The long and short of financing government spending*

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Abstract

This paper shows that debt-financed fiscal multipliers vary depending on the maturity of debt issued to finance spending. Utilizing state-dependent SVAR models and local projections for post-war US data, we show that a fiscal expansion financed with short term debt increases output more than one financed with long term debt. The reason for this result is that only the former may lead to a significant increase in private consumption. We then construct an incomplete markets model in which households invest in long and short assets. Short assets have a lower return (in equilibrium) since they provide liquidity services, households can use them to cover sudden spending shocks. An increase in the supply of these assets through a short term debt financed government spending shock makes it easier for constrained households to meet their spending needs and therefore crowds in private consumption. We first prove this analytically in a simplified model and then show it in a calibrated standard New Keynesian model. We finally study the optimal policy under a Ramsey planner. The optimizing government faces a trade-off between the hedging value of long term debt, as its price decreases in response to adverse shocks, and the larger multiplier when it issues short term debt. We find that the latter effect dominates and that the optimal policy for the government is to finance spending predominantly with short term debt.

Keywords: Spending multiplier; Fiscal Policy; Debt Maturity, Incomplete Markets, SVAR, Local Projections.
JEL classifications: D52, E31, E43, E62

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1 Introduction

A considerable literature consisting of both empirical and theoretical contributions has investigated the size of the fiscal multiplier, the increase in the dollar value of aggregate output per additional dollar of spending.[1] This research is of course immensely important since public expenditures, in consumption and investment goods, are a key margin that governments can use to stabilize aggregate economic activity in the face of business cycle shocks.

On the empirical side of the literature, a recent stream of papers, conditions the propagation of fiscal shocks on policy variables showing that fiscal multipliers can vary according to the sign of the shock (e.g. Barnichon et al. (2022), to the degree of progressivity of the tax code (Navarro and Ferriere (2022)), the exchange rate regime (e.g. Born, Juessen, and Müller (2013); Ilzetzki, Mendoza, and Végh (2013)) and according to the type of debt (external vs. internal) that governments issue to finance spending (e.g. Priftis and Zimic (2021) and Broner et al. (2022)).

In this paper we advocate that an important determinant of the size of the multiplier is the maturity of debt being issued. In particular, using data from the US economy, we show that when the government has financed its spending shocks with short maturity debt, then the size of the multiplier has been larger and it exceeded unity. In contrast, when spending is financed with long term debt, then the fiscal multiplier was lower and close to one. Moreover, this difference in the magnitude of the response of output to changes in the level of expenditures was driven by the sign of the response of consumption: Short term financing led to a crowding in of private consumption following an increase in spending, whereas long term financing yielded the opposite, consumption was crowded out after the spending shock.

Our empirical analysis is presented in Section 2 and relies on two approaches of identifying shocks, and two complementary methods that have been used recently to show that multipliers depend on the location of the government's creditor (Priftis and Zimic (2021), Broner et al. (2022)). We apply the empirical approaches of these papers to our question, to investigate how the maturity composition of issued debt affects the propagation of spending shocks.

More specifically, Priftis and Zimic (2021) show that the fiscal multiplier is larger when spending is financed with external debt, using the variation in the ratio of domestic public debt to foreign debt, following a spending shock. Their framework is an SVAR identified with sign restrictions; a domestically-financed spending shock is one which produces an increase in spending and simultaneously increases the ratio of domestic to foreign; a foreign-financed shock increases spending and lowers the ratio.

Similar to them, our first identification strategy is based on a proxy-SVAR, conditioning on the contemporaneous movement of the short-term over long-term debt ratio, to identify the impact of maturity-financing. Our choice of proxy follows Ramey and Zubairy (2018), and so government spending is instrumented with news about military spending. Our approach is then to extract short-term financed shocks as those occurring in the periods in which the ratio of short-term debt to long-term debt increases; analogously long-term financed shocks are those occurring in the periods in which the ratio decreases.

Our second empirical strategy makes use of the (Jordà, 2005) local projection method, as in Broner et al. (2022). Broner et al. (2022) exploit variation in the stock of external debt (as a fraction of total marketable debt) and relying on the evidence that the stock is persistent over time, estimate the spending multiplier. They also find that the fiscal multiplier is higher when a larger share of debt is held by external creditors.

[1] See Blanchard and Perotti (2002); Hall (2009); Alesina and Ardagna (2010); Mertens and Ravn (2013); Uhlig (2010); Parker (2011); Ramey (2011a,b); Auerbach and Gorodnichenko (2012); Ramey and Zubairy (2018); Barnichon, Debortoli, and Matthes (2022); Priftis and Zimic (2021); Broner, Clancy, Erce, and Martin (2022); Bouakez, Rachedi, and Santoro (2022) for examples of the empirical papers written on this topic. See below for extensive references to the theoretical work in this literature.

We carry out our second empirical exercise in similar spirit. In US data the share of short term over long term debt and the share of short term over total debt are very persistent variables (see, for example, Faraglia, Marcet, Oikonomou, and Scott (2019)). Thus, the outstanding stock is a good proxy for the issuance of the Treasury and through this evidence we are able to separately identify our shocks of interest, conditioning on the maturity composition and using local projections augmented with interaction terms. We further complement these findings with results from a state dependent version of the empirical model (as in e.g. Auerbach and Gorodnichenko (2013)), but also we consider government spending shocks when identified as in Blanchard and Perotti (2002).

Our results using either the proxy-SVAR or the local projections are robust to alternative specifications of the empirical models. For example, controlling for private sector wages, short and long term rates (that capture the responses of monetary policy and of the term premium to spending shocks), or the debt to GDP ratio, does not change our estimates. Moreover, our results hold regardless of whether the model is estimated using post 1980s observations (when arguably US monetary policy targeted inflation more actively) or when we use data since the 1960s. Analogously, dropping the Great Recession sample makes little difference for our estimates. We consistently obtain a multiplier that persistently exceeds unity under short term financing and a much more moderate value when long bonds have been issued to finance spending.

These findings highlight the importance of the choice of debt maturity to finance a spending shock and thus highlight an important role for debt management policy which to our knowledge has been overlooked by the existing literature. In Sections 3 and 4 of the paper we turn to theory in order to investigate a model that can rationalize the empirical findings but also to think of policy going forward, to study how a government facing a portfolio choice between short and long debt may want to exploit the fact that the fiscal multiplier hinges on this choice.

Our model is is an incomplete markets economy where households that are heterogeneous in terms of their spending needs, choose to save in a long and a short term asset. Short term bonds provide 'liquidity services' enabling households to finance *urgent consumption needs* subject to a 'collateral constraint' that sets the maximum expenditure equal to the real value of the short term asset. In equilibrium, the return to this asset, is lower (relative to the return of the long term bond) reflecting the money-like services that short bonds provide to the private sector. The model is otherwise a standard New Keynesian economy, featuring monopolistic competition and sticky prices, and is augmented with a fiscal block, the government that issues debt financed by taxes. Spending is exogenous and is assumed to follow a random process, as is common in many New Keynesian models. Moreover, to keep our modelling as tractable as possible, we abstract from investment (in private and public capital). The empirical analysis of Section 2 did not show a robustly significant effect of maturity on investment; private consumption was clearly the important margin.

We show that this model can rationalize the empirical evidence, that when spending is financed short term, the size of the multiplier is larger. This result is driven by a larger impact on consumption; increasing the supply of short term debt relaxes the constraint, enabling households to finance a higher consumption stream. We prove this result both analytically and in a calibrated (linearized) version of our model, investigating also how monetary and fiscal policies affect the differences of the multiplier between short and long term financing.

Section 4 then turns to optimal policy. We study how an optimizing government that can set distortionary taxes and the portfolio of short and long bonds would devise its debt issuance policy, taking into account the effect of financing on the fiscal multiplier and hence on its revenue stream. The government in our model faces a non-trivial trade-off: long term bonds have a hedging value, their price covaries negatively with spending. Then, a government that issues long debt, can benefit from the negative comovement, and is able to smooth distortionary taxes over time.[2] At the same

[2] See, for example, Angeletos (2002); Buera and Nicolini (2004) and the debt management literature referenced later on.

time, however, financing short term, provides money-like services to the private sector and leads to a larger increase in output, when spending levels increase. This also enables to better smooth distortionary taxes through time.

In solving the calibrated model numerically, we find that the optimizing government focuses on issuing short term debt. Under the optimal policy, long bonds are either not at all issued, or, if allowed, the government targets to have a negative position in this asset, i.e. it lends to the private sector.

Our findings, jointly with the empirical evidence that we present, reveal a novel channel through which short bonds can be attractive to debt management, enabling to smooth tax distortions across time. This complements recent work in a related literature on public debt management (see references below).

This paper is related to a few more strands of the literature. First, our finding that the financing of spending shocks with short or long bonds matters for the fiscal multiplier is incompatible with standard macroeconomic asset pricing models where bond yields purely reflect intertemporal substitution of consumption. To build our theoretical model we thus turned towards a recent literature in finance and macroeconomics considering models where the relative bond supply, of short or long maturity bonds, affects interest rates.[3]

Our paper is most closely related to Greenwood et al. (2015), who document that short term US Treasury debt functions like money, providing liquidity services to the private sector. The authors provide relevant empirical evidence and set up a formal model in which short bonds enter into utility giving rise to a money-like demand function for this asset. Our modelling is similar in that we assume that only short bonds can be used to finance part of consumption spending, and households invest in long term assets only for their return properties. Though Greenwood et al. (2015) set up a 3-period model with exogenous interest rate shocks, we use a fully fledged New Keyenesian model with infinitely lived agents and focus on spending shocks.

Second, our paper is related to the literature on optimal debt management policy in macroeconomic models with distortionary taxes.[4] The seminal contributions were Angeletos (2002) and Buera and Nicolini (2004) who first pointed out that in the canonical business cycle model, governments ought to save in short term assets, and focus on issuing long term debt. In this way, they can fully exploit the negative covariance between long bond prices and deficits and smooth tax distortions over time.

A recent strand of this literature, extends the baseline model with realistic frictions and finds reasons for governments to issue short term debt. Faraglia et al. (2019) argue that in the presence of financial market frictions and when the payment profiles of long term bonds are modelled to be close to the data analogues, then issuing short term debt may be useful to smooth taxes. In Debortoli et al. (2021) governments that cannot commit to future policies find it optimal to issue short term debt, in order to limit the incentive of future governments to distort taxes intertemporally. Finally, Bhandari et al. (2019) show that short bonds are useful to hedge against exogenous shocks to the real rate and avoid tax volatility. Our paper complements this line of work, identifying a new channel through which issuing short term debt is important for tax smoothing.[5]

[3] Vayanos and Vila (2021); Greenwood and Vayanos (2014); Greenwood, Hanson, and Stein (2015); Guibaud, Nosbusch, and Vayanos (2013); Bansal and Coleman (1996) are important references in this context.

[4] See, for example, Angeletos (2002); Buera and Nicolini (2004); Nosbusch (2008); Lustig, Sleet, and Yeltekin (2008); Faraglia, Marcet, and Scott (2010); Faraglia, Marcet, Oikonomou, and Scott (2016); Faraglia et al. (2019); Canzoneri, Collard, Dellas, and Diba (2016); Greenwood et al. (2015); Debortoli, Nunes, and Yared (2021); Bhandari, Evans, Golosov, Sargent, et al. (2019); Passadore, Nuno, Bigio, et al. (2017) among others.

[5] Greenwood et al. (2015) who, as discussed previously, consider a model in which short bonds provide liquidity, also study the maturity composition of debt. In their model the optimizing government trades off the (money-like) demand for the short term asset against the insurance value of long term debt. Though this trade-off is also present here, the focus of the two papers is different: Greenwood et al. (2015) use their model to think about policy when the private

In addition, this paper is related to the recent work of Canzoneri et al. (2016) and Angeletos, Collard, and Dellas (2022) studying optimal tax and debt issuance policies when government bonds provide liquidity to the private sector. Canzoneri et al. (2016) are interested in characterizing the conditions under which an 'extended Friedman rule' is optimal, whereas Angeletos et al. (2022) unravel interesting transitional dynamics from an initial debt level to the optimal policy equilibrium, in their model which features multiple steady states. We add to this line of work, by studying the optimal tax/portfolio choice over the business cycle and simultaneously identifying that government maturity management is crucial for the effects of fiscal shocks.

Finally, our paper is related to the vast literature that investigates the propagation of fiscal shocks in macroeconomic models (see, for example, Gali, Lopez-Salido, and Valles (2007); Woodford (2011); Christiano, Eichenbaum, and Rebelo (2011); Bilbiie (2011); Hagedorn (2018); Hagedorn, Manovskii, and Mitman (2019); Auclert, Bardóczy, and Rognlie (2021); Rannenberg (2021); Bayer, Born, and Luetticke (2020a); Ferriere, Grübener, Navarro, and Vardishvili (2021).

Closest to ours are papers that study the fiscal multiplier within the context of models in which debt is net wealth; its value exceeds that of tax liabilities. One rapidly growing line of work characterizes the multiplier in quantitatively rich heterogeneous agents models with incomplete financial markets (for example, Bilbiie (2021); Bayer, Born, and Luetticke (2020b); Auclert and Rognlie (2020); Hagedorn et al. (2019)). In this class of models government debt provides insurance to households, it is an asset that can be used to accumulate precautionary savings and buffer consumption against labour income shocks. Another stream of papers takes a shortcut, assuming a representative household with explicit preferences over debt (e.g. Rannenberg (2021)).

The model that we set up in this paper is a heterogeneous agent economy in which short debt has an insurance value to households; however, to keep the equilibrium tractable we assume that households are part of a family that redistributes wealth at the end of every period. Therefore, our exercise does not consider the possibly important interactions between wealth heterogeneity and the multiplier as for example Hagedorn et al. (2019) do.

Finally, in Rannenberg (2021) the fiscal multiplier is shown to be higher in a model where government debt is an argument in household utility in the canonical New Keynesian model. Our empirical evidence and theory show that short debt leads to a higher multiplier when households can arbitrage across short and long bonds and the former provide money like services.

2 Empirical Analysis

2.1 Econometric Methodology

In this section we carry out our empirical estimation of the fiscal multiplier and show its dependence on the maturity of debt being issued. We follow two separate approaches: First, we rely on a form of state-dependent estimation applied to an SVAR framework. Second, we use local projections.

2.1.1 Proxy-SVAR

Our first identification approach extends the proxy-SVAR framework with the appealing features of sign restriction methodology. Following Stock and Watson (2012) and Mertens and Ravn (2013), we obtain a proxy for the government spending shock, whose exogenous variation is then included in the VAR system, and which is assumed to be correlated with the structural spending shock but orthogonal to other shocks. Our choice of the proxy follows Ramey and Zubairy (2018), who derive a *defense news* series, based on movements of spending related to political and military events.

sector can compete with the government in liquidity provision; instead we consider the case where spending shocks lead to a larger expansion in aggregate output under short term financing. Our papers are therefore complementary.

Then, to disentangle the debt-maturity financing of the (instrumented) government spending shock, we exploit variation in defense news across different periods based on the ratio of short term debt to long term debt. Precisely, we extract a defense news series for periods in which the ratio increases, as a proxy for the short term financed (STF) spending shock and conversely, we use the defense news in periods in which the ratio has dropped, as a proxy for long term financing (LTF). Notably, this approach resembles the identification of domestic- and foreign-debt financed spending employed by Priftis and Zimic (2021).

Formally, our objective is to estimate the following system of equations:

$$\mathbf{A}\mathbf{Y}_t = \sum_{i=1}^{p} \mathbf{C}_i \mathbf{Y}_{t-i} + \varepsilon_t \tag{1}$$

where $\mathbf{Y}_t$ is $n \times 1$ vector of endogenous variables in quarter t. $\mathbf{C}_i, i = 1, ..., p$ are $n \times n$ coefficient matrices of the own- and cross-effects of the i^{th} lag of the variables, and ε_t is $n \times 1$ vector of orthogonal i.i.d. shocks with $E[\varepsilon_t] = 0$ and $E\left[\varepsilon_t \varepsilon_t^{'}\right] = I$. $\mathbf{A}$ is $n \times n$, matrix capturing contemporaneous interactions between the elements of $\mathbf{Y}_t$.

An equivalent representation of the above system is:

$$\mathbf{Y}_t = \sum_{i=1}^{p} \delta_i \mathbf{Y}_{t-i} + \mathbf{B}\epsilon_t \tag{2}$$

where $\mathbf{B} = \mathbf{A}^{-1}$, $\delta_i = \mathbf{A}^{-1}\mathbf{C}_i$ and let $\mathbf{u}_t = \mathbf{B}\varepsilon_t$ denote the vector of reduced form residuals. As is well known, the estimate of the covariance matrix of $\mathbf{u}_t$ provides $n(n+1)/2$ independent restrictions, less than the number required for identification of $\mathbf{B}$.

As in Mertens and Ravn (2013) we use covariance restrictions from the proxy of the true (latent) exogenous variable. Let $\widetilde{p}_t$ be a $k \times 1$ vector of proxy (defense news) variables satisfying $E(\widetilde{p}_t) = 0$, that are correlated with the k structural shocks of interest ($\varepsilon_{g,t}$ for government spending) but orthogonal to other shocks ($\varepsilon_{x,t}$ for non-government spending shocks). The proxy variables can be used to identify $\mathbf{B}$ provided the following conditions hold:

$$E\left[\widetilde{p}_t \varepsilon_{g,t}^{'}\right] = \Psi$$

$$E\left[\widetilde{p}_t \varepsilon_{x,t}^{'}\right] = 0$$

where Ψ is non-singular $k \times k$ matrix. Given these conditions hold, we can identify the columns of $\mathbf{B}$, relevant for the innovations in government spending.

In turn, disentangling STF spending shocks from LTF shocks is obtained by defining $\widetilde{p}_t = \begin{bmatrix} \widetilde{p}_{s,t} \\ \widetilde{p}_{l,t} \end{bmatrix}$ with

$$\begin{array}{llll} \widetilde{p}_t = & \widetilde{p}_{S,t}, & if & R_t \quad increases \\ \widetilde{p}_t = & \widetilde{p}_{L,t}, & if & R_t \quad decreases, \end{array}$$

where $R_t = \frac{b_{S,t}}{b_{L,t}}$ denotes the ratio of short-term debt to long-term debt.

Finally, estimation proceeds following the standard two-step procedure for proxy-SVARs. For each element of $\widetilde{p}_t$ i) we run a two-stage least squares estimation of non-goverrnment spending residuals on the residuals of government spending using $\widetilde{p}_t$ as an instrument, and ii) we impose covariance restrictions to identify the elements in the relevant column of $\mathbf{B}$.

2.1.2 Fiscal multipliers

We calculate the cumulative fiscal multiplier m_{t+s} as

$$m_{t+s} = \frac{\sum_{q=t}^{t+s} \Delta X_q}{\sum_{q=t}^{t+s} \Delta G_q} \left(\frac{\overline{X}}{\overline{G}} \right) \tag{3}$$

which measures the cumulative change of the endogenous variable X per unit of additional government consumption G, from the impulse at time t, up to the horizon s.[6] $\left(\frac{\overline{X}}{\overline{G}} \right)$ is the sample average of the endogenous variable over government consumption.

2.2 Empirical Results

Our benchmark estimates for the effects of government spending shocks are based on a VAR with four variables: $Y_t = [G_t, Y_{t,}, C_t, I_t]$, where G_t are government expenditures, Y_t is real gross domestic product, C_t is private consumption, and I_t is private investment. The baseline specification estimates the system in (1) in log differences.[7] We employ four lags of the endogenous variables applying the HQ criterion. The sample consists of quarterly observations for the period 1954Q3-2015Q4. Precise data definitions are provided in the online appendix. Along with the median estimates, we report confidence bands of one and two standard deviations using the procedure in Goncalves and Kilian (2004).

2.2.1 Short-term and long-term debt financed government spending shocks

In Figures 1 and 2 we plot the impulse responses and cumulative multipliers of consumption investment and output, following a 1% government spending shock. The top panels show these objects under STF and LTF separately, and in the bottom panels we plot the response of the differences between the two. Table 1 complements the exposition reporting the point estimates of the cumulative multipliers and the confidence intervals at different horizons.

As the Figures show financing the shock with short term debt leads to a much stronger reaction of aggregate output. Output increases on impact by more in the STF case (blue dashed line, left panel of Figure 1), and moreover, it continues to increase during the 12 quarters covered by the Figure. The difference between short and long term financing (blue and red lines, respectively) grows throughout this horizon and remains statistically significant.

This difference in the propagation of the fiscal shock can be more easily stated in terms of the fiscal multipliers. When spending is financed short-term, the impact multiplier is 1.48 and converges to a level of 1.91 after 3 years. On the other hand, if the shock is financed with long-term debt, the impact output multiplier is 1.08 and drops to 0.58 after 3 years.

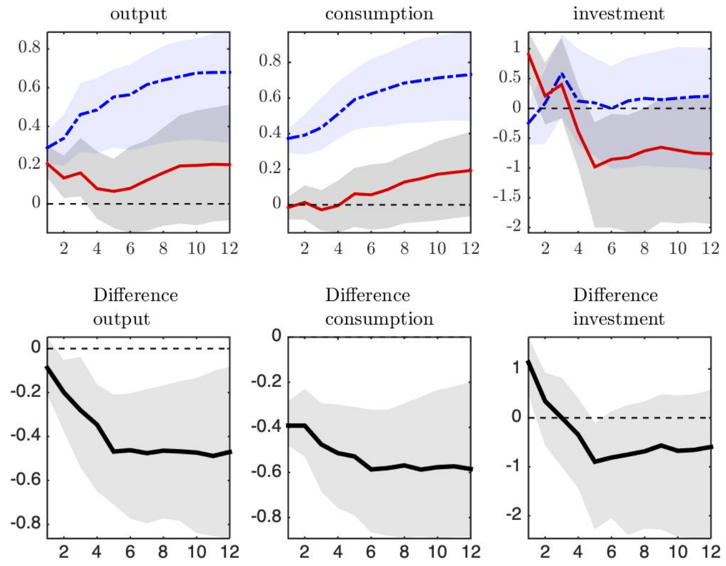
The left panels of the Figures, show where these differences derive from. Notice that the effect is clearly driven by the response of consumption in each case. The short-term debt-financed spending shock produces a crowding in of consumption (the consumption multiplier is 1.16 on impact and remains around that level throughout the horizon). However, when spending is financed with long-term debt, private consumption does not respond. In contrast to consumption, aggregate investment shows no statistically significant reaction to the spending shock neither under STF or LTF; the difference between the two investment responses is also found to be statistically insignificant.

We conclude from this baseline exercise, that the way the US government finances its spending, relying on either short or long term debt, exerts an influence on the effects of the shock to the macroeconomy and in particular on the paths of aggregate consumption and output. We next build

[6] See, for example, Ilzetzki et al. (2013).

[7] Our results do not change when we use log levels instead of differences.

Figure 1: Proxy-SVAR: Baseline specification. Impulse response functions



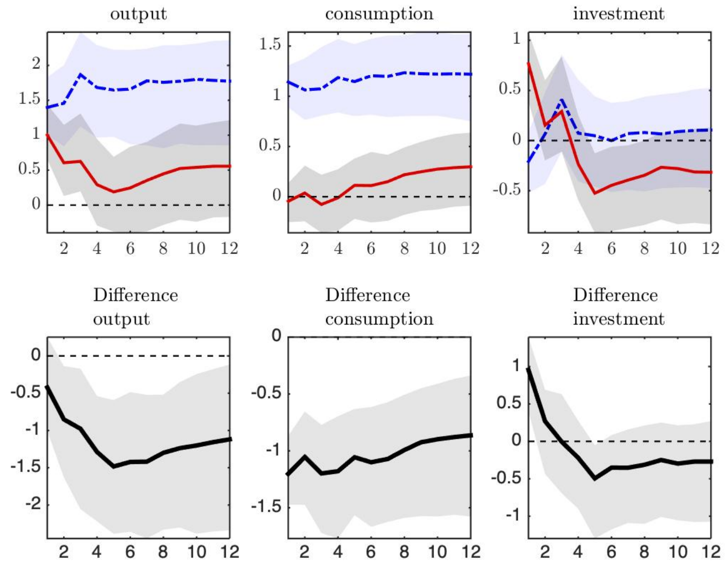
Notes: Top panel: Impulse response functions following a shock to short-term (blue, dash-dotted) and long-term debt-financed (red, solid) government expenditures. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. Bottom panel: The difference in impulse response function between long-term and short-term debt financed government expenditures. Shaded areas correspond to confidence bands of one standard deviation.

Table 1: Proxy-SVAR: Baseline specification. Cumulative multipliers

	horizon	"Long-G shock"		"Short-G shock"		difference	
Output							
	1	**1.08**	[0.68 , 1.51]	**1.48**	[1.03 , 1.86]	-0.42	[-1.06 , 0.19]
	4	**0.42**	[-0.38 , 0.99]	**1.85**	[1.23 , 2.51]	-1.44	[-2.70 , -0.62]
	12	**0.55**	[-0.29 , 1.11]	**1.91**	[1.12 , 2.85]	-1.42	[-2.80 , -0.21]
Consumption							
	1	**-0.03**	[-0.28 , 0.16]	**1.16**	[0.96 , 1.40]	-1.21	[-1.55 , -0.89]
	4	**0.00**	[-0.40 , 0.34]	**1.31**	[0.93 , 1.68]	-1.24	[-1.98 , -0.82]
	12	**0.33**	[-0.21 , 0.62]	**1.35**	[0.85 , 1.92]	-1.08	[-2.00 , -0.46]
Investment							
	1	**0.80**	[0.44 , 1.14]	**-0.17**	[-0.55 , 0.17]	0.96	[0.55 , 1.50]
	4	**-0.12**	[-0.68 , 0.41]	**0.17**	[-0.30 , 0.72]	-0.31	[-1.34 , 0.35]
	12	**-0.33**	[-0.82 , 0.14]	**0.15**	[-0.34 , 0.78]	-0.42	[-1.40 , 0.30]

Notes: The table reports cumulative multipliers for output, consumption, and investment at different horizons for short-term debt-financed and long-term debt-financed government spending shocks, as well as the difference in multipliers, defined as Long-Short. Confidence bands of one standard deviation are denoted inside the brackets.

Figure 2: Proxy-SVAR: Baseline specification. Cumulative multipliers



Notes: Top panel: Cumulative multipliers following a shock to short-term (blue, dash-dotted) and long-term debt-financed (red, solid) government expenditures. Cumulative multipliers are calculated as in Equation 3. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. Bottom panel: The difference in cumulative multipliers between long-term and short-term debt financed government expenditures. Shaded areas correspond to confidence bands of one standard deviation.

on this finding, extending our baseline exercise, considering additional controls in estimation and running the model on different subsamples.

2.2.2 Extensions of the empirical model

Adding further macroeconomic variables

We first show the robustness of our findings towards including in the VAR macroeconomic variables besides output, investment and consumption. In particular, we repeat the estimation of system (1) controlling for real wages of the private sector, the yields on short and long term government debt, the overnight interest rate, and the GDP deflator. We do so to treat possible endogeneity issues that may have contaminated our baseline estimates, using the standard approach of adding variables to the VAR and showing that the results do not change significantly. To motivate the experiments that we conduct in this paragraph let us briefly discuss the types of biases and endogeneity issues that we believe are more important in the context of our exercise.

First, the endogeneity of the decision of the Treasury to finance with short or long term debt. It is well known, that debt management decisions are influenced by the interest rate costs of financing. Thus, when faced with a steeply upward sloping yield curve debt managers are more likely to issue short term debt, than when the yield curve is downward sloping and long term debt becomes less costly. Moreover, downward sloping yield curves predict recessions. The lower multipliers for long term financing could thus be reflecting that the economy is set on a recessionary path.[8] We control for this possibility by adding the term premium and the long term rate (to capture both the level

[8]Arguably the opposite could also be true, if fiscal multipliers are higher during economic recessions (see, for example, Auerbach and Gorodnichenko, 2012)

and the slope of the yield curve).

Second, adding wages as well as interest rates to the VAR enables us to also control for possible differential impacts of the STF and LTF shocks on these variables which may be relevant if the shocks are of a different nature and thus affect the macroeconomy differently. For example, a STF shock may put more upward pressure on wages, when the government is hiring in certain sectors. This could then result in a larger increase in the consumption of hand to mouth households and thus in a stronger effect on aggregate output. Though our shocks have been identified using news about military spending, showing robustness in this regard is useful.[9] Finally, we control for the (endogenous) response of monetary policy through adding the overnight interest rate in the VAR.

Figure 3 shows the cumulative multipliers we obtain from the VAR when we include these variables together in the VAR.[10] [11] As is evident from the Figure, the cumulative output multiplier in the case of short term financing continues being larger; once again the difference is driven by the differential responses of private sector consumption to the spending shock, under short and long term financing. Our previous findings thus continue to hold.

Moreover, to show how each of the variables considered affects our estimates, in Table 2 we report the consumption and output multipliers from 4 separate models when we include wages (top panel), the short term interest rate (second panel), the long term rate (third panel) and the 'yield curve' (short rate and the term premium) (bottom panel) in the VAR.[12] We report the point estimates at horizons of 1, 4 and 12 quarters. Notice that across all specifications, there are significant differences between STF and LTF, and most notably at 4 or 12 quarters after the shock has hit. Though spending multipliers can be quite large on impact also in the long term financing case, i.e. in some of the models we run, very fast, 4 quarters after the shock, they drop significantly. In contrast, the multipliers in the STF remain persistently above 1 throughout the horizon.

Additional experiments: High vs. low total debt regimes and monetary policy regimes.

We now conduct two additional experiments to further condition our estimates on the macroeconomic policy environment and in particular we focus on the debt to GDP ratio and on the monetary policy regime.

A well-known feature of US debt management is that the Treasury has typically titled its issuance more towards long term debt, when the debt to GDP ratio was high (Greenwood et al., 2015).[13] At high debt levels, the response of output to a fiscal shock may be weaker if, for example, the private sector expects that distortionary taxes are more likely to increase significantly, or if high debt implies political controversies about how to manage government liabilities.

[9] Moreover, we have found that the paths of spending following a shock under STF and LTF are similar, both in terms of the magnitude of the responses and their persistence. This also indicates that

[10] The term premium has been defined as the difference between the yield of the 10 year Treasury note and the overnight rate. Our results are almost identical when we define the term premium as the difference between the 10 year and the 3 month yields.

[11] For brevity, responses of these variables to the spending shock are shown in the online appendix. The qualitative features are: for the yield curve we obtain that a STF shock increases the short term interest rate and reduces the term premium. In contrast, a LTF shock increases the term premium without affecting the short term rate. Moreover, the STF shock increases the price level persistently, whereas the effect of the LTF shock on prices is nearly 0. Finally, real wages decrease slightly under STF, though possibly this is due to the stronger reaction of inflation.

[12] The multipliers for investment were found insignificant in most of these models and for brevity we leave those outside the table.

Moreover, the big picture relative to what we report here did not change when we included in the VAR the GDP deflator either separately or together with any of the other variables used in this subsection. For brevity we did not report these estimates in the Table.

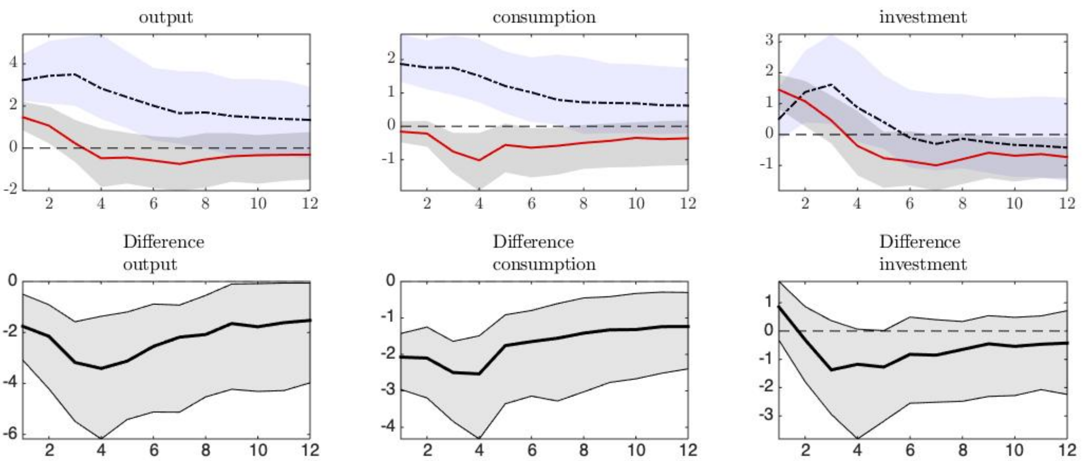
[13] The explanation is that when overall debt rises the refinancing risk increases and debt managers face a trade off between issuing more expensive and less risky debt, long term, or cheaper and riskier debt, short term. In general they prefer to issue long term debt to reduce overall refinancing risks of government portfolios.

Table 2: Proxy-SVAR: Baseline specification with additional controls. Impact multipliers

		horizon	"LTF shock"		"STF shock"		difference	
Wages	Y	1	**0.46**	[-0.12 , 0.93]	**1.72**	[0.96 , 2.33]	-1.24	[-2.22 , -0.51]
		4	**-0.64**	[-1.71 , -0.01]	**1.55**	[0.64 , 2.83]	-2.57	[-3.88 , -0.84]
		12	**-0.28**	[-1.30 , 0.58]	**1.47**	[0.50 , 2.65]	-1.95	[-3.23 , -0.44]
	C	1	**-0.31**	[-0.65 , -0.11]	**1.10**	[0.78 , 1.45]	-1.43	[-1.96 , -1.09]
		4	**-0.51**	[-1.11 , -0.18]	**0.88**	[0.37 , 1.56]	-1.53	[-2.33 , -0.82]
		12	**-0.10**	[-0.58 , 0.37]	**0.94**	[0.41 , 1.58]	-1.18	[-1.66 , -0.38]
Short rate	Y	1	**1.32**	[0.86 , 1.58]	**1.72**	[1.20 , 2.22]	-0.48	[-1.12 , 0.18]
		4	**0.59**	[-0.23 , 1.31]	**1.66**	[0.88 , 2.53]	-1.09	[-2.26 , 0.02]
		12	**0.40**	[-0.40 , 1.15]	**1.39**	[0.73 , 2.43]	-1.02	[-2.56 , 0.16]
	C	1	**0.23**	[0.02 , 0.45]	**1.57**	[1.26 , 1.78]	-1.31	[-1.65 , -0.98]
		4	**0.16**	[-0.21 , 0.50]	**1.26**	[0.92 , 1.73]	-1.13	[-1.90 , -0.55]
		12	**0.25**	[-0.17 , 0.65]	**1.06**	[0.61 , 1.70]	-0.86	[-1.78 , -0.17]
Long rate	Y	1	**1.26**	[0.60 , 1.88]	**1.49**	[1.00 , 2.01]	-0.22	[-1.08 , 0.49]
		4	**-0.83**	[-2.71 , 0.37]	**2.11**	[1.38 , 3.32]	-2.95	[-5.30 , -1.72]
		12	**-0.97**	[-2.39 , -0.13]	**2.20**	[1.18 , 3.43]	-3.26	[-5.43 , -1.79]
	C	1	**0.03**	[-0.30 , 0.29]	**1.45**	[1.19 , 1.78]	-1.36	[-1.97 , -1.06]
		4	**-1.10**	[-2.02 , -0.54]	**1.60**	[1.13 , 2.22]	-2.72	[-3.83 , -2.02]
		12	**-0.75**	[-1.42 , -0.25]	**1.58**	[1.00 , 2.34]	-2.37	[-3.63 , -1.54]
Short rate; term premium	Y	1	**1.79**	[1.00 , 2.58]	**1.46**	[0.99 , 1.90]	0.36	[-0.51 , 1.14]
		4	**0.82**	[-0.49 , 1.80]	**1.75**	[0.93 , 2.57]	-1.05	[-2.65 , 0.67]
		12	**0.11**	[-1.16 , 0.96]	**1.71**	[0.99 , 2.52]	-1.57	[-3.73 , -0.59]
	C	1	**0.20**	[-0.08 , 0.52]	**1.51**	[1.28 , 1.82]	-1.38	[-1.71 , -0.92]
		4	**-0.27**	[-1.22 , 0.21]	**1.42**	[1.02 , 1.92]	-1.80	[-2.91 , -1.11]
		12	**-0.11**	[-0.95 , 0.37]	**1.34**	[0.92 , 1.92]	-1.54	[-2.80 , -0.86]

Notes: The table reports multipliers for Y and C for short-term and long-term debt-financed government spending shocks, as well as the difference in multipliers, defined as Long-Short, for different proxy-SVAR specifications. Each specification augments the system in 2.2.1 with the variables in the first column. Confidence bands of one standard deviation are denoted inside the brackets.

Figure 3: Proxy-SVAR: Baseline specification with additional controls. Cumulative multipliers



Notes: Top panel: Cumulative multipliers following a shock to short-term (blue, dash-dotted) and long-term debt-financed (red, solid) government expenditures. Cumulative multipliers are calculated as in eq. 3. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. Bottom panel: The difference in cumulative multipliers between long-term and short-term debt financed government expenditures. Shaded areas correspond to confidence bands of one standard deviation. The list of controls includes the term premium, real wages, overnight rate, and the GDP deflator.

To explore whether this is a crucial dimension we re-estimated the baseline system in (1), separately using 'a high debt sample', (that is focusing on periods where the debt to GDP ratio was above the median of the full sample of observations) and a 'low debt sample', where the debt to GDP is below the median. Our results were unaffected. We continued to find a large difference in the fiscal multipliers of output and consumption in both of these samples.

Moreover, we also run the model using only observations from the post 1980 period. It has been well documented, that US monetary policy did not react strongly to inflation during the 1960s and 70s but it satisfied the 'Taylor principle' after the early 1980s[14] We were therefore interested to see whether this change in policy conduct has a bearing on the fiscal multiplier under STF and LTF. The online appendix shows in a graph the results that we obtained from this exercise: The difference across the two cases remains, and the consumption multiplier remains significant only in the STF scenario.

Lastly, we run our sample dropping observations from the financial crisis and the years the Fed kept the short term nominal interest at its effective lower bound. Again we found no significant change in our estimates when we run the model with this subsample. For brevity, we show these results in the online appendix.

2.3 Local projections

We now explore an alternative empirical strategy to investigate the effect of financing on the propagation of spending shocks, relying on the local projection method of Jordà (2005) and identifying the spending shock using the same news variable considered in the previous paragraphs, but also using the structural VAR approach of Blanchard and Perotti (2002). To distinguish between government spending shocks, financed with short-term debt and shocks financed with long-term debt, we employ both a state-dependent specification of the model (as in e.g., Auerbach and Gorodnichenko (2013);

[14] See, for example, Bianchi and Ilut (2017) for recent work on this.

Ramey and Zubairy (2018)) as well as use interaction terms as in Broner et al. (2022).

2.3.1 State-dependent local projections

As it is known, the (non-linear) local projection framework allowing for state-dependence, requires estimation of a series of regressions of the following form:

$$Y_{t+h} = I_{t-1}\left[a_{A,h} + \beta_{A.h}\varepsilon_t + \psi_{A,h}(L)X_{t-1}\right] + (1 - I_{t-1})\left[a_{B,h} + \beta_{B,h}\varepsilon_t + \psi_{B,h}(L)X_{t-1}\right] + qtrend + u_{t+h}$$

where Y is the variable of interest (e.g., output, consumption, investment), h denotes the horizon over which the effect of the shock is being traced, X is a vector of control variables, $\psi_{A,h}(L)$ is a polynomial in the lag operator, and finally ε is the identified spending shock.[15] Following Ramey and Zubairy (2018), we also include a quadratic trend to control for slow-moving demographics.

The state-dependent regression allows distinguishing between different types of debt financing through variable I. This is an indicator variable of the ratio of short over long term debt. In particular $I_{t-1} = 1$ when the ratio of short over long debt increased between periods $t-2$ and $t-1$, and $I_{t-1} = 0$ otherwise.[16] Note finally that the coefficients of interest in this local projection model are $\beta_{A.h}$ and $\beta_{B.h}$. These coefficients measure the impulse response of Y_{t+h} to the spending shock in t under short and long term financing respectively.

Figures 4 and 5 plot these impulse responses for output, consumption and investment, when the government spending shock is identified using the defense news variable (Figure 4) and the Blanchard-Perotti approach (Figure 5).

Notice that using either of these identification approaches results in a significant response of output under short term financing (blue lines), whereas we find no significant effect in the long term financing case (red lines).[17]

The middle panel in the two Figures indicates the strong reaction of aggregate consumption under STF. Whether we use the news variable to identify the shock or the Blanchard Perotti identification, we obtain a statistically significant consumption response, a few quarters after the shock has occurred. The response of consumption under LTF is either non-significant (in Figure 5) and may even be negative and significant (at around quarter 10 in Figure 4). These results are in line with our previous estimates using the proxy SVAR. Finally, note that the local projections method employed in this paragraph, indicates a more significant effect of spending on aggregate investment. We obtain a singificant crowding out effect under LTF when we apply the Blanchard-Perotti identification assumption. Our results, however, show that consumption is clearly a robust margin to account for the differences in the output multipliers under STF and LTF.

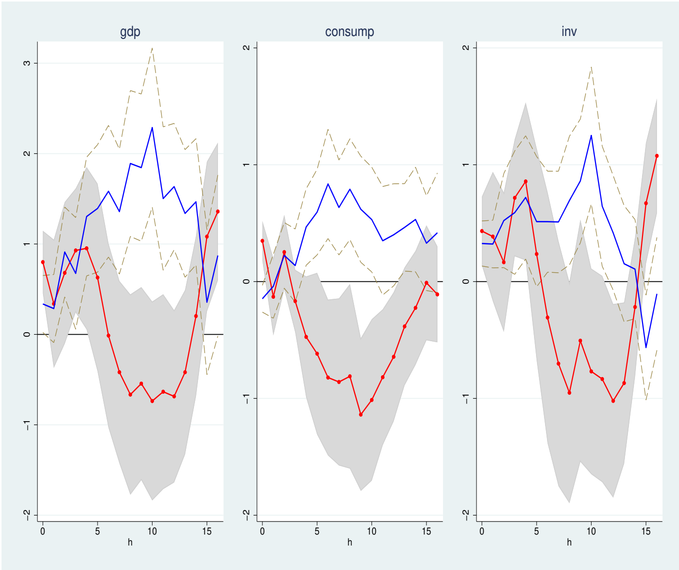
[15] Applying standard criteria we set $\psi_{A,h}(L)$ to have 4 lags. Moreover, we experiment with a variety of specifications of the model in terms of the control variables X. In the results we show here X includes wages and the term spread as well as lags of consumption, output and investment.

Finally, across all specifications, to control for any serial correlation, X also includes lags of the news variable in the case we identify the shock based on news, and the lags of the SVAR shock when we apply the Blanchard Perotti identification. .

[16] We also experimented with conditioning on the current change in the short to long ratio, i.e. variable I_t instead of I_{t-1}. Moreover, we run the projection using the average change in the ratio between $t-1$ and $t+2$, to allow for a better conditioning of medium and long term effects, which are typically better captured by the method employed here (especially when the news variable is being used). None of these alternative specifications altered significantly our findings and therefore we followed the more standard approach of conditioning on I_{t-1}.

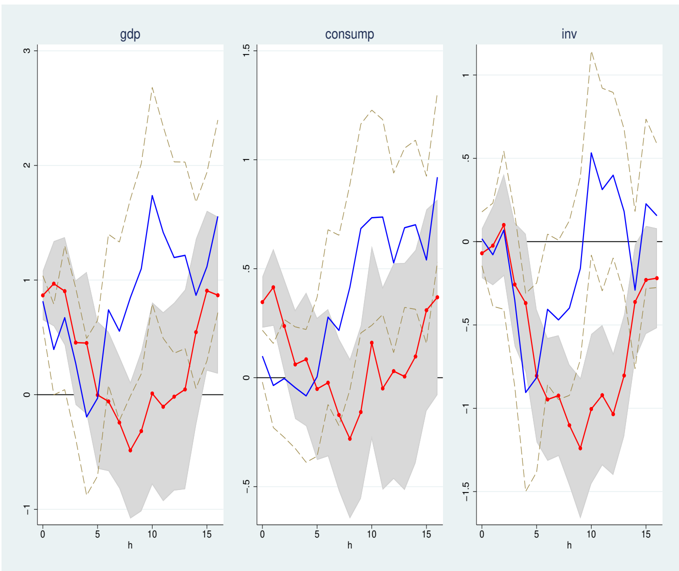
[17] The hump-shaped responses of the macro aggregates to the spending shock are to be expected in a local projection setting, especially when using the defense news proxy.

Figure 4: State-dependent local projections: Baseline specification. IRFs News shock.



Notes: Impulse response functions following a shock to short-term (blue) and long-term debt-financed (red) government expenditures. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. The specification includes the following control variables: GDP, private consumption, private investment, wages, long-term rate, and total debt, as well as their lags.

Figure 5: State-dependent local projections: Baseline specification. IRFs Blanchard-Perotti shock.



Notes: Impulse response functions following a shock to short-term (blue) and long-term debt-financed (red) government expenditures. Lines correspond to median responses. See notes of Figure 4 for further details on the specification of the empirical model.

2.3.2 Local projections with interaction terms

We now estimate a linear specification using local projections and interact the spending shock with the ratio of short-term to long-term debt. Our empirical model in this paragraph is:

$$Y_{t+h} = a_h + \beta_h \varepsilon_t + \gamma_h R_{t-1} \times \varepsilon_t + \psi_h X_{t-1} + qtrend + u_{t+h} \quad (4)$$

where $R_{t-1} = \frac{b_{S,t-1}}{b_{L,t-1}}$ is the lagged ratio of short over long, and coefficient γ_h measures the over-and-above effect of the government spending shock on the endogenous variable, when the ratio R is high. The total response to the shock is then: $\frac{\partial Y_{t+h}}{\partial \varepsilon_t} = \beta_h + \gamma_h R_{t-1}$.[18]

A couple of comments are needed to explain this empirical strategy. Note that differently from the previous empirical exercises, the margin by which the maturity composition impacts the fiscal multipliers in (4) is the outstanding stocks of debt (the ratio in $t-1$). This is of course different to the proxy-SVAR, which identified spending shocks based on the contemporaneous response of the maturity composition ratio. (Ideally), our empirical approach in the previous subsections was successful in identifying shocks that were financed with newly issued short term debt (i.e. in the STF scenario) and financed with new issues of long term bonds under LTF.

Relying on the stocks (rather on the contemporaneous movements of the ratio) may be seen as capturing different margins through which debt maturity can influence the size of the fiscal multiplier. However, for the case of a variable that is as persistent as the share of short term debt is in US data, it is possible to argue that outstanding stocks are strongly correlated with new issues. Indeed this is a central feature of US debt management. In our sample, the serial autocorrelation of R_t is 0.936. Moreover, Faraglia et al. (2019) document that the ratio of short term debt (again defined as all debt of maturity less than one year) over total debt displays a first order autocorrelation of 0.94 at the annual horizon and above 0.98 in quarterly data. This property then suggests that the lagged value of the share can serve as a good proxy for the current and future issuance decisions of the Treasury.[19] We rely on this observation to interpret the empirical findings which we now state.

In Figures 6 and 7 we plot the interaction coefficients γ_h. Notice that the estimated coefficients for output and consumption are strongly significant, suggesting that an increase in the R ratio translates into a larger fiscal multiplier.

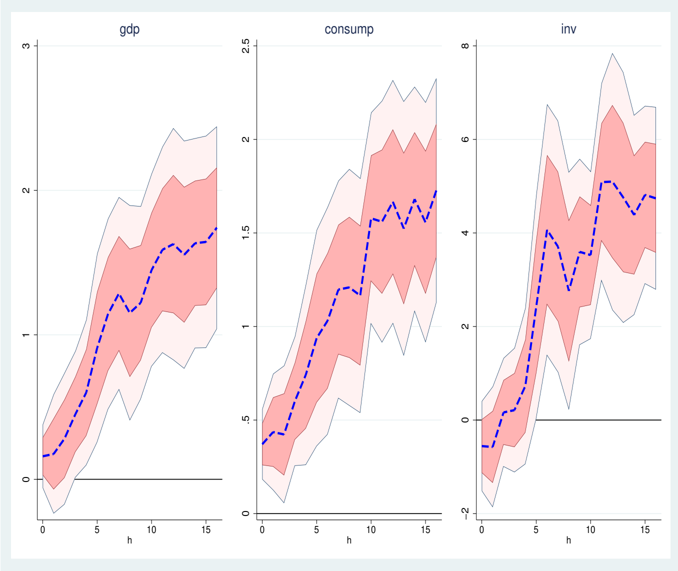
Since we find that γ_h are positive and statistically significant at all horizons, it is easy to conclude that financing short term increases the magnitude of the fiscal multiplier. Moreover, the results shown in this paragraph validate the finding that an important channel is the response of consumption to the fiscal shock.

To close this subsection let us note that for the linear and non-linear local projections models we studied, we run a number of additional checks. We found that our results were robust when we include different sets of control variables in the VAR, when we specified the variables in log-levels or in log-differences, and when we smoothed the linear impulse response functions using a centered moving-average representation. Moreover, our results also hold in the post 1980s subsample and when we drop observations from the Great recession and the zero short term nominal interest rate period. For brevity we do not show these experiments here.

[18] Note that since variable R is measured in percentage points, these coefficients are measuring the additional effect of the shock on Y when the share of short to long has increased by, say, 1 percentage point.

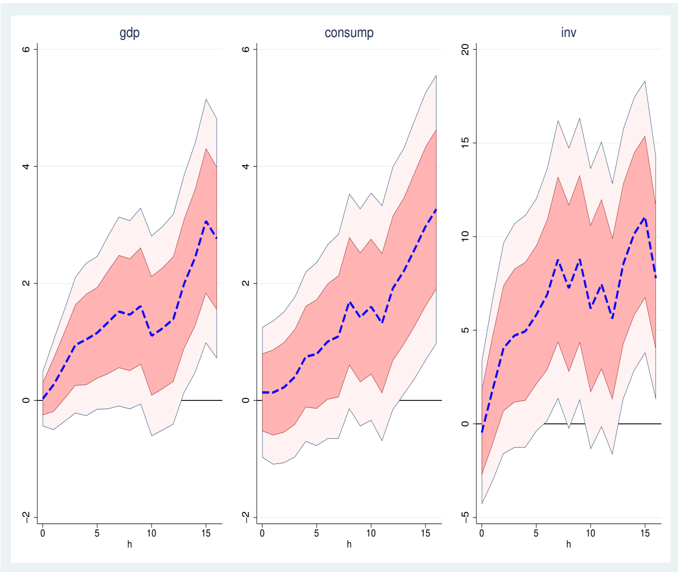
[19] Broner et al. (2022) also use the assumption that the lagged value of the variable on which they condition the multiplier is a good proxy for the current value.

Figure 6: Local projections with interaction: Baseline specification. IRFs News shock.



Notes: Impulse response functions of the interaction effect (γ) of the spending shock with the ratio of short-term debt to long-term debt. Lines correspond to median responses. Dark shaded areas correspond to confidence bands of one standard deviation. Light shaded areas correspond to confidence bands of two standard deviations. For each endogenous variable we consider, the specification includes controls of its own lags as well as contemporaneous GDP and its lags.

Figure 7: Local projections with interaction: Baseline specification. IRF Blanchard-Perotti shock.



Notes: Impulse response functions of the interaction effect (γ) of the spending shock with the ratio of short-term debt to long-term debt. Lines correspond to median responses. Dark shaded areas correspond to confidence bands of one standard deviation. Light shaded areas correspond to confidence bands of two standard deviations. For each endogenous variable we consider, the specification includes controls of its own lags as well as contemporaneous GDP and its lags.

3 A model of short and long term financing of spending shocks

3.1 Discussion

The empirical analysis showed that the spending multiplier is higher when then government finances its deficit issuing short term debt. Before presenting our formal model in the next section we provide here a general discussion to outline theories that can rationalize this new empirical fact. We then build a theoretical model selecting one of the alternatives, and show that indeed it is consistent with the empirical evidence provided in the previous section. In Section 4 we use the theoretical model to talk about optimal debt maturity policy.

The empirical finding that debt maturity influences the spending multiplier cannot be rationalized by a model where bonds of different maturities are only used by investors to substitute consumption inter-temporally in (almost) frictionless financial markets. In standard representative agent models where Ricardian equivalence holds and the yield curve can be derived as a function of consumption growth and inflation, it is well known that consumption and interest rates will depend on the path of spending only, and not on how spending is financed. In this framework the relative supply of short and long term bonds exerts no influence on yields and therefore no influence on consumption growth or the multiplier.[20]

Departing from this standard framework, adding elements that make relative bond supply matter for allocations is thus key to explaining the fiscal multiplier. Theoretical models in which investors have preferences over particular maturities, where short bonds facilitate transactions and function as money or long term bonds provide savings to finance retirement, imply non trivial effects of bond quantities on yields and therefore we need to turn to these theories to interpret the empirical evidence.

Fortunately, the literature is abundant of models in which short and long bond prices do not line up with real consumption growth when, bonds of different maturities offer *convenience* to investors that hold them. In an early contribution, Bansal and Coleman (1996) set up a model in which safe and liquid Treasury debt is used by banks to back up checkable deposits accounts. Short term Treasury bonds fulfill both the safety and liquidity criteria and so banks use these types of bonds. In equilibrium short bond yields line up with the yields of checkable deposits accounts, a property that Bansal and Coleman (1996) exploit to explain the term and equity premia that we observe in the data.

This idea was picked up by Greenwood et al. (2015) who provide empirical evidence and a formal model to validate the view that short bonds have money like attributes and earn a lower return than other assets, including long term Treasuries, due to their role in backing deposits or collateralizing and facilitating transactions.[21] In their model, these attributes are formalized through assuming a standard reduced form money like demand for short term debt. Investors hold short term debt when it affects directly utility and not only for its return properties.

On the other hand, Guibaud et al. (2013) focus on the services provided by long term bonds to finance retirement. In their overlapping generations model, *bond clienteles* are agents at different stages of the life cycle: The young have a stronger demand for long term assets that they will use to finance consumption in retirement. When the supply of long term bonds decreases (or when the number of long horizon (young) investors increases) long bond yields rise, as they do in the data (see Greenwood and Vayanos (2010); Guibaud et al. (2013)).

Guibaud et al. (2013) abstract from the money-like services of short assets and they also abstract

[20]See, for example, Greenwood and Vayanos (2014) and the irrelevance of Quantitative Easing in this class of models (see, for example, Wallace, 1981; Curdia and Woodford, 2011).

[21]See also Gorton and Metrick (2012).

from inflation, therefore their model cannot explain why the yield curve is (on average) upward sloping in the data. In practice, long term government debt is subject to repricing risk and moreover, (in the case of nominal debt) inflation can considerably erode the real value of the principal over the long horizon of the investment. Thus, even when long bonds provide certainty over an ultimate nominal repayment to finance retirement, the safety provided by short term bonds and the money like services that they provide can rationalize the term premium and be consistent with the evidence that the relative supply of Treasuries can have non-trivial effects at the short and long ends of the yield curve.[22]

In the recent literature on quantitative easing the above features are introduced in the standard New Keynesian framework in a reduced form manner. In these models, bond clienteles are introduced by assuming that certain households have *preferred habitat* over particular maturities (and only trade in those) whilst other households can arbitrage across all maturities subject to portfolio adjustment costs.[23] Obviously, in the context of these linear models (where only first derivatives matter and strict assumptions over functional forms are not needed) assuming a transaction cost for long term bonds or a money like demand for short bonds is essentially the same. The QE model thus applies the above elements in the standard New Keyenesian framework.

Finally, another class of models in which the relative bond supply can impact yields is models of heterogeneous agents and incomplete financial markets (e.g. Huggett (1993); Aiyagari (1994) and the considerable literature that followed these papers). In this framework households value safe and liquid assets when they can be used to build a stock of precautionary savings, a buffer against labour income shocks. Then, assets earn a lower rate of return in equilibrium due to their insurance value and the return varies positively with the supply of safe/liquid assets.

Arguably, short term debt is likely a more useful asset for precautionary savings purposes than long term debt is. Households may be reluctant to bear the interim repricing risk of long term bonds and in the presence of even mild transaction costs, long bonds will have a lower hedging value, especially when income shocks are temporary and frequent. When short and long bonds are not seen as perfect substitutes by households, their relative supplies will matter for yields.

The model that we develop below is inspired by this literature and in particular by papers focusing on the money-like services of short term bonds (e.g. Greenwood et al. (2015)). We consider an

[22]A large number of papers have explained the term premium in standard representative agent models, relying on the inflation risk channel. See, for example, Piazzesi, Schneider, Benigno, and Campbell (2007); Bansal and Shaliastovich (2013); Rudebusch and Swanson (2012) and the considerable literature that followed. These models, however, are not likely to generate an effect of bond supply on the yield curve.

Another view for why long term bonds command a higher rate of return is that this is necessary to compensate investors for the lower liquidity of these assets. Amihud and Mendelson (1991) (building on Amihud and Mendelson (1986)) present a model in which agents with shorter investment horizons (i.e. those facing a higher risk of needing to liquidate their portfolio) self select in short bond markets where assets carry lower transaction costs. In contrast, low risk investors, have a preference for less liquid long term assets. The authors show that in this model the return on long term debt is higher than its short term counterpart. (See also Huang (2003) and Vayanos and Vila (1999) for a life cycle microfundation of bond clienteles)

The model of Amihud and Mendelson (1991) can rationalize non-trivial effects of the relative bond supply on the yield curve. Since bond markets are segmented a change in the supply of long term debt (for example) will increase the long term interest rate, without impinging a significant effect on the short term rate.

Moreover, though Amihud and Mendelson (1991) motivate (il)liquidity relying on the observation that bid-ask spreads are roughly 3-4 times higher in long Treasury markets, other sources of illiquidity may be equally important in the context of the long bond market. For example, when long bonds are part of household's retirement plan portfolios (e.g. a 401k or an IRA account) selling the portfolio before retirement may entail a cost proportional to the value of the investment. The price of long term debt thus reflects expected portfolio adjustment costs and due to these costs long bonds become effectively a risky asset (e.g. Huang, 2003). See Bennett, Garbade, and Kambhu (2000) for an informative discussion of liquidity in the US bond market. See also Sack and Elsasser (2004) for evidence in the case of inflation indexed long term debt in the US.

[23]See, for example, Chen, Cúrdia, and Ferrero (2012).

economy where ex ante identical agents are ex post heterogeneous in terms of their spending needs. In particular, agents consume in two stages: they firstly solve a standard consumption/savings problem, where savings can be accumulated in a short or a long term government bond. Then, they may face urgent consumption needs according to the realization of a random preference variable. Those that experience high utility from consumption in the second stage, can run down their accumulated stock of short term bonds. Some agents are constrained, and their fraction is decreasing in the short term bond supply. A larger supply, then increases the short term interest rate, without impinging a significant effect on the long rate.

The result that we obtain from calibrating and solving this model is that the fiscal multiplier is larger when the government finances the deficit short term. This is driven by the positive impact that short term debt has on consumption and ultimately on output.

Finally, we note that though our modelling focuses on the liquidity services provided by short term bonds, we believe that our result will hold in the presence of long bond clienteles (e.g. Guibaud et al. (2013); Greenwood and Vayanos (2014) and the baseline QE framework) and could also hold in the more standard heterogeneous agents model with labour income shocks and precautionary savings.[24] In the latter case, a plausible mechanism is that increasing the supply of the safe/liquid asset reduces idiosyncratic consumption risk, and exerts a positive effect on household consumption. Verifying whether this channel is important is left to future work.

3.2 The baseline model

We now present our baseline model which can be seen as an extension of Hagedorn (2018) to two assets (short/long bonds government bonds) under the additional assumption that only short term debt provides liquidity. The model is otherwise essentially a Diamond and Dybvig (1983) economy, in terms of preferences and trading frictions. However, following Hagedorn (2018), we assume for tractability that agents/households are members of large families that pool resources (income and savings) every period.

We provide a brief description of the model here, explaining the new elements we introduce, the short/long bonds and the New Keynesian pricing frictions. Further details on the derivations of the model's equations are to be found in the online appendix.

3.2.1 Timing and preferences

The economy is populated by a continuum of infinitely lived, ex-ante identical agents/households. Time is discrete and each period t can be divided in two subperiods, t_1, t_2. Technically t_1 and t_2 may not represent different points in time, they are simply used to introduce the idea that households can participate in asset markets and make savings decisions (in t_1) before the full vector of state variables has been revealead.

The preferences of household i are:

$$u(C_t^i) + \theta v(c_t^i) - \chi \frac{{h_t}^{i,1+\gamma}}{1+\gamma} \tag{5}$$

where C_t^i (c_t^i) denote the consumption of i in sub-period t_1 and t_2 respectively. $\theta \in [\underline{\theta}, \infty] \sim f_\theta$ is a random variable affecting the relative utility derived from consumption in sub-period 2. Implicitly, a high θ household will face a high urgent expenditure need in t_2 and therefore will desire a high

[24] In the QE model, for example, we know that a decrease in the long bond supply increases current consumption. This is one of the main mechanisms via which QE works.

consumption level c^i. We further assume that θ is an i.i.d random variable following a distribution with probability density function f (F denotes the cdf).[25]

Finally, h_t^i denotes hours worked by i. Parameter χ affects the disutility of working and γ is the inverse of the Frisch elasticity of labour supply.

3.2.2 Assets and asset demand

In subperiod t_1 the household solves a portfolio choice problem, choosing the optimal quantity of a short term (one period) nominal asset and a long term nominal bond. We denote by $B_{t,S}^i, B_{t,L}^i$ the nominal quantities of the short and long bonds respectively and $b_{t,S}^i, b_{t,L}^i$ denote the real quantities (scaled by the price level P_t).

Long term assets, B_L, are perpetuities paying coupons that decay geometrically over time (see, for example, Woodford, 2001). We let δ denote the decay factor, so that a bond pays a stream $1, \delta, \delta^2, ...$ to the investor. The price of the long-term bond in period t is denoted $q_{L,t}$. The ex-post holding period return can be expressed as

$$R_{L,t+1} = \frac{1 + \delta q_{L,t+1}}{q_{L,t}}.$$

Short term nominal bonds are purchased by households for two reasons: First, for their return (the inverse of the price $q_{S,t}$) and second for providing liquidity to finance consumption in subperiod 2. As in Hagedorn (2018) we assume that expenditures c_t^i are subject to the following constraint:

$$c_t^i \leq b_{S,t}^i \tag{6}$$

and therefore a household that desires to finance a high level of expenditures maybe constrained by the quantity of short term it chose in the portfolio.

It is important to note in subperiod 2 a households has access only to her portfolio to finance c_t^i.[26] However, since as discussed previously, households are part of a family that pools resources when transactions have been carried out, households will have the same level of resources (wealth) at the portfolio choice stage in t_1 and thus will end with the same quantity of short and long term assets in the portfolio.

3.2.3 Household's problem

We now define formally the household's program. The budget constraint in sub-period 1 is:

$$P_t C_t^i + q_{L,t} B_{L,t}^i + q_{S,t} B_{S,t}^i = P_t(1-\tau_t) w_t h_t^i + (1 + q_{L,t}\delta) B_{L,t-1}^i + B_{S,t-1,2}^i + D_t P_t - T_t P_t - P_t \bar{C}_t^i \tag{7}$$

On the LHS we have the household's choice variables, stage 1 consumption C_t^i and the market value of the portfolio $(B_{S,t}^i, B_{L,t}^i)$. The leading term on the RHS represents the household's net wage income $(1-\tau_t) w_t h_t^i$ where w is the real wage rate and τ_t represents a proportional tax levied on labour income. The terms $(1 + q_{L,t}\delta) B_{L,t-1}^i + B_{S,t-1,2}^i$ represent the nominal pay out of long and short term assets bought by the household in the previous period. Notice that $B_{S,t-1,2}^i$ has a subscript '2' which

[25] This assumption will rule out selection effects into different bond market segments (as in e.g. Amihud and Mendelson (1991)), for example when agents that experience a high θ today will likely expect a high θ tomorrow and have a stronger demand for short term assets. Introducing this element should not be difficult, but for now we leave it to future work.

[26] The interpretation of the uninsurability of the expenditure shock, θ, could then be a spatial one. In sub-period 2, family members are spatially separated and so the goods c_t^i have to be obtained from other families in exchange for the liquid asset (the short-term bond).

is used to denote that these are short bonds that remained in the household's portfolio after the transactions at stage 2 in period $t-1$ had been realized.

Variable D_t is used to denote income from dividends. Since ours is a New Keynesian model, there is a continuum of monopolistically competitive firms earning profits (see below). Households are the owners of these firms and we assume that each household owns an equal amount of shares as any other household in the economy.[27] It should be noted that firm profits are taxed in the model at the proportional rate τ_t. Therefore D_t is profits net of taxation. In addition, we also assume that households can be taxed in a lump sum fashion. T_t denotes lump sum tax.[28]

Finally, the term $\bar{C}_t^i$ denotes the goods the family expects to sell to other families in sub-period 2. It is important to note that $\bar{C}_t^i$ is not a choice variable for the household, and rather it is used here to ensure market clearing in the goods market (see Hagedorn, 2018). It holds that:

$$E_\theta(c_t(\theta)) = \bar{C}_t^i, \tag{8}$$

and so the household will enter the next period with short term bonds equal to

$$B_{S,t,2} = E_\theta(B_{S,t}^i - P_t(c_t(\theta)) + P_t\bar{C}_t^i, \tag{9}$$

We can now express the household's program formally. Optimal choices solve the following value function:

(10)

$$V_t(B_{L,t-1}^i, B_{S,t-1,2}^i, X_t) = \max_{B_{L,t}^i, B_{S,t}^i, C_t^i, c_t^i, h_t^i} \left\{ u(C_t^i) + E_\theta \theta v(c_t^i) - \chi \frac{{h_t}^{i,1+\gamma}}{1+\gamma} + \beta E_t \left[V_{t+1}(B_{L,t}^i, B_{S,t,2}^i, X_{t+1}) \right] \right\}$$

subject to constraints (7) and (9), the constraint (6) governing consumption in sub-period 2. We use state variable X to denote the vector of aggregate shocks to the economy (to be described later).

Solving the Bellman equation leads to the following optimality conditions:[29] First,

$$u'(C_t^i) = \theta v'(c_t^i) \quad \text{if} \quad \theta < \widetilde{\theta}_t \tag{11a}$$

$$c_t^i = b_{t,S}^i \quad \text{if} \quad \theta \geq \widetilde{\theta}_t \tag{11b}$$

defines the optimal choice of c^i. When the realized value of θ is below the threshold $\widetilde{\theta}_t$ the optimal choice is unconstrained and the household sets $\theta v'(c_t^i) = u'(C_t^i)$. In contrast, if θ exceeds the threshold, then (6) is binding and trivially c^i is equal to $b_{t,S}^i$. Obviously, at the threshold, we have $\widetilde{\theta}_t v'(b_{t,S}^i) = u'(C_t^i)$.

Second, the optimal choice of short term bonds leads to :

$$q_{t,S} u'(C_t^i) = F(\widetilde{\theta}_t)\beta E_t \frac{u'(C_{t+1}^i)}{\pi_{t+1}} + \int_{\widetilde{\theta}_t}^{\infty} \theta v'(b_{t,S}^i) dF_\theta \tag{12}$$

The interpretation of (12) is standard. At the margin the household equates the utility costs of saving $q_{t,S}$ in the short term bond, with the utility benefit of acquiring more of the asset. The benefit has two components: On the one hand, the short term asset provides liquidity to finance subperiod 2 consumption (this is the term $\int_{\widetilde{\theta}_t}^{\infty} \theta v'(b_{t,S}^i) dF_\theta$). On the other hand, with probability $F(\widetilde{\theta}_t)$, the preference shock is below the threshold value, and short term bonds will be carried over to the next period. The standard asset pricing formula applies for this asset which pays $\frac{1}{\pi_{t+1}}$ units of real income.

[27] To simplify, we assume (as many papers in the literature do) that shares cannot be traded. This makes stocks a more illiquid asset than bonds.

[28] We will use both, lump sum and distortionary taxes in the following sections. Lump sum taxes allow us to derive tractable analytical results. Distortionary taxes make the optimal policy program we consider in Section 4 meaningful.

[29] See online appendix.

Third, the price of the long-term bond satisfies a standard Euler equation:

$$q_{t,L}u'(C_t^i) = \beta E_t \frac{u'(C_{t+1}^i)}{\pi_{t+1}}(1 + \delta q_{t+1,L}) \tag{13}$$

Finally, the optimal choice of hours gives the familiar labour supply condition:

$$\chi \frac{h_t^\gamma}{U'(C_t)} = w_t(1 - \tau_t) \tag{14}$$

3.2.4 Production / Government / Resource Constraints

We now describe the production side of the model and the government.

As discussed previously, we assume, in the standard New Keyenesian fashion, that a final good is produced as the aggregate of infinitely many differentiated products. Each of the products is produced under monopolistic competition by a single producer operating a technology that is linear in the labour input:

$$Y_t(j) = H_t(j)$$

The final good is then given by the following Dixit-Stiglitz aggregator

$$Y_t = \left(\int_1^0 Y_t(j)^{\frac{1}{1+\eta}} dj \right)^{1+\eta}$$

where η governs the elasticity of substitution across the differentiated goods.

Producers of goods $Y_t(j)$ solve a standard problem, setting the price level to maximize discounted profits subject to the demand curve, and taking as given the costs of hiring labour, w. Moreover we assume that price setting may involve paying a resource cost as in Rotemberg (1982). In particular,

$$\Omega_t = \frac{\omega}{2} \left(\frac{P_{jt}}{P_{jt-1}} - 1 \right)^2,$$

which implies that the firm pays a cost whenever it changes the price relative to the previous period. Parameter ω governs the degree of price rigidity. A high value for this parameter implies a steep cost of adjusting prices. When $\omega = 0$ prices are perfectly flexible.

Note that the above is a standard set up (see, for example, Schmitt-Grohé and Uribe, 2004) and for brevity we will not define formally the firm's program . In this model, the equilibrium is symmetric and all firms end up charging the same price and hiring the same units of labour h_t. Moreover, the model admits the following New Keynesian Phillips curve:

$$\pi_t(\pi_t - 1) = \frac{\eta}{\omega}(\frac{1+\eta}{\eta} - w_t)h_t + \beta E_t \frac{U'(C_{t+1})}{U'(C_t)} \pi_{t+1}(\pi_{t+1} - 1) \tag{15}$$

Let us now turn to fiscal/debt policies in the economy. The government levies taxes and issues debt to finance spending G_t. We assume that G_t is a random variable and the only source of uncertainty in the model. The government issues debt in short and long term bonds and, as usual, market clearing requires that the total supply of debt by the government is equated with the aggregate demand for the short and long assets by the households.

The government budget constraint can be written as:

$$q_{t,S}B_{t,S}^g + q_{t,L}B_{t,L}^g = B_{t-1,S}^g + B_{t-1,L}^g(1 + \delta q_{t,L}) + P_t(G_t - w_t\tau_t h_t - T_t) \tag{16}$$

where the superscript g is used to denote the supply of bonds by the government. Using market clearing and dropping superscripts (equating demand and supply) we can express the government constraint in real terms as:

$$q_{t,S}b_{t,S} + q_{t,L}b_{t,L} = \frac{b_{t-1,S}}{\pi_t} + \frac{b_{t-1,L}}{\pi_t}(1+\delta q_{t,L}) + G_t - w_t\tau_t h_t - T_t \tag{17}$$

Finally, putting together the household and the government budget constraints we can derive the following economy wide resource constraint:

$$C_t + \int c_t^i(\theta)dF_\theta + G_t + \frac{\omega}{2}(\pi_t - 1)^2 = h_t = Y_t \tag{18}$$

stating that total consumption by the households ($C_t + \int c_t^i(\theta)dF_\theta$) and the government ($G_t$), together with the resource costs of inflation make up for the total output produced in this economy. The latter is obviously equal to hours worked.

3.3 The Fiscal Multiplier in the Linearized Model

We now turn to study the propagation of spending shocks in our model, and to characterize the spending multiplier under short and long term financing. To do so we rely on a log-linear version of the model assuming also, in this paragraph, that taxes are lump sum. With this assumption we can derive analytical results. Later on we consider the case of distortionary taxes.

Let us further assume that the period utility functions u, v are both log. In the online appendix we show that the Phillips curve, the resource constraint, the government budget constraint and the two bond pricing equations we previously derived can be written as:

$$\hat{\pi}_t = \frac{1+\eta}{\omega}\overline{h}(\gamma\hat{h}_t + \hat{C}_t) + \beta E_t\hat{\pi}_{t+1} \tag{19}$$

$$\overline{C}\hat{C}_t + \int_0^{\overline{\tilde{\theta}}} \theta dF_\theta \overline{C}\hat{C}_t + \overline{\tilde{\theta}}^2 f_{\overline{\tilde{\theta}}}\overline{C}\hat{\tilde{\theta}}_t + \overline{b}_S(1 - F_{\overline{\tilde{\theta}}})\hat{b}_{t,S} - f_{\overline{\tilde{\theta}}}\overline{\tilde{\theta}}\overline{b}_S\hat{\tilde{\theta}}_t + \overline{G}\hat{G}_t = \overline{Y}\hat{Y}_t \tag{20}$$

(21)

$$\overline{q}_S\overline{b}_S(\hat{q}_{t,S} + \hat{b}_{t,S}) + \overline{q}_L\overline{b}_L(\hat{q}_{t,L} + \hat{b}_{t,L}) = \overline{G}\hat{G}_t - \overline{T}\hat{T}_t + \overline{b}_S(\hat{b}_{t-1,S} - \hat{\pi}_t) + \overline{b}_L(1+\delta\overline{q}_L)(\hat{b}_{t-1,L} - \hat{\pi}_t) + \delta\overline{q}_L\overline{b}_L\hat{q}_{t,L}$$

$$\frac{\overline{q}_S}{\overline{C}}(\hat{q}_{t,S} - \hat{C}_t) = -F_{\overline{\tilde{\theta}}}\frac{\beta}{\overline{C}}E_t(\hat{C}_{t+1} + \hat{\pi}_{t+1}) + \frac{\beta}{\overline{C}}f_{\overline{\tilde{\theta}}}\overline{\tilde{\theta}}\hat{\tilde{\theta}}_t - \frac{1}{\overline{b}_S}\int_{\overline{\tilde{\theta}}}^{\infty}\theta dF_\theta\hat{b}_{t,S} - \frac{1}{\overline{b}_S}\overline{\tilde{\theta}}^2 f_{\overline{\tilde{\theta}}}\hat{\tilde{\theta}}_t \tag{22}$$

$$\frac{\overline{q}_L}{\overline{C}}(\hat{q}_{t,L} - \hat{C}_t) = -\frac{\beta}{\overline{C}}(1+\delta\overline{q}_L)E_t(\hat{C}_{t+1} + \hat{\pi}_{t+1}) + \frac{\overline{q}_L}{\overline{C}}\delta\overline{q}_L E_t\hat{q}_{t+1,L} \tag{23}$$

where hats denote that variables are expressed in log deviation from their steady state values. $\hat{\tilde{\theta}}_t + \hat{C}_t = \hat{b}_{t,S}$ defines the threshold $\tilde{\theta}_t$ in this log-linear model.

Equations (19) to (23) are sufficient for a competitive equilibrium when we further specify monetary and fiscal policies, setting the path of the short -term nominal interest rate and the tax schedule respectively. We next explore the fiscal multiplier in this model under various specifications of these policies.

3.3.1 Simple analytics.

We first show that issuing short term debt increases the size of the spending multiplier, in an analytical version of the model. To show this we focus on an environment where the Phillips curve, the Euler equation for short term debt and the resource constraint (equations (19), (20) and (22)) are sufficient to determine the path of output and consumption following a spending shock. In particular, we assume that lump sum taxes are set by the government so that the budget constraint (21) is satisfied. Then, we do not have to keep track of equation (21) to derive output and also we can dispense with equation (23) since the price $\hat{q}_{L,t}$ can be set to satisfy this equation given the path of consumption and inflation.

Recall that our empirical analysis had linked the size of the fiscal multiplier to the share of short debt over long term debt. We assume in this paragraph that the response of the share to the spending shock is of the same sign as the response of $\hat{b}_{t,S}$, the real value of short term bonds in t.[30] We consider paths $\hat{b}_{t,S} = \varrho \hat{G}_t$ where ϱ is of positive value if the government finances the shock short term (the share of short bonds then increases) and $\varrho < 0$ when the shock is financed with long term debt (short term share drops).

Consider the Euler equation (22) that prices short term debt. Substituting in the condition $\hat{\tilde{\theta}}_t = \hat{b}_{t,S} - \hat{C}_t$ and rearranging we get:

(24)
$$\frac{\overline{q}_S}{\overline{C}}\hat{q}_{t,S} + F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}}E_t\hat{\pi}_{t+1} + F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}}\hat{C}_{t+1} = \underbrace{\left(\frac{\overline{q}_S}{\overline{C}} + (1-\beta)\frac{1}{\overline{C}}f_{\bar{\tilde{\theta}}}\bar{\tilde{\theta}}\right)}_{\alpha_1}\hat{C}_t - \underbrace{\left((1-\beta)\frac{1}{\overline{C}}f_{\bar{\tilde{\theta}}}\bar{\tilde{\theta}} + \frac{1}{\overline{b}_S}\int_{\bar{\tilde{\theta}}}^{\infty}\theta dF_\theta\right)}_{\alpha_2}\hat{b}_{t,S}$$

where evidently $\alpha_1, \alpha_2 > 0$.

Let us first assume that monetary policy sets the path of the nominal interest rate so that $\frac{\overline{q}_S}{\overline{C}}\hat{q}_{t,S} + F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}}E_t\hat{\pi}_{t+1} = 0$. Notice that under this policy, the real rate would be constant if $\frac{\overline{q}_S}{\overline{C}} = F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}}$. This would in turn hold if short term debt had no liquidity value to finance consumption.[31] In contrast, when short bonds generate liquidity services in subperiod 2, then $\overline{q}_S > \beta > \beta F_{\bar{\tilde{\theta}}}$ and the nominal interest rate will not increase proportionally with expected inflation to keep the real interest rate constant.[32]

Under this policy, we can write (24) as:

$$F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}}\hat{C}_{t+1} = \alpha_1\hat{C}_t - \alpha_2\hat{b}_{t,S}$$

which defines a first order difference equation in $\hat{C}$. Since $F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}} < \alpha_1$[33] we can solve forward to obtain:

$$\hat{C}_t = \frac{\alpha_2}{\alpha_1}E_t\sum_{\bar{t}\geq 0}(F_{\bar{\tilde{\theta}}}\frac{\beta}{\alpha_1\overline{C}})^{\bar{t}}\hat{b}_{t+\bar{t},S}$$

[30] This is not a restrictive assumption since we assume that taxes satisfy the government budget for any path of long term debt after the shock. We can thus always ensure that the share is of the same sign as $\hat{b}_{t,S}$.

[31] For a sufficiently large stock of short term bonds we have that $\overline{q}_S \approx \beta$ and $F_{\bar{\tilde{\theta}}} \approx 1$. We then obtain the standard 3 equation NK model in which targeting a constant real interest rate implies no consumption response to the spending shock (Woodford, 2011). Then also $\alpha_2 = 0$.

[32] A way to interpret this condition is the following: Since $F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}}E_t\hat{\pi}_{t+1}$ is the expected decrease of the real value of short bond holdings for households that retain their stock of short bonds after subperiod 2, monetary policy compensates these households for higher expected inflation. As we will now show, under this policy and if in addition we assume $\hat{b}_{S,t} = 0$, so that the supply of the short term asset also does not change the payoff of holding the asset, then consumption remains constant through time.

[33] This follows from $F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}} < F_{\bar{\tilde{\theta}}}\frac{\beta}{\overline{C}} + \frac{1}{\overline{b}_S}\int_{\bar{\tilde{\theta}}}^{\infty}\theta dF_\theta = \frac{\overline{q}_S}{\overline{C}} < \frac{\overline{q}_S}{\overline{C}} + (1-\beta)\frac{1}{\overline{C}}f_{\bar{\tilde{\theta}}}\bar{\tilde{\theta}} \equiv \alpha_1$.

which expresses consumption in period t as a function of the sequence of real short bonds. Using this result, it is simple to characterize the path of $\hat{C}_t$ following a shock to spending when $\hat{b}_{S,t} = \varrho \hat{G}_t$. Let us make the standard assumption, that spending follows a first order auto-regressive process with coefficient ρ_G. Then, considering a positive innovation to spending at date 0 we have that

$$\hat{C}_t = \rho_G^t \frac{\alpha_2}{\alpha_1} \frac{1}{1 - F_{\bar{\bar{\theta}}} \frac{\beta}{\alpha_1 \overline{C}} \rho_G} \varrho \hat{G}_0, \qquad t \geq 0 \tag{25}$$

Analogously, the response of total consumption (in both subperiods) can be derived as:

$$\hat{TC}_t = \kappa_1 \varrho \rho_G^t \hat{G}_0$$

where $\kappa_1 > 0$[34]

Using these expressions we can easily derive analytically the fiscal multiplier. Define the impact multiplier as the dollar increase in output for each dollar increase in spending, or $m_0 = \frac{\overline{Y} d\hat{Y}_0}{\overline{G} d\hat{G}_0}$. It is simple to show that:

$$m_0 = \frac{\overline{Y} d\hat{Y}_0}{\overline{G} d\hat{G}_0} = 1 + \frac{1}{\overline{G}} \left[\frac{\alpha_2}{\alpha_1} \frac{\overline{C}(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta)}{1 - F_{\bar{\bar{\theta}}} \frac{\beta}{\alpha_1 \overline{C}} \rho_G} + \bar{b}_S (1 - F_{\bar{\bar{\theta}}}) \right] \varrho \tag{26}$$

Notice that a key parameter determining the size of the multiplier is ϱ. When the government finances spending short term, or $\varrho > 0$, then the multiplier exceeds 1. Otherwise, assuming $\varrho < 0$ yields an impact multiplier that is less than 1. With short term financing, private sector consumption is crowded in after the shock, since the higher supply of the short term asset implies that less households will be constrained in sub-period 2. Moreover, as is evident from (26), the impact multiplier also depends on parameters $\alpha_1, \alpha_2, F_{\bar{\bar{\theta}}}$ that influence the elasticity of consumption with respect to $\hat{b}_{S,t}$. The more responsive is total spending to the share $\hat{b}_{S,t}$, the larger is the multiplier.

Our quantitative experiments below will discipline these parameters to match relevant moments from US data. In particular, we will discipline parameter ϱ, measuring the response of the share to the spending shock, using the empirical model of the previous section. Parameters $\alpha_1, \alpha_2, F_{\bar{\bar{\theta}}}$ (their analogues in the calibrated model of the next subsection) will be such that the model produces a realistic response of the term spread to a change in the share of short term bonds. For the moment our interest is is verifying that the model possesses a mechanism which makes the fiscal multiplier depend on how the government finances spending shocks.

[34] In the appendix, we derive the following formula:

$$\kappa_1 = \frac{1}{\overline{C}(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta) + \bar{b}_S(1 - F_{\bar{\bar{\theta}}})} \left[\frac{\alpha_2}{\alpha_1} \frac{\overline{C}(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta)}{1 - F_{\bar{\bar{\theta}}} \frac{\beta}{\alpha_1 \overline{C}} \rho_G} + \bar{b}_S (1 - F_{\bar{\bar{\theta}}}) \right]$$

Notice that depending on the persistence of the shocks κ_1 could exceed 1. For i.i.d spending however κ_1 is strictly smaller than 1. To see this notice that

$$\alpha_1 = \frac{\overline{q}_S}{\overline{C}} + (1-\beta)\frac{1}{\overline{C}} f_{\bar{\bar{\theta}}} \bar{\bar{\theta}} = \beta \frac{F_{\bar{\bar{\theta}}}}{\overline{C}} + \frac{1}{\bar{b}_S} \int_{\bar{\bar{\theta}}}^{\infty} \theta dF_\theta + (1-\beta)\frac{1}{\overline{C}} f_{\bar{\bar{\theta}}} \bar{\bar{\theta}} > \frac{1}{\bar{b}_S} \int_{\bar{\bar{\theta}}}^{\infty} \theta dF_\theta + (1-\beta)\frac{1}{\overline{C}} f_{\bar{\bar{\theta}}} \bar{\bar{\theta}} = \alpha_2$$

and therefore the ratio $\frac{\alpha_2}{\alpha_1}$ is strictly smaller than 1. Then if $\rho_G = 0$, obviously, $\kappa_1 < 1$. For a sufficiently persistent shock we may have $\frac{\alpha_2}{\alpha_1} \frac{1}{1 - F_{\bar{\bar{\theta}}} \frac{\beta}{\alpha_1 \overline{C}} \rho_G} > 1$ and κ_1 exceeds unity. Clearly, shock persistence exerts an influence due to the assumption that the short bond follows G (implying a bigger increase in the short asset supply inter-temporally when $\rho_G > 0$) and due to the forward looking nature of total consumption.

This prediction can also be verified under more plausible assumptions regarding monetary policy than what we assumed above, for example when the nominal interest rate follows a rule targeting inflation or the output gap. To simplify, let us assume a policy function of the form:

$$\hat{i}_t = \phi_\pi \hat{\pi}_t$$

Moreover, to keep the algebra tractable let us also assume that shocks to spending are i.i.d, or $\rho_G = 0$. Then, conjecturing a solution of the form

$$\hat{\pi}_t = \chi_1 \hat{G}_t \qquad \hat{C}_t = \chi_2 \hat{G}_t \qquad \hat{Y}_t = \chi_3 \hat{G}_t$$

for some coefficients χ_1, χ_2, χ_3 which satisfy the three equilibrium conditions (19), (20) and (22), we find

$$(27) \qquad m_0 = \overbrace{\frac{1}{1 + \frac{\overline{C}\left(1+\int_0^{\overline{\overline{\theta}}} \theta dF_\theta\right)\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{C}}\phi_\pi}{1+\frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{C}}\phi_\pi}\frac{1+\eta}{\omega}\gamma_h}}^{\equiv \alpha_3}\left[1 + \left(\frac{1}{\overline{\overline{G}}}\frac{\alpha_2}{\alpha_1}\frac{\overline{C}\left(1+\int_0^{\overline{\overline{\theta}}} \theta dF_\theta\right)}{1+\frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{C}}\phi_\pi} + \overline{b}_S(1 - F_{\overline{\overline{\theta}}})\right)\varrho\right]$$

(see appendix).

A couple of comments are in order. First, comparing (27) with (26) (the latter when we set $\rho_G = 0$) it is easy to see that the impact multiplier is now smaller in magnitude. As expected, when monetary policy raises the nominal rate in response to inflation (and therefore also following a positive spending shock which is typically inflationary), then the real interest rate increases, and this suppresses private consumption. In (27) this effect is visible from the leading fraction ($\alpha_3 < 1$) and the fraction in the square bracket featuring ϕ_π in the denominator. Both fractions decrease in ϕ_π.[35] [36]

Second, parameter ϱ continues being important. We can show that when $\varrho = 0$ (the share remains constant after the shock) then the multiplier falls short of unity (due to the crowding out of consumption). Moreover, it is possible to find sufficiently positive values of ϱ for which the multiplier exceeds 1. In the latter case the crowding out effect of the higher real interest rate on consumption, following the spending shock, is compensated by the crowding in effect deriving from the larger short bond supply.

[35] Note that we did not specify under which condition for ϕ_π the solution to (19), (20) and (22) is a unique stable equilibrium. It is perhaps worth to discuss this briefly.

In this model the usual condition $\phi_\pi > 1$ (i.e. the Taylor principle) does not need to hold for a unique equilibrium. Instead it is sufficient to have $\phi_\pi > \beta \frac{F_{\overline{\overline{\theta}}}}{\overline{q}_S}$ which, since $\overline{q}_S > \beta$ and $F_{\overline{\overline{\theta}}} < 1$, defines a threshold value that is strictly less than 1. Intuitively, the Euler equation (22) features 'discounting' and this enables to rule out multiple equlibria even when the Taylor principle does not hold (an analogous property obtains in the HANK model (see, for example, Bilbiie, 2021)).

The reader may also wonder whether the assumption of an exogenous path of real debt, $\hat{b}_{S,t}$, is important for this property. Indeed this is so: Suppose that debt issuance is set according to a rule $\hat{b}_{S,t} + \hat{\pi}_t = \varrho \hat{G}_t$. Then, (for some parameterizations of the model) even setting $\phi_\pi = 0$ could induce determinacy of the equilibrium. The logic follows Hagedorn (2018). In this model where the real value of debt enters the Euler equation the price level (and hence also inflation) may be determinate even under a simple interest rate peg.

[36] It is worth briefly commenting on the square bracketed terms in (27). Notice that ϕ_π exerts an influence only through the term $\frac{1}{\overline{G}}\frac{\alpha_2}{\alpha_1}\varrho\frac{\overline{C}\left(1+\int_0^{\overline{\overline{\theta}}} \theta dF_\theta\right)}{1+\frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{C}}\phi_\pi}$ and not through $\overline{b}_S(1 - F_{\overline{\overline{\theta}}})$. This is intuitive. The former term concerns the intertemporal substitution of consumption, whereas the latter measures consumption at the constraint. The second term is thus only affected by the short term bond supply not by the inflation coefficient (and thus the path of the real interest rate).

Finally, the influence of ϕ_π on the leading fraction in (27), the term labeled α_3, measures the indirect effect of inflation through the Phillips curve on the multiplier.

3.4 A calibrated model

We now calibrate the model to US data to investigate quantitatively how the spending multiplier varies with the financing of the spending shock. We continue assuming that utility is log - log as in the previous paragraph. Moreover, we make the following assumptions about fiscal/monetary policies and the share of short term debt in the model. First, we assume that taxes follow a standard rule of the form:

$$\hat{T}_t = \phi_T \hat{D}_{t-1} \tag{28}$$

where $\hat{D}$ denotes the real face value of total debt (both long and short term bonds).

Second, we assume that the share of short term debt over long term debt follows

$$\hat{s}_t^{\text{Short/Long}} = \varrho \hat{G}_t \tag{29}$$

where as in the empirical model we assume that short term debt represents any debt that is of maturity less than one year.[37]

Finally, for the baseline model we assume that monetary policy follows an interest rate rule of the form:

$$\hat{i}_t = \phi_\pi \hat{\pi}_t + \phi_Y \hat{Y}_t \tag{30}$$

In our quantitative experiments below, we first consider the case where $\phi_Y = 0$, thus assuming as before a simple inflation targeting rule. We also provide results for the case where ϕ_Y is positive.

The values for the remaining parameters of the model have been chosen as follows:

Since the model horizon is quarterly, we set $\beta = 0.995$. We then set $\delta = 0.975$ so that the long term bond is of (average) maturity equal to 40 quarters. Further more, we set the steady state ratio of total debt to GDP equal to 60 percent at an annual horizon.

To calibrate $\overline{b}_S, \overline{b}_L$ we follow Faraglia et al. (2019) who report that in post world war II US data, the average share of short term debt (in their case defined as all debt of maturity less than or equal to one year) over total debt was roughly 40 percent. We map this quantity to our model and calculate the values of $\overline{b}_S, \overline{b}_L$.[38]

We now describe how we chose objects $F_\theta, \overline{\overline{\theta}}, \varrho$ and $\overline{q}_S$. First, given $\overline{q}_L = \frac{\beta}{1-\beta\delta}$ in steady state, we calibrate $\overline{q}_S$ so that the term premium at the annual horizon is equal to 1 percentage point. The quarterly net rate of return on the long term asset is $\overline{R}_L - 1 = \frac{1+\delta\overline{q}_L}{\overline{q}_L} - 1 = 0.5\%$ and the analogous short term rate $(\frac{1}{\overline{q}_S})$ equals 0.25%.

Given $\overline{q}_S$ our principle in calibrating F is the following: We assume that F is log normal which leaves us with two parameters (the mean and the variance) to hit relevant targets. We calibrate the mean so that in state state, total consumption is 80% of output which we normalize to 1. Government

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[37] In other words, we strip the coupons of the long term asset and consider the payments that are of maturity less than 4 quarters as short term debt. Therefore, the share (in levels) is defined as

$$s_t^{\text{Short/Long}} = \frac{b_{S,t} + b_{L,t}\frac{1-\delta^4}{1-\delta}}{b_{L,t}\frac{\delta^4}{1-\delta}}$$

The loglinear approximation gives

$$\hat{s}_t^{\text{Short/Long}} = \frac{1}{\overline{s}^{\text{Short/Long}}} \frac{\overline{b}_S}{\overline{b}_L \frac{\delta^4}{1-\delta}} \left(\hat{b}_{S,t} - \hat{b}_{L,t} \right).$$

[38] We obtain similar values for $\overline{b}_S, \overline{b}_L$. when we instead target an average debt maturity of 5 years, which is commonly assumed in the literature.

spending then accounts for 20% of aggregate output since we assume that the inflation rate is zero in the deterministic steady state.

We then set the variance of F so that our model produces an elasticity of the term premium with respect to the short term debt to GDP ratio in line with the estimates of Greenwood et al. (2015). This paper reports that an increase of the ratio by 1 percent, reduces the (annualized) spread between T-bills and T-notes/bonds by 16 basis points in the case of 4 week bills and about 8 basis points for 10 week yields. Both are relevant numbers since the data counterpart for b_S is all debt that is of maturity up to one quarter. We target a 2.5 basis points change in the spread, corresponding to our quarterly model.[39]

Third, we discipline the value of ϱ using the empirical evidence: In the proxy VAR we identified the effects of a spending shock under short term financing relying on observations where the average increase in $s_t^{\text{Short/Long}}$ is 0.6% and the shock is a 1% increase in government spending. Under long term financing the share was lower by roughly 0.6% on average. We thus set $\varrho = 0.6$ as our baseline when the government finances short and $\varrho = -0.6$ in the case long term financing. We conduct robustness checks with respect to the value of ϱ.

Finally, for the remaining model parameters we adopt standard values. ω and η are set to 17.5 and -6 respectively, following Schmitt-Grohé and Uribe (2004). γ_h equals 1 implying a Frisch elasticity of labour supply of the same magnitude. The persistence of the spending shock ρ_G is 0.95. Parameter ϕ_τ, governing the response of taxes to lagged debt, is set equal to 0.01 to get a smooth and gradual response of taxes to the shock. Notice also that this value is close to the threshold that defines the determinacy region in the model.[40]

3.4.1 Baseline experiments

Figure 8 shows the responses of consumption (top panel) and output (middle panel) to a shock which increases spending by 1 percent on impact. The blue lines show the responses under short term financing (STF) whereas the red lines are the analogous objects in the case where the government finances with long term debt (LTF). The solid lines represent the case where monetary policy follows an inflation targeting rule setting the inflation coefficient,ϕ_π equal to 1.5; the dashed lines correspond to the case where $\phi_\pi = 1$.

The differences between short and long term financing are easy to spot in the Figure. Financing the deficit short term, leads to a stronger output response due to the fact that consumption is not crowded out considerably and may even be crowded in, depending on the inflation coefficient. In contrast, under long term financing, consumption drops significantly after the spending shock, and this translates into a weaker response of output to the shock.

To better highlight the key driving forces behind these results let us go back to the Euler equation (24). Under the assumed monetary policy in this section we can write this equation as

$$\phi_\pi \hat{\pi}_t = F_{\bar{\bar{\theta}}} \frac{\beta}{\overline{q}_S} E_t \hat{\pi}_{t+1} + F_{\bar{\bar{\theta}}} \frac{\beta}{\overline{q}_S} \hat{C}_{t+1} - \frac{\overline{C}\alpha_1}{\overline{q}_S} \hat{C}_t + \frac{\overline{C}\alpha_2}{\overline{q}_S} \hat{b}_{t,S} \tag{31}$$

Note that the crucial element in (31) is the last term on the RHS, $\frac{\overline{C}\alpha_2}{\overline{q}_S}\hat{b}_{t,S}$. This term acts like

[39]To hit this target, we consider a shock to the ratio $\hat{b}_{S,t} - \hat{Y}_t$ using the baseline version of the model where monetary policy is assumed to follow an inflation targeting rule with coefficient equal to 1.5. This can be seen as a good approximation of US monetary policy in the post 1980s sample that Greenwood et al. (2015) use to run their regressions.

[40]Assuming constant taxes (for example) violates the Blanchard-Kahn condition.

Moreover, we chose ϕ_τ to be nearly at the threshold since this is consistent with the estimates of medium scale DSGE models (see e.g. Bianchi and Ilut (2017) among others.) For ϕ_τ near the threshold, debt is close to a random walk, which is generally a good approximation of the data process.

a standard demand shock to the Euler equation.[41] Under short term financing, the increase in spending is accompanied by a positive shock, the opposite could happen under long financing, when inflation reduces the real quantity of short term debt, or when total debt (both long and short) increases by less than the long bond issuance implying a reduction in the amount of short bonds outstanding.[42]

The reaction of monetary policy is key. As with any positive demand shock a stronger reaction of the nominal rate (a higher inflation coefficient) will reduce the expansionary effects. This basically explains why the responses of consumption and output are more muted when $\phi_\pi = 1.5$. Opposite, in the case of long term financing we may see monetary policy aggravating the effects of a negative innovation to demand. We return to discuss this further below.

The bottom panel of the Figure shows how the response of output translates into the cumulative multiplier (defined here as in the empirical section) under the 4 alternative calibrations considered. As is evident from the graph, issuing short term debt, leads to a multiplier that is close to 1 (exceeds 1 in the case $\phi_\pi = 1$) whereas we obtain multipliers much smaller than one when we assume that the government issues long term debt.

These findings are clearly in line with our previous analytical results, that we can obtain stronger expansions from fiscal shocks, when debt is short term. We next experiment with alternative calibrations of the model and alternative assumptions regarding fiscal and monetary policies to show the robustness of our findings.

3.4.2 Extensions

We first consider the case where monetary policy follows interest rate rule (30) but now $\phi_Y > 0$. In particular, we assume $\phi_Y = 0.5$. In Figure 9 we repeat the impulse responses shown in Figure 8. The results do not change: We continue to find significant differences in the fiscal multiplier depending on how the government finances spending. Once again short term financing leads to a higher multiplier when the increase in spending does not impinge a very negative effect on consumption. The inflation coefficient in an important parameter also in this case.

Assume now that monetary policy follows an inertial rule of of the form:

$$\hat{i}_t = \rho_i \hat{i}_{t-1} + (1 - \rho_i)\phi_\pi \hat{\pi}_t$$

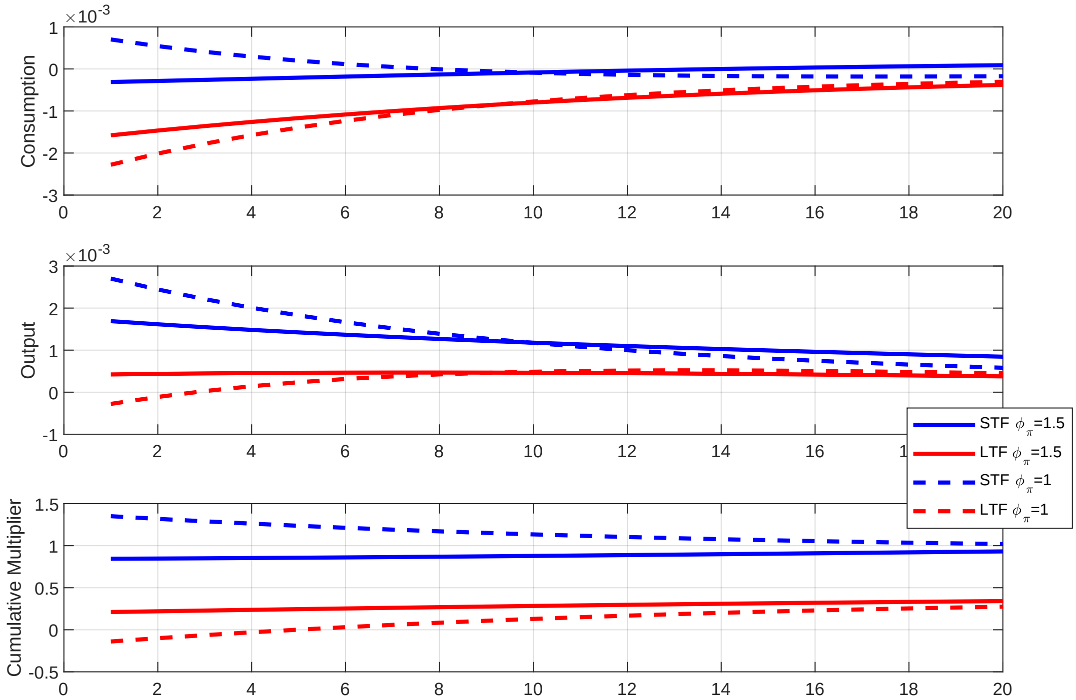
and note that a higher value of the coefficient ρ_i ought to increase the fiscal multiplier under short term financing and maybe decrease it in the LTF case. This will be due to two channels: First, (independent of how the shock is being financed) a more gradual response of the nominal rate to inflation will increase the multiplier (this is the standard New Keynesian model effect) and second since bond supply acts as a demand disturbance, a nearly constant interest rate when ρ_i is close to 1, will magnify the effect of that shock as well. This is shown clearly in Figure 10, where we assumed $\rho_i = 0.9$. Notice that the fiscal multiplier under STF is now considerably higher and can even be greater than 3 (when measured near impact). On the other hand, the multiplier under LTF decreases.

Furthermore, our baseline model focuses on a scenario in which monetary policy responds strongly to inflation and fiscal policy ensures the solvency of government debt through taxes. We run a model in which we reversed these assumptions, letting taxes be constant through time (i.e. $\phi_\tau = 0$ in

[41] This is therefore analogous to a preference shock in the baseline New Keynesian model.

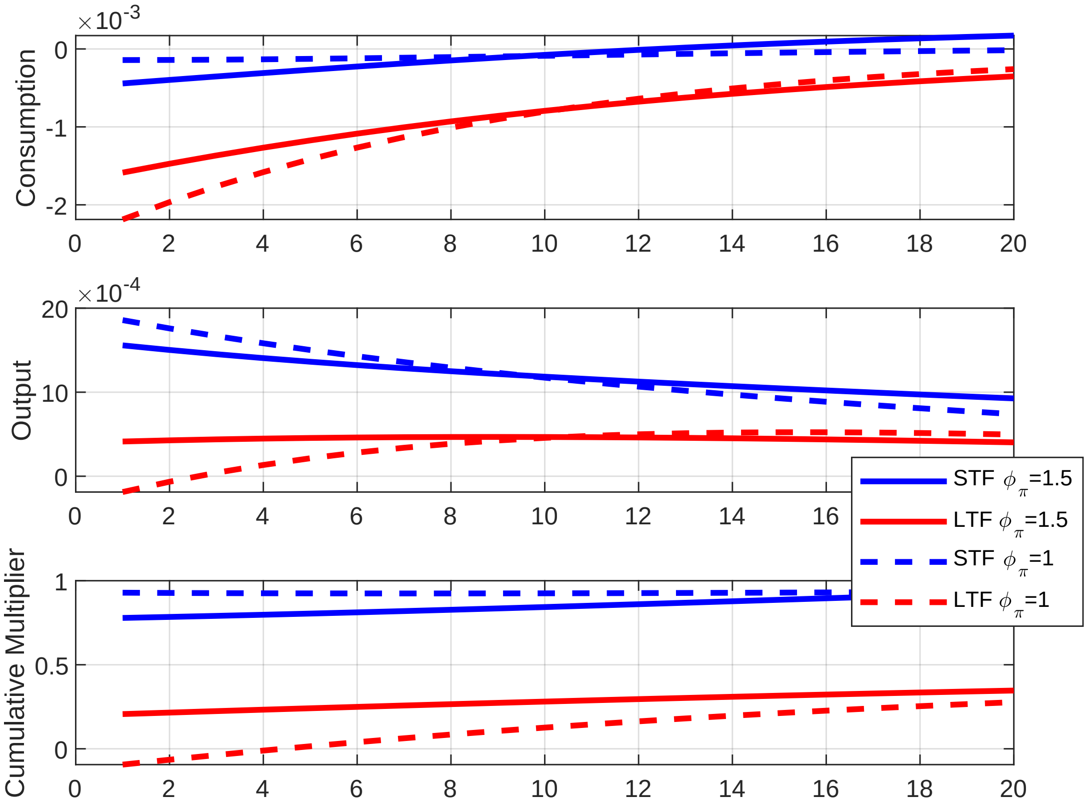
[42] Note that the latter possibility is not unrealistic. Since short bonds mature after one period, a government that, temporarily, focuses on issuing long term debt could see a sharp contraction in the quantity of short bonds outstanding. A well-known episode where this took place in the US is the late 1990s/early 2000s when large primary surpluses brought about a rapid reduction in short bond quantities, eventually leading the Treasury to engage in buybacks of long term bonds, in order to avoid further reductions.

Figure 8: **Responses to a spending shock: Baseline Taylor rule.**



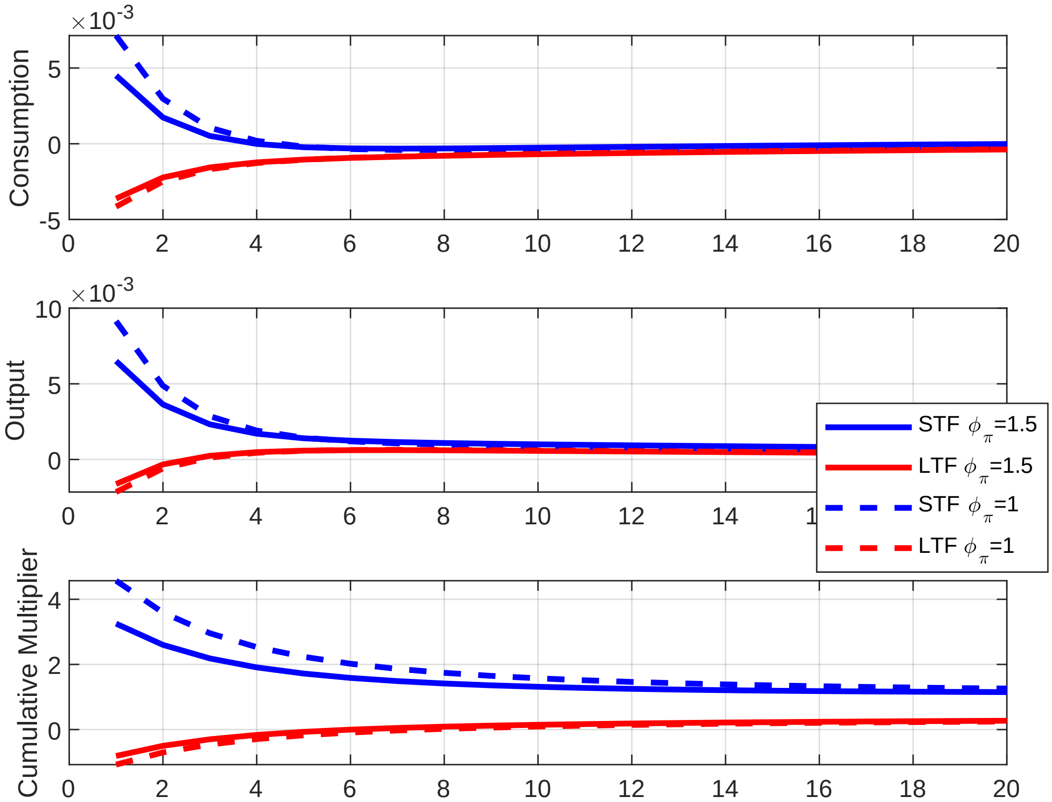
Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier following a shock that increases spending by 1 percent on impact. Monetary policy sets the nominal interest rate according to $\hat{i}_= \phi_\pi \hat{\pi}_t$*. The dashed lines set* $\phi_\pi = 1$ *and the solid lines* $\phi_\pi = 1.5$*. Responses in blue correspond to the case where the government finances with short term debt. Red lines are for long term financing.*

Figure 9: **Responses to a spending shock: Inflation and Output Targets.**



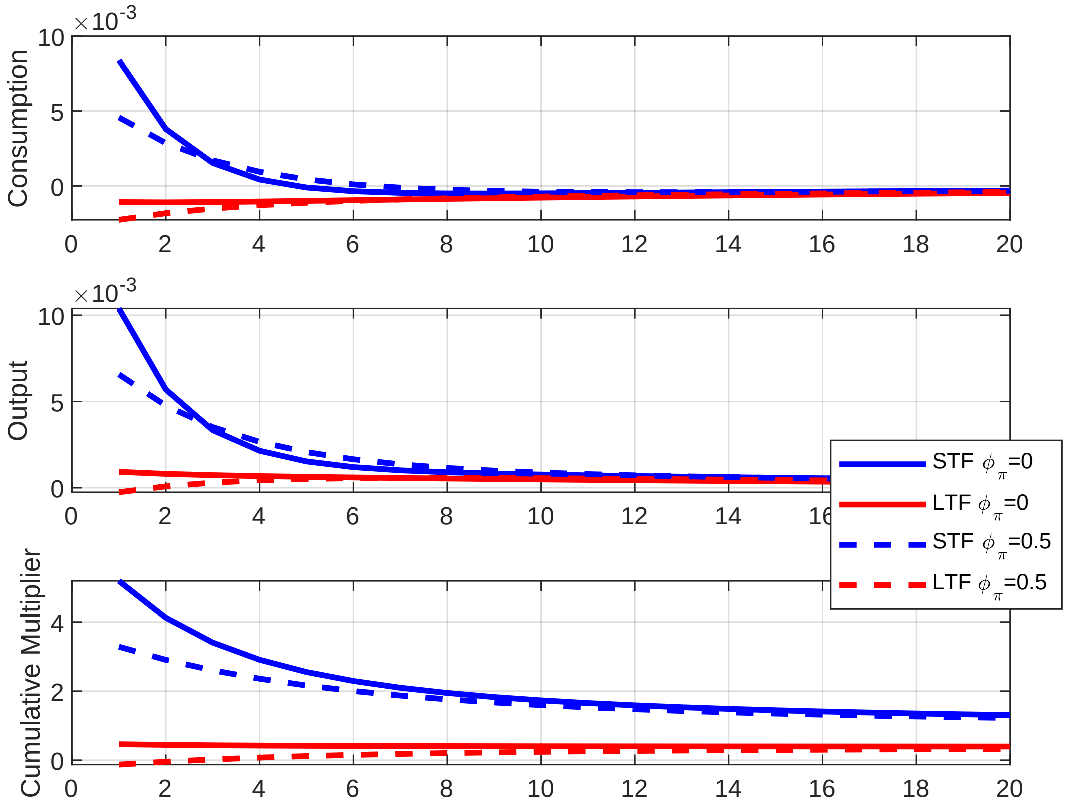
Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier following a shock that increases spending by 1 percent on impact. Monetary policy sets the nominal interest rate according to $\hat{i}_= \phi_\pi \hat{\pi}_t + \phi_Y \hat{Y}_t$. *The dashed lines set* $\phi_\pi = 1$ *and the solid lines* $\phi_\pi = 1.5$. *Throughout we fix* $\phi_Y = 0.5$. *Responses in blue correspond to the case where the government finances with short term debt. Red lines are for long term financing.*

Figure 10: **Responses to a spending shock: Inertial Interest Rate Rules.**



Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier following a shock that increases spending by 1 percent on impact. Monetary policy sets the nominal interest rate according to $\hat{i}_t = \rho_i \hat{i}_{t-1} + (1-\rho_i)(\phi_\pi \hat{\pi}_t)$*. The dashed lines set* $\phi_\pi = 1$ *and the solid lines* $\phi_\pi = 1.5$*. We set* $\rho_i = 0.9$ *Responses in blue correspond to the case where the government finances with short term debt. Red lines are for long term financing.*

Figure 11: **Responses to a spending shock: Passive Monetary Policy.**



Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier following a shock that increases spending by 1 percent on impact. Red lines are for long term financing. The monetary/fiscal policy mix is such that monetary policy is 'passive' and fiscal policy is 'active'. See text for further details.

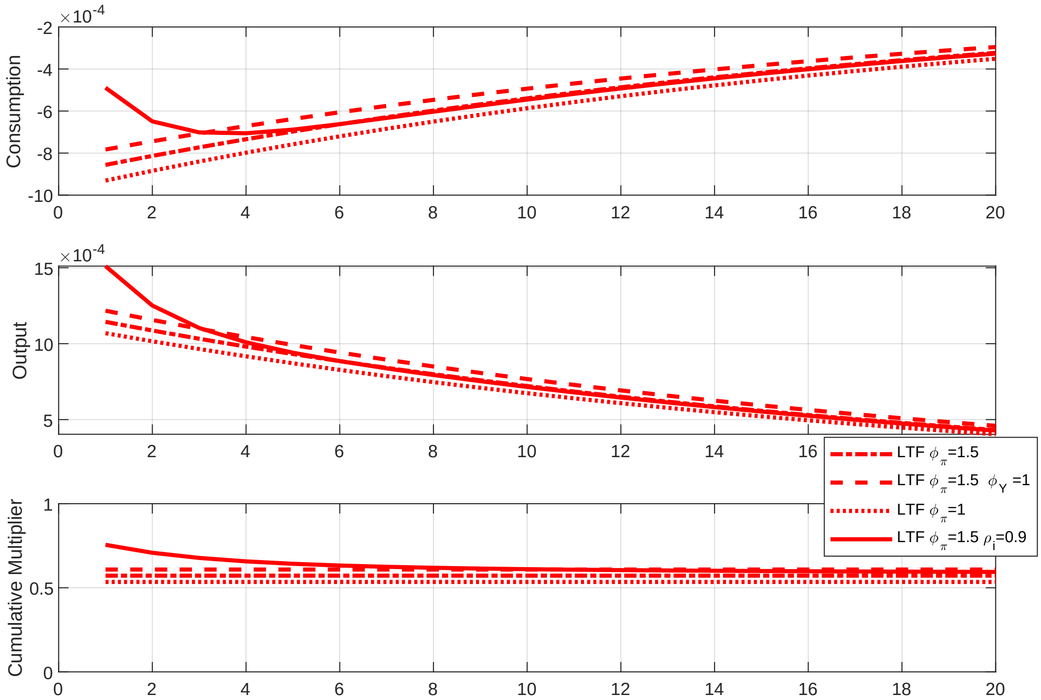
terms of previous notation) and letting the nominal interest rate weakly respond to inflation (i.e. $\phi_\pi = 0, 0.5$. Under this parameterization of the model we have an equilibrium in which inflation (rather than taxes) satisfies the consolidated budget constraint.[43]

The results are shown in Figure 11. Notice that now the spending multiplier is larger. This is of course to be expected: In an equilibrium where monetary policy cannot focus fully on stabilizing inflation and has to satisfy debt solvency, inflation will be pinned down by the intertemporal government budget constraint and so a spending shock will not only impact the macroeconomy through the usual channels (the Euler equation and the Phillips curve) but also will be filtered through the consolidated budget. This adds more volatility, macroeconomic variables in this model are more exposed to the fiscal shock (see, for example, Leeper, Traum, and Walker (2017)). The differences in the fiscal multiplier stemming from how the government finances spending are clearly also present in this model.

Next, we experiment with a model in which financing long term is coincident to keeping the real value of short term bonds constant following the shock. As discussed previously, in the LTF case and under some parameterizations of the model, we can observe that the short bond quantity drops (i.e. when the long bond issuance increases rapidly enough or inflation reduces the real value of the short

[43]This is the so called 'passive monetary/active fiscal' policy regime (see e.g. Leeper (1991) and the considerable literature on the fiscal theory of the price level) .

Figure 12: **Responses to a spending shock:** $\hat{b}_{S,t} = 0$



Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier with long term financing and assuming that the real value of short term debt stays constant after the spending shock.

term asset). To give sense of the magnitude of the multiplier when this is not allowed to happen, we run a model where we set $\hat{b}_{S,t} = 0$ everywhere along the transition path. Figure 12 shows the impulse responses and the multiplier for some of the specifications of monetary policy considered previously. As is evident, the fiscal multipliers remain much smaller that their STF counterparts shown in previous figures. For example, in the case where monetary policy follows an inertial rule (solid red line in Figure 12) the multiplier is around 0.75 on impact and gradually converges to around 0.5. The analogous multiplier under STF shown in Figure 10 exceeded 3 on impact, and was greater than 1 throughout the entire path.

As a final experiment, we replaced the assumption that taxes are lump sum with the assumption that taxes are levied on labour and dividend income at a proportional rate τ. Under distortionary taxes equations (20), (22) and (23) continue to hold, the only changes to the system of equilibrium conditions concern the government's budget constraint and the Phillips curve. In particular, the government's revenue now becomes

$$\overline{\tau}\overline{Y}\frac{1+\eta}{\eta}\left((1+\gamma_h)\hat{Y}_t + \hat{C}_t + \frac{1}{1-\overline{\tau}}\hat{\tau}_t\right)$$

which reveals that revenue depends also on aggregate output and on consumption, and hence of the path of these variables following a spending shock. Moreover, the Phillips curve now is:

$$\hat{\pi}_t = \frac{1+\eta}{\omega}\overline{Y}(\gamma\hat{Y}_t + \hat{C}_t + \frac{\overline{\tau}}{1-\overline{\tau}}\hat{\tau}_t) + \beta E_t\hat{\pi}_{t+1}$$

and therefore the path of taxes will also influence inflation in this version of the model.

The effects of spending shocks were found to be very similar to the ones shown in previous figures. We experimented with all the specifications of monetary tax policies considered above and found only small quantitative differences, the big picture does not change when taxes are assumed to be distortionary.[44]

4 Optimal Policy

The previous sections showed evidence that the size of the fiscal multiplier is larger when deficits are financed short term. This result may lead to the conclusion that an optimizing government, even facing a random spending sequence as we have assumed in this paper, may prefer to issue short maturity debt: when taxes are distortionary, so that revenue depends on output, a higher multiplier will translate to lower fiscal deficits in times of high expenditures. This will enable the government to better smooth tax distortions across time. Moreover, since in deciding the composition of its portfolio the government will consider the costs of financing debt, focusing on short bonds again seems an optimal strategy: In our model, short term yields are lower, and therefore issuing short bonds lowers the overall costs of servicing debt and hence lowers also the average level of taxes.

These arguments ignore the potential benefits from issuing long term debt. In canonical macroeconomic models an increase in the spending level leads to a drop in long bond prices. Since consumption is crowded out following a positive shock, but is expected to revert back to steady state, the real long term rate increases. Thus, a government that issues long term debt, benefits from *fiscal insurance*, from the drop in the real value of its outstanding debt obligations when the deficit rises.

Angeletos (2002) and Buera and Nicolini (2004) show that the optimal policy under full commitment in the canonical model with distortionary taxation, fully exploits this channel. Optimal debt portfolios feature a large quantity of long term debt, that can even be several times as large GDP, financed through savings in the short term asset. Lustig et al. (2008) extend their approach to a New Keyensian economy with simple frictions in financial markets, ruling out the ability of the government to invest in private assets, and find that it is still optimal for the government to focus on issuing long term debt.

We now turn to study optimal debt policy in our model. As Angeletos (2002) and Buera and Nicolini (2004), we assume that an optimizing government sets the path of distortionary taxation and the debt portfolio to maximize household welfare under full commitment. Issuing long bonds, enables the government to benefit from fiscal insurance, when consumption is crowded out following an adverse spending shock. Issuing short bonds however, leads to a crowding in of consumption and to a larger fiscal multiplier.

We first briefly describe the policy setup and derive the first order conditions of the government's program. We then discuss these optimality conditions and the properties of the optimal portfolio showing simulations from the model. The appendix contains details on the solution algorithm that we employ to approximate numerically the optimal policy equilibrium.

4.1 Optimal Policy Program.

The benevolent government chooses sequences $\left\{\boldsymbol{\pi}, \boldsymbol{Y}, \boldsymbol{\theta}, \boldsymbol{\tau}, \boldsymbol{q_S}, \boldsymbol{q_L}, \boldsymbol{b_L}, \boldsymbol{b_S}, \widetilde{\boldsymbol{\theta}}, \boldsymbol{C}\right\}$ to maximise household welfare subject to the competitive equilibrium constraints. The latter are the Phillips curve, the resource constraint, the government budget constraint and the condition $C_t\widetilde{\theta}_t = b_{S,t}$. Moreover, the Euler equations for short and long term bonds need to hold, to determine the prices of the assets.

[44] These results can be found in the online appendix.

The optimal policy[45] solves the following maximization problem:

$$\max E_0 \sum_{t\geq 0} \beta^t V(C_t, b_{S,t}, Y_t, \widetilde{\theta}_t)$$

subject to:

$$\widetilde{\theta}_t C_t = b_{S,t}$$

$$C_t(1+\int_0^{\widetilde{\theta}_t} \theta dF_\theta) + \int_{\widetilde{\theta}_t}^{\infty} b_{S,t}\theta dF_\theta + G_t + \frac{\omega}{2}(\pi_t - 1)^2 = Y_t$$

$$\pi_t(\pi_t - 1)U'(C_t) - \frac{\eta}{\omega}(\frac{1+\eta}{\eta}U'(C_t) - \frac{1}{1-\tau_t}\chi Y_t^{\gamma_h})Y_t - \beta E_t U'(C_{t+1})\pi_{t+1}(\pi_{t+1}-1)$$

$$b_{t,S}\left[\int_{\widetilde{\theta}_t}^{\infty} \theta v'(b^i_{t,S})dF_\theta + F(\widetilde{\theta}_t)E_t\frac{u'(C_{t+1})}{\pi_{t+1}}\beta\right] + b_{L,t}\sum_{j\geq 1}\beta^j\delta^{j-1}E_t\frac{u'(C_{t+1})}{\Pi_{k=1}^j \pi_{t+k}}$$
$$-\frac{b_{t-1,S}}{\pi_t}u'(C_t) - \frac{b_{L,t-1}}{\pi_t}(u'(C_t) + \delta\sum_{j\geq 1}\beta^j\delta^{j-1}E_t\frac{u'(C_{t+j})}{\Pi_{k=1}^j\pi_{t+k}}) - G_t u'(C_t) + \frac{\tau_t}{1-\tau_t}\chi Y_t^{1+\gamma_h}$$

where we scaled the government budget constraint and the Phillips curve multiplying by the marginal utility $u'(C_t)$. Moreover, the welfare function V can be expressed as:

$$V(C_t, b_{S,t}, Y_t, \widetilde{\theta}_t) \equiv \left(1+\int_0^{\widetilde{\theta}_t}\theta dF_\theta\right)\log(C_t) + \int_0^{\widetilde{\theta}_t}\theta\log(\theta)dF_\theta + \int_{\widetilde{\theta}_t}^{\infty}\theta\log(b_{S,t})dF_\theta - \chi\frac{Y_t^{1+\gamma_h}}{1+\gamma_h} \quad (32)$$

Optimality

We attach the multipliers $\psi_{RC,t}, \psi_{PC,t}, \psi_{gov,t}$ to the resource constraint, the Phillips curve, the government budget respectively and multiplier $\psi_{\widetilde{\theta},t}$ to the constraint $\widetilde{\theta}_t C_t = b_{S,t}$. For brevity the Lagrangian function is written in the appendix where we also derive the first order conditions characterizing the optimum. To discuss here a few crucial elements of these optimality conditions let us focus on a subset of the equations. We can show that:

$$\frac{dV}{db_{S,t}} + \psi_{RC,t}\left(1 - F_{\widetilde{\theta}_t}\right) - \psi_{\widetilde{\theta},t} + \beta\left(\psi_{gov,t}F_{\widetilde{\theta}_t}E_t\frac{u'(C_{t+1})}{\pi_{t+1}} - E_t\frac{u'(C_{t+1})}{\pi_{t+1}}\psi_{gov,t+1}\right) = 0 \quad (33)$$

$$\psi_{gov,t}\sum_{j\geq 1}\beta^j\delta^{j-1}E_t\frac{u'(C_{t+j})}{\Pi_{k=1}^j\pi_{t+k}} = E_t\psi_{gov,t+1}\sum_{j\geq 1}\beta^j\delta^{j-1}\frac{u'(C_{t+j})}{\Pi_{k=1}^j\pi_{t+k}} \quad (34)$$

(35)
$$\omega C_t\psi_{RC,t}(\pi_t - 1) - \frac{\omega}{\eta}(2\pi_t - 1)\Delta\psi_{gov,t} + \frac{b_{S,t-1}}{\pi_t^2}(\psi_{gov,t} - \psi_{gov,t-1}F_{\widetilde{\theta}_{t-1}}) + \frac{\xi_t}{\pi_t}\sum_{j\geq 0}\delta^j\frac{b_{L,t-j-1}}{\Pi_{k=0}^j\pi_{t-k}}\Delta\psi_{gov,t-j} = 0$$

where $\psi_{RC,t} = \Lambda(Y_t, \tau_t, C_t, \psi_{gov,t})$ where Λ is a function of the arguments and satisfies $\Lambda = -\chi Y_t^{\gamma_h}$ when $\psi_{gov,t} = 0$. Moreover, variable ξ_t is defined in the appendix.

[45] We show in the appendix how simplify the optimal policy program using the standard approach of dispensing with bond prices by substituting them into the government budget constraint.

Equations (33) and (34) are the first order conditions with respect to short and long term bonds respectively. (35) has been derived from the first order condition of inflation.

Consider first equation (34) which defines the optimum for $b_{L,t}$. According to this condition, the multiplier $\psi_{gov,t}$ follows a risk adjusted random walk, we can write $\psi_{gov,t} = \frac{E_t \psi_{gov,t+1} \varpi_{t+1}}{E_t \varpi_{t+1}}$ where $\varpi_{t+1} \equiv \sum_{j \geq 1} \beta^j \delta^{j-1} E_{t+1} \frac{u'(C_{t+j})}{\Pi_{k=1}^j \pi_{t+k}}$ Notice that this is a standard property in optimal debt policy models (see Aiyagari, Marcet, Sargent, and Seppälä, 2002). Long term bonds are chosen by the government to smooth taxes across time. The optimal policy spreads evenly the burden of the distortions as it is measured by the multiplier $\psi_{gov,t}$.

Equation (33) then shows that an analogous property does not generally characterize the optimal quantity of short term debt. There are two reasons: Firstly, bond supply directly influences the welfare function , the resource constraint and the threshold $\widetilde{\theta}_t$. This is captured by the leading three terms in (33). Second, even if the three leading terms were 0, the last term in (33) will not define a risk adjusted random walk, when $F_{\widetilde{\theta}_t} < 1$. Intuitively, since short term interest rates are low in this model, the government has the incentive to distort taxes inter-temporally targeting a path of debt that maximizes rents.[46]

We can thus anticipate that when $F_{\widetilde{\theta}_t} < 1$ and the sum of the three leading terms in (33) is not zero, then short term debt will display different dynamics in the model than long term debt (which as discussed previously is chosen solely on the basis of smoothing taxes across time). However, if $F_{\widetilde{\theta}_t} \approx 1$ then also $\frac{dV}{db_{S,t}}, \psi_{\widetilde{\theta},t}$ will be approximately 0, and the random walk property will be restored in (33) and short and long bonds follow similar dynamics.

Notice that the latter scenario will be relevant when a sufficiently large quantity of short bonds is being issued. If the planner chooses to increase the quantity of short term debt, to the point where only a few households are constrained (or $F_{\widetilde{\theta}_t} \approx 1$), then financing a positive spending shock with short or long term debt, will make little difference for the fiscal multiplier. (Our model then essentially becomes equivalent to the canonical model of optimal debt management.) In contrast, if the supply of short bonds is more moderate, and a short term financed shock relaxes the constraint for a larger fraction of households, the spending multiplier will be larger.

Finally, consider (35) determining optimal inflation and focus on the last two terms in this equation. These terms capture the incentive of the government to use inflation to reduce the real value of outstanding debt. The term $\sum_{j \geq 0} \delta^j \frac{b_{L,t-j-1}}{\Pi_{k=0}^j \pi_{t-k}} \Delta \psi_{gov,t-j}$ pertains to the inflation tax levied on long term debt and is a weighted average of $\Delta \psi_{gov,t-j} b_{L,t-j-1}$ for $j \geq 0$ because inflation in t affected not only the debt that was issued in $t-1$ but also debt issued in $t-2, t-3, \ldots$.[47] Analogously, the term $(\psi_{gov,t} - \psi_{gov,t-1} F_{\widetilde{\theta}_{t-1}})$ pertains to the incentive to reduce real short term debt outstanding using inflation.

The steady state In order to further illustrate these properties it is helpful to first focus on the deterministic steady state. Dropping the time subscripts and the conditional expectations and dropping terms that cancel out at steady state, we can write equations (33) and (35) as

$$\frac{dV}{d\bar{b}_S} + \psi_{RC}\left(1 - F_{\bar{\widetilde{\theta}}}\right) - \psi_{\widetilde{\theta}} + \beta \frac{u'(\overline{C})}{\overline{\pi}} \psi_{gov} \left(F_{\bar{\widetilde{\theta}}} - 1\right) = 0 \tag{36}$$

$$\omega \overline{C} \psi_{RC}(\overline{\pi} - 1) + \frac{\bar{b}_S}{\overline{\pi}^2} \psi_{gov}(1 - F_{\bar{\widetilde{\theta}}}) = 0 \tag{37}$$

[46]Rents emerge here because short term debt provides liquidity services to the private sector, see also Angeletos et al. (2022).

[47]Under commitment an announcement about period t inflation made in $t-s$ will impact the value of debt outstanding in that period. As new shocks arrive in every period before t the government will continue making announcements about period t inflation, which then impacts debt outstanding in $t-s+1$, $t-s+2$ and so on.

Note further that (34) trivially holds at steady state and therefore we can dispense with this equation to solve for the optimal allocation. This is a standard feature of optimal debt policy models (see, for example, Aiyagari et al., 2002); the debt level is not uniquely defined at steady state. This applies to long term debt in our model.

(36) and (37) define the solution for optimal inflation and short term bonds in the optimal policy equilibrium. Let us use these expressions to discern what this solution might look like. Consider first (37); this equation defines a positive inflation rate at steady state. To understand the property, focus on the relevant scenario where the budget constraint of the government affects the solution to the optimal policy program and $\psi_{gov} > 0$.[48] Then, since $F_{\bar{\tilde{\theta}}} < 1$ it is trivial to show that inflation is positive.

To understand why this is so, recall that agents in the model purchase short term bonds not only for their return properties but also for liquidity. An increase in the inflation rate, will then not decrease the bond price proportionally, households will not demand to be compensated fully through an increase in the nominal rate. This basically enables the government to use the inflation tax even at steady state and, as the budget constraint binds, it will optimally do so.

Obviously, the importance of this channel hinges on parameter ω which determines the resource cost of inflation, as well on the quantity of short term debt that solves (36). Assuming a large ω or when the optimal supply of the short asset is large, then the government will not resort to using the inflation tax.

To determine the solution, we need to solve the steady state model numerically. We assumed the same values for the model parameters as in our baseline calibration in Section 3, assuming also the same quantity of long term bonds. We found that the optimal policy model at steady state, features nearly 0 inflation and the debt level is almost twice as high as the calibrated value in Section 3 (1.5 and 0.8 respectively). Thus, the optimal policy increases the supply of short term bonds significantly relative to the model calibrated to US data. Finally, to get the same quantity of short bonds as in the data, we need to set ω equal to 0.03 (considerably below our assumed value of 17.5). Then the optimal quarterly inflation rate becomes equal to 3%.

4.2 Stochastic Simulations

Though useful to investigate the channels of optimal policy, the deterministic steady state may not be visited by the simulations of the model when we have solved for the optimal policy with aggregate shocks. This property is well known for the canonical model with distortortionary taxation. Aiyagari et al. (2002) and Faraglia et al. (2016) solve the optimal policy problem when the government can issue debt in one maturity. Though the deterministic steady state debt level is undefined, the optimal quantity of bonds in the stochastic equilibrium is defined and is a negative stock that the government will use as a buffer against spending shocks. Analogously, in Angeletos (2002) and Buera and Nicolini (2004), the optimal government portfolios are also not defined in the absence of shocks. With aggregate shocks there is a unique optimal portfolio featuring long term debt and short term savings.

These properties are relevant here and in particular since our modelling of the long term bond market is similar to these papers. Thus, the government may desire to accumulate savings in the long term asset, or maintain a low level of debt and at the same time finance shocks short term, to exploit the larger multiplier. Analogously, it may be that the optimal policy maintains a roughly constant supply of short bonds (so that $F_{\tilde{\theta}_t} \approx 1$), and uses long bonds to finance spending shocks. Under such a policy the government will benefit from fiscal insurance; when long bond prices negatively co-move with spending, the market value of accumulated long term debt decreases in times of high deficits.

[48] We can then show that $\psi_{RC} < 0$.

It is to these issues that we now turn. To solve the model numerically we assume as Aiyagari (1994) and Faraglia et al. (2016, 2019) that long debt is subject to ad-hoc limits of the form

$$b_{L,t} \in [\underline{M}, \overline{M}] \tag{38}$$

where $\underline{M}, \overline{M}$ are finite. We separately consider the case where $\underline{M} < 0$ (the government can purchase private long term bonds) and the case where lending to the private sector is ruled out and thus $\underline{M} = 0$.[49]

Since we solve the model using the Parameterized expectations algorithm of den Haan and Marcet (1990), imposing debt constraints as in (38) is necessary to for numerical stability.[50] Assuming very tight debt limits is, however, not necessary. We therefore set $\overline{M}$ to correspond to an issuance of long term debt equal to 200% of (steady state) GDP and analogously in the case where we allow the government to lend to the private sector we set $\underline{M}$ so that lending can be as large as -200% of GDP. These numbers concern the total market value of the issuance.

In the case of no lending, we set $\underline{M} = 0$ and so the government may face a tight limit in terms of the long bond issuance. This scenario has been motivated in the related literature based on the presumption that governments are not willing to bear the uninsurable risk involved in holding private assets (e.g. Lustig et al., 2008).[51] We consider this case, also for completeness, to show how the optimal portfolio changes when we tighten the debt constraint.

The results are shown in Figure 13 which plots the optimal debt portfolios in the 'Lending' model in the top panels and the 'No Lending' model in the bottom panels. The left graphs show the issuance of short bonds over a long simulation of 1000 model periods. The right graphs are the analogous simulations for the long bond quantity, $b_{L,t}$.

Consider first the top panels. It is evident that the optimal policy is to focus on short term bonds. Initially, the government has inherited a large stock of long term bonds, but gradually it runs down this stock and $b_{L,t}$ converges to $\underline{M}$. Thus, following a transition period, the optimal policy converges to financing spending shocks short term, and investing in private sector long term debt.

There are basically two ways to interpret this finding: First, as discussed previously, Aiyagari et al. (2002) and Faraglia et al. (2016) find in the canonical model, that the optimizing government accumulates *precautionary savings* to create a buffer against spending shocks. In Aiyagari et al. (2002), when the ad hoc limits are loose enough, then debt can converge to a negative lower bound and remain constant over time. The interest payments on the asset stock enable the government to finance spending shocks without resorting to distortionary taxation. This is consistent with the path of long term debt we see in Figure 13. Even though interest rate receipts will not be enough to finance spending (the debt limits are not loose enough here) they will help to stabilize taxes and total debt. Precautionary savings is therefore a valid channel.

Second, when long bonds converge to the negative limit, the fiscal insurance argument can be reversed. If the government has a constant negative position in the long bond market, an adverse spending shock (which is then necessarily financed short term) will crowd in consumption and long bond prices will co-vary positively with spending. Negative long debt, will thus increase the government's wealth in times of high fiscal needs.

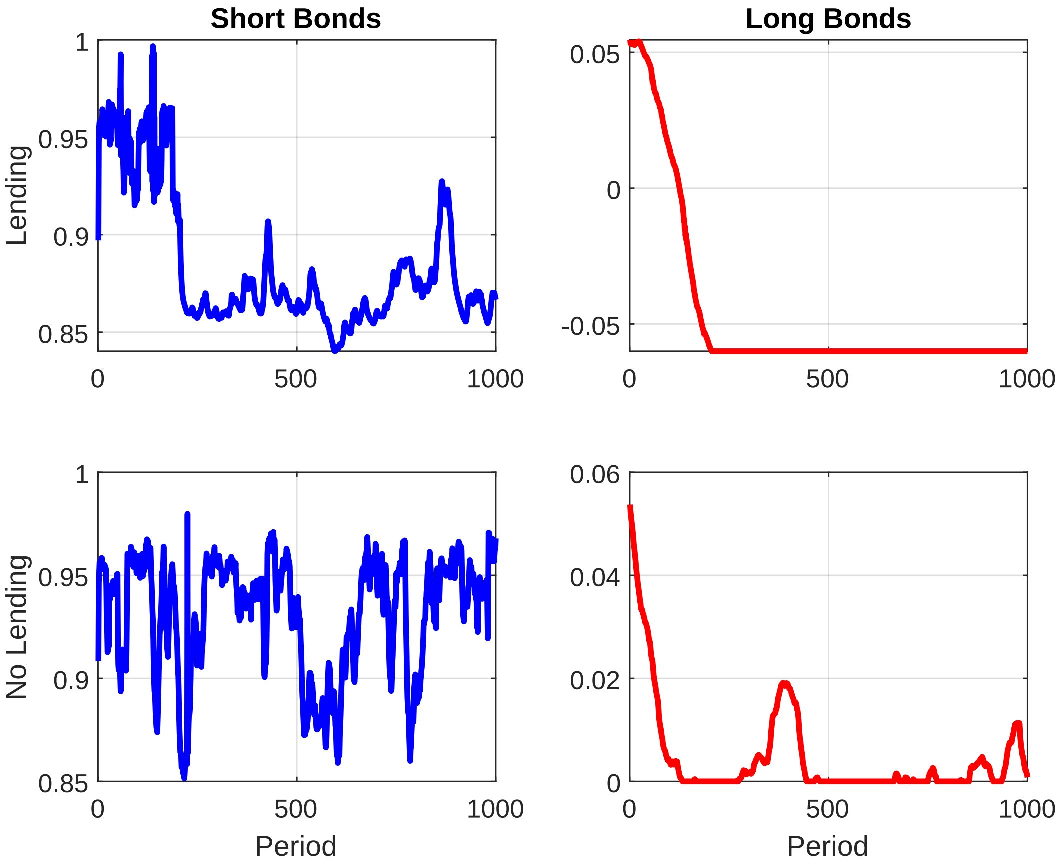
Note that this is a valid channel because the supply of short bonds in our stochastic simulations is lower than the deterministic steady state level and (on average) not high enough to be in a region

[49] See Aiyagari (1994) and Faraglia et al. (2016, 2019) and also Lustig et al. (2008) and Nosbusch (2008) for analogous assumptions in the context of optimal debt models. A detailed discussion on how we can modify the optimal policy program in the presence of these additional constraints is presented in the online appendix.

[50] See also, for example, Maliar and Maliar (2003)

[51] Of course, during the 2008-9 financial crisis the Fed and the Treasury purchased private assets, however, this had to do with financial market disruptions rather than with financing spending shocks.

Figure 13: **Simulations of Short and Long Bond Issuances.**



Notes: The Figure plots the optimal government portfolios over 1000 model periods in the optimal policy model. The top panels show the case where the government can purchase private assets (Lending), and in the bottom panels we assumed that lending to the private sector is ruled out. The left panels correspond to the issuance of short term bonds and the right panels is the analogous issuance of long bonds.

where $F_{\tilde{\theta}} \approx 1$. Then a spending shock will indeed crowd consumption in, resulting in a higher fiscal multiplier.

Let us now turn to the case of 'No Lending' shown in the bottom panel of the Figure. The policy is similar. After a short transition, long term debt hits the lower bound and the government uses mainly short bonds to finance spending shocks. Notice that this model rules out precautionary savings, and benefiting from the comovement of long bond prices and spending is not present when long bonds are at 0. However, issuing short term debt remains optimal due to the larger fiscal multiplier. In response to an adverse spending shock, the stronger response of aggregate output leads to larger revenues and enables to smooth taxes across time.[52]

To conclude this paragraph, we note that our model reverses the conclusions of the canonical approach to government debt management that governments should focus on financing deficits with long term debt (e.g Angeletos (2002) and Buera and Nicolini (2004)). Considering an extension of the standard model which allows the relative supply of short and long term debt to influence yields, consumption and the fiscal multiplier, we have found that the optimizing government will focus on issuing short term debt. Our paper complements recent contributions in the optimal fiscal policy/debt management literature using alternative microfoundations to explain why governments may desire to issue short bonds to smooth taxes over time (see, for example, Faraglia et al. (2019); Greenwood et al. (2015); Debortoli et al. (2021); Bhandari et al. (2019); Passadore et al. (2017) among others). We bring a new dimension to this line of work.

5 Conclusion

We have provided empirical evidence showing that the fiscal multiplier, the increase in aggregate output per additional dollar spent by the US government, has been higher when the Treasury issued short term debt. We explored a theoretical explanation of this phenomenon, relying on an incomplete markets model in which short bonds provide liquidity, enabling ex post heterogeneous to finance a higher consumption stream. Our tractable modelling follows a growing stream of literature considering environments in which the relative supply of debt affects the yield curve.

Using the model we studied the interactions between debt financing and monetary/fiscal policies in determining the magnitude of the response of output to a spending shock. We then turned to optimal policy to investigate how an optimizing government might want to allocate its portfolio of short and long term debt to take advantage of the new channel we identified. We found that focusing on issuing short term debt is the optimal policy. Our model therefore assigns an important role to short term debt, which is absent from the canonical model of debt management with distortionary taxation.

A number of fruitful extensions of our work spring to mind. First, our tractable model abstracted from heterogeneity that could lead to segmented bond markets. In particular, we assumed that the idiosyncratic consumption risk is i.i.d so that agents are ex ante homogeneous in every period of the model. Extending the model to non-i.i.d shocks will impinge selection effects, when agents expecting to face high consumption needs hold more short term debt than other agents. This could partly mitigate the large differences in the fiscal multipliers we have found in our model. Equivalently, selection effects according to household wealth (in a model where the latter is allowed to differ across households) could also be important.

[52] Short term debt under no lending, is on average higher than in the lending model but still not high enough to get no gains in terms of the multiplier when financing short term. The fact that the government at times resorts to long term debt to finance spending (i.e. when short bonds are around 0.95) reveals that the difference in terms of the multiplier between STF and LTF is smaller, and exploiting the fiscal hedging properties of long bonds becomes optimal.

Ideally, a quantitatively rich heterogeneous model in which agents face both consumption and labour income risk and therefore have a strong incentive to accumulate precautionary savings would be a good laboratory to look at the propagation of spending shocks. Solving such a model when long bonds are realistically risky assets and when households have reasons to hold them beyond for their return properties (e.g. to finance retirement) maybe an important next step in this agenda. We leave it to future work.

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Appendices

A Analytical Results in Section 3

TBC

B Optimal Policy.

We now describe the optimal policy program of Section 4. The setup follows closely numerous papers studying optimal fiscal or monetary policy under a Ramsey planner (e.g. Aiyagari et al. (2002); Schmitt-Grohé and Uribe (2004); Lustig et al. (2008); Faraglia et al. (2016, 2019) among many others).) As in these papers we assume that a benevolent planner maximizes household welfare by setting policy variables subject to the set of sufficient implementability conditions for a competitive equilibrium. Since this is a well known setup, we will not discuss in too much detail the policy problem and optimality. We wil also only briefly describe the numerical procedure that we follow to approximate numerically the equilibrium, and which is based on Parameterizing expectations (e.g. Den Haan and Marcet (1990); Faraglia et al. (2019)). **Policy objective and constraints.** Per period household utility can be written as:

$$V_t \equiv \left(1 + \int_0^{\widetilde{\theta}_t} \theta dF_\theta\right) \log(C_t) + \int_0^{\widetilde{\theta}_t} \theta \log(\theta) dF_\theta + \int_{\widetilde{\theta}_t}^{\infty} \theta \log(b_{S,t}) dF_\theta - \chi \frac{Y_t^{1+\gamma_h}}{1+\gamma_h} \tag{B.1}$$

The planner maximizes (B.1) choosing the sequence of variables $\left\{\pi_t, Y_t, \theta_t, \tau_t, q_{S,t}, q_{L,t}, b_{L,t}, b_{S,t}, \widetilde{\theta}_t, C_t\right\}_{t\geq 0}$ subject to the competitive equilibrium conditions, namely the Phillips curve, the resource constraint, the government budget constraint, the Euler equations for short and long term bonds and the condition $C_t\widetilde{\theta}_t = b_{S,t}$.

TBC

C Appendix Extensions

C.1 Wealth Heterogeneity

In this section we investigate a model in which individuals do not pool resources at the end of every period and there is wealth heterogeneity. TBC

C.2 Assuming Long Bonds provide partial liquidity services

We now extend the baseline model presented in the paper to the case where long bond can provide partial liquidity services to the private sector. More specifically we now assume the following constraint on subperiod 2 consumption:

$$P_t c_t^i(\theta) \leq B_{S,t}^i + \kappa B_{L,t}^i$$

where κ is the fraction of long term debt that can be used to finance consumption in subperiod 2 (expressed as a function of the long bond price).

TBC

C.3 Assuming Long Bonds provide partial liquidity services

We now extend the baseline model presented in the paper to the case where long bond can provide partial liquidity services to the private sector. More specifically we now assume the following constraint on subperiod 2 consumption:

$$P_t c_t^i(\theta) - \kappa B_{L,t}^i \leq B_{S,t}^i$$

where κ is the fraction of long term debt that can be used to finance consumption in subperiod 2.

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