Government Spending Multipliers and Imperfect Asset Substitution*

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Abstract

There has been a renewed interest in the ability of fiscal policy to play an active role in stabilizing economies since the Great Recession. We illustrate in a tractable New Keynesian model that imperfect asset substitutability in the bond market can serve as an important channel for fiscal policy away from the effective lower bound on interest rates. Specifically, in the presence of imperfect asset substitution, government spending shocks can generate a positive consumption multiplier if the fiscal authority finances the shock by issuing bonds of a relatively shorter maturity. This channel works through the imperfect pass-through from short- to long-term bonds, inducing fluctuations in the interest rate spread. This spread is shown to have a substantial impact on consumption decisions. Policy-wise, this implies that the Treasury can play an active role in economic stabilization, an idea commonly relegated to monetary policy, by actively managing the maturity structure of its debt portfolio.

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1 Introduction

The US Financial Crisis of 2007-2008 and the aftermath that followed have sparked a renewed interested in the stabilization abilities of fiscal policy. This is particularly important in light of the possibility of positive consumption multipliers (i.e. Blanchard and Perotti, 2002; Fatás and Mihov, 2001; Ramey, 2011). However, the standard, negative wealth effect caused by fiscal spending shocks in small-scale DSGE models has continued to be a wedge between empiricists and theorists addressing the "what" and "why" of fiscal multipliers. Attempts to square the empirical results within the standard theoretical framework have led to a myriad of mechanisms, most of which add a lot of complication with little explanatory power.

Methods of getting around the Baxter and King (1993) wealth effect have typically come in two forms.[1] The first focuses on the use of nominal or real frictions. These can be wage frictions, which keep wage rates from falling while labor hours rise (i.e. Dupor, Li and Li, 2017). This causes an increase in labor income upon impact, pushing consumption up with it. These frictions can also take the form of incomplete asset markets *a la* Galí, López-Salido and Vallés (2007). As fiscal spending increases, the negative wealth effect only applies to the fraction of unconstrained households. With a large enough fraction of hand-to-mouth households, spending shocks have a net-positive effect on consumption. The second area of focus lies in utility function manipulation (i.e. Monacelli and Perotti, 2008; Zubairy, 2014; Ganelli and Tervala, 2009, and others). While there are many variations of these mechanisms, they generally manipulate the internal substitution preferences of the household, i.e. substitution between private and public consumption or the consumption-leisure tradeoff. These modeling techniques, however, can quickly run into sensitivity, tractability, and versatility issues and are often difficult to reliably calibrate.

We propose a more versatile, frictions-based mechanism that exploits the imperfect substitutability of long- and short-term bonds. Specifically, our results show that this mechanism yields positive consumption multipliers in a tractable manner that is easy to implement in small-scale DSGE models and is flexible so as to match many of the empirical dynamics. The success of this approach comes from disrupting the standard negative wealth effect via the imperfect pass through of interest rates along the term structure. Fiscal spending financed with short-term debt increases the relative supply of short-term bonds, which causes short rates to rise, but long rates to fall. The exploitation of the interest rate spread drives aggregate demand, providing a flexible channel through which fiscal policy propagates.

Why develop a new approach when there are many other serviceable mechanisms that can produce the desired dynamics? First, this mechanism incorporates the tractability of the Ganelli and Tervala (2009) channel, but does not rely on utility function manipulation. Second, the existence of imperfect substitutability between assets is also well-documented (D'Amico and King, 2013), making it a more intuitive channel for these purposes. When considering the

[1]In addition to these two general areas of interest, there is a strand of literature which considers fiscal policy at the effective lower bound (ELB) on interest rates. While this is a valid and important string of literature, this paper focuses on these mechanisms away from the ELB.

dynamics of fiscal multipliers specifically, the more in-depth mechanisms are quite useful. For those using these models for tangential purposes, these other channels can quickly add more cost without much benefit.

We then explore the plausibility and sensitivity of the mechanism. First, we estimate the model to show that the parameter value needed to achieve a positive consumption multiplier is well-within the empirically-likely range. Second, we consider the relationship between the degree of imperfect-substitutability and the present-value multiplier, showing that the consumption multiplier is quite persistent. Finally, we consider a variety of policy stances for robustness, showing that the mechanism is dependent upon the maturity structure of fiscal debt financing, but is rather robust to changes in the stance of monetary policy. Together, these aspects make this mechanism flexible, yet reliable and robust.

Our results are appealing for four primary reasons. First, the mechanism is easily implemented in small-scale models – requiring as few as one additional first order condition above the simplest of New Keynesian (NK) models. Second, it is tractable enough to be reduced to one equation. Third, it is flexible enough to match any desired empirical dynamics with just one parameter, but can also be easily calibrated/estimated to match the data. Finally, while there are multiple modeling techniques that can be used (i.e. Woodford, 2001; Andrés *et al.*, 2004), even the simplest of them (i.e. Falagiarda, 2014) achieves the same qualitative results. Combined, these factors make for a very useful mechanism across many fields of macroeconomics.

One interesting policy implication draws on the principles outlined by Greenwood, Hanson, Rudolph and Summers (2015): that fiscal policy can regulate the impact of its own spending shocks through the maturity structure of its debt portfolio. That is, we show that the impact of fiscal spending can depend critically on the maturity of the debt used to finance it. Spending financed with short-term debt is more expansionary than that financed with long-term debt. In fact, we show that simply shifting outstanding debt across maturities can have business cycle implications via the term structure. This implies that, the Treasury can play an active role in economic stabilization. Provided that the average maturity of federal debt outstanding has steadily increased since the Financial Crisis, this is particularly relevant in today's policy environment.

Our paper builds-upon and connects multiple literature streams. Specifically, it contributes a novel channel to the fiscal multiplier literature (see Leeper, Traum and Walker, 2017, for a thorough analysis) that matches the tractability of the simplest of existing mechanisms without making sensitive assumptions about the makeup of households or their utility functions. It does so by borrowing a commonly used mechanism from the quantitative easing literature (Falagiarda, 2014; Harrison, 2012, and others) and the imperfect-asset-substitution models of Andrés *et al.* (2004); Woodford (2001) and others. Connecting these vast literatures, while also providing the theoretical underpinning of a channel in which fiscal policy can be actively involved in the stabilization of the economy, makes this paper useful in both the macroeconomic and policy realms.

The rest of the paper is organized as follows: Section 2 describes the theoretical model; Section 3 presents the mechanism in a linear, tractable manner; Section 4 details the Bayesian estimation procedure; Section 5 outlines the resulting transmission of fiscal shocks; Section 6 reports the implied fiscal multipliers; Section 7 serves as a robustness check to the benchmark assumptions; Section 8 considers some policy implications; and Section 9 concludes.

2 A DSGE Model With Imperfect Asset Substitution

The core of this analysis begins with a small scale NK model. That is, there is one representative household, a perfectly competitive final good market, a continuum of monopolistically-competitive intermediate firms and authorities representing the fiscal and monetary sides of policy, respectively. The households maximize a simple consumption-leisure utility function subject to a budget constraint. Likewise, the firms at each level maximize profits subject to their respective production functions and budget constraints. Most models attempting to emulate a positive consumption multiplier (Galí *et al.*, 2007; Leeper *et al.*, 2017, for example) require some combination of extreme nominal rigidities, habit formation at the household level, a complementarity between fiscal and household consumption, and a portion of non-Ricardian households. Outside of a level of price rigidity consistent with the broader literature, none of these elements are assumed. Thus the foundation of this analysis is rooted within a simple, standard framework.

To this, we incorporate a longer-term bond market which acts as an imperfect substitute for the standard, one-period bond. As a baseline, we model it as a two-period bond with a secondary market *a la* Falagiarda (2014). Households purchase these long-term bonds and resell them in the next period at the going price for one-period bonds. This type of mechanism is the simplest to implement; though other, more rigorous modeling assumptions (i.e. Woodford, 2001; Andrés *et al.*, 2004; Harrison, 2012) do not qualitatively change the results. The imperfect pass-through from short- to long-term interest rates generated by the resulting term structure leads to a situation where fiscal spending shocks can compel households to consume more in the short-run.

2.1 Representative Household

An infinitely-lived, representative agent gains utility by choosing consumption bundle C_t, and labor hours N_t according to the utility function

$$u\left(C_t, N_t\right) = \frac{C_t^{1-\gamma}}{1-\gamma} - \chi \frac{N_t^{1+\varphi}}{1+\varphi}$$

where $\chi > 0$, $\gamma > 0$ is the coefficient of risk aversion, and $\varphi \geq 0$ is the inverse of the Frisch elasticity of labor supply. The representative household thus maximizes life-time utility

$$U_t = E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, N_t).$$

with $\beta \in (0, 1)$ as the discount factor. Incorporating a secondary market for bond trading as in Ljungqvist and Sargent (2004), the household's budget constraint is given by equation (1) where P_t is the aggregate price level in the economy.

$$\frac{B_t}{P_t R_t} + \frac{B_{L,t}}{P_t R_{L,t}}(1+\rho_t) + T_t \leq \frac{B_{t-1}}{P_t} + \frac{B_{L,t-1}}{P_t R_t} + \frac{W_t}{P_t}N_t - C_t - \frac{D_t}{P_t} \tag{1}$$

The household allocates wealth between two zero-coupon bonds which differ in maturity. These short- and long-term bonds, denoted B_t and $B_{L,t}$, respectively, yield gross nominal rates R_t and $R_{L,t}$.

In particular, the right-hand side of the household budget shows that outstanding long-term bonds are priced with short-term rates, that is, the agent carries over long term bonds purchased at time $t-1$ and sells it on the secondary market at the rate $1/R_t$.[2] However, at time $t-1$, an agent who buys long-term bonds and intends to sell them in period t faces price uncertainty as R_t is not known at time $t-1$.[3] This formulation of the budget constraint to incorporate secondary market allows for a straightforward modeling of assets of different maturities. Moreover, intuitively captures the active secondary markets seen in the U.S.

As mentioned earlier, imperfect asset substitution is introduced in the model through a portfolio adjustment cost similar to that described by Andrés *et al.* (2004), Falagiarda and Marzo (2012), Harrison (2012), Falagiarda (2014), and Francois (2016). Specifically, it is assumed that intratemporal trading between government bonds of different maturities is costly to agents. This means agents pay a cost whenever they shift the portfolio allocation between short and long-term bonds. The endogenous cost function is then modeled as:

$$\rho_t = \frac{\phi_L}{2}\left(\kappa_L \frac{B_t}{B_{L,t}} - 1\right)^2 Y_t$$

where $\phi_L > 0$ and $\kappa_L = B_L/B$ is the inverse of steady state household holding of short-term to long-term bonds. This implies that ρ_t is zero at steady state. The financial friction term is a simply, tractable mechanism for modeling imperfect substitutability between long and short term bonds.

2.2 Optimality Conditions

The first order conditions for the optimizing consumer's problem is given as:

$$C_t^{-\gamma} = \lambda_t \tag{2}$$

[2] Preliminary results in an ongoing project suggest that the results of this model do not qualitatively change with modeling variations (i.e Andrés *et al.*, 2004; Woodford, 2001).

[3] As explained by Ljungqvist and Sargent (2004) the price R_t follows from a simple arbitrage argument: in period t, the existing long-term bonds and the newly issued one-period bonds represent identical sure claims to consumption goods at the time of maturity. See also Falagiarda (2014) for a similar formulation of long-term bonds.

$$\chi N_t^{\varphi} = \lambda_t \left(\frac{W_t}{P_t}\right) \tag{3}$$

$$\beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t \pi_{t+1}}\right] = \frac{1}{R_t} + \frac{\kappa_L \phi_L}{R_{L,t}}\left(\kappa_L \frac{b_t}{b_{L,t}} - 1\right) Y_t \tag{4}$$

$$\beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t \pi_{t+1} R_{t+1}}\right] = \frac{1}{R_{L,t}} + \frac{\phi_L}{2R_{L,t}}\left(\kappa_L \frac{b_t}{b_{L,t}} - 1\right)^2 Y_t - \frac{\phi_L \kappa_L b_t}{R_{L,t} b_{L,t}}\left(\kappa_L \frac{b_t}{b_{L,t}} - 1\right) Y_t \tag{5}$$

While equations (2) and (3) are standard to the literature, equations (4) and (5) are the Euler equations for short- and long-term bond holdings respectively. Combined, these two equations reveal a term structure relationship linking long- and short-term rates.[4]

2.3 Production

Final Goods A final goods producing firm purchases intermediate inputs at nominal price $P_t(i)$ and produces the final composite good using the following constant returns to scale $Y_t = (\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di)^{\frac{\varepsilon}{\varepsilon-1}}$ where $\varepsilon > 0$ is the elasticity of substitution between goods. Profit-maximization by the final goods producing firm yields a demand for each intermediate good given by

$$Y_t(i) = \frac{P_t(i)}{P_t}^{-\varepsilon} Y_t$$

Intermediate Goods Monopolistically competitive intermediate goods producing firm i chooses price $P_t(i)$ to maximize the expected present value of profits:

$$E_t \sum_{j=0}^{\infty} \beta^j Q_{t+j} \frac{D_{t+j}(i)}{P_{t+j}}$$

where $Q_{t+j} = \frac{\lambda_{t+j}}{\lambda_t}$ is the household's stochastic discount factor, $D_t(i)$ are nominal profits for firm i and P_t is the nominal aggregate price level in the economy. These firms are also subject to a Rotemberg (1982) quadratic cost of price adjustment.[5] Real profits are therefore given by,

$$\frac{D_{t+j}(i)}{P_{t+j}} = \left(\frac{P_{t+j}(i)}{P_{t+j}}\right)^{1-\varepsilon} Y_{t+j} - \Psi_{t+j}(i)\left(\frac{P_{t+j}(i)}{P_{t+j}}\right)^{-\varepsilon} Y_{t+j} - \frac{\psi}{2}\left(\frac{P_{t+j}(i)}{\bar{\pi} P_{t+j-1}} - 1\right)^2 Y_{t+j}$$

[4] Similar results can be found in Andrés *et al.* (2004), Marzo *et al.* (2009) and Falagiarda (2014)

[5] In its log-linearized form, the choice of introducing price stickiness–either through Calvo pricing or Rotemberg pricing– is innocuous.

where $\psi \geq 0$ governs adjustment costs and $\Psi_t(i)$ is real marginal cost. Since the production technology remains consistent across these firms, they make identical decisions, yielding a symmetric first order condition:

$$0 = (1-\varepsilon) + \varepsilon\Psi_t - \psi\left(\frac{\pi_t}{\pi} - 1\right)\frac{\pi_t}{\pi} + \psi E_t\left[Q_{t+1}\left(\frac{\pi_{t+1}}{\pi} - 1\right)\frac{\pi_{t+1}}{\pi}\frac{Y_{t+1}}{Y_t}\right]$$

2.4 The Government

Government expenditure is financed by lump-sum taxes on the household and the issuance of short- and/or long-term bonds. Thus the government budget constraint is given as

$$\frac{B_t}{P_t R_t} + \frac{B_{L,t}}{P_t R_{L,t}} + T_t = \frac{B_{t-1}}{P_t} + \frac{B_{L,t}}{P_t R_t} + G_t \tag{6}$$

Government expenditure G_t is set according to the AR(1) process:

$$\log\left(\frac{G_t}{G}\right) = \phi_G \log\left(\frac{G_{t-1}}{G}\right) + \varepsilon_t^G \tag{7}$$

where $\phi_G \in (0,1)$ and ε_t^G is an i.i.d shock with zero mean and standard deviation σ_G

Lump sum taxes T_t are a function of the total outstanding government liabilities:

$$\log\left(\frac{T_t}{T}\right) = \xi_1 \log\left(\frac{b_{t-1}}{b}\right) + \xi_2 \log\left(\frac{b_{L,t-1}}{b_L}\right) \tag{8}$$

where T is the steady-state lump sum tax and the policy parameters ξ_1 and ξ_2 are initially assumed equal so taxes respond to both short and long-term debt.

Finally, the central bank conducts monetary policy with a Taylor (1993)-style rule augmented to include interest rate smoothing:

$$\log\left(\frac{R_t}{R}\right) = \rho_R \log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_R)\left[\rho_\pi \log\left(\frac{\pi_t}{\pi}\right) + \rho_Y \log\left(\frac{Y_t}{Y}\right)\right] + \varepsilon_t^R$$

The exogenous policy shifter in monetary policy, ε_t^R is assumed to be a white noise monetary policy disturbance.

The issuance of new long-term bonds responds to lagged long-term debt and government spending.

$$\log\left(\frac{b_{L,t}}{b}\right) = \rho_{L,b} \log\left(\frac{b_{L,t-1}}{b_L}\right) + \rho_g \log\left(\frac{G_t}{G}\right) + \varepsilon_t^{bL}$$

In the baseline estimation, ρ_g is restricted to zero so that new expenditures do not affect new issuance of long-term debt. This strong assumption provides a baseline from which to assess this mechanism. The robustness analysis in section 7.3 lifts this assumption to examine the role of long-term debt as an additional financing option alongside taxes and short term debt.

2.5 Resource Constraint

With the introduction of endogenous financial cost frictions, aggregate output of the economy is not simply allocated to consumption, government expenditure and price adjustment costs but also to a portfolio adjustment cost term. Thus the model is closed by a resource constraint given as:

$$Y_t = C_t + G_t + \frac{B_{L,t}}{P_t R_{L,t}}\rho_t - \frac{\psi}{2}\left(\frac{\pi_t}{\pi} - 1\right)^2 Y_t$$

3 Analyzing the Fiscal Channel

Below, we derive a very tractable fiscal policy channel from the model. To do so, we first log-linearize the model around its steady state. Then we derive the term structure of the interest rates and the relationship between household consumption and said term structure. Finally, we combine the two relationships to extract the direct relationship between the debt portfolio of the fiscal authority and household consumption. This channel not only implies that positive consumption multipliers are easily obtained in small-scale models, but also that the fiscal authority can directly influence the impact of its own fiscal shocks – making them positive or negative.

3.1 The Term Structure

Log-linearization of (4) provides a simple term structure of the interest rates.[6]

$$\tilde{R}_{L,t} = \tilde{R}_t + E_t\tilde{R}_{t+1} + \phi_L(\kappa_L\beta + 1)(\tilde{b}_{L,t} - \tilde{b}_t) \tag{9}$$

Under perfect substitutability ($\phi_L = 0$), the long rate would simply be a combination of the current and future short rates – the first two terms on the right side. In this case, long-term rates have no additional impact on the dynamics of the model. This is what commonly leads many to dispense with long-term bonds altogether. Allowing $\phi_L > 0$ generates a term premium determined by the relative supply of long- and short-term bonds, providing an additional channel for long-term rates.

There are two primary motivations/explanations for a term premium of this nature. First, the term premium can be determined by the bond supply relative to demand. Since equilibrium dynamics imply that demand for such securities must absorb the full amount supplied, any increase in the supply of long-term bonds must come with a yield increase to foster demand.[7] In relative terms, this same argument also suggests that increasing the supply of short-term

[6] As is standard, tildes represent a variable's log-deviation from its steady state value.

[7] Though not modeled specifically, a change in the relative size of short- and long-term bond markets could also be viewed as an adjustment to the markets' relative liquidity, which is a common component of term premiums. Increasing the size of the short-term bond market would, therefore, be shown as a reduction in the relative liquidity of long-term bonds forcing a compensatory increase in long-term rates.

bonds would force the interest rate spread, or the "term spread", $(R_{L,t} - R_t)$ to fall. Second, term premiums also account for relative risk. The household's budget constraint (1) allows for a secondary market in long-term bonds, which are sold at the new short-term rate. Thus, the level of exposure to the long-term bond market (determined by its supply) dictates how much interest rate risk the household is subjected to. A greater exposure to long-term bonds requires increased long-term rates to compensate for this risk. Whether its a basic supply-demand or a compensation for risk, both of these motivations should generate the dynamics seen in this term premium.

3.2 Rate Spreads and Consumption

To see how these long-term rates influence the consumption decision, consider the linearization of Equation (5):

$$\tilde{C}_t = \zeta_0 \tilde{R}_t - \zeta_1(\tilde{R}_{L,t} - \tilde{R}_t) + h(\tilde{C}_{t+1}, \tilde{\pi}_{t+1}, \tilde{R}_{t+1}), \tag{10}$$

where $\zeta_0 = -\frac{1}{\gamma} < 0$ and $\zeta_1 = \frac{\beta}{\gamma(\pi+\beta\kappa_L)} > 0$. All else held constant, raising the short R_t or the long $R_{L,t}$ rate will cause consumption to fall. However, the expression above shows that the term spread also plays a prominent role.[8] This is the imperfect pass-through discussed by Estrella and Mishkin (1997) where, in the event of a rise in the policy/short rate, a lagged effect on the longer rates can impede the impact of monetary policy. Holding the long-term rate constant, a sudden increase in the short rate should have a direct, negative effect on consumption, but the reduction in the term spread will have the opposite effect. While there are other variables to consider, such as expected inflation and future short rates, the direct impact of the term spread will outweigh that of the short rate so long as $\kappa_L > -\pi/\beta$. Simply assuming that the households do not borrow from the government, $B_t, B_{L,t} \geq 0$ for all t, satisfies this requirement. This suggests that the spread between the interest rates may be more important than their absolute levels.

3.3 Maturity Structure and Consumption

Lastly, combining equations (9) and (10) and assuming the steady-state inflation rate π to be unity,

$$\tilde{C}_t = \zeta_0 \tilde{R}_t - \zeta_1 E_t \tilde{R}_{t+1} + \frac{\phi_L \beta}{\gamma}(\tilde{b}_t - \tilde{b}_{L,t}) + h(\tilde{C}_{t+1}, \tilde{\pi}_{t+1}, \tilde{R}_{t+1}) \tag{11}$$

shows that fiscal spending influences consumption through the maturity structure of its debt portfolio. That is, financing an increase in government spending with short-term bonds – shortening the maturity of consolidated public debt – causes consumption to rise. On the other hand, financing via long-term bonds increases the term spread and drives consumption spending down. The magnitude of this mechanism increases with the degree of imperfect substitutability, ϕ_L.

[8] The existence of a direct connection between term spreads and consumption is not a new concept. Bernanke (1990) and Estrella and Mishkin (1997) both find that the spread between long-term bonds and policy rates have strong predictive power when forecasting consumption.

This maturity structure result is consistent with discussions by Greenwood *et al.* (2015) as well as the results of Leeper *et al.* (2017), which find that multipliers decrease as the maturity length of government debt is increased. Thus the financing choice for an increase in government spending is crucial in either offsetting or reinforcing the standard negative wealth effect generated by a rise in government spending.

4 Estimation

Though small-scale models are not typically estimated, the imperfect substitutability of the long- and short-term bonds is too obscure to calibrate with any degree of confidence. Thus, estimation of the model will allow the data to choose the proper parameter values. By log-linearizing the nonlinear set of equations presented in section 2 around a non-stochastic steady state, the model can be expressed as

$$s_t = F(\Omega)s_{t-1} + P(\Omega)\varepsilon_t, \tag{12}$$

where s_t represents the variables in the model, the matrices F and P are functions of Ω, the model's structural parameters and finally, ε_t is a vector of te structural shocks of the model.

4.1 Data and Estimation Strategy

With the term spread dictating the impact of fiscal shocks, the long-term interest rate becomes the variable of focus. Hence, in addition to traditional macroeconomic variables usually employed in estimation, the long-term interest rate is included as an observable. Using quarterly data from 1955Q1 to 2016Q4 the estimation is carried out employing the following observables, $[R_t \; R_{L,t} \; \pi_t]$ where R_t, $R_{L,t}$ and π_t represent the federal funds rate, the 5-year constant maturity rate, and price inflation respectively. The 5-year constant maturity rate is used to match the average maturity of outstanding US bonds. Details on time series construction are provided in Appendix B.

The number of structural shocks are equal to the number of observables used for the estimation. Hence, measurement errors are not included in the specified measurement equation connecting the selected observables to the model variable. The dynamic system in equations (12), along with the measurement equations, are estimated using Bayesian methods to construct the parameters' posterior distributions from the prior distributions and the likelihood function computed via the Kalman filter.

150,000 draws are taken from the multivariate normal posterior distribution $N(0, c\Sigma)$ using the Metopolis Hastings algorithm. The scaling factor c is fixed such that the acceptance ratio is 32.8.[9] However, for inference purposes the first 50,000 draws are used as a burn-in period to ensure that there is no dependence on the initial values. Several post-estimation convergence

[9]This value lies between the accepted interval of 20 to 40 percent.

tests are carried out to determine chain convergence including cumulative sum of the draws (CUSUM) plots, trace plots and correlation plots.[10]

4.2 Calibrated Parmeters, Priors, and Estimation Results

A subset of parameters and steady state values in the model are calibrated in a standard way and model implied. The discount factor, β is set at $1.04^{-1/4}$ implying a steady-state nominal short-term interest rate of 4%. The coefficient of risk aversion is set to unity so that utility over consumption is logarithmic. As a benchmark, the parameter $\rho_{L,g}$ is set to zero, isolating the effect of shortening the average maturity of outstanding debt.[11] Fixing the goods elasticity of substitution ϵ at 6 sets the steady state markup of price over marginal cost at 20%.[12] Steady state labor hours, $\bar{n}$ is set to 1/3. As in Falagiarda (2014) steady state values of short-term debt to GDP ratio is set to 18% while long-term debt to GDP ratio is set to 30%. Finally, the aggregate constant technology A is set such that is normalizes steady state output to unity.

Table 1 presents the priors, which are set to be consistent to values employed in Bayesian estimation of models in Leeper *et al.* (2017) and Zubairy (2014). Since the primary interest is in the portfolio adjustment cost parameter ϕ_L, its prior is set close to zero so that the prior on the model itself is perfect asset substitution. This helps ascertain whether the data reveals significant imperfect asset substitution in the bond market.

The last column of the Table 1 reports the mean and 90 percent credible intervals for the estimated parameters. Generally the estimated parameters are consistent with those in the literature. The estimate of the portfolio adjustment cost parameter ϕ_L reveals there is some degree of imperfect asset substitution in the bond market and it is within the stipulated interval 0.1 to 0.01 usually used in the literature.

5 Transmission of Fiscal Shocks

This section presents the effects of the two fiscal shocks: i) a spending shock and ii) a shock to the supply of long-term bonds, via impulse response functions derived from the estimated model described in Section 4. As a benchmark, it is assumed that the debt financing of new government spending is purely short-term ($\rho_{L,g} = 0$). Restricting the government's portfolio in this fashion isolates the mechanism, making the initial results and any extensions more tractable. This and other assumptions are relaxed in Section 7.

[10] Available upon request.

[11] In section 7.3 a sensitivity analysis is conducted on this parameter to explore deviations from the baseline model.

[12] See Ireland (2004, 2014) for examples of this calibration.

Table 1: Estimated Parameters

Parameter	Description	Prior			Posterior	
		Dist.	Mean	SE	Mean	[5th, 95th]
φ	labor elast. of sub	G	2	0.5	1.85	[1.13, 2.53]
ϕ_L	Portfolio Adj. Cost	N	0.001	0.05	0.0849	[0.069, 0.101]
ψ	Price Adj. Cost	N	25	5	28.18	[18.32, 37.58]
ρ_R	int. rate smoothing	B	0.5	0.20	0.83	[0.80, 0.85]
ρ_π	π_t coef.: monetary rule	N	1.6	0.20	1.72	[1.52, 1.91]
ρ_Y	y_t coef.: monetary rule	N	0.125	0.05	0.09	[0.01, 0.17]
ξ_1	Response of T_t to long-term debt	G	0.5	0.30	0.68	[0.62, 0.75]
ξ_2	Response of T_t to short-term deb	G	0.5	0.30	0.23	[0.14, 0.33]
ϕ_G	Autocorr. of g_t	B	0.5	0.20	0.75	[0.71, 0.80]
$\rho_{L,b}$	Autocorr. of $b_{L,t}$	B	0.5	0.20	0.96	[0.94, 0.97]
σ_g	Std. Dev. of ε_t^g	IG	1	0.1	0.019	[0.016, 0.022]
σ_l	Std. Dev. of ε_t^L	IG	1	0.1	0.005	[0.004, 0.006]
σ_r	Std. Dev. of ε_t^r	IG	1	0.1	0.002	[0.002, 0.003]

Notes: Notational definition for the distribution are as follows, B denotes Beta; G denotes Gamma; N denotes Normal and IG denotes Inverse Gamma. The last column represents 90 percent credible sets. The log-posterior density at the mode is given as -4349.17 and the acceptance ratio is 31.70%

5.1 Government Spending Shock

Figure 1 depicts the relative responses for selected variables to a one percent government spending shock. The solid (blue) lines represent the posterior mean responses while the dashed (black) lines denote the 90 percentile credible bands. As is expected of demand shocks in the real business cycle literature, output and inflation rise. Contrary to these models, consumption increases due to the presence of an imperfect substitute for short term bonds. As was shown in the analysis of the model (Section 3), the transmission mechanism of this shock is dependent on the term premium attached to the long-term interest rate. The term premium in this model is a function of the relative bond supply ($B_t/B_{L,t}$), which rises under the short-term financing restriction. This pushes the long-term rates down even as the short-term rates are rising. The reduction in the term spread is expansionary, offsetting the traditional wealth effect that would cause consumption to contract.

As was explained in Section 2, the model abstracts from some commonly-used features in order to isolate the impact of this mechanism. In particular, the absence of habit formation at the household level eliminates the traditional "hump-shaped" responses of the variables to shocks. While adding a degree of superficial habits to the utility function does increase its persistence, it comes at the expense of the magnitude of the impact. Allowing for deep habits, as in Zubairy (2010), could maintain the magnitude of impact and gain persistence simultaneously.

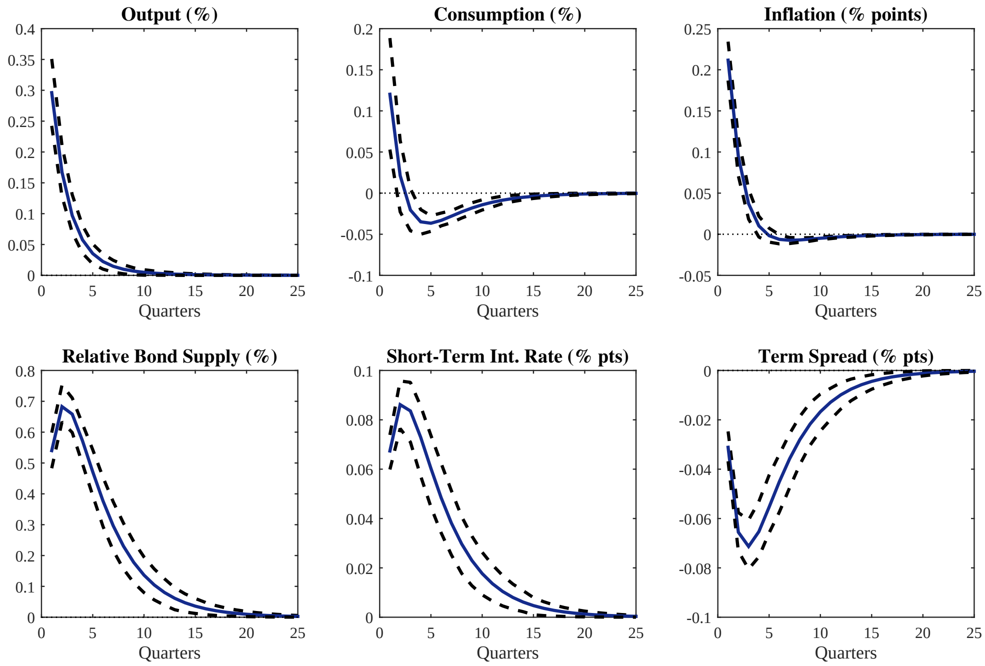

Figure 1: Shock to government spending

Note: Figures depict relative impulse responses to a one percent government spending shock ε_t^G. Dashed lines represent 90 percent credible bands. This fiscal shock is restricted to financing with short-term bonds and lump sum taxes. All values represent deviation from simulated steady state.

5.2 Long-Term Bond Supply Shock

Figure 2 shows the response of the same selected variables to an increase in the supply of long-term bonds. Since spending has not changed, this can be interpreted simply as a lengthening of the maturity structure of outstanding fiscal debt. As can be seen in Equations (9) and (11), an increase in the relative supply of long-term bonds will raise long-term rates. Though short-term rates actually fall due to active monetary policy, the increase in the term spread is contractionary; causing output, consumption, and the inflation rate to fall. With this in mind, it is fairly intuitive that any value of $\rho_{L,g} > 0$ would diminish the magnitude of the multiplier seen in Figure 1. This result is similar to that of Leeper *et al.* (2017) and the literature explored therein, finding that a longer maturity structure reduces the probability of a positive consumption multiplier.[13] Further exploration of this is done in Section 7.

[13]Leeper *et al.* (2017) do find that a longer maturity structure increases the persistence of the multiplier over longer horizons. This result seems to be dependent on their restriction that long-term bonds be held to maturity, and is therefore not captured in this model.

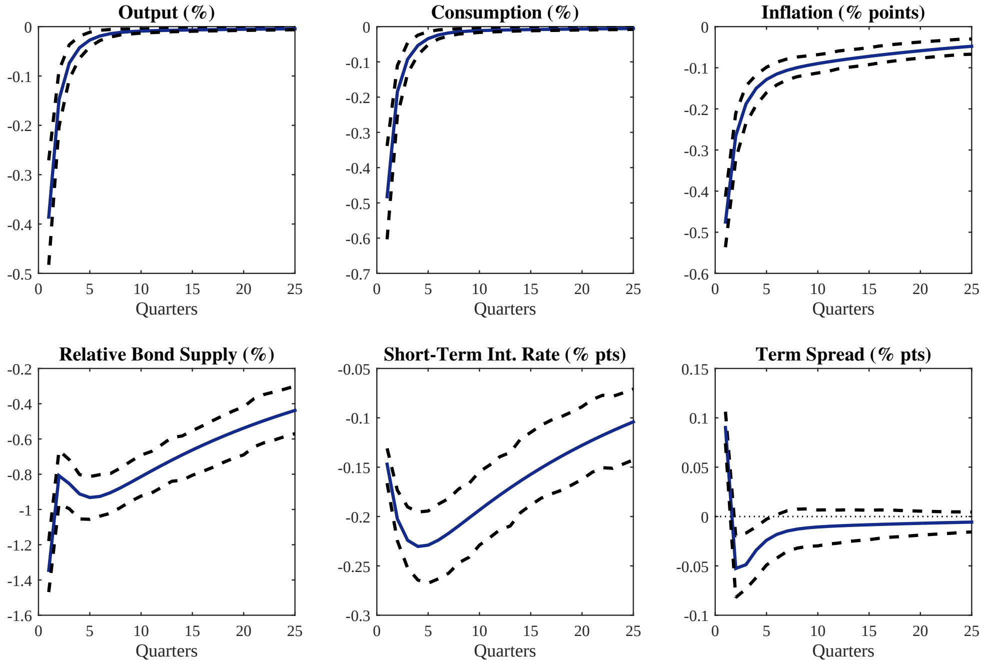

Figure 2: Shock to the supply of long-term bonds

Note: Figures depict relative impulse responses to a one percent shock to the supply of long-term bonds ε_t^{bL}. Dashed lines represent 90 percent credible bands. All values represent deviation from each simulation steady state.

6 Estimated Multipliers

Generally, empirical studies quantify the effect of exogenous changes in government spending report the impact multiplier as:

$$\text{Impact Multiplier}(j) = \frac{\Delta Y_{t+j}}{\Delta G_t},$$

which is defined as the increase in the level of output j periods ahead ΔY_{t+j} in response to an increase in government spending equal to size ΔG_t at time t. Though informative, it precludes the future path of government spending and hence the cumulative effects of the shock. Here this effect is captured a la Mountford and Uhlig (2009) and Zubairy (2014): the present value multiplier.[14]

$$\text{Present Value Multiplier}(j) = \frac{E_t \sum_{k=0}^{j} R^{-k} \Delta Y_{t+k}}{E_t \sum_{k=0}^{j} R^{-k} \Delta G_{t+k}}$$

Table 2 reports the present value multipliers over different horizons, denoted by j. At $j = 1$, the impact and the present value multipliers are equivalent by definition. In general, the output multiplier resulting from a one percent increase in government spending is greater than unity. Since $Y_t = C_t + G_t$ in this model, the consumption multiplier must be positive.[15] As was discussed in Sections 3 and 5, the expansionary reduction in the term spread outweighs the contractionary wealth effect on consumption.

Table 2: Present Value Multipliers for Output and Consumption

	Impact	Quarter 4	Quarter 12	Quarter 25
$\frac{PV\Delta Y_{t+j}}{PV\Delta G_{t+j}}$	1.48 [1.21, 1.75]	1.22 [1.01, 1.42]	1.07 [0.9, 1.22]	1.01 [0.86, 1.14]
$\frac{PV\Delta C_{t+j}}{PV\Delta G_{t+j}}$	0.48 [0.21, 0.75]	0.22 [-0.01, 0.43]	0.07 [-0.17, 0.26]	0.01 [-0.24, 0.21]

Notes: Over a period of j quarters, these measures the present discounted value of the cumulative change in output divided by the present value of the cumulative change in government spending. The reported values are the posterior mean multipliers. 90 percent credible sets are given in the brackets

It is therefore clear that the combination of imperfect asset substitution and the financing choice–short-term debt issuance–helps generate a positive consumption multiplier. The positive consumption multipliers lingers, on average, for over five years, though its statistical significance dissipates around the one-year mark. This matches the general response to a stochastic government shock as empirically found by Blanchard and Perotti (2002).[16] It also matches the general response to a government spending shock in Zubairy (2014), which considers a medium-scale model that include both deep habits and complimentary government consumption. Thus, this simple mechanism, even in a small scale model, delivers similar results to both the empirical literature and the literature considering medium-scale models.[17]

[14]Davig and Leeper (2007) use a different definition; though it usually produces similar results to those found by Mountford and Uhlig (2009) and others.

[15]This follows from $\frac{\Delta C_{t+k}}{\Delta G_t} = \frac{\Delta Y_{t+k}}{\Delta G_t} - 1$, which is derived from the resource constraint mentioned.

[16]Additionally, with a consumption impact multiplier of 0.33, the credible sets contain the empirical results.

[17]It should be noted that Leeper *et al.* (2017) finds much more persistent and statistically significant con-

7 Robustness

This section analyzes the sensitivity of the output multiplier under varying parameter values in a similar fashion to Zubairy (2014). The components considered include the imperfect substitutability of the assets, monetary policy, and fiscal policy's option to finance spending with long-term bonds.

7.1 Sensitivity of Fiscal Multiplier to Imperfect Substitutability

As shown in section 3, the degree of substitutability between the short- and long-term bonds shapes the yield curve and how fiscal policy impacts aggregate demand. This mechanism is governed by ϕ_L, whose posterior mean is estimated to be 0.0849. However, in order to fully understand the mechanism, it is important to explore the model's sensitivity to other values. In this section, ϕ_L is adjusted to consider varying degrees of substitutability, from perfect ($\phi_L = 0$) to even higher levels of imperfect substitutability than the estimate. Figure 3 shows

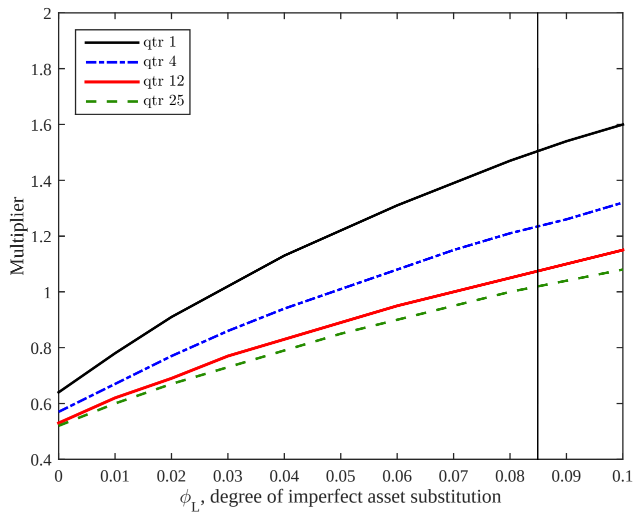

Figure 3: Sensitivity of the Output Multiplier: ϕ_L

Note: The lines in the figure represent the present value output multipliers at the given level of imperfect substitutability. Each line corresponds to a different horizon, with "qtr 1" representing the impact multiplier, for example. The vertical line corresponds to the estimated posterior mean of the parameter.

the present value government spending multiplier for output at the various horizons while varying ϕ_L between 0 and 0.1. In both the short and long-run, the output multiplier is a

sumption multipliers under a corresponding AM/PF regime. In terms of their contribution to these results, the complementarity of government consumption and habit formation are frequently in the top three, regardless of policy regime.

positive and nearly linear function of the degree of imperfect asset substitution. In the case of perfect substitutability, $\phi_L = 0$, the multiplier is well below one and there is little variability in the multiplier over the different horizons considered. This corresponds to traditional small-scale DSGE models, where the relative supply of bonds plays no role in influencing aggregate demand. As can be seen, there is a level of imperfect substitutability ($\phi_L > 0$), that pushes the multiplier above unity at each horizon. This suggests that the degree imperfect substitution has to be sufficiently large enough to generate positive multipliers in both the short and long-term. The estimated value of ϕ_l (denoted by the vertical line) however, generates an output multiplier greater than unity at all horizons.

7.2 Sensitivity of Fiscal Multiplier to Monetary Policy

Leeper *et al.* (2017), following the seminal works of Sargent and Wallace (1981) and Leeper (1991), emphasize the importance of policy interaction when describing the multiplier. If the term spread is the mechanism by which the fiscal channel works, it is important to consider monetary policy, which directly influences its short-term component. In this section, monetary policy's impact on the fiscal multiplier is considered.

Any principles of macroeconomics course considers the *loanable funds market* and the channel through which interest rates rise as the supply of loanable funds is absorbed by increases in government spending. Monetary policy, in effect, shortcuts this process by raising rates in the face of a positive demand shock. Either way, crowding out of investment and consumption is caused by the resulting rise in interest rates. With this in mind, the results in Figure 4 are intuitive. Increasing the smoothing parameter ρ_R (top panel) pushes the monetary authority closer to a constant rate policy, reducing the crowding-out effect and increasing the impact of fiscal policy. Contrastingly, increases in the central bank's response to inflation ρ_π and the output gap ρ_Y (bottom two panels), imply a greater reaction to demand shocks. This forces interest rates to move more dramatically, increasing the crowding-out effect and decreasing the impact of fiscal policy.

7.3 Long-Term Debt as a Financing Option

So far the multiplier has been studied in an environment with only short term debt and taxes as the main financing source of new expenditures. In this section the parameter $\rho_{L,g}$ is allowed to deviate from zero in order to study the impact of long-term debt financing on the size of the multiplier. The long-term bond supply equation is therefore modified to

$$b_{L,t} = \rho_{L,b} b_{L,t-1} + \rho_{L,g} g_t + \epsilon_t^{bL}$$

To appreciate the role of long-term debt financing, the parameter that governs the willingness of fiscal authority to finance spending will long-term bond, $\rho_{L,g}$ is gradually increased from the benchmark case of zero to 0.1.[18]

[18] To the authors' knowledge, there are no direct estimates of this parameter, though a summary of fiscal policy parameters by Coenen *et al.* (2012) suggests that these types of parameters are generally small in nature.

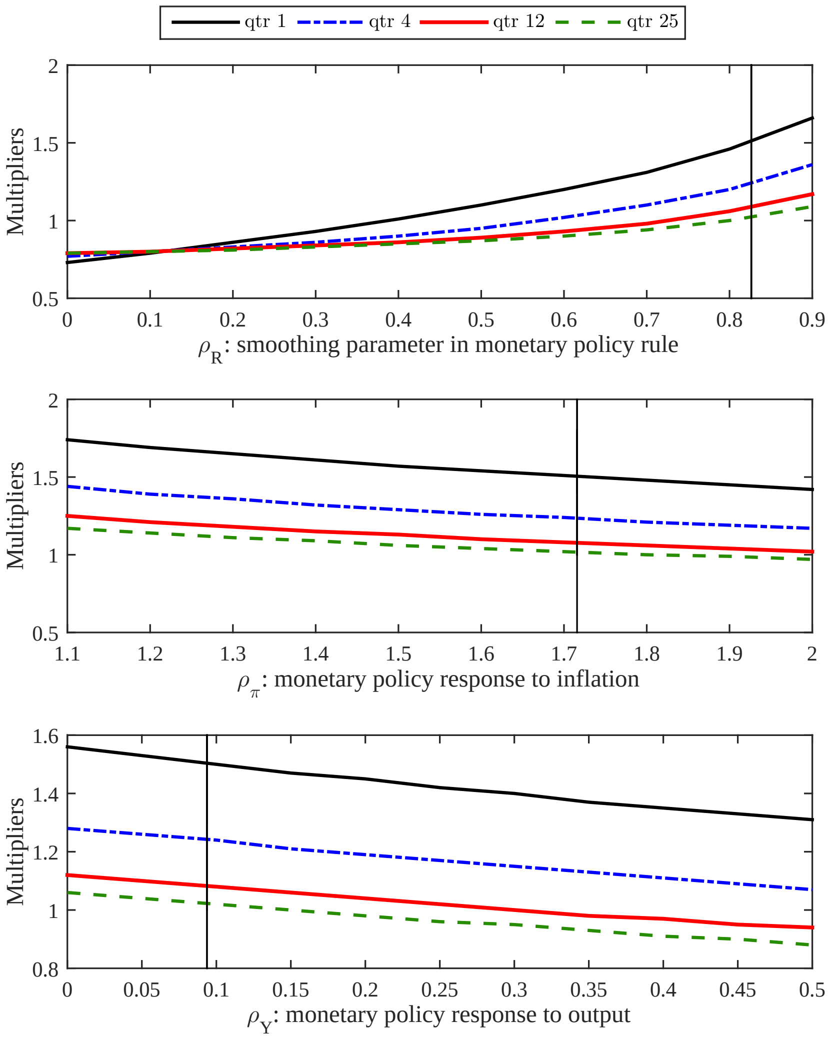

Figure 4: Sensitivity of the Output Multiplier: Monetary Policy

Note: The lines in the figures represent the present value output multipliers at the given level of each respective monetary policy parameter. Each line corresponds to a different horizon, with "qtr 1" representing the impact multiplier, for example. The vertical lines correspond to the estimated posterior means of the parameters. Each panel assumes that the other monetary policy parameters are held at their estimated values.

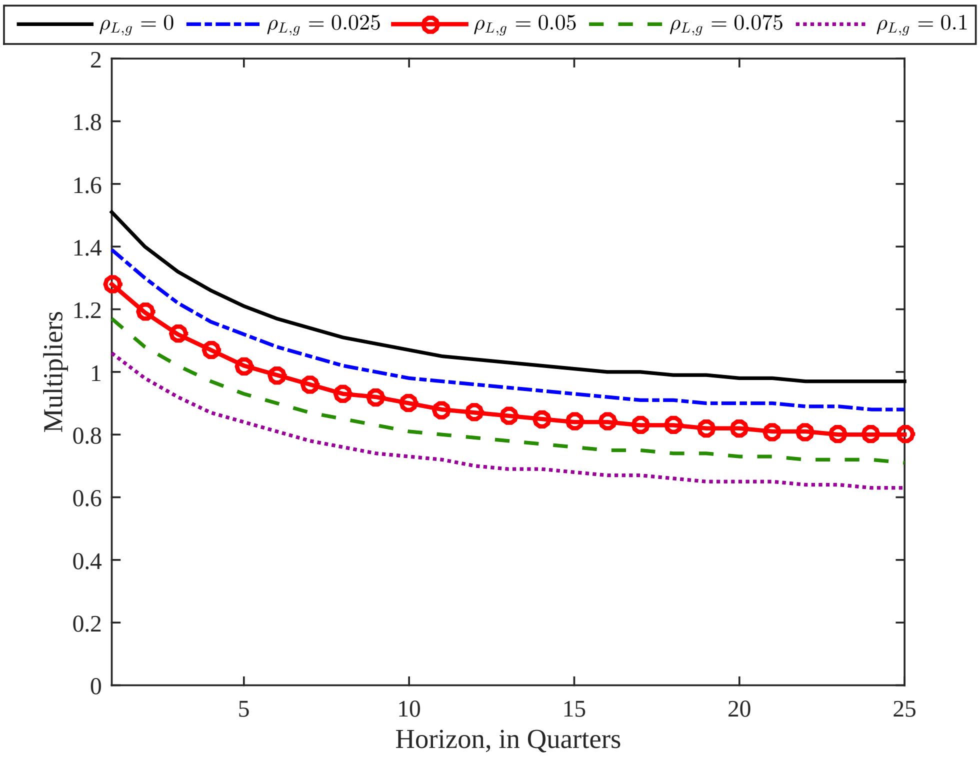

Figure 5: Counterfactual Analysis: Long-term Debt Financing

Note: The lines in the figure represent the present value output multipliers at the given horizon. Each line corresponds to a different degree of long-term bond financing $\rho_{L,g}$.

Figure 5 shows how the multiplier adjusts to variations in $\rho_{L,g}$. It is clear that the output multiplier is at its upper limit when spending is financed from a purely short-term perspective ($\rho_{L,g} = 0$), though there is some room for long-term financing while maintaining at least a positive consumption multiplier on impact. This is intuitive when considering that the increase in long-term bonds impacts the economy in two ways: a) through the term structure, increasing long-term interest rates, and b) through the tax code, potentially increasing the magnitude of the wealth effect. While the former is the focus of this paper, both are consistent with the combined results discussed in Section 5. Allowing for an increase in long-term bonds causes the corresponding interest rate to rise with the short-term rate, reducing/eliminating the term spread effect of fiscal policy. Hence, when government spending is financed by issuing a combination of short- and long-term bonds, the increase in both short and long-term interest rates makes saving more attractive and agents give up consumption for saving.

8 Policy Implications

The results of this model, coupled with the existing literature, suggest that the Department of the Treasury can have an important impact on the stability of the economy away from the effective lower bound on interest rates. We find that fiscal spending shocks are more expansionary when financed with short-term debt, rather than long-term debt. This implies that any fiscal spending intended to be stimulative should be financed with short-term bonds. This would put downward pressure on long-term rates, reducing the term spread and promoting an increase in consumption spending. On the other hand, any increases in fiscal spending that are not intended to be stimulative, such as an increase in defense spending or needed infrastructure investment, could be financed at the long end to reduce the expansionary pressures. This all works through a similar channel exploited by the Federal Reserve through its quantitative easing progams.

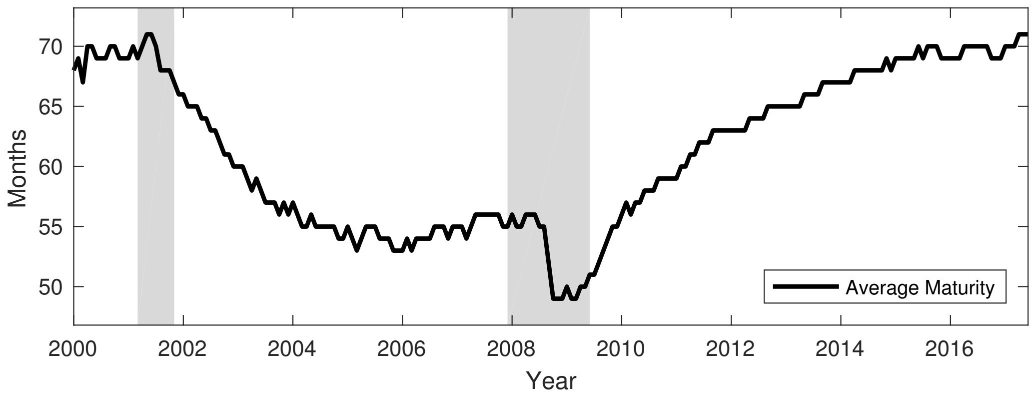

Figure 6: Weighted Average Maturity of Marketable Debt Outstanding

Note: The figure above presents monthly data from January 2000 through June 2017 rounded to the nearest month. Source: Office of Debt Management, US Department of the Treasury.

This leads a particularly poignant view of the fiscal stimulus in the wake of the recession of 2008-2009. Figure 6 presents the weighted average maturity of marketable debt outstanding for the US Treasury. Decreases in this metric imply that the Treasury is issuing more short-term debt, while increases suggest that more long-term bonds are being issued to finance either new spending or repayment of maturing debt. As can be seen, the stimulus spending of the American Recovery and Reinvestment Act (ARRA) of 2009, and subsequent roll-overs, have been primarily through the issuance of long-term bonds. The simple results derived from this model imply that the choice of financing by the US Treasury may have reduced the effectiveness of fiscal stimulus when it was needed most.

9 Conclusion

This paper explores a simple mechanism that delivers the positive consumption multipliers seen in the empirical literature. The theoretical literature typically considers medium-scale DSGE models, which require multiple adjustments and parameter restrictions to produce these results. The most common of these include the need for extreme levels of nominal rigidities, habit formation at the household level, a complementarity between fiscal and household consumption, and a portion of non-Ricardian households. This paper makes one intuitive adjustment to a standard small-scale New Keynesian model: the inclusion of a long-term, imperfect substitute for the traditional short-term bond market. Commonly seen in the monetary policy literature on quantitative easing, the imperfect substitutability provides a channel for fiscal policy to influence household consumption through the term structure of the interest rates. The robust results of this model suggest that the consumption multiplier is more likely to be positive when the fiscal shock is financed primarily through the short-term bond market. This depresses the long-term interest rate, reducing the term spread and the impact of rising short-term rates. From a policy perspective, these results suggest not only that the Department of the Treasury can plan an active role in the stabilization of the economy, but also that the ARRA of 2009 was financed with too much long-term debt, putting upward pressure on the term spread and reducing its stimulative power.

Though the purpose of this paper is to provide a fiscal channel which produces positive consumption multipliers even in small-scale DSGE models, there are many natural extensions to be explored. For instance, future work should introduce heterogenous investors with differing preferences on the maturity structure of their portfolios. This would require the full maturity structure to be modeled (e.g. Woodford, 2001; Andrés *et al.*, 2004) in order to further investigate how these long-term bonds can impact the fiscal multiplier. Additionally, given the plethora of model specifications that can generate imperfect asset substitution (See for instance Andrés *et al.*, 2004; Chen *et al.*, 2012; Falagiarda, 2014; Harrison, 2012; Falagiarda and Marzo, 2012), more work needs to be done to further shed light on the relative impacts of these techniques. While the specification used in this model is preferred for its simplicity and tractability, one can hardly believe that it is optimal for all models and questions.

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A Complete Symmetric Equilibrium Conditions

All equations are log-linearized.

$$\tilde{R}_{L,t} = \tilde{R}_t + E_t\tilde{R}_{t+1} - \phi_L(\kappa_L\beta + 1)(\tilde{b}_t - \tilde{b}_{L,t}) \tag{A.1}$$

$$\gamma(\tilde{c}_{t+1} - \tilde{c}_t) = \tilde{R}_t - \tilde{\pi}_{t+1} - \phi_L\kappa_L\beta(\tilde{b}_t - \tilde{b}_{L,t}) \tag{A.2}$$

$$\tilde{w}_t = \varphi\tilde{n}_t + \gamma\tilde{c}_t \tag{A.3}$$

$$\tilde{y}_t = \tilde{n}_t \tag{A.4}$$

$$\tilde{c}_t + \tilde{g}_t = \tilde{y}_t \tag{A.5}$$

$$\tilde{R}_t = \rho_R\tilde{R}_{t-1} + (1-\rho_R)\left[\rho_\pi\tilde{\pi}_t + \rho_Y\tilde{Y}_t\right] + \varepsilon_t^R \tag{A.6}$$

$$\tilde{\pi}_t = \beta E_t\tilde{\pi}_{t+1} + \frac{\epsilon - 1}{\phi}\tilde{mc}_t \tag{A.7}$$

$$\tilde{mc}_t = \tilde{w}_t \tag{A.8}$$

$$\tilde{g}_t = \phi_G\tilde{g}_{t-1} + \epsilon_t \tag{A.9}$$

$$b_{L,t} = \rho_{L,b}b_{L,t-1} + \rho_{L,g}g_t + \epsilon_t^{bL} \tag{A.10}$$

$$\log\left(\frac{T_t}{T}\right) = \xi_1\log\left(\frac{b_{t-1}}{b}\right) + \xi_2\log\left(\frac{b_{L,t-1}}{b_L}\right) \tag{A.11}$$

$$\tilde{b}_t - \tilde{R}_t + \frac{b_L R}{R_L b}\tilde{b}_{L,t} - \frac{b_L R}{R_L b}\tilde{R}_{L,t} = \frac{R}{b}\tilde{g}_t \tag{A.12}$$

B Data employed in the estimation

The following quarterly data series were used in the estimation.

1. Federal Funds Rate: Monthly federal funds rate series from St. Louis FRED database was averaged to create quaterly data series.
2. Long-term Interest Rate: The 5-year constant maturity rate from St. Louis FRED database.
3. Inflation: First difference of GDP deflator