_t^p \equiv p_t - p_{t-1}$ denotes price inflation, $\mu_t^p \equiv p_t - \psi_t$ is the average price markup, and $\lambda_p \equiv (1-\theta_p)(1-\beta\theta_p)/\theta_p$.

Equilibrium in the goods market requires:

$$Y_t = C_t + I_t + G_t$$

which can be written in log-linearized form as:

$$\widehat{y}_t = (1-\gamma_i-\gamma_g)\widehat{c}_t + \gamma_i \widehat{\imath}_t + \widehat{g}_t$$

where $\widehat{\imath}_t \equiv \log(I_t/I)$ and $\gamma_i \equiv \frac{\alpha\delta}{\mathcal{M}_p(\rho+\delta)}$ is the steady state investment share.

A.2. The New Keynesian Model with non-Ricardian Households: Optimality and Equilibrium Conditions

The optimality condition for Keynesian consumers takes the form

$$M_t^K/P_t = (\vartheta/(1-\vartheta))^{\frac{1}{\upsilon}}\, C_t^K\, \left(1 - E_t\{\Lambda_{t,t+1}^K(P_t/P_{t+1})\}\right)^{-\frac{1}{\upsilon}}$$

where $\Lambda_{t,t+1}^K \equiv \beta\left(C_{t+1}^K/C_t^K\right)^{-\upsilon}\left(X_{t+1}^K/X_t^K\right)^{\upsilon-\sigma}$. Note that in the steady state velocity will be the same across household types, i.e. $V^R = V^K = V$.

Log-linearizing the optimality condition an the budget constraint of Keynesian consumers (and ignoring constant terms):

$$l_t^K \equiv m_t^K - p_t = c_t^K - \eta(\sigma E_t\{\Delta c_{t+1}^K\} + E_t\{\pi_{t+1}\}) + \varpi E_t\{\Delta l_{t+1}^K - \Delta c_{t+1}^K\}$$

$$c_t^K = w_t - p_t + n_t^K - (1/V_c)\Delta m_t^K$$

The optimality condition for the union's problem can be written as follows (after invoking symmetry, and thus dropping the z index)

$$\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t \left\{ N_{t+k|t} \left(\frac{W_t^*}{P_{t+k}} - \mathcal{M}_w \left(\frac{\lambda}{MRS_{t+k|t}^K} + \frac{1-\lambda}{MRS_{t+k,t}^R} \right)^{-1} \right) \right\} = 0$$

where $MRS_t^j \equiv (1-\vartheta)^{-1}(C_t^j)^{\upsilon}(N_t^j)^{\varphi}(X_t^j)^{\sigma-\upsilon}$, for $j = R, K$, and $\mathcal{M}^w \equiv \frac{\epsilon_w}{\epsilon_w - 1}$.

Log-linearizing the previous expression and assuming that $C^K = C^R$ holds in the steady state yields the approximate wage-setting rule:

$$w_t^* = \mu^w + (1-\beta\theta_w)\sum_{k=0}^{\infty}(\beta\theta_w)^k E_t \left\{ mrs_{t+k|t} + p_{t+k} \right\}$$

where $\mu^w \equiv \log \mathcal{M}^w$ and $mrs_{t+k|t} \equiv \sigma(\lambda c_{t+k}^K + (1-\lambda)c_{t+k}^R) + \varphi n_{t+k|t} + \varpi i_{t+k}$. The previous condition can be combined with the labor demand schedule and (52) to obtain a wage inflation equation identical to (53) but with $mrs_t \equiv \sigma(\lambda c_t^K + (1-\lambda)c_t^R) + \varphi n_t + \varpi i_t$

Note that the firm's objective function will now be given by

$$\max_{P_t^*} \; E_t \sum_{k=0}^{\infty} \theta^k E_t \left\{ \Lambda_{t,t+k}^R (1/P_{t+k}) Y_{t+k|t} \left(P_t^* - \Psi_{t+k} \right) \right\}$$

i.e. will use the Ricardian households' stochastic discount factor. That modification does not affect, however, the resulting log-linearized price-setting equation (55).

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Table 1. Baseline Calibration

	Description	*Value*
Classical Model		
φ	Curvature of labor disutility	5
β	Discount factor	0.99
η	Interest rate semi-elasticity of money demand	4
V	Velocity (quarterly)	4
γ	Government spending share	1/5
ρ_g	Fiscal stimulus persistence	0.5
b^H	Steady state debt ratio (quarterly)	2.4
ϕ_π	Taylor rule coefficient	1.5
NK Model (additional)		
α	Decreasing returns to labor	1/4
δ	Depreciation rate	0.025
ς	q-elasticity of investment	0.1
ϵ_w	Elasticity of substitution (labor)	4.5
ϵ_p	Elasticity of substitution (goods)	6
θ_p	Index of price rigidities	3/4
θ_w	Index of wage rigidities	3/4

Table 2. The Effects of Money-Financed Government Spending ($\rho_g = 0.5$)											
	Output			**Inflation**			**Tradeoff**			**Debt Ratio**	
Horizon	0	4	12	0	4	12	0	4	12	12	12ADJ
Classical											
M-financing	**0.2**	**0.01**	**0**	**29.6**	**0.02**	**0**	**0.03**	**0.05**	**0.05**	**−4.3**	–
Taylor	0.2	0.01	0	2.1	0.1	0	0.38	0.38	0.38	0.7	–
IT	0.2	0.01	0	0	0	0	∞	∞	∞	1.1	–
New Keynesian											
M-financing	**4.5**	**2.6**	**0.9**	**3.8**	**2.2**	**0.7**	**4.7**	**4.7**	**4.7**	**−3.3**	–
Taylor	0.92	0.05	0	0.2	0	0	19.7	20.8	21.5	0.5	2.6
IT	0.03	0.01	0	0	0	0	∞	∞	∞	1.3	195
NK-Flexible											
M-financing	0.15	0.01	0	30.1	0	0	0.02	0.03	0.03	−4.4	–
Taylor	0.15	0.01	0	2.1	0.1	0	0.27	0.27	0.26	0.8	0.8
IT	0.15	0.01	0	0	0	0	∞	∞	∞	1.2	1.2
NK-GLV											
M-financing	4.5	2.6	0.9	3.8	2.2	0.7	4.7	4.7	4.7	−3.4	–
Taylor	1.33	0.13	0	0.45	0.02	0	11.7	13.1	14.1	0.5	1.7
IT	0.04	0.01	0	0	0	0	∞	∞	∞	2.1	236

Table 3. The Effects of Money-Financed Government Spending ($\rho_g = 0.9$)											
	Output			Inflation			Tradeoff			Debt Ratio	
Horizon	0	4	12	0	4	12	0	4	12	12	$12ADJ$
Classical											
M-financing	0.2	0.12	0.04	58.9	6.4	2.4	0.01	0.03	0.05	−9.7	–
Taylor	0.2	0.12	0.04	0.7	0.4	0.2	1.07	1.07	1.07	2.2	–
IT	0.2	0.12	0.04	0	0	0	∞	∞	∞	2.4	–
New Keynesian											
M-financing	8.0	6.6	3.6	11.8	8.7	4.3	2.7	2.8	3.1	−5.8	–
Taylor	0.58	0.36	0.14	0.45	0.26	0.10	5.1	5.3	5.6	2.1	28.6
IT	0.03	0.07	0.03	0	0	0	∞	∞	∞	2.6	587
NK-Flexible											
M-financing	0.11	0.06	0.02	59.9	6.3	2.4	0.01	0.02	0.02	−9.7	–
Taylor	0.16	0.10	0.03	0.9	0.6	0.2	0.67	0.66	0.64	2.3	1.6
IT	0.16	0.10	0.03	0	0	0	∞	∞	∞	2.5	1.7
NK-GLV											
M-financing	8.1	6.6	3.7	11.8	8.7	4.3	2.7	2.8	3.1	−5.9	–
Taylor	0.93	0.62	0.23	0.84	0.51	0.18	4.4	4.7	4.8	2.2	19.1
IT	0.07	0.03	0	0	0	0	∞	∞	∞	3.3	381

Figure 1. The Effects of a Money-Financed Fiscal Stimulus in the Classical Economy

Baseline Calibration

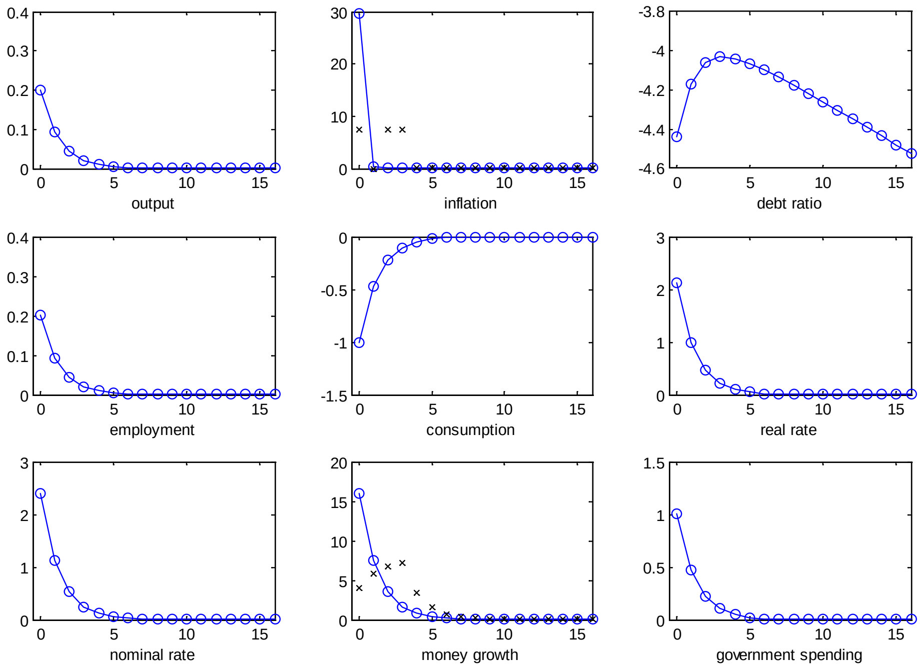

Figure 2. The Effects of a Money-Financed Fiscal Stimulus in the Classical Economy

Dynamic Multiplier and Tradeoff Ratio

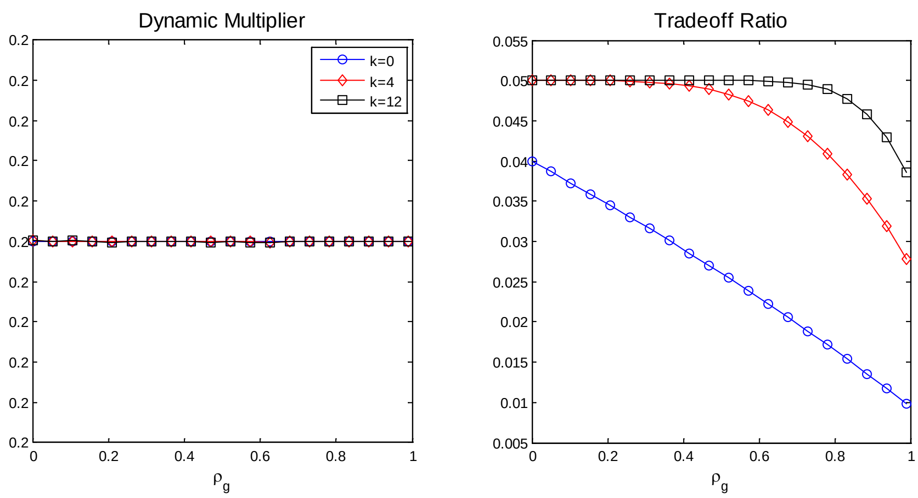

Figure 3. The Effects of a Fiscal Stimulus in the Classical Economy

Money vs. Debt Financing

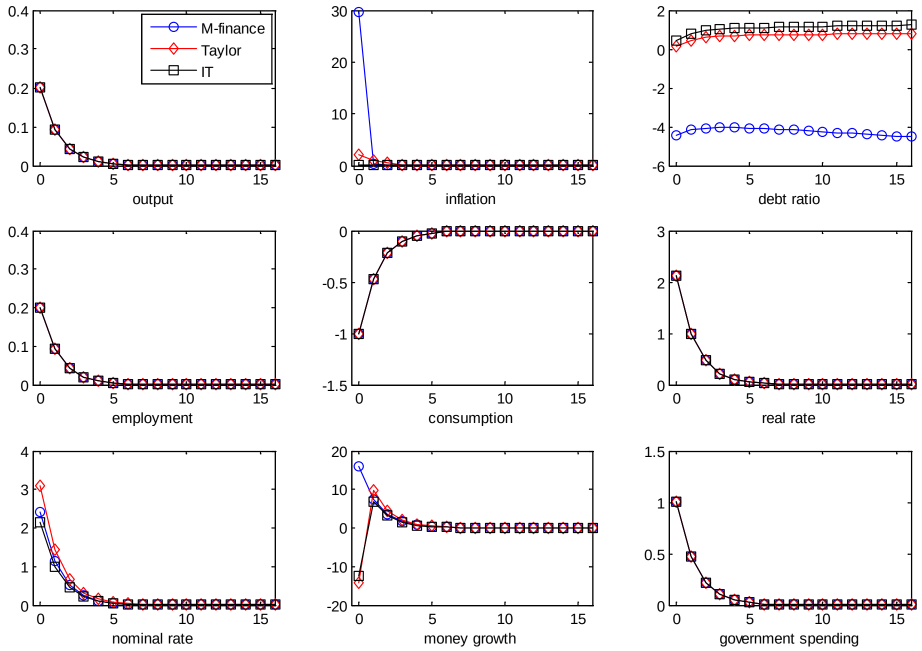

Figure 4. The Effects of a Fiscal Stimulus in the Classical Economy

Money vs. Debt Financing: Dynamic Multiplier and Tradeoff Ratio

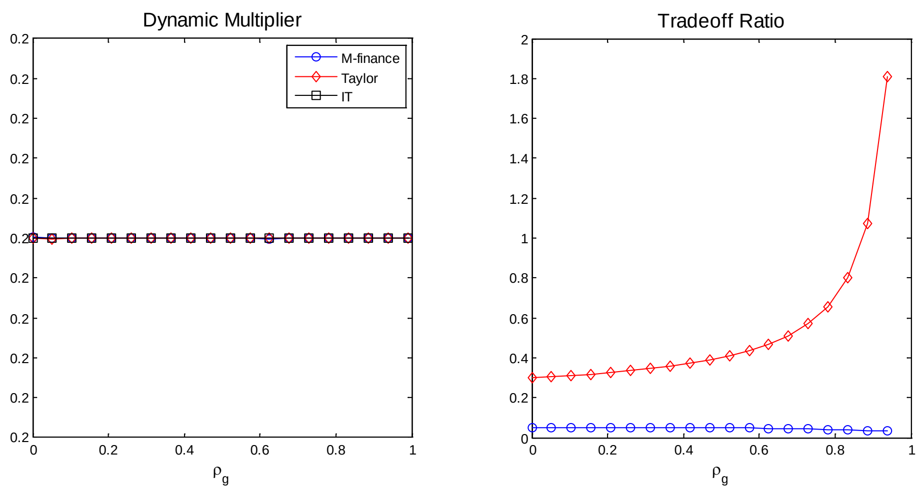

Figure 5. The Effects of a Money-Financed Fiscal Stimulus in the New Keynesian Economy

Baseline Calibration

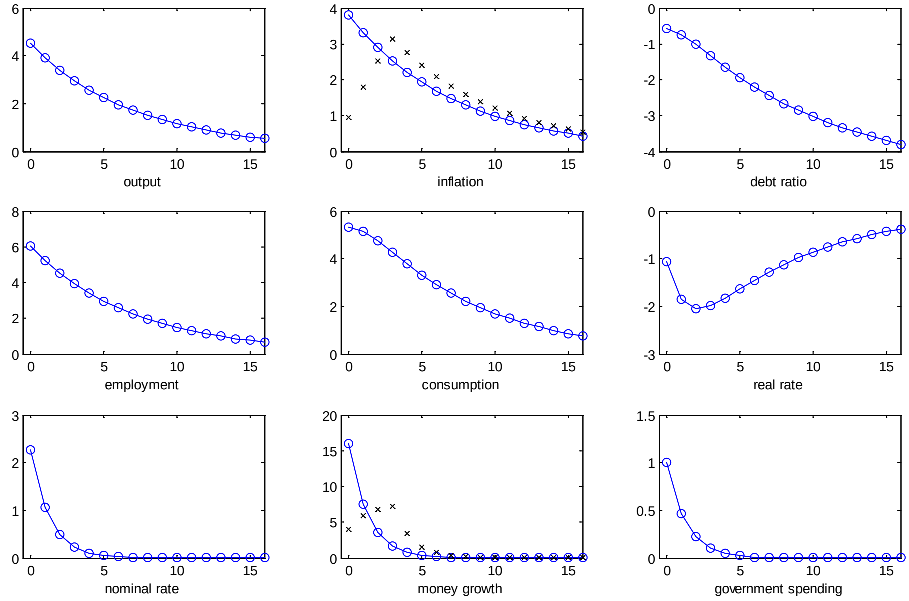

Figure 6. The Effects of a Money-Financed Fiscal Stimulus in the New Keynesian Economy

Multiplier and Tradeoff Ratio: Baseline Calibration

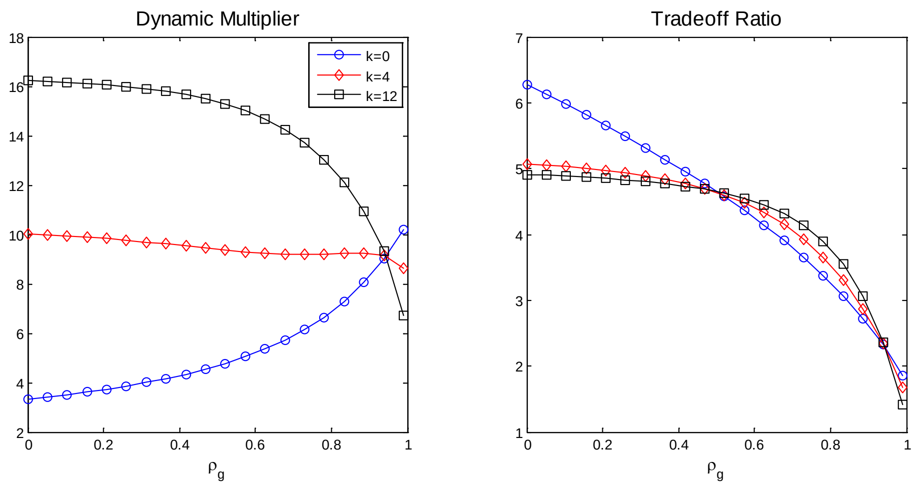

Figure 7. The Effects of a Fiscal Stimulus in the New Keynesian Economy

Money vs. Debt Financing

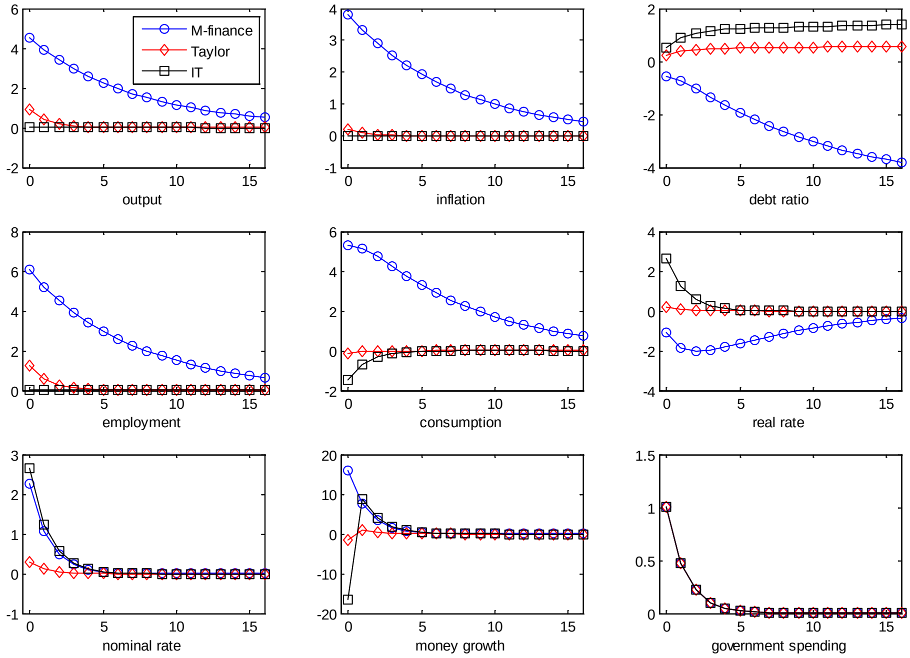

Figure 8. The Effects of a Fiscal Stimulus in the New Keynesian Economy

Money vs. Debt Financing: Multiplier and Tradeoff Ratio (k=4)

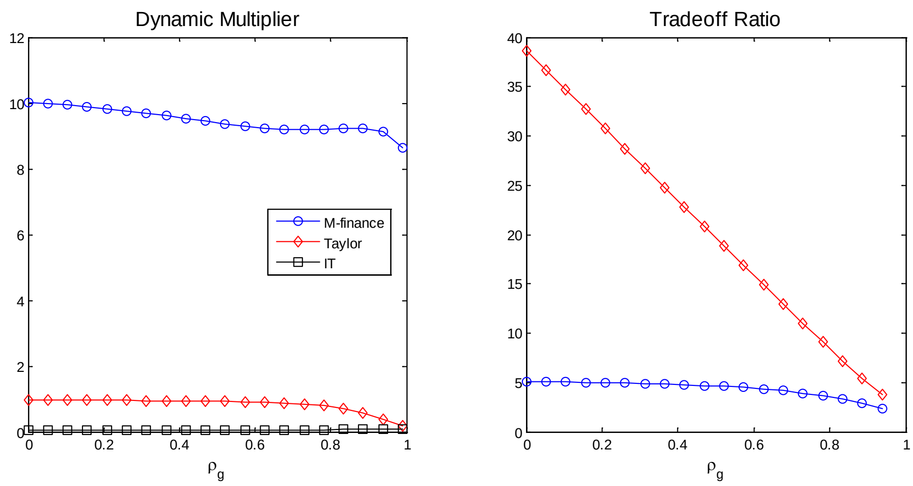

Figure 9. The Effects of a Fiscal Stimulus in the New Keynesian Economy

Money vs. Debt Financing: The Effects on Welfare