Online appendix for *Fiscal Multipliers and the Maturity Financing of Government Spending Shocks*

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Appendices

This appendix contains 2 sections. Section A complements our empirical analysis by providing data variables definition and sources and carrying out additional empirical exercises and robustness checks. Section B derives the analytical formulae shown in Section 3 of the main text and extends the results to alternative calibrations of the model.

A Empirical Analysis: Definitions and Robustness Checks

A.1 Variable definitions and data sources

We obtain quarterly data on GDP, private consumption, private investment, government expenditures, wages, the short-term and long-term rates, federal government debt aggregates (short, long and total), the GDP deflator and taxes. All variables are seasonally adjusted except for interest rates and the debt aggregates (the latter are used as ratios, i.e. short over long, in the empirical analysis). The national account variables are obtained from NIPA statistics. The gross domestic product, private consumption and investment and government expenditures are all in billions of US dollars. Moreover, our measure of wages is Real Compensation Per Hour in the Nonfarm Business Sector. Taxes corresponds to total federal government tax receipts.

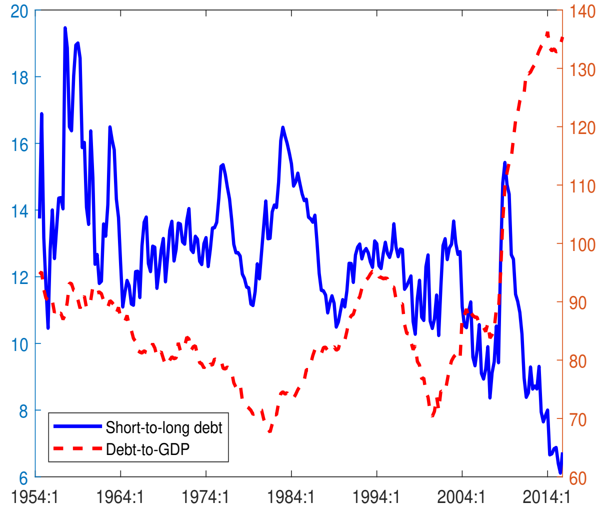
Interest rates and debt aggregates are extracted from the OECD database. As discussed in the main text, we defined as short-term debt, all government debt with maturity less than or equal to one year. Long-term debt is the remaining federal debt outstanding. Moreover, in our empirical analysis we used two different definitions for the short-term interest rate: The overnight interbank rate and the 3-month interbank rate. The long-term interest rate corresponds to the yield of 10 year US government bonds.

The data variables along with the precise definitions and the sources are listed in Table 1 for completeness. The first column of the table lists the variables with the names they will appear in the labels of the various figures. Our sample covers the period 1955:Q1- 2015:Q3.

Variable	Description	Source
output	Gross domestic product in billions of dollars	NIPA
consumption	Private consumption, in billion dollars	NIPA
investment	Private Investment, in billion dollars	NIPA
government expd.	Government total spending, billion dollars	NIPA
wage	Nonfarm Business Sector: Real Compensation Per Hour, Index 2012=100	NIPA
tax	Total federal government tax receipts	NIPA
gdp_deflator	Implicit gdp price deflator	NIPA
r_overnight	Overnight interbank rate, no seasonally adjusted	OECD
r_three	3-month interbank rate, not seasonally adjusted	OECD
r_long	Long-term interest rate, not seasonally adjusted	OECD
debt	General government total debts, billion dollars	OECD
debt_short	General government short-term debts, billion dollars	OECD
debt_long	General government long-term debts, billion dollars	OECD
News	Military news shock	Ramey and Zubairy (2018)

Figure 1 traces the evolution of the debt to GDP ratio (right axis, dashed red line) along with ratio of short-term over long-term debt (right axis, blue solid line). Though the short to long-term ratio displays some volatility over time, it should be noted that it is highly persistent, the first order autocorrelation coefficient is 0.93. Moreover, the standard deviation of the ratio is 0.024 and the correlation with debt over GDP is -0.43.

Figure 1: Debt-to-GDP and the share of short-to-long term debt

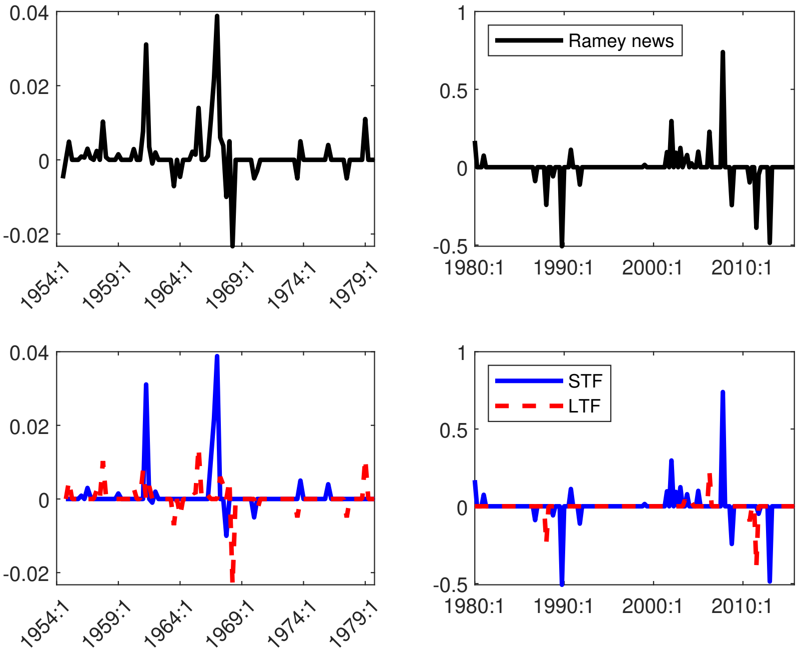


Red dotted line: US debt-to-GDP (in percentage terms, left y-axis); Solid blue line: US short-to-long government debt (in percentage terms, right y-axis). Data obtained from NIPA, OECD. Definitions provided in online appendix.

Figure 2 plots the Ramsey defense new series. The graphs in the top panels span the whole sample period. To make all shocks clearly visible we split the sample in two subsamples, 1954:Q1 to 1979:Q4 on the left and 1980:Q1 onwards on the right graph. The larger volatility of news shocks about government spending in the second subsample, is driven by the wars in Afganistan and Iraq in the 2000s and the subsequent cuts in spending in the late 2000s and early 2010s. Large cuts also took place in the early 1990s when the Cold War ended.

The bottom panels of the figure show separately short-term financed (STF) and long-term financed (LTF) shocks. As can be seen from the plots, the STF and LTF shocks concern both subperiods of our sample.

Figure 2: Identified fiscal shocks using Ramey defense news



Notes: Top row: Military spending news series from Ramey and Zubairy (2018) over the period 1954Q1 to 1979Q4 (left panel) and over 1980Q1 to 2015Q4 (right panel). Bottom row: Identified short-term (STF) and long-term (LTF) debt financed spending shocks over the period 1954Q1 to 1979Q4 (left panel) and over 1980Q1 to 2015Q4 (right panel). Series are scaled by the trend of GDP.

A.2 Additional Exercises and Robustness in the Proxy VAR

We now perform additional exercises to show the robustness of our main finding that short-term financing leads to a larger fiscal multiplier. The results that we show in this subsection mainly correspond to the robustness checks we had mentioned in text. We also show additional output from the baseline specifications of the empirical model studying the impulse responses of wages, interest rates etc.

Impulse responses of government spending. In Figure 3 we plot the cumulative impulse response functions of government expenditures to the spending shock under short-term financing (blue) and long-term financing (red). As is evident from the figure, the IRFS are similar across the two financing schemes. This evidence leads us to conclude that the differences in the cumulative multipliers we reported in the main text are not driven by differences in the spending processes. The US government does not issue short-term debt to finance a different type of shock than it does when it finances with long-term debt.

Impulse responses of additional controls. Table 2 in the main text reported the fiscal multipliers when we run the model including additional variables (interest rates, wages, the GDP deflator). These variables were included one at a time. In Figure 4 we plot the impulse response functions of these variables to the spending shock. The top left panel shows the responses of real wages. As can be seen from the figure both types of shocks induce a small drop in wages and the response is more negative in the case of short-term financing. These reactions of wages are indeed small (even though significant) and so we are not troubled by the fact that wages drop following the spending shock.[1] The finding that wages do not react more positively in the case of short-term financing is a more important finding for our main result. It reassures us that the larger multiplier we found under STF was not driven by a stronger reaction of wages to the shock.[2]

The middle and right top panels and the bottom left panel show the IRFS of the short and long-term rates and the term premium respectively, when these variables are included in the model. STF increases the short-term interest rate (top right) and decreases the term premium (bottom left). LTF increases the long-term rate and increases the term premium. Notice that these patterns are easy to rationalize within the context of theoretical models in which the relative supply of short and long bonds affects yields (as is the case in our theory). STF increases the relative supply of short bonds and increases yields at the short end of the yield curve; LTF increases the supply to long bonds and impacts the long end of the curve. These findings are at odds with the canonical macro model in which only the path of spending impacts interest rates.

Finally, the bottom right panel of Figure 4 shows the impulse response of the GDP deflator to LTF and STF shocks. As can be seen from the graph, the price level increases after a short-term financed shock and decreases (or responds insignificantly) in the case of long-term financing. This pattern is consistent with the finding that STF induces a larger expansion of output and consumption and is consistent with our New Keynesian model (see below).

Figure 5 shows the impulse response functions from a structural VAR when we include all controls together. This robustness check serves to illustrate that controlling simultaneously for all possible endogeneity concerns does not change our results. As can be seen the responses are consistent with our finding that STF induces a larger expansion of output and consumption than LTF. Moreover, the patterns of adjustment of wages, short and long-term rates and the GDP deflator are similar to those we previously found in Figure 4.

[1]This response is also easy to explain given the responses of aggregate prices to the shocks (see below). Since inflation increases considerably in the STF shock case, but not under LTF, a mild rigidity in nominal wages coupled with the responses of the aggregate price level, can indeed explain the pattern we find in the data.

[2]We continue finding similar responses of spending across STF and LTF in all models considered in this subsection. For brevity we do not show the IRFS of government expenditures.

A VAR with taxes.

We separately run a VAR with taxes (tax revenues as a % of GDP) as an additional control variable. The result that STF leads to a larger multiplier continued to hold. Interestingly, this exercise showed that taxes responded positively to an LTF shock and negatively to an STF shock. Though the responses were small in both cases, we wanted to address the possible concern that LTF shocks are partly tax financed whereas STF shocks are only debt financed. (In theory, tax financed shocks lead to smaller multipliers than debt financed shocks.)

We therefore run a VAR in which we constrained the responses of taxes to be zero for 4 quarters for each of the two financing schemes and treat this as our benchmark. The output is shown in Figure 6 where we plot the cumulative multipliers under STF and LTF. As is evident from the figure, the main finding that STF leads to a crowding in of aggregate consumption and a larger fiscal multiplier continues to hold.

Pre and Post 1980s samples, High and Low debt and the Zero Lower bound.

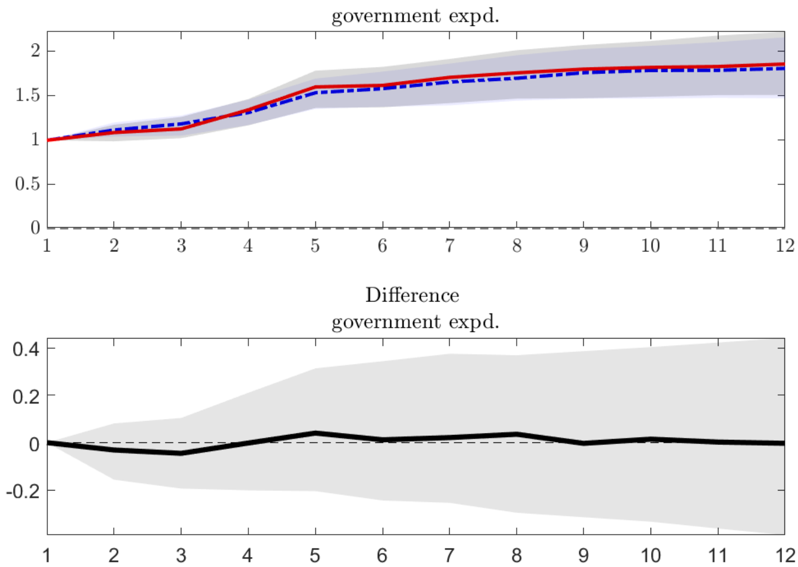
We now consider three additional robustness checks. First we run the model separately using the subsample of observations in which debt is above the median to investigate whether our results were driven by the fact that at high debt levels, the US Treasury typically issues more long-term debt (see Greenwood, Hanson, and Stein, 2015). In Figure 7 we plot the cumulative multipliers for the high debt subsample. Qualitatively the patterns that we identified with the full sample do not change. (If anything the gap in the STF and LTF multipliers is even slightly larger now). Therefore, the debt level is not important to explain our findings.

Next, we run our empirical model using observations post 1980. This enables us to identify whether the well documented structural break in the interest rate policy of the Federal reserve during the Volcker chairmanship, has an effect on our estimates. Figure 8 shows the cumulative multipliers under STF and LTF. The estimates are similar in magnitude to the analogous objects reported in the main text for the full sample.[3]

Finally, we run our empirical model, using observations up to 2007Q4 (dropping the Great recession and all quarters where the nominal interest rate was at its effective lower bound). During these years, the US economy suffered a severe recession, and government debt levels increased considerably. We also observed an increase in the new issuance of long-term debt by the US Treasury. Figure 9 however shows that omitting the post 2008 observations plays essentially no role in our estimates of the cumulative multipliers. We therefore conclude that our findings are not driven by the financial crisis period.

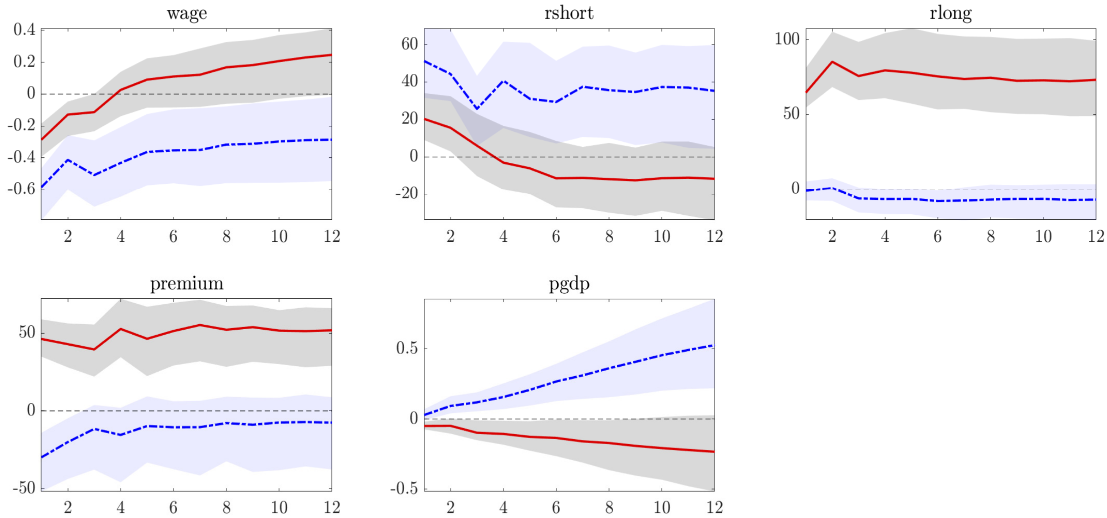
[3]For brevity we did not include a separate graph for the pre 1980s subsample, but the results were again similar. We also run several empirical models including variables from the list discussed previously. Again these additional exercises showed no significant difference with our full sample estimates.

Figure 3: Proxy-SVAR: Baseline specification. Cumulative impulse responses of government expenditures



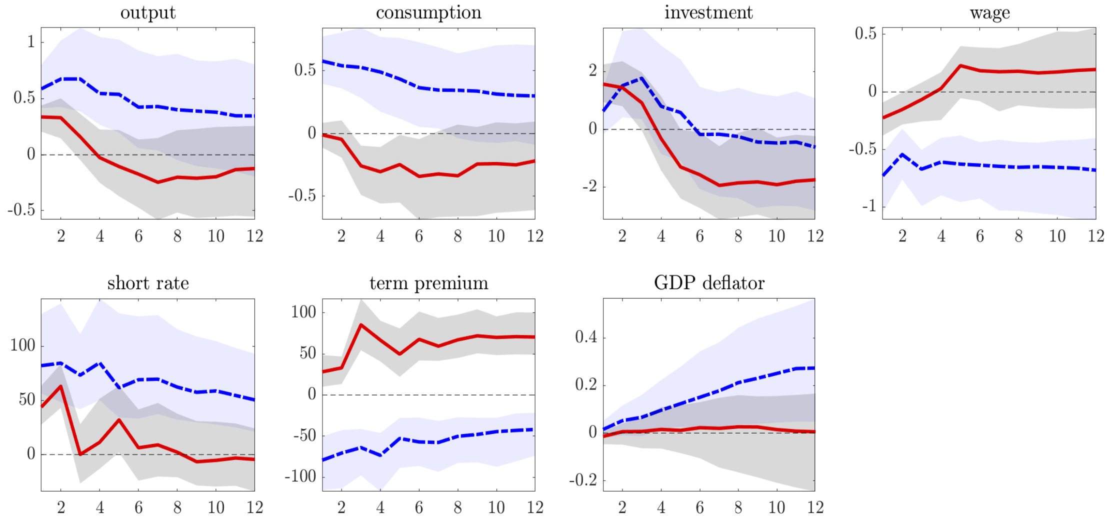
Notes: Top panel: Cumulative impulse response functions of government expenditures following a shock to short-term (blue, dash-dotted) and long-term debt-financed (red, solid) government expenditures. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. The bottom panel shows the difference in the estimated IRFS and the shaded area corresponds to one standard deviation confidence bands.

Figure 4: Proxy-SVAR: Robustness with additional controls included separately. Cumulative impulse response functions



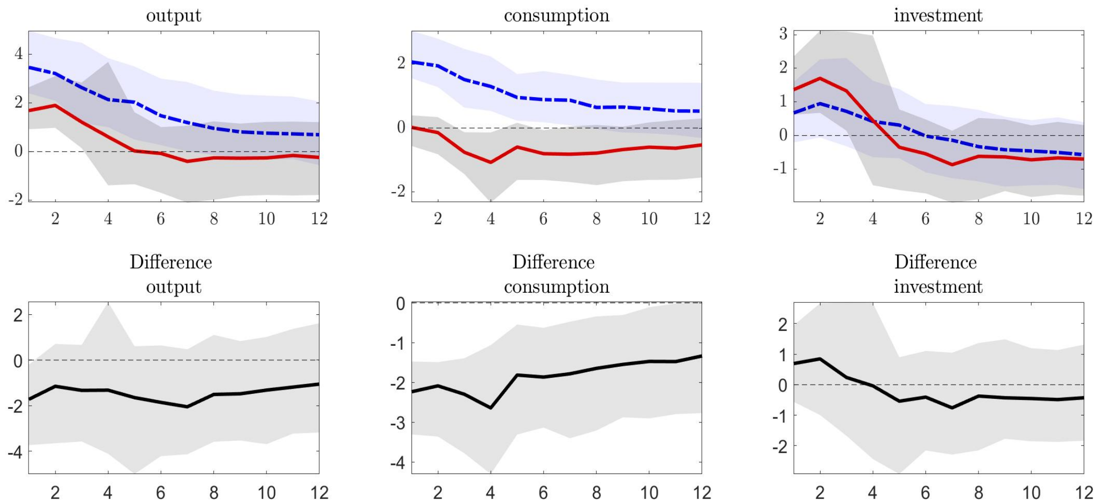
Notes: Cumulative impulse response functions following a shock to short-term (blue, dash-dotted) and long-term debt-financed (red, solid) government expenditures. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. Variables are reported in per cent deviations. Short-term and long-term rates and the term premium are in basis points.

Figure 5: Proxy-SVAR: Robustness with all additional controls together. Cumulative impulse response functions



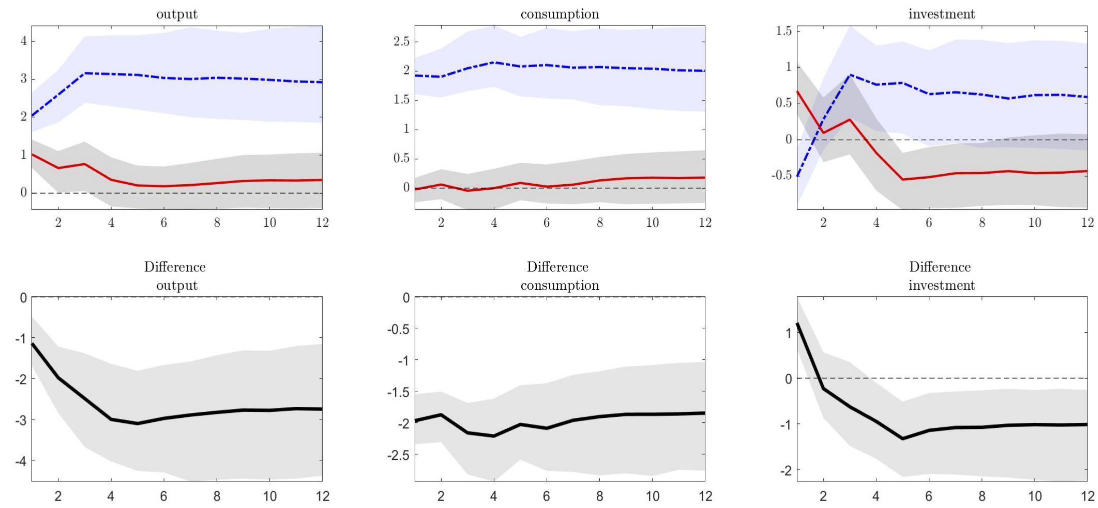
Notes: Cumulative impulse response functions following a shock to short-term (blue, dash-dotted) and long-term debt-financed (red, solid) government expenditures. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. Variables are reported in per cent deviations. Short-term and long-term rates and the term premium are in basis points.

Figure 6: Proxy-SVAR: Robustness with zero restrictions on tax revenues. Cumulative multipliers



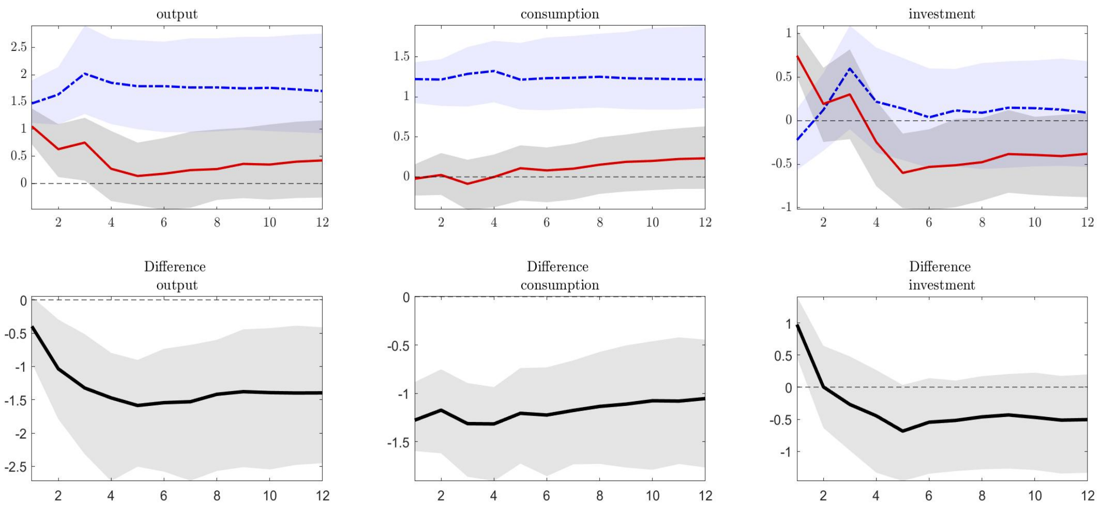
Notes: Cumulative multipliers following a shock to short-term (blue, dash-dotted) and long-term debt-financed (red, solid) government expenditures. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. Variables are reported in per cent deviations.

Figure 7: Proxy-SVAR: High debt subsample. Cumulative multipliers



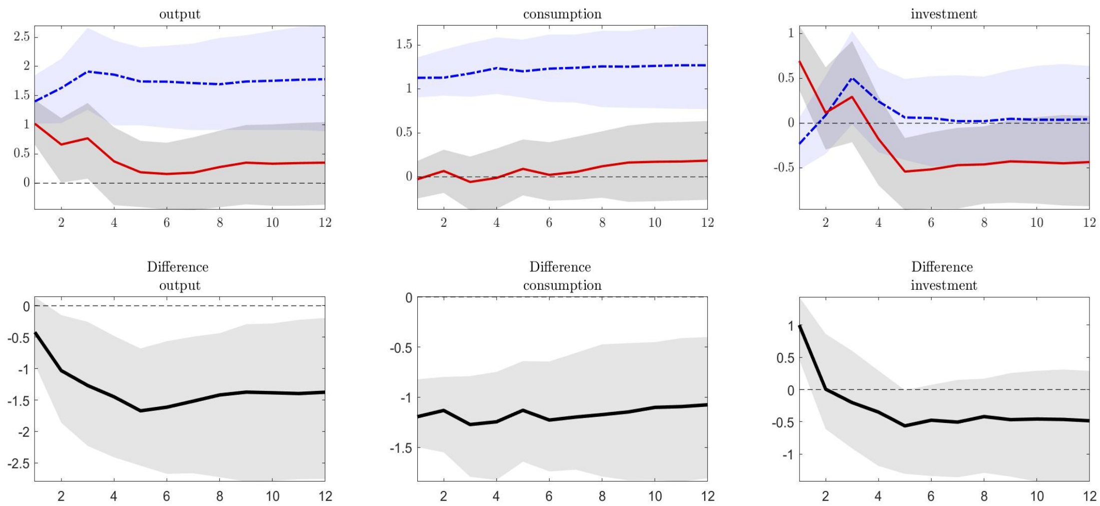
Notes: Cumulative multipliers following a shock to short-term (blue, dash-dotted) and long-term debt-financed (red, solid) government expenditures. Lines correspond to median responses. Shaded areas correspond to confidence bands of one standard deviation. Variables are reported in per cent deviations.

Figure 8: Proxy-SVAR: post-1980 subsample. Cumulative multipliers



Notes: Cumulative multipliers 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.

Figure 9: Proxy-SVAR: pre-2008 subsample. Cumulative multipliers



Notes: Cumulative multipliers 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.

A.3 Local Projections: Robustness Exercises

We now turn to the local projection method to extend the baseline results we showed in text. As discussed, we followed Ramey and Zubairy (2018) and Broner, Clancy, Erce, and Martin (2022) to estimate fiscal multipliers with instrumental variables where the instruments for cumulative government spending are the narrative spending news shock and the Blanchard and Perotti (2002) shocks for government spending.

Consider the following baseline specification of the local projection model

$$\sum_{j=0}^{h} Y_{t+j} = \text{Trend}^2 + \beta_h \sum_{j=0}^{h} G_{t+j} + \sum_{k=1}^{4} \Theta_{k,h} \mathrm{X}_{t-k} + \varepsilon_{t+h}, \quad h = 0, 1, 2, ... \tag{A.1}$$

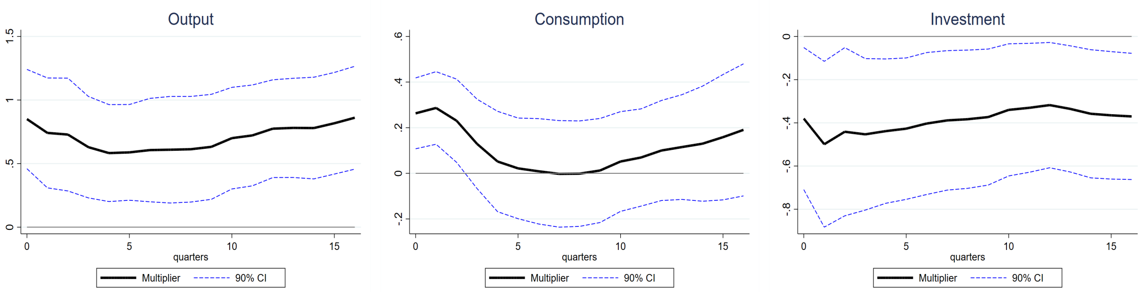
Y denotes the variable whose response to spending we want to estimate (i.e. GDP, consumption, and investment), $\sum_{j=0}^{h} G_{t+j}$ denotes the cumulative sum of government spending. Trend^2 is a quadratic time trend, and X includes GDP, government investment, consumption, private investment, and narrative shocks.

Equation (A.1) enables us to estimate the cumulative multipliers of the spending shock, but notice that we have not yet conditioned on the financing of the shock with short/long term bonds. We do this in the next subsection.

To estimate (A.1) we proceed in two steps: First, the term $\sum_{j=0}^{h} G_{t+j}$ is estimated using (both) narrative shocks and the government spending series, conditioning on the same set of control variables included in X [4]. The fitted values are then used in the second step to estimate equation (A.1). All variables are detrended by potential GDP[5] Coefficient β_h then measures the government spending multiplier at each horizon h.

Figure 10 shows our results for output, consumption and investment. As can be seen from the figure, we estimate an output multiplier less than 1 a positive cumulative multiplier for consumption in the short run, which however becomes insignificant after a couple of quarters, and a negative multiplier for government investment. These results are in line with the literature.

Figure 10: Cumulative multiplier of a government expenditure shock.



Notes: The black solid line represents the estimated β_h in equation A.1 for different horizons and the blue dashed lines indicate the 90% confidence interval. Standard errors are adjusted for serial correlation and heteroscedasticity.

Accounting for debt maturity financing

As in the text we define R_t, the ratio of short-term to long-term debt. We account for the interaction of this ratio with government spending, to discern how maturity financing affects the size of the spending multiplier. Our baseline specification is given by the following equation:

[4]As in Ramey and Zubairy (2018) we included government expenditures in t in this first stage regression to identify the Blanchard-Perotti shocks (that is controlling for lagged GDP and expenditures)

[5]we estimate potential GDP as a 6th-degree polynomial of the time-trend, following Ramey and Zubairy (2018). Our main results remain unaffected if we compute potential GDP as HP-filtered real output.

(A.2)

$$\sum_{j=0}^{h} Y_{t+j} = \text{Trend}^2 + \beta_h \sum_{j=0}^{h} G_{t+j} + \gamma_h R_{t-1} \sum_{j=0}^{\hat{h}} G_{t+j} + \sum_{k=1}^{4} \Theta_{k,h} \mathrm{X}_{t-k} + \sum_{k=1}^{4} \Delta_{k,h} R_{t-1} \mathrm{X}_{t-k} + R_{t-1} + \varepsilon_{t+h}$$

A few comments are in order. First, note that equation (A.2) is basically specified as in Broner et al. (2022). Like them, we will identify differences in the fiscal multiplier through the interaction of the stock value of the variable of interest (in our case R) with the spending shocks. Therefore, in this case, financing a spending shock with short term debt is coincident with a large value of the ratio R.

As discussed in text, though relying on the stocks (rather on the changes of the ratio) may be seen as capturing different margins through which debt maturity can influence the size of the fiscal multiplier, for the case of a variable that is as persistent as the share of short-term debt is in US data, outstanding stocks are strongly correlated with new issues.[6] Thus, we view the stock variable to be a good proxy for the issuance of new debt. Furthermore, in order to purge our estimates from (for example a high R_t is driven by past shocks that have flattened the yield curve) we will present several estimates including empirical specifications that account for wages, interest rates as we did with the proxy VAR model.

Equation A.2 is again estimated in two steps. The total impact of a government spending shock on variable Y is now given by $\beta_h + \gamma_h R_{t-1}$. Thus, by varying the value of the ratio R we can trace the impact of the maturity financing on the cumulative spending multiplier. Figure 11 presents our baseline estimates for the two different values R defined as the 90th and 10th percentiles of the short to long term public debt ratio. As explained in text, these two values are deliberately chosen to help the reader visualize the effects over a wide range for R.

We next consider how our results are affected when we augment our local projection framework with further macroeconomic variables.

[6] The reader should note that persistence of R really tells us something about new issuances since a large fraction of short term debt (defined here as maturities less than one year) is redeemed in every quarter. Hence, we can credibly argue that R is persistent when new shocks have been financed short term when the value of R is high and long-term when it is low.

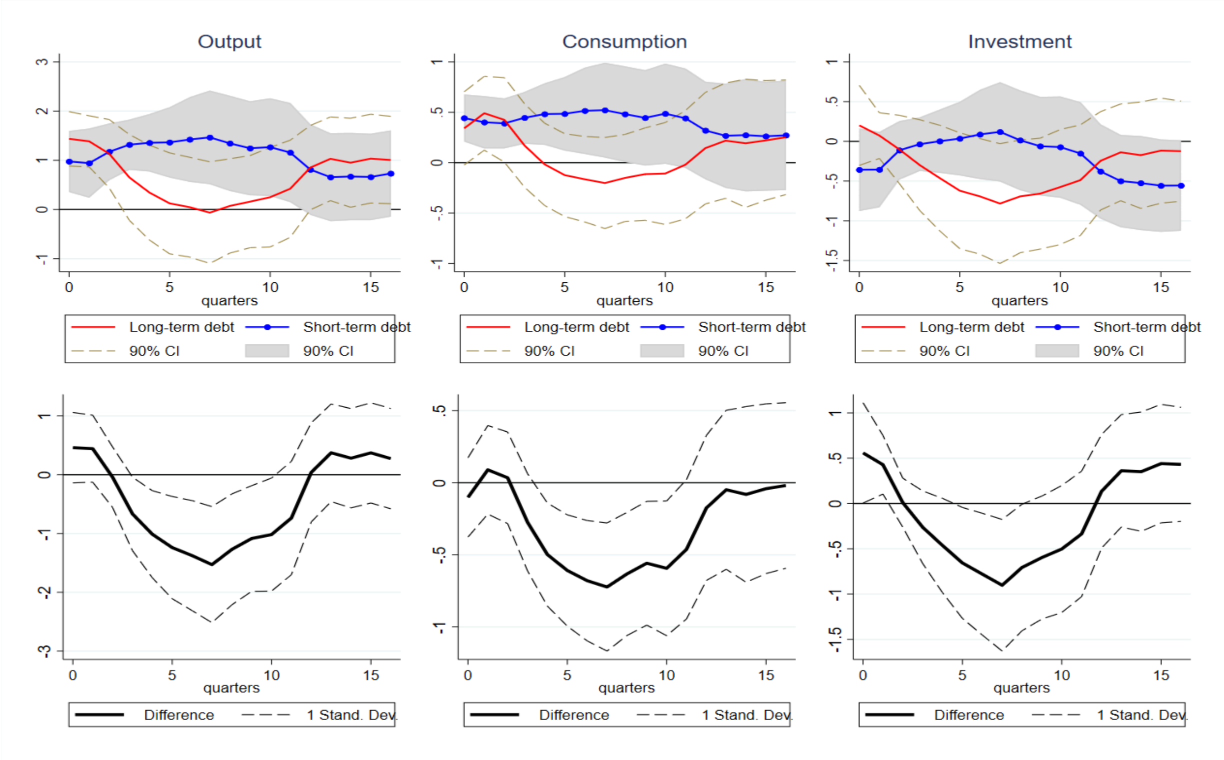


Figure 11: Cumulative multiplier of a government expenditure shock: The dotted blue line represents the estimated multiplier in equation A.2 for short-term debt and the solid red line indicates the multiplier for long-term debt. The black solid line shows the difference between these two multipliers, accompanied by a one standard deviation interval. Short-run debt is defined as the 90th percentile of the short-to-long-term debt maturity ratio, while long-run debt is defined as the 10th percentile of the same ratio. Standard errors are adjusted for serial correlation and heteroscedasticity.

Adding macroeconomic variables.

Table A1 documents the cumulative fiscal multipliers when we add to the local projection model one macroeconomic variable at a time. More specifically, we experimented with introducing the Term spread (defined as in the main text), wages, the short and long term rates and the GDP deflator as additional variables to the model. These exercises are in the spirit of the analogous robustness test we conducted with our proxy VAR and so the reader can find a detailed discussion motivating them in text. The table reports the values of the multipliers 1 and 3 years after the shock and more precisely the four columns of the table report (respectively) the average (unconditional) values of the multipliers (1 column) the values under STF and LTF (2nd and 3rd columns defined as the 90th and 10th percentiles of the R ratio) and the difference between STF and LTF (last column).

As can be easily read off the table, adding further controls to the model magnifies the differences between the STF and LTF multipliers. Across all of the specifications we consider we obtain statistically significant differences for the consumption and output multipliers.

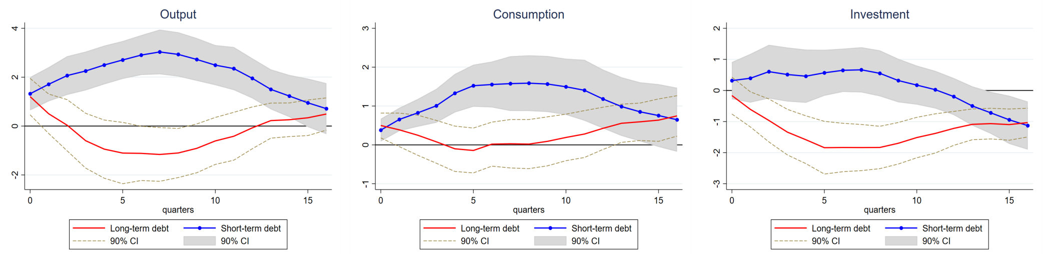
To showcase our estimates over a longer horizon in Figure 12 we plot the cumulative multipliers for output, consumption and investment in every quarter over a window of 4 years. Consistently with our baseline model the differences across the STF and LTF estimates are statistically significant, and (with some of the controls) larger in magnitude. Thus controlling for macroeconomic variables, addresses the potential biases we discussed in text, and at the same time results in sharper differences in terms of the spending multipliers.

Finally, Figures 14, 15 and 16 show the results that we obtained when we combined the macroeconomic control variables in the model. Figure 14 controls for the interest rate spread and the real wages. Figure 15 adds also the GDP deflator, and finally

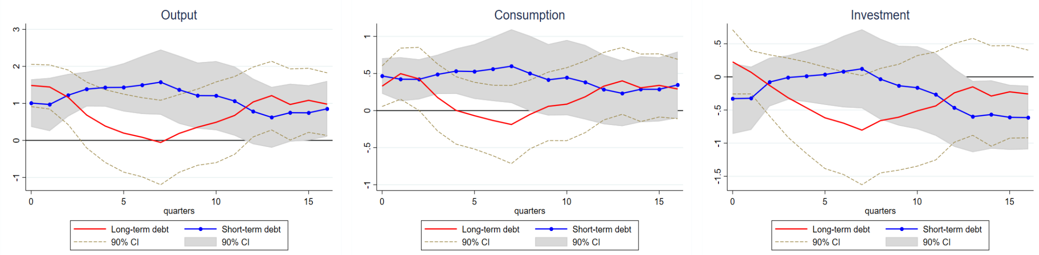
Extra controls		Horizon	Average	Short-term debt	Long-term debt	Difference
	Output	1-year	**0.46**	**2.25**	**-0.6**	**-2.85**
			(0.34)	(0.48)	(0.68)	(0.91)
		3-year	**0.07**	**2.35**	**-0.42**	**-2.77**
			(0.34)	(0.53)	(0.59)	(1.0)
Term Spread	Consumption	1-year	**0.29**	**1.01**	**0.08**	**-0.93**
			(0.15)	(0.26)	(0.33)	(0.51)
		3-year	**0.30**	**1.41**	**0.28**	**-1.13**
			(0.25)	(0.47)	(0.37)	(0.72)
	Investment	1-year	**-0.74**	**0.51**	**-1.34**	**-1.85**
			(0.27)	(0.53)	(0.44)	(0.76)
		3-year	**-1.29**	**0.03**	**-1.38**	**-1.41**
			(0.21)	(0.37)	(0.38)	(0.65)
	Output	1-year	**0.70**	**1.38**	**0.69**	**-0.70**
			(0.24)	(0.28)	(0.54)	(0.60)
		3-year	**0.78**	**1.06**	**0.67**	**-0.39**
			(0.23)	(0.56)	(0.64)	(0.91)
Wages	Consumption	1-year	**0.16**	**0.49**	**0.18**	**-0.31**
			(0.12)	(0.16)	(0.27)	(0.36)
		3-year	**0.10**	**0.38**	**0.19**	**-0.20**
			(0.13)	(0.30)	(0.29)	(0.46)
	Investment	1-year	**-0.43**	**-0.01**	**-0.31**	**-0.30**
			(0.22)	(0.20)	(0.36)	(0.40)
		3-year	**-0.35**	**-0.27**	**-0.44**	**-0.17**
			(0.19)	(0.38)	(0.49)	(0.69)
	Output	1-year	**0.62**	**1.44**	**0.02**	**-1.42**
			(0.30)	(0.41)	(0.70)	(0.97)
		3-year	**0.17**	**1.76**	**-0.06**	**-1.82**
			(0.33)	(0.67)	(0.52)	(1.05)
Short-term rate	Consumption	1-year	**0.36**	**0.57**	**0.42**	**-0.15**
			(0.14)	(0.27)	(0.37)	(0.54)
		3-year	**0.33**	**1.15**	**0.47**	**-0.68**
			(0.24)	(0.41)	(0.29)	(0.58)
	Investment	1-year	**-0.63**	**-0.06**	**-0.97**	**-1.03**
			(0.26)	(0.52)	(0.54)	(0.90)
		3-year	**-1.21**	**0.08**	**-1.46**	**-1.54**
			(0.19)	(0.51)	(0.34)	(0.78)
	Output	1-year	**0.53**	**1.26**	**0.30**	**-0.96**
			(0.21)	(0.34)	(0.58)	(0.71)
		3-year	**0.54**	**0.50**	**0.00**	**-0.49**
			(0.27)	(0.56)	(0.75)	(0.90)
GDP Deflator	Consumption	1-year	**0.03**	**0.32**	**-0.02**	**-0.35**
			(0.09)	(0.15)	(0.30)	(0.36)
		3-year	**-0.02**	**0.10**	**-0.24**	**-0.34**
			(0.12)	(0.28)	(0.36)	(0.47)
	Investment	1-year	**-0.48**	**-0.06**	**-0.42**	**-0.36**
			(0.18)	(0.22)	(0.37)	(0.44)
		3-year	**-0.45**	**-0.55**	**-0.70**	**-0.15**
			(0.22)	(0.36)	(0.46)	(0.55)
	Output	1-year	**0.77**	**1.45**	**1.01**	**-0.44**
			(0.39)	(0.62)	(0.75)	(0.98)
		3-year	**0.19**	**2.47**	**-0.22**	**-2.69**
			(0.64)	(0.61)	(0.69)	(1.11)
All controls	Consumption	1-year	**0.36**	**0.42**	**1.00**	**0.58**
			(0.20)	(0.40)	(0.35)	(0.52)
		3-year	**0.35**	**1.85**	**0.25**	**-1.60**
			(0.43)	(0.49)	(0.47)	(0.80)
	Investment	1-year	**-0.34**	**0.39**	**-0.07**	**-0.45**
			(0.29)	(0.53)	(0.73)	(1.02)
		3-year	**-0.97**	**0.73**	**-1.24**	**-1.97**
			(0.41)	(0.45)	(0.63)	(0.93)

Table A1: Comparing 1-year and 3-year government spending cumulative multiplier for short and long-run debt financing. Short-run debt is defined as the 90th percentile of the short-to-long-term debt maturity ratio, while long-run debt is defined as the 10th percentile of the same ratio. In each exercise, a new control variable is added to the vector X in equations A.1 and A.1

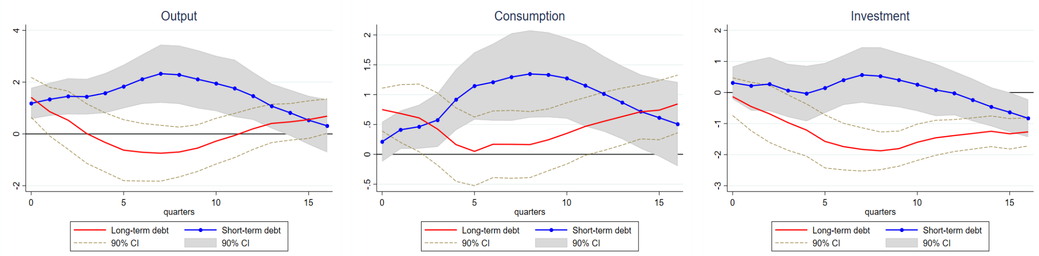
Figure 12: Local Projections with additional macroeconomic variables



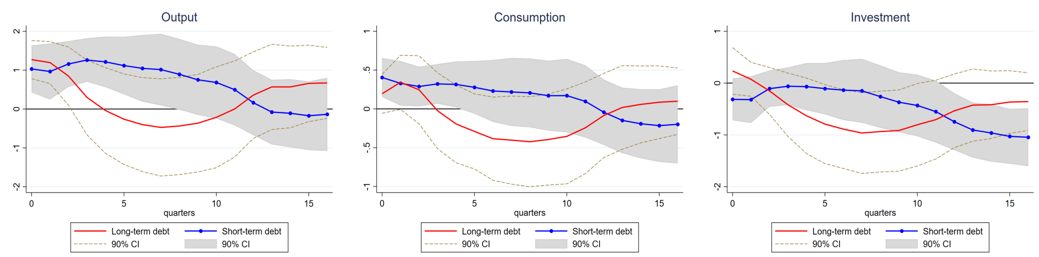
a) Interest rate spread



b) Wages



c) Short-term rate



d) GDP Deflator

Figure 13: Cumulative multiplier of a government expenditure shock: The dotted blue line represents the estimated multiplier in equation A.2 for short-term debt and the solid red line indicates the multiplier for long-term debt. Short-run debt is defined as the 90th percentile of the short-to-long-term debt maturity ratio, while long-run debt is defined as the 10th percentile of the same ratio. Standard errors are adjusted for serial correlation and heteroscedasticity.

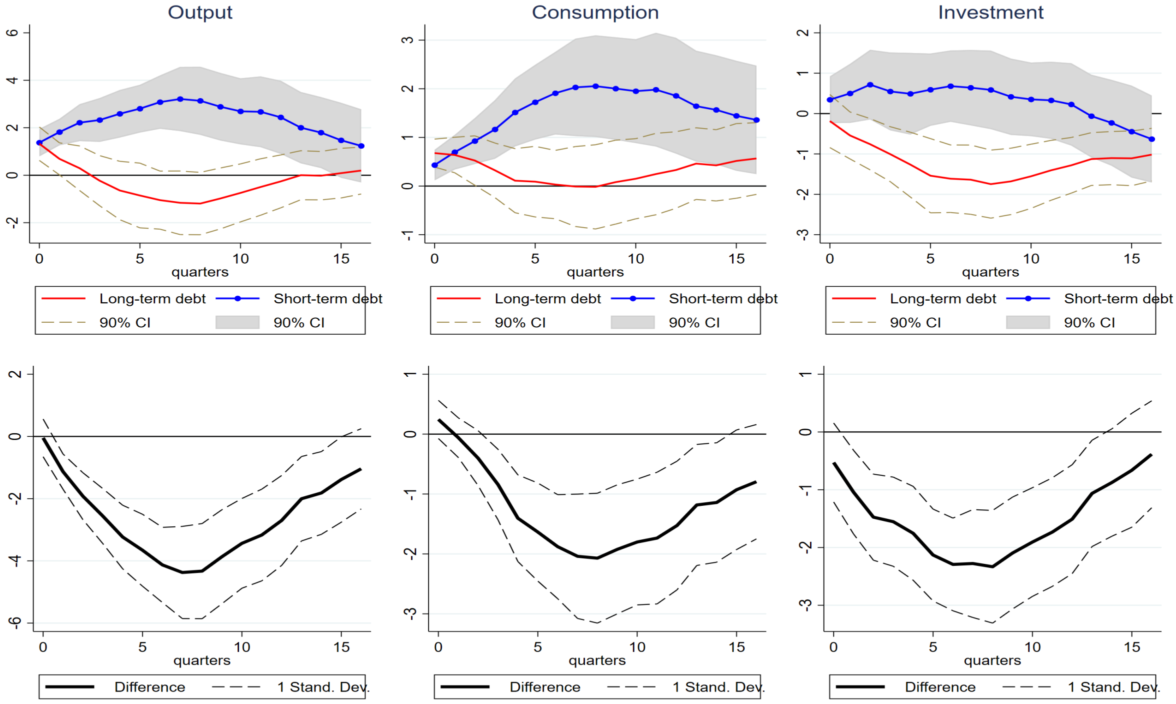


Figure 14: Cumulative multiplier of a government expenditure shock- with additional control variables (**interest rate spread and real wages**).

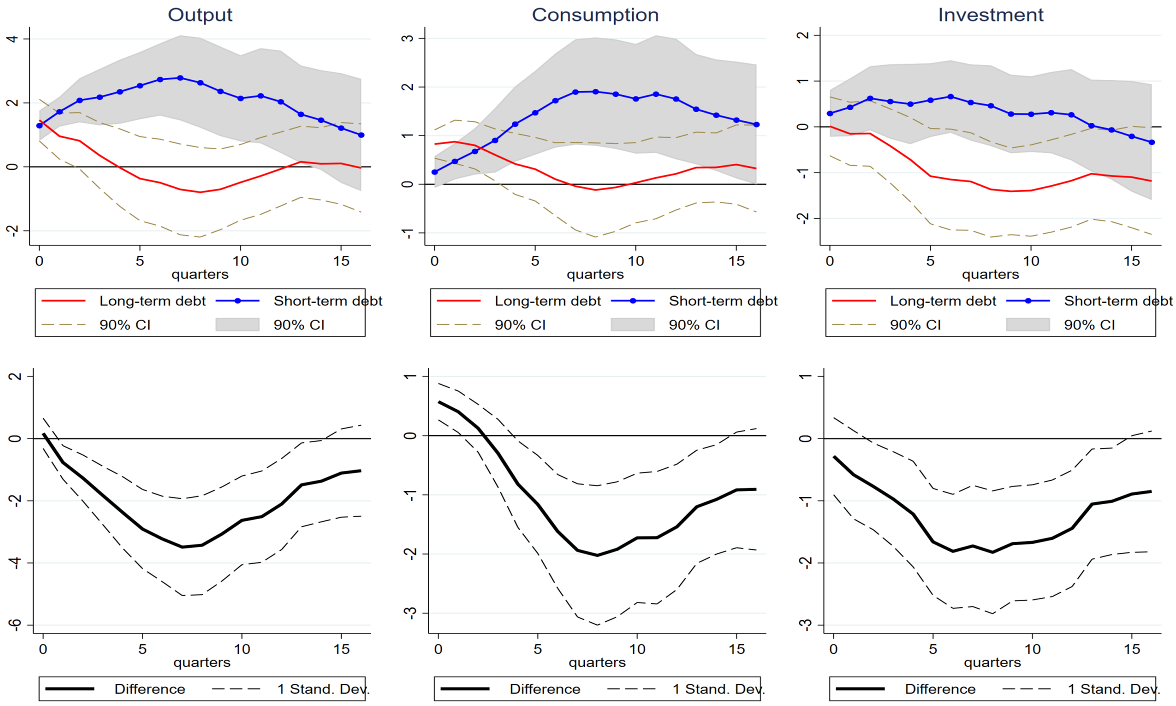


Figure 15: Cumulative multiplier of a government expenditure shock- adding extra control variables: Extra controls in this exercise include; **interest rate spread, real wages, and GDP deflator**.

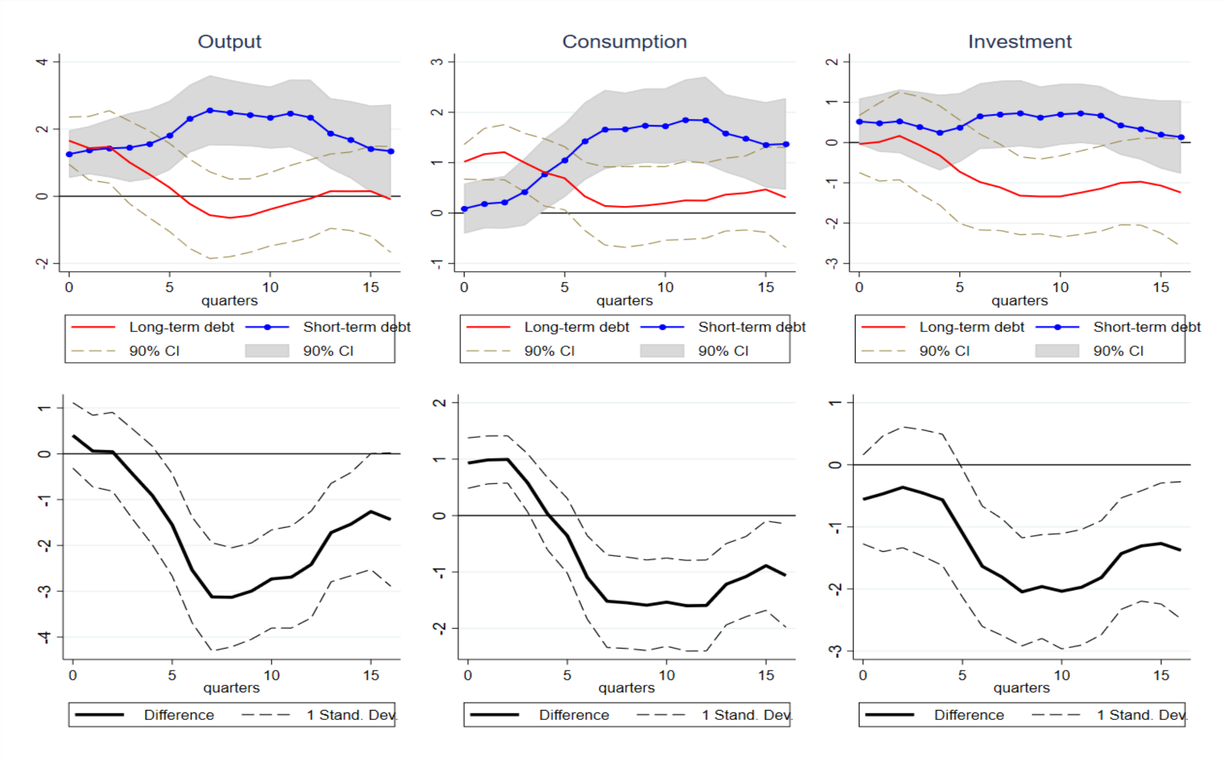


Figure 16: Cumulative multiplier of a government expenditure shock- adding extra control variables (**interest rate spread, real wages, GDP deflator and the short term interest rate**).

Further robustness checks We present a few more robustness exercises to complement the results we showed thus far. First, instead of detrending the variables with a high-degree polynomial as we did for our baseline model, we employ the Hodric Prescot filter. The results are shown in Figure 17. Further, we experimented with running our model using two lags of the control variables (instead of 4 which was the baseline). The estimates of the cumulative multipliers are depicted in Figure 18. Moreover, in Figure 19 we run the model dropping the observations post 2008, focusing on the observations prior to the Great recession and the period where the short term nominal rate was at its effective lower bound in the United states. Figure 20 separately estimated the fiscal multipliers using only government consumption as the spending series and shows large differences in multipliers. Finally, in Figures 21 and 22 we show the estimates of the cumulative multipliers that we got when we run the model using the post 1980s and high public debt sample, respectively. As can be seen from these Figures our main finding that STF leads to bigger fiscal multipliers continues to hold.

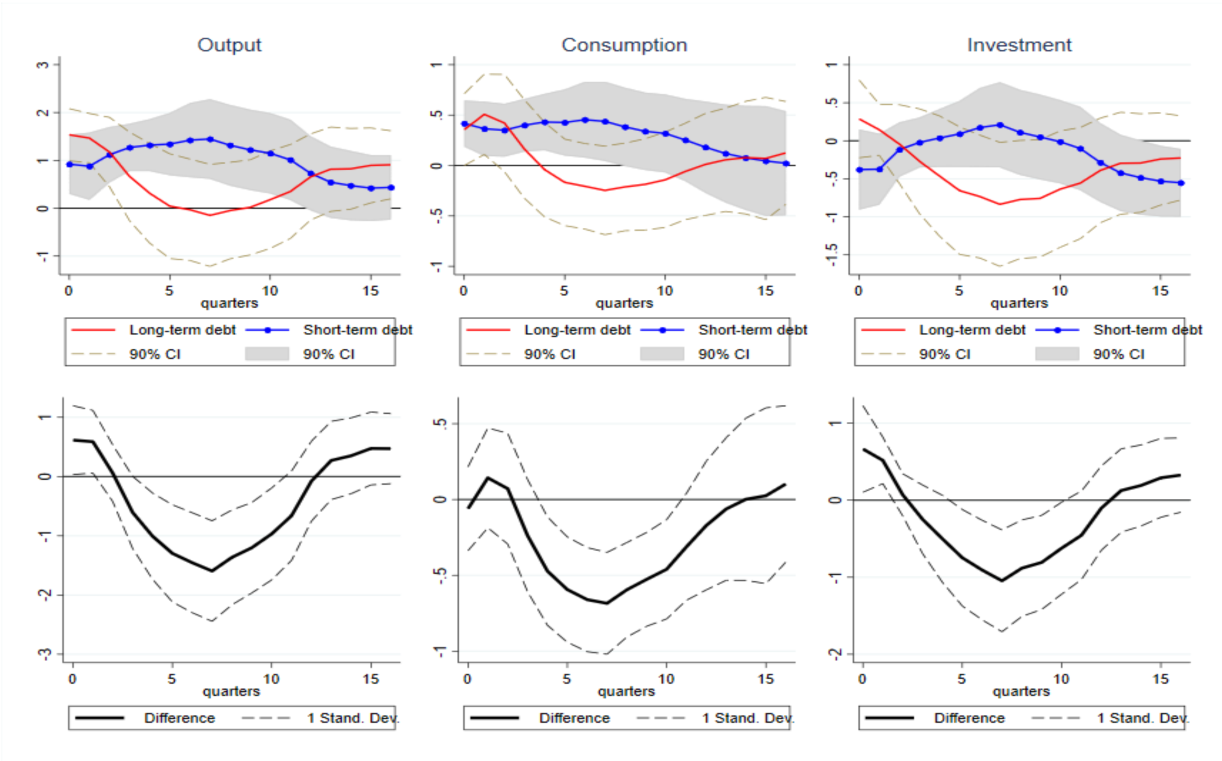


Figure 17: Cumulative fiscal multipliers under LTF and STF: HP filtered data.

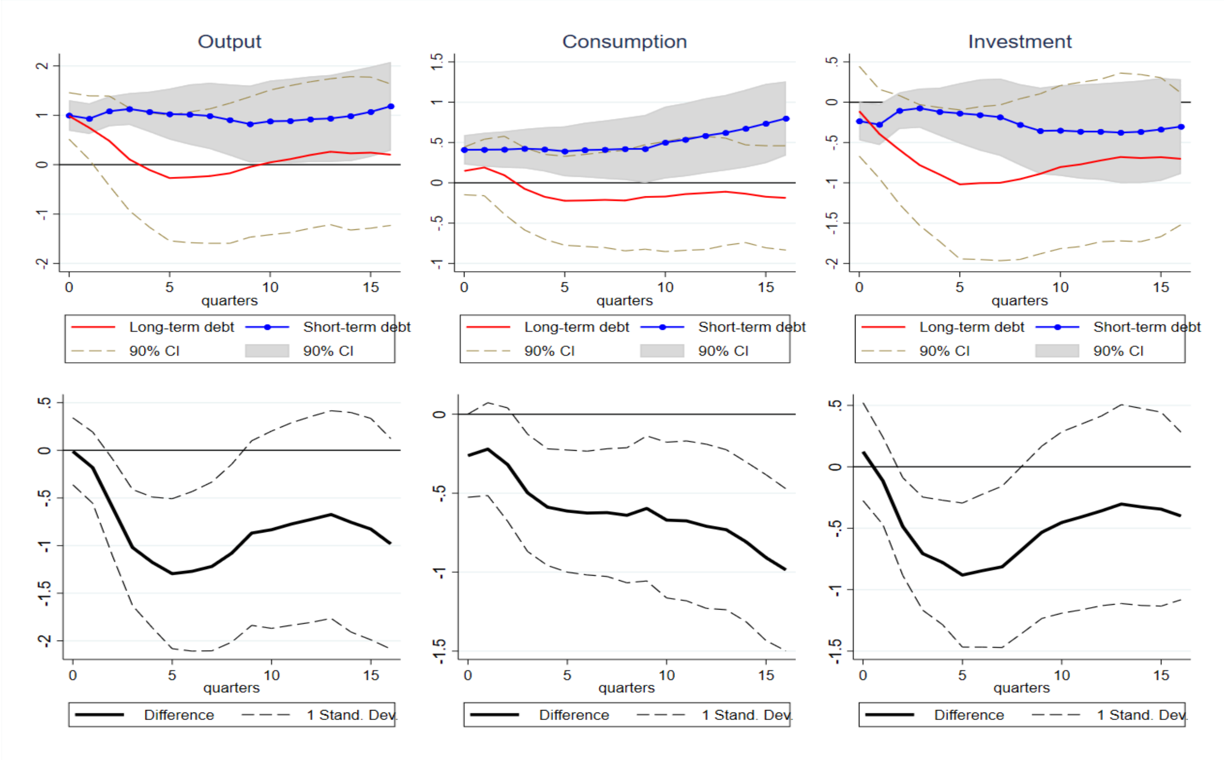


Figure 18: Cumulative fiscal multipliers under LTF and STF: Shorter lag structure.

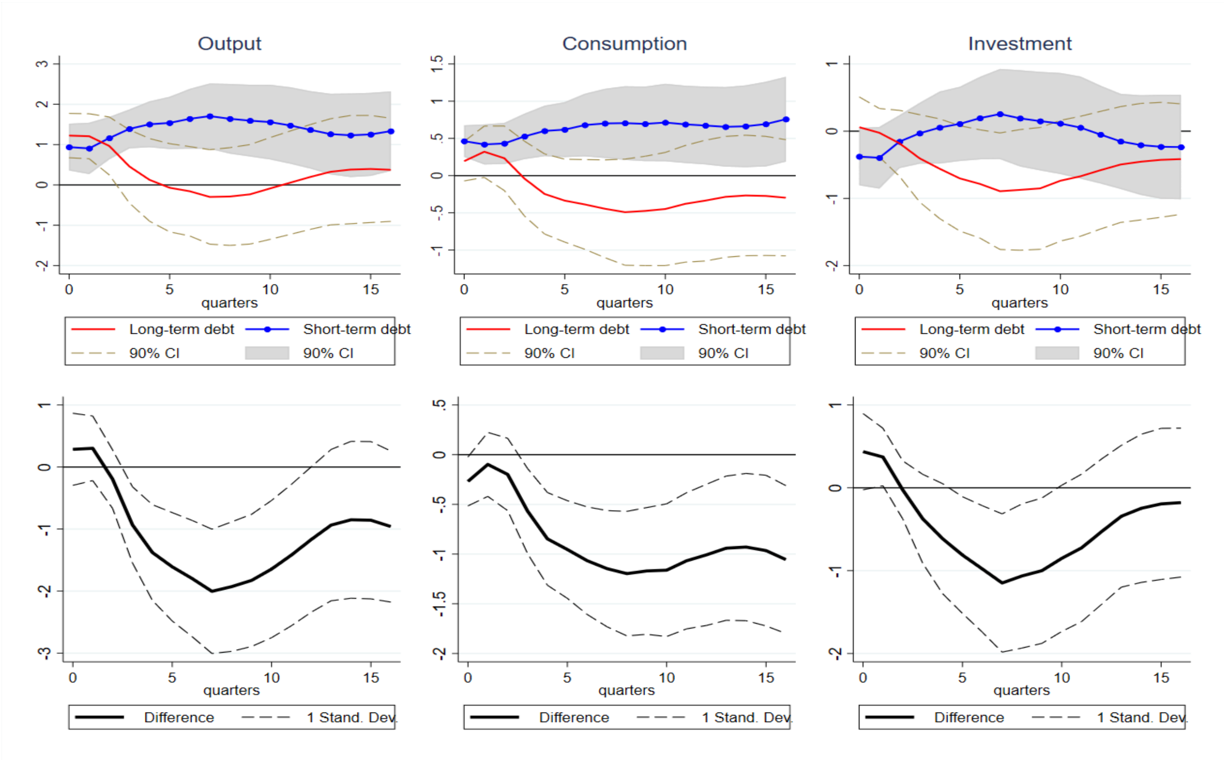


Figure 19: Cumulative fiscal multipliers under LTF and STF: Excluding the ZLB episode

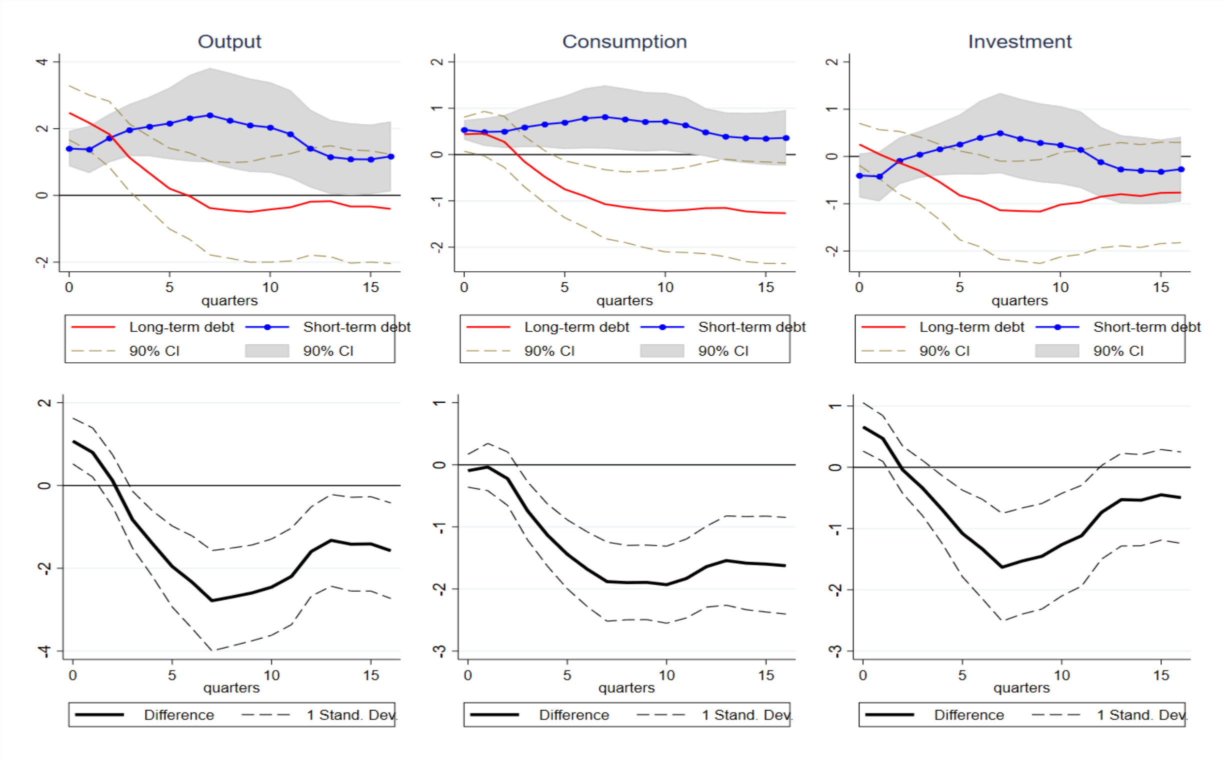


Figure 20: Cumulative fiscal multipliers under LTF and STF: Public consumption

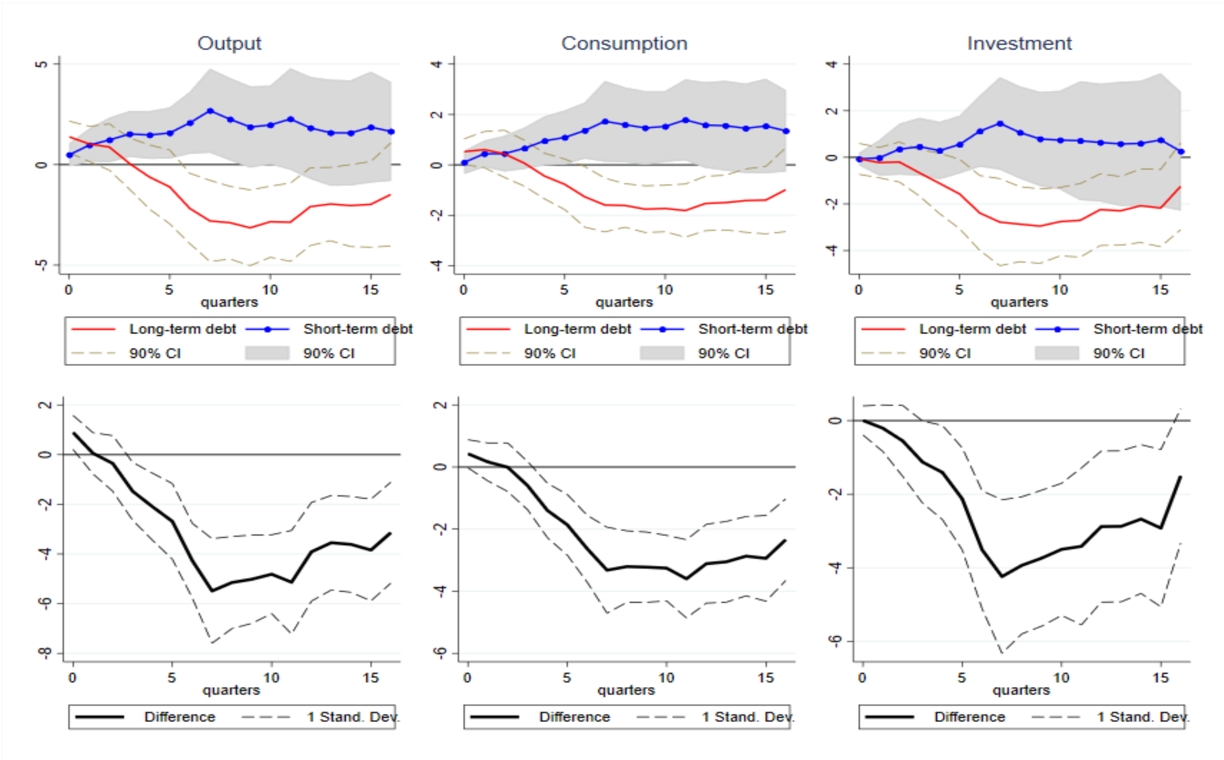


Figure 21: Cumulative fiscal multipliers under LTF and STF: Post 1980s sample

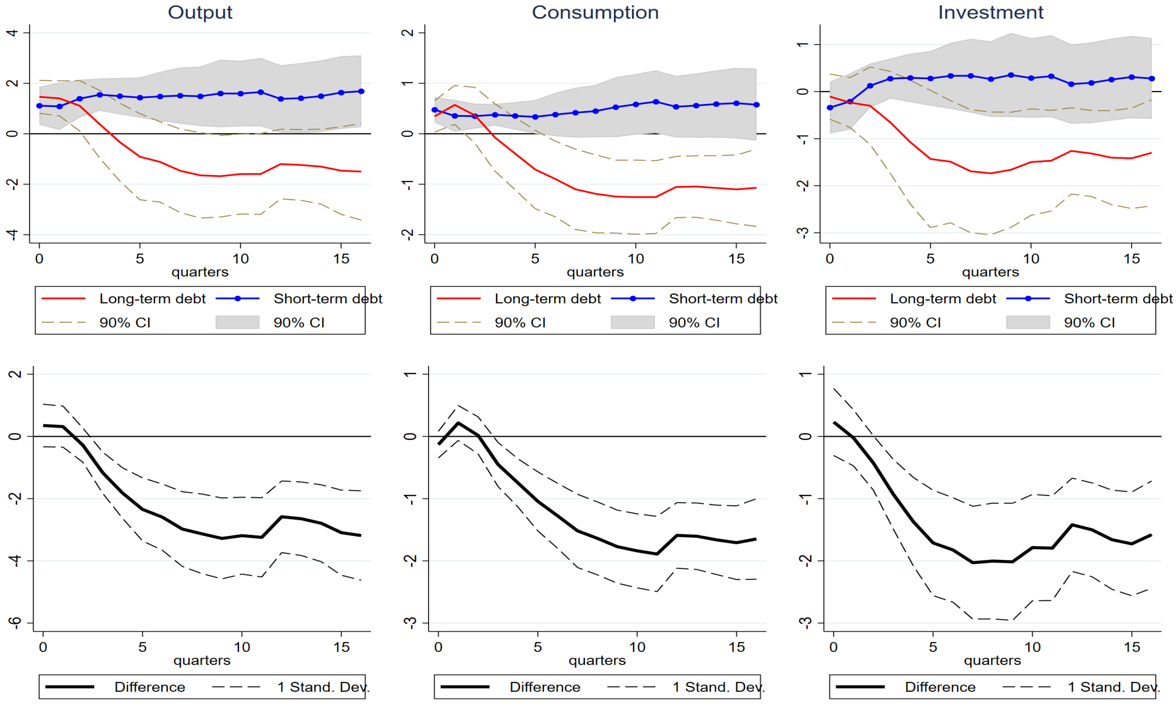


Figure 22: Cumulative fiscal multipliers under LTF and STF: High debt sample

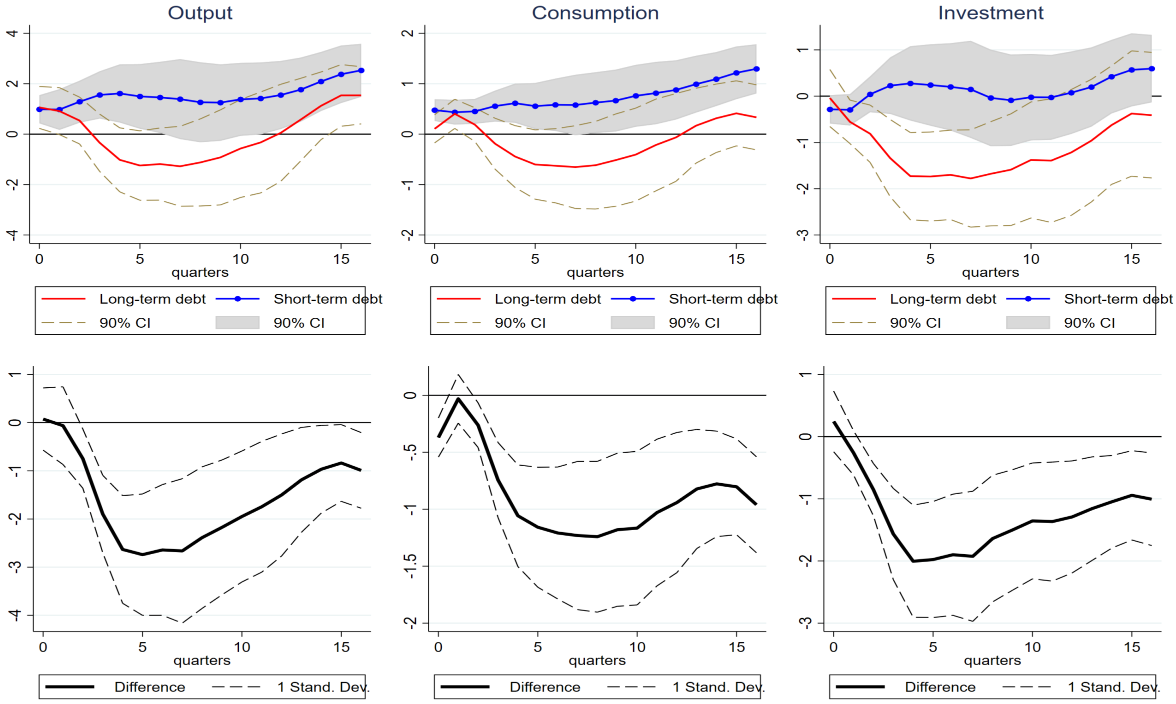


Figure 23: Cumulative fiscal multipliers under LTF and STF: High domestic debt holders ratio

Conditioning on the domestic to foreign debt ratio.

Our final robustness exercise in this paragraph accounts for the possibility that different maturities are purchased by domestic /foreign investors. Broner et al. (2022) and Priftis and Zimic (2021) made the point that fiscal multipliers are larger when government debt is bought by foreign investors, since then the crowding out impact of a government spending shock on private consumption and investment tends to be smaller. We want to investigate whether this channel may be important for our estimates of STF and LTF multipliers. If (for instance) STF shocks are more likely to be foreign financed then applying the argument of Broner et al. (2022) and Priftis and Zimic (2021) they are more likely to a stronger impact on the macroeconomy. To test this, we study the propagation of STF and LTF shocks in periods when the domestic to total debt ratio (the variable utilized by Broner et al. (2022)) is high (above the median). A.3 shows the results. Notice that the differences between STF and LTF multipliers continue being significant. We thus conclude that our results are robust toward controlling for domestic/foreign financing of spending shocks.

A.4 State-dependent local projections

We now explore an alternative empirical strategy to investigate the effect of financing on the propagation of spending shocks. In particular, we continue relying on the local projection method of Jordà (2005) however, to distinguish between spending shocks financed with short-term debt and shocks financed with long-term debt, we employ a state-dependent specification of the model (as in e.g. Auerbach and Gorodnichenko, 2013; Ramey and Zubairy, 2018).

More specifically, the (non-linear) local projection framework that we utilize in this subsection estimates a series of regressions of the following form:

(A.3)

$$Y_{t+h} = I_{t-1}\left[a_{A,h} + \beta_{A.h}\varepsilon_t + \psi_{A,h}(L)X_{t-1}\right] + (1 - I_{t-1})\left[a_{B,h} + \beta_{B,h}\varepsilon_t + \psi_{B,h}(L)X_{t-1}\right] + \text{Trend}^2 + u_{t+h}$$

to identify the impulse response of the variable Y (e.g., output, consumption, investment), traced over the horizon h denotes the horizon and where X is a vector of control variables and $\psi_{A,h}(L)$ is a polynomial in the lag operator. As before, ε is the identified spending shock.

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

Note that this approach of identifying differential effects of spending shocks along the maturity financing is quite different than the interaction terms we had worked with in the previous paragraph following more closely Broner et al. (2022). Besides the non-linearity of (A.3) recall that in the previous section we utilized the lagged value of the ratio R as a proxy for the financing of the spending shock, whereas now we adopt the lagged change in the ratio to discern the differences between STF and LTF. Therefore, we specify the model in a way that resembles more our exercise with the proxy VAR. We however, condition on the lag value of I_{t-1}, instead of the contemporaneous value for our baseline, since this appears to be more common for state dependent models in the literature. Once again it is worth noting that for the case of a variable which is as persistent as the share of short-term debt is in US data, the issuances of debt can be expected to display strong serial correlation, so that effectively I_{t-1} is a good proxy the financing of the shock in t and for the issuance of debt in subsequent periods. [7]

Given the estimates of coefficients $\left\{\beta_{A.h}, \beta_{B.h}\right\}_h$ in (A.3) we can easily compute the cumulative multipliers under STF and LTF. We show these objects in Figures 24 (in which we idenfity spending shocks using the news variable) and 25 (where we identify exogenous spending using the Blanchard and Perotti approach).[8]

[7] We also experimented with conditioning on the average change in the ratio between $t-1$ and $t+1$, as well as $t-1$ and $t+4$. In these cases our conditioning works well for medium and long-term effects (which are anyway typically better captured by the projection method, when the news variable is being used). None of these alternative specifications altered significantly our findings. Moreover, run our non-linear model defining I to be equal to one when the lagged ratio exceeded the median and 0 otherwise and our results went through.

[8] Applying standard criteria we set $\psi_{A,h}(L)$ to have 4 lags. Moreover, we experimented 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; however, alternative specifications of X (e.g. without wages and/ or interest rates) did not significantly change our findings. Finally, across all specifications, to control for any serial correlation, X also includes lags of the news variable. Following Ramey and Zubairy (2018), we also include a quadratic trend to control for slow-moving demographics.

Using the state dependent method does not change our results. In the middle panel of Figure 24, we note the strong reaction of aggregate consumption under STF. We obtain a statistically significant increase in consumption, a few quarters after the shock has occurred. In contrast, the response of consumption under LTF turns negative and significant suggesting a strong crowding out effect of the shock. (Notice also that the hump-shaped responses of the macro aggregates to the spending shock are to be expected in this local projection method with news shocks. This also applies to our estimates in the previous subsection where we used the news variables together with the BP shocks).

Furthermore in Figure 25 we continue finding significant differences between STF and LTF multipliers, especially at medium or long horizons. Specifically, the consumption and output multipliers for the STF shock are statistically significant, and the output multiplier exceeds unity. The output multiplier in the case of the LTF shocks is significant only for the first 3 quarters.

We thus conclude that our results are robust towards using state dependent local projections as an alternative estimation approach of the effect of maturity financing on the fiscal multipliers.

Figure 24: State-dependent local projections: Defense news shock.

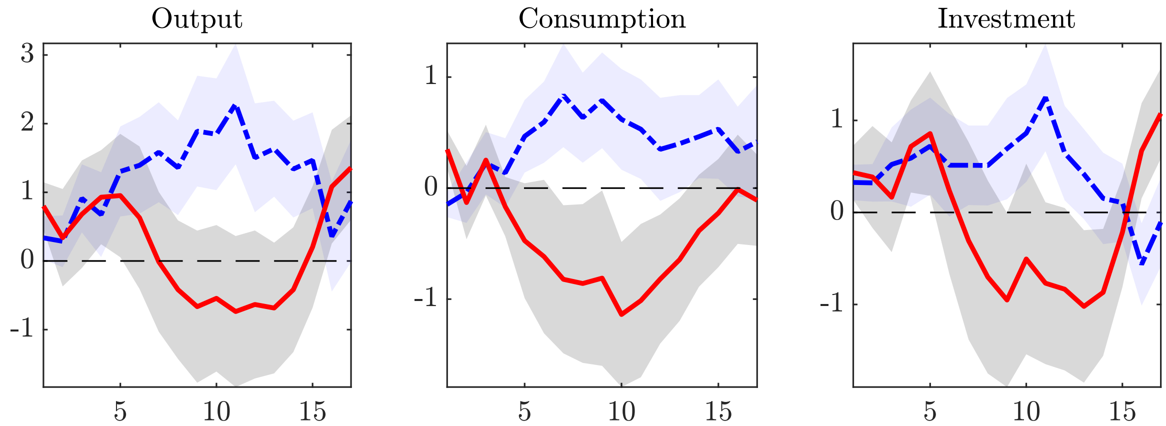
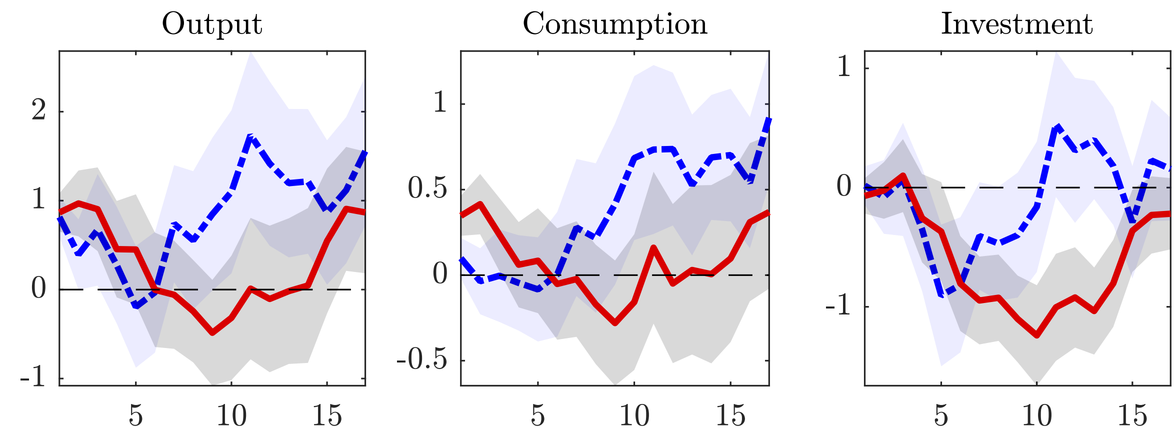


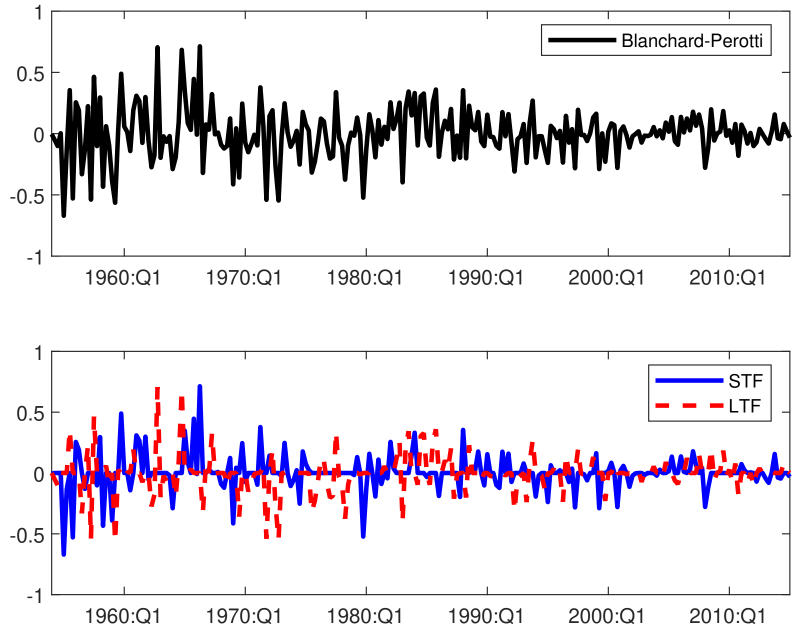
Figure 25: State-dependent local projections: Defense news shock.



Notes: Fiscal multipliers 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, term spreads, and total debt, as well as their lags.

To close this paragraph we show in a graph the identified BP shocks as they are identified from the VAR, and the partition between STF and LTF shocks according to our definition I_t (bottom panel). Figure 26 is the analogue of Figure 2 shown previously for the defense new shocks.

Figure 26: Identified fiscal shocks using Blanchard and Perotti (2002)



Notes: Top row: Aggregate fiscal shock identified as in Blanchard and Perotti (2002). Bottom row: Identified short-term (STF) and long-term (LTF) debt financed spending shocks. Series are scaled by the trend of GDP.

B Model Supplements, Analytic Formulae and Further Numerical Experiments.

This subsection derives the analytic results we showed in Section 3 of the paper and presents additional results from alternative calibrations of the baseline model. We also setup the program of the household in the baseline model and derive the Euler equations. Finally, we consider an extension of the baseline framework, in which we assume that long-term bonds provide partial liquidity services to the private sector.

B.1 Analytical Results in Section 3

Consider the log-linear model of Section 3. Assume that monetary policy sets $\frac{\overline{q}_S}{\overline{C}}\hat{q}_{t,S} + \beta\frac{F_{\bar{\bar{\theta}}}}{\overline{C}} = 0$. We derive the coefficient κ_1 shown in the main text.

First, noting that $\bar{\bar{\theta}}^2 f_{\bar{\bar{\theta}}}\overline{C} - f_{\bar{\bar{\theta}}}\bar{\bar{\theta}}\overline{b}_S = 0$ we can write the resource constraint as:

$$\overline{TC}\hat{TC}_t = \overline{C}\hat{C}_t + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta \overline{C}\hat{C}_t + \overline{b}_S(1 - F_{\bar{\bar{\theta}}})\hat{b}_{t,S}$$

where from the steady state definition of total consumption it holds that:

$$\overline{TC} = \overline{C}(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta) + \overline{b}_S(1 - F_{\bar{\bar{\theta}}}).$$

Using formula (25) in the main text and the policy $\hat{b}_{t,S} = \rho_G^t \varrho \hat{G}_0$ we can write

$$\overline{TC}\hat{TC}_t = \left[\frac{\alpha_2}{\alpha_1}\frac{\overline{C}(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta)}{1 - F_{\bar{\bar{\theta}}}\frac{\beta}{\alpha_1 \overline{C}}\rho_G} + \overline{b}_S(1 - F_{\bar{\bar{\theta}}})\right]\rho_G^t \varrho \hat{G}_0.$$

Combining the above it is easy to show that:

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

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

[9] Given these formulae it is easy to derive the expression for the fiscal multiplier we showed in text.

Now let us turn to the model where monetary policy follows an inflation targeting rule. We apply the method of undetermined coefficients to find coefficients χ_1, χ_2, χ_3 (in $\hat{\pi}_t = \chi_1 \hat{G}_t$, $\hat{C}_t = \chi_2 \hat{G}_t$

[9]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

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

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.

$\hat{Y}_t = \chi_3 \hat{G}_t$ the expressions in the main text) to satisfy the Phillips curve, the resource constraint and the Euler equation. Recalling also that shocks are i.i.d (so expected future consumption and inflation are 0) we get:

$$\chi_2 = \frac{\alpha_2}{\alpha_1}\varrho - \chi_1 \frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi$$

from the Euler equation,

$$\chi_1 = \frac{1+\eta}{\omega}\overline{Y}(\gamma_h \chi_3 + \frac{\alpha_2}{\alpha_1}\varrho - \chi_1 \frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi)$$

from the Phillips curve. This expression can be rearranged to:

$$\chi_1 = \frac{1}{1 + \frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}\frac{1+\eta}{\omega}\overline{Y}(\gamma_h \chi_3 + \frac{\alpha_2}{\alpha_1}\varrho)$$

Finally, the resource constraint gives:

$$\overline{C}\left(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta\right)\chi_2 + \bar{b}_S(1 - F_{\bar{\bar{\theta}}})\varrho + \overline{G} = \overline{Y}\hat{Y}_t\chi_3 \rightarrow$$

$$\overline{C}\left(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta\right)[\frac{\alpha_2}{\alpha_1}\varrho - \chi_1 \frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi] + \bar{b}_S(1 - F_{\bar{\bar{\theta}}})\varrho + \overline{G} = \overline{Y}\chi_3 \rightarrow$$

$$\frac{\alpha_2}{\alpha_1}\varrho[\frac{\overline{C}\left(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta\right)}{1 + \frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}] + \bar{b}_S(1 - F_{\bar{\bar{\theta}}})\varrho + \overline{G} = \left[1 + \frac{\overline{C}\left(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta\right)\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}{1 + \frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}\frac{1+\eta}{\omega}\gamma_h\right]\overline{Y}\chi_3$$

The final equation can be solved for χ_3. Since $\frac{d\hat{Y}_t}{d\hat{G}_t} = \chi_3$ it becomes easy to show that

$$m_0 = \frac{\overline{Y}d\hat{Y}_0}{\overline{G}d\hat{G}_0} = \frac{1}{\left[1 + \frac{\overline{C}\left(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta\right)\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}{1 + \frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}\frac{1+\eta}{\omega}\gamma_h\right]}\left[1 + (\frac{1}{\overline{\overline{G}}}\frac{\alpha_2}{\alpha_1}[\frac{\overline{C}\left(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta\right)}{1 + \frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}] + \bar{b}_S(1 - F_{\bar{\bar{\theta}}}))\varrho\right]$$

Finally notice that in the notation we used in text we defined

$$a_3(\phi_\pi) = \frac{1}{\left[1 + \frac{\overline{C}\left(1 + \int_0^{\bar{\bar{\theta}}} \theta dF_\theta\right)\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}{1 + \frac{1+\eta}{\omega}\frac{1}{\alpha_1}\frac{\overline{q}_S}{\overline{\overline{C}}}\phi_\pi}\frac{1+\eta}{\omega}\gamma_h\right]}$$

B.2 Household Optimality in the Baseline Model

We now derive the first order optimality conditions from the household's program in the baseline model. The dynamic program of household i is the following:
(B.4)

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

subject to:

(B.5)

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

(B.6) $$B_{S,t,2}^i = E_\theta(B_{S,t}^i - P_t c_t(\theta)) + P_t \bar{C}_{t,S}^i,$$

(B.7) $$P_t c_t^i(\theta) \leq B_{S,t}^i.$$

Let λ_t denote the multiplier on the budget constraint, $\omega_{S,t}$ and $\psi_t(\theta)$ the analogous objects on constraints (B.6) and (B.7); the first order conditions for the variables defining the optimal portfolio are the following:

$$\begin{aligned}
B_{S,t}^i &: \lambda_t q_{S,t} - \omega_{S,t} + \int \psi_t(\theta) dF_\theta = 0 \\
B_{L,t} &: \lambda_t q_{L,t} - \beta E_t V_{B_L,t+1} = 0 \to \lambda_t q_{L,t} = \beta E_t \lambda_{t+1} \\
B_{S,t,2}^i &: \omega_{S,t} = -\beta E_t V_{B_S,t+1} = \beta E_t \lambda_{t+1} \\
c_t^i(\theta) &: \theta v_c^i f_\theta + \omega_{S,t} P_t f_\theta - \psi_t(\theta) P_t f_\theta = 0
\end{aligned}$$

where we also made use of the envelope conditions $V_{B_S,t} = -\lambda_t$ and $V_{B_L,t} = -\lambda_t(1 + \delta q_{L,t})$. Complementary slackness gives: $\psi_t(\theta) \geq 0$, $\psi_t(\theta)(B_{S,t}^i - P_t c_t^i(\theta)) = 0$.

The solution is characterized by $\widetilde{\theta}_t$ such that if $\theta \geq \widetilde{\theta}_t$ then (B.7) binds. Realizing also that $\lambda_t = -\frac{u_{C,t}}{P_t}$ (from the FONC of C_t) we can then show that:

$$\begin{aligned}
\lambda_t q_{S,t} - \omega_{S,t} + \int_{\widetilde{\theta}_t} \psi_t(\theta) dF_\theta = \lambda_t q_{S,t} - \omega_{S,t} + \int_{\widetilde{\theta}_t} \frac{\theta v_c^i}{P_t} dF_\theta + \omega_{S,t}(1 - F_{\widetilde{\theta}_t}) = 0 \\
\to q_{S,t} \frac{u_{C,t}}{P_t} = \int_{\widetilde{\theta}_t} \frac{\theta v_c^i}{P_t} dF_\theta + \beta F_{\widetilde{\theta}_t} E_t \frac{u_{C,t+1}}{P_{t+1}}
\end{aligned}$$

the Euler equation for short-term debt as in the main text. Subsituting $\lambda_t = -\frac{u_{C,t}}{P_t}$ is the FONC for $B_{L,t}$ we can easily get the Euler equation for long-term bonds.

Finally, note that it is trivial to derive the static labour supply condition from the above dynamic program. We therefore omit the derivations.

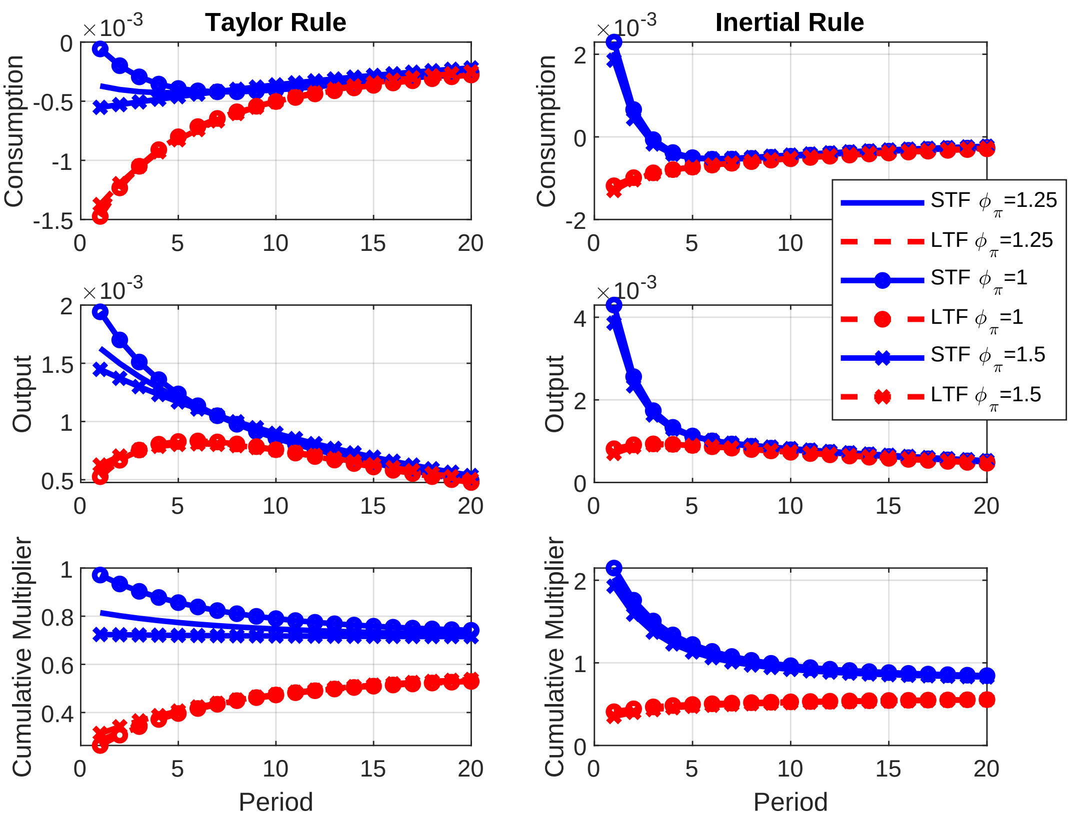
B.3 Alternative Interest rate rules, distortionary taxes.

We now show additional output from our baseline model. In the main text our numerical results relied on interest rate rules in which the nominal rate tracks the inflation rate and the lagged interest rate. We now perform additional experiments with broader calibrations of the inflation coefficients and also consider rules in which the output gap is targeted by the monetary authority along with inflation and the lagged interest rate.

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

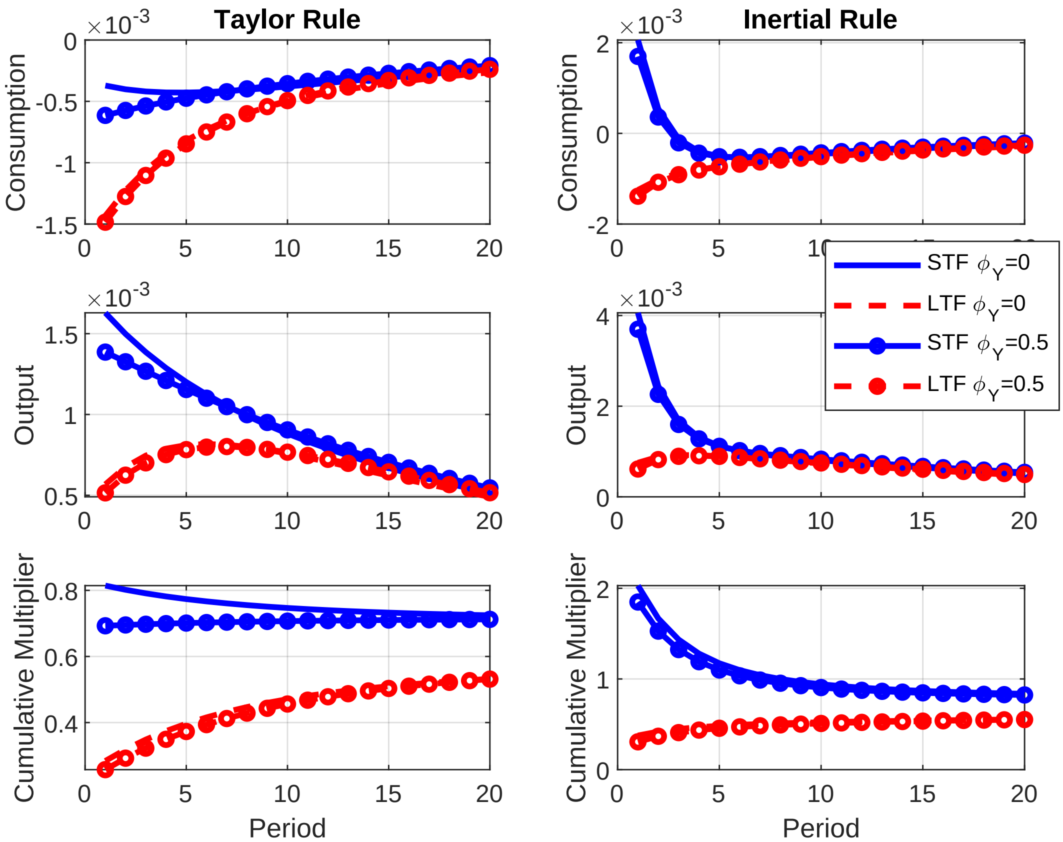
In Figure 27 we constrain ϕ_Y to be zero (our baseline calibration for this parameter) and show the impulse responses for $\phi_\pi = 1, 1.25$ (the baseline values) and 1.5. As can be seen from the figure, assuming a higher inflation coefficient does reduce somewhat the response of the economy to the STF shock, but the gap with LTF remains. Moreover, the inflation coefficient effectively does not matter for the responses of output, consumption and the multiplier in the case of LTF, since inflation reacts very little to the shock in that case.

Figure 27: Responses to a spending shock: Inflation coefficients



Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier following a shock that increases spending by 1 percent on impact. The interest rate rule is $\hat{i}_t = (1-\rho_i)\phi_\pi\hat{\pi}_t + \rho_i\hat{i}_{t-1}$ *The 'Taylor rule' assumes* $\rho_i = 0$. *The 'Inertial Rule' sets* $\rho_i = 0.9$. *We assume that* $\phi_\pi \in \{1, 1.25, 1.5\}$

Figure 28: Responses to a spending shock: Output gap target



Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier following a shock that increases spending by 1 percent on impact. The interest rate rule is $\hat{i}_t = (1-\rho_i)\phi_\pi\hat{\pi}_t + \phi_Y\hat{Y}_t + \rho_i\hat{i}_{t-1}$ *The 'Taylor rule' assumes* $\rho_i = 0$. *The 'Inertial Rule' sets* $\rho_i = 0.9$. *We assume that* $\phi_\pi = 1.25$ *and* $\phi_Y \in \{0, 0.5\}$

In Figure 28 we contrast the responses in the case $\phi_Y = 0$ with the analogous objects when $\phi_Y = 0.5$ (output gap target). We focus on the 'active' monetary policy scenario, assuming that taxes adjust to make government debt solvent. We set $\phi_\pi = 1.25$ as in the baseline calibration of the model.

The results show that setting a positive output target coefficient does not change our conclusions under both the 'Taylor rule' and the inertial monetary policy rule. We continue finding a large difference between STF and LTF.

Next, we study the impulse response functions in an economy with distortionary taxation. Under distortionary taxes the Euler equations we derived in the main text continue to hold, the only changes to the system of equilibrium conditions concern the government's budget constraint and the Phillips curve. The government's revenue now becomes

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

where $\overline{\tau}$ denotes the steady state distortionary tax. Notice that now 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:

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

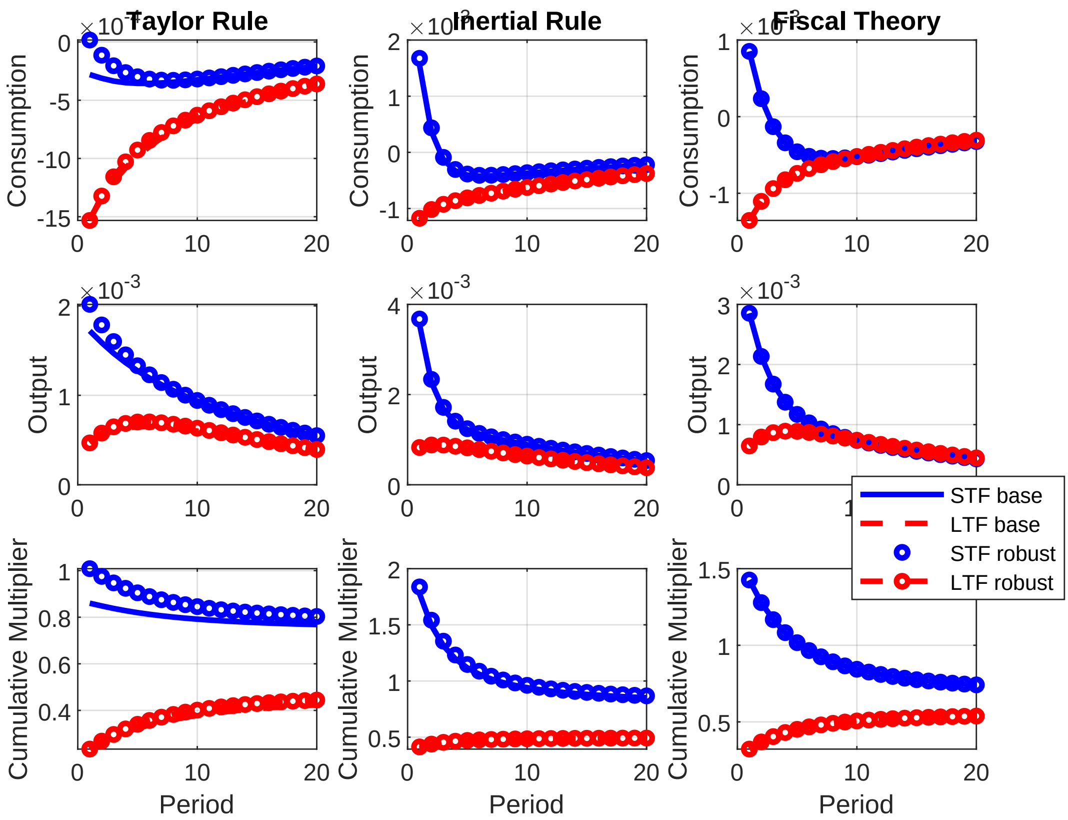
To solve the model we specify fiscal policy using the following tax rule

$$\hat{\tau}_t = \phi_\tau \hat{D}_{t-1}$$

As in the case of lump sum taxes we studied in the main text, we consider separately the case where monetary policy is 'active' (assuming that ϕ_τ is close to the threshold defining the determinacy region, so that government debt displays a near unit root) and the case where monetary policy is 'passive' (then setting $\phi_\tau = 0$.)

Figure 29 shows the impulse response functions for the same parameter values we considered ϕ_π, ρ_i we considered in the main text. Clearly, the model responses are (essentially) the same as in the model with lump sum taxation.

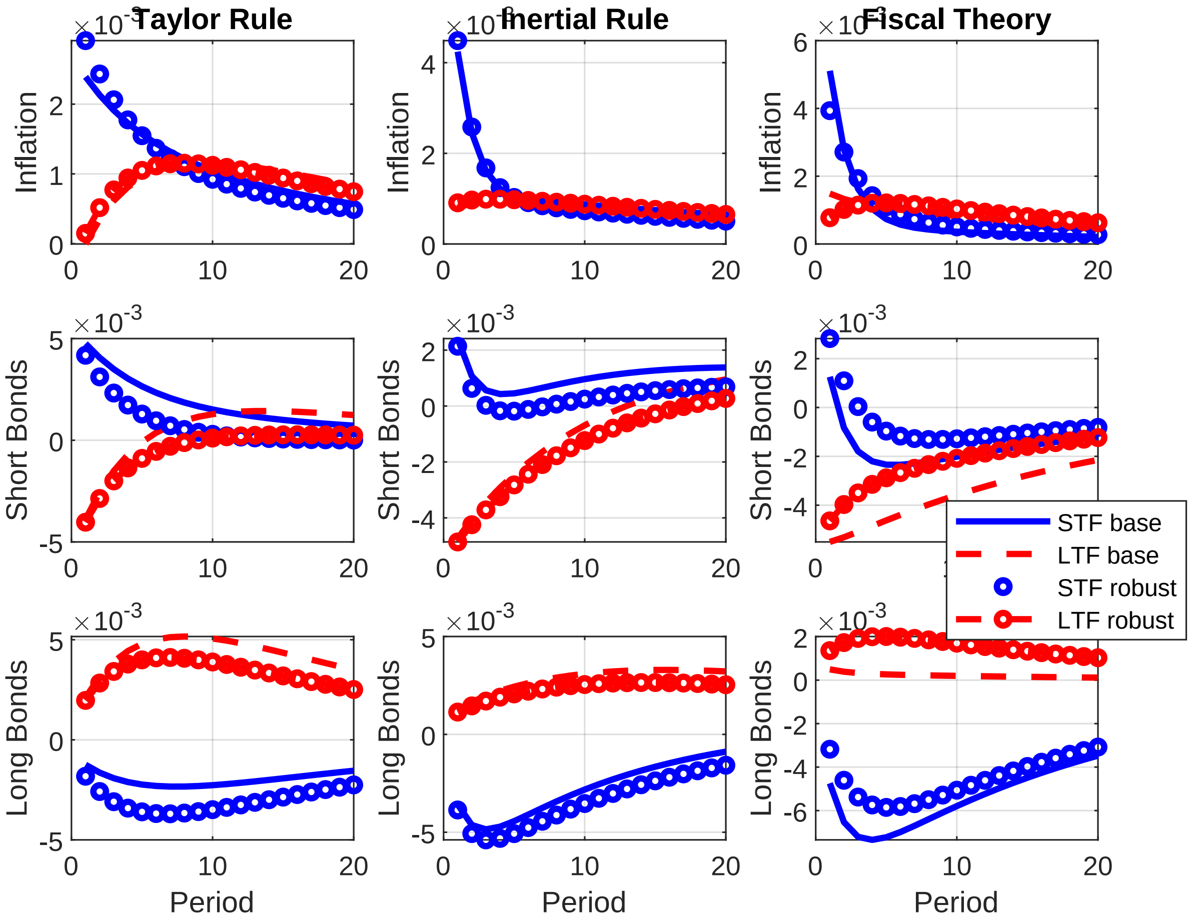
Figure 29: Responses to a spending shock: Distortionary Taxes



Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier following a shock that increases spending by 1 percent on impact. The interest rate rule is $\hat{i}_t = (1-\rho_i)\phi_\pi \hat{\pi}_t + \rho_i \hat{i}_{t-1}$ *The 'Taylor rule' assumes* $\rho_i = 0$. *The 'Inertial Rule' sets* $\rho_i = 0.9$. *We assume in both cases that* $\phi_\pi \in \{1, 1.25\}$. *The Fiscal Theory scenario sets the baseline inflation coefficient to zero and the 'robust' graphs assume* $\phi_\pi = 0.5$.

B.4 Responses of Inflation, Short and Long Bonds.

Figure 30: Responses to a spending shock: inflation, short and long term bonds



Notes: The figure plots the responses of inflation, short bonds and long bonds, under the different specifications of monetary policy, which we considered in the main text. The left panel shows results for a standard Taylor rule, the middle panel for an inertial monetary policy rule, and the right panel for a passive monetary policy rule.

We now study the responses of inflation and the quantities of short and long term bonds to a spending shock under the different specifications of monetary policy we considered in the main text. The left panels in Figure 30 show the case of a standard Taylor rule, the middle panels an inertial monetary policy rule, and the right panels a 'passive' monetary policy as in the Fiscal Theory of the Price Level.

As shown in the top panels, under the STF shock, inflation increases substantially in all versions of the model. In contrast, the LTF shocks lead to much more moderate increases in inflation across all models. This is not surprising. As explained in the main text, financing the spending shock short-term, is equivalent to a positive demand shock (a shock to the Euler equation). Since the demand shock results in positive inflation, it reinforces the inflationary effect of the spending shock.

Interestingly, under the Taylor rule (left panels) the quantity of short term bonds in the LTF case turns higher than under STF after eight quarters. This is not as surprising as it initially sounds. Since initial inflation in the STF case is higher and more frontloaded, total debt increases by less than in the LTF scenario. Initially, the relative effect, the mechanical decline in the share of short bonds dominates the quantity effect stemming from the increase in total debt. Over time, the net effect changes sign in the case of a Taylor rule.

In the case of the Fiscal Theory (right panel) the increase in LTF inflation above STF inflation, is mainly explained by the paths of taxes and spending. Inflation in the LTF regime has to eventually rise above STF to ensure intertemporal budget solvency. In other words, the fiscal shock in the STF case is financed with higher and more frontloaded inflation and in the LTF case with lower and more persistent inflation that reduces the real value of debt. But, it is worth noting that the two models will not result in the same cumulative increase in the price level to finance the spending shock. The reason is that with liquid debt, debt is not only financed by surpluses but also by 'liquidity rents' (See Section **??** of this appendix); and these rents will tend to decrease when the government expands the short bond supply under STF.

The figure also shows that total debt under the Fiscal theory is, as it ought to be, lower than in the other two scenarios. This reflects that the fiscal deficits in this model are unbacked and that, therefore, inflation rises by more than in the other scenarios to ensure intertemporal debt solvency.

The middle graphs in Figure 30 illustrate that for all STF shocks, the quantity of short term bonds increases. In contrast, the real quantity of long term debt (in log deviation from the steady state level) may decrease (the LTF case produces the opposite patterns). Real long bonds decrease for two reasons. First, due to the rise in inflation (holding constant the nominal value of debt). Second, because of portfolio rebalancing (some of the long term debt outstanding has matured) and the government refinances with short term bonds when the ratio of short over long is higher.

B.5 Assuming Long Bonds provide partial liquidity services

We now consider an extension of the baseline model in which long bonds 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 asset that can be used to finance consumption in subperiod 2.[10] $\kappa = 0$ is our baseline. For $\kappa > 0$ long bonds can be liquidated along with short bonds to finance c_t^i.

The program of household i now is:

$$\text{(B.8)} \quad V_t(B_{L,t-1}^i, B_{S,t-1,2}^i, X_t) = \max_{B_{L,t}^i, B_{S,t}^i, C_t^i, c_t^i, h_t^i} \left\{ u(C_t^i) + E_\theta \theta v(c_t^i) - \chi \frac{{h_t}^{i,1+\gamma}}{1+\gamma} + \beta E_t \left[V_{t+1}(B_{L,t}^i, B_{S,t,2}^i, X_{t+1}) \right] \right\}$$

subject to:

$$\text{(B.9)} \quad P_t C_t^i + q_{L,t} B_{L,t}^i + q_{S,t} B_{S,t}^i = P_t(1-\tau_t) w_t h_t^i + (1 + q_{L,t}\delta) B_{L,t-1}^i + B_{S,t-1,2}^i + D_t P_t - T_t P_t - P_t(\bar{C}_{t,S}^i + \bar{C}_{t,L}^i)$$

$$\begin{aligned}
\text{(B.10)} \quad B_{S,t,2}^i &= E_\theta(B_{S,t}^i - P_t(c_t(\theta) - \kappa d_{L,t}^i(\theta)) + P_t \bar{C}_{t,S}^i, \\
\text{(B.11)} \quad B_{L,t,2}^i &= E_\theta(B_{L,t}^i - d_{L,t}^i(\theta) P_t) - P_t \bar{C}_{t,L}^i \\
\text{(B.12)} \quad P_t c_t^i(\theta) &\leq B_{S,t}^i + \kappa d_{L,t}^i(\theta) P_t \\
\text{(B.13)} \quad d_{L,t}^i(\theta) P_t &\leq B_{L,t}^i
\end{aligned}$$

[10]For simplicity, we assume a constant fraction of the quantity of bonds can be liquidated (or κ is a constant times the steady state bond price). As in the case of short-term debt we use only the bond quantity in the constraint (not quantity times price) to get an analogous Euler equation for long-term bonds.

We let variable $d^i_{L,t}$ denote the withdrawals from long-term asset account for convencience. $\bar{C}^i_{t,S}$ and $\bar{C}^i_{t,L}$ are the appropriate sales of household goods in subperiod 2 corresponding to short and long bonds respectively.

Let λ_t denote the multiplier on the budget constraint, $\omega_{S,t}$ $\omega_{L,t}$ $\psi_t(\theta)$ and $\epsilon_t(\theta)$ the analogous objects on constraints (B.10) to (B.13); the first order conditions for the variables defining the optimal portfolio are the following:

$$\begin{aligned}
B^i_{S,t}: &\quad \lambda_t q_{S,t} - \omega_{S,t} + \int \psi_t(\theta) dF_\theta = 0 \\
B^i_{L,t}: &\quad \lambda_t q_{L,t} - \omega_{L,t} + \int \epsilon_t(\theta) dF_\theta = 0 \\
d^i_{L,t}(\theta): &\quad -\kappa\omega_{S,t}P_t f_\theta + \omega_{L,t}P_t f_\theta + \kappa\psi_t(\theta)P_t f_\theta - \epsilon_t(\theta)P_t f_\theta = 0 \\
B^i_{S,t,2}: &\quad \omega_{S,t} = -\beta E_t V_{B_S,t+1} = \beta E_t \lambda_{t+1} \\
B^i_{L,t,2}: &\quad \omega_{L,t} = -\beta E_t V_{B_L,t+1} = \beta E_t \lambda_{t+1}(1+\delta q_{L,t+1}) \\
c^i_t(\theta): &\quad \theta v^i_c f_\theta + \omega_{S,t}P_t f_\theta - \psi_t(\theta)P_t f_\theta = 0
\end{aligned}$$

where we also made use of the envelope conditions $V_{B_S,t} = -\lambda_t$ and $V_{B_L,t} = -\lambda_t(1+\delta q_{L,t})$. Complementary slackness gives: $\psi_t(\theta) \geq 0$, $\epsilon_t(\theta) \geq 0$ $\psi_t(\theta)(B^i_{S,t} + \kappa d^i_{L,t}(\theta)P_t - P_t c^i_t(\theta)) = 0$ and $\epsilon_t(\theta)(B^i_{L,t} - d^i_{L,t}(\theta)P_t) = 0$.

As before, the solution is characterized by $\widetilde{\theta}_t$ such that if $\theta \geq \widetilde{\theta}_t$ then (B.12) and (B.13) bind. Realizing also that $\lambda_t = -\frac{u_{C,t}}{P_t}$ we can then show that

$$\begin{aligned}
\lambda_t q_{S,t} - \omega_{S,t} + \int_{\widetilde{\theta}_t} \psi_t(\theta) dF_\theta &= \lambda_t q_{S,t} - \omega_{S,t} + \int_{\widetilde{\theta}_t} \frac{\theta v^i_c}{P_t} dF_\theta + \omega_{S,t}(1 - F_{\widetilde{\theta}_t}) = 0 \\
\rightarrow q_{S,t}\frac{u_{C,t}}{P_t} &= \int_{\widetilde{\theta}_t} \frac{\theta v^i_c}{P_t} dF_\theta + \beta F_{\widetilde{\theta}_t} E_t \frac{u_{C,t+1}}{P_{t+1}}
\end{aligned}$$

the same Euler equation for short-term debt as in the main text. For long-term bonds we have:

$$\begin{aligned}
\lambda_t q_{L,t} - \omega_{L,t} + \int_{\widetilde{\theta}_t} \epsilon_t(\theta) dF_\theta &= \lambda_t q_{L,t} - \omega_{L,t} + \int_{\widetilde{\theta}_t} [-\kappa\omega_{S,t} + \omega_{L,t} + \kappa\psi_t(\theta)] dF_\theta \\
\rightarrow \lambda_t q_{L,t} - \omega_{L,t} F_{\widetilde{\theta}_t} + \kappa \int_{\widetilde{\theta}_t} \frac{\theta v^i_c}{P_t} dF_\theta &= 0 \\
\rightarrow \frac{u_{C,t}}{P_t} q_{L,t} &= \kappa \int_{\widetilde{\theta}_t} \frac{\theta v^i_c}{P_t} dF_\theta + \beta F_{\widetilde{\theta}_t} E_t \frac{u_{C,t+1}}{P_{t+1}}(1+\delta q_{L,t+1})
\end{aligned}$$

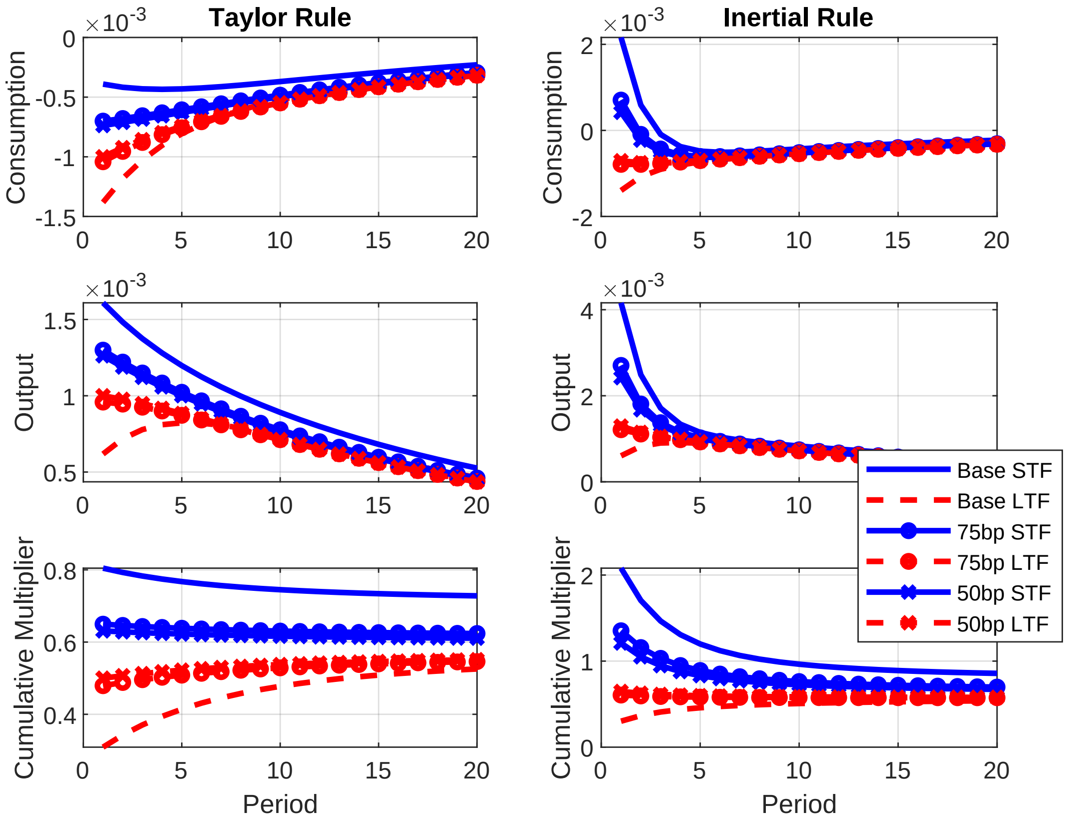
The resource constraint can be modified to reflect that now the consumption of constrained agents is given by $b_{t,S} + \kappa b_{t,L}$. For brevity, we omit the derivation since it is trivial.

We run the model for different calibrations of parameter κ. We discipline our exercise by choosing different κs to target different levels of the term spread. Our baseline calibration in the main text assumes a term spread that is equal to 1 percent per annum when $\kappa = 0$. We consider two alternative calibrations of κ to have an annual term premium equal to 75 and 50 basis points.[11]

[11] In each case we adjust the parameters of the distribution f_θ to match the estimates of Greenwood et al. (2015). Generically, positive κ implies a stronger reaction of the term premium to an increase in the Bills to GDP ratio (the variable used by Greenwood et al. (2015) in their empirical exercise) and so we need to increase the variance of f_θ to the empirical evidence. If we keep the variance constant as in our baseline calibration we get a much stronger reaction of the spending multiplier to financing.

The impulse responses are plotted in Figure 31. The left panels assume a non-inertial rule with inflation coefficient equal to 1.25 and in the right panels we set $\rho_i = 0.9$. As can be seen from the figure assuming partial liquidity services of long-term debt does mute the STF multipliers and increase the LTF multipliers. However, the differences continue being substantial, even when the term premium is as small as 50bps per annum, and especially in the case of the more empirically relevant inertial interest rate rule. We therefore conclude that our results do not hinge on the assumption that long bonds are not liquid and can be used to transfers resources across periods.

Figure 31: Responses to a spending shock when long bonds provide partial liquidity



Notes: We plot the paths of consumption, output and the cumulative fiscal multiplier following a shock that increases spending by 1 percent on impact. The various plots correspond to alternative calibrations of the model when long bonds can provide partial liquidity. Solid lines without markers are the baseline calibration (no liquidity). Lines with circles calibrate the liquidity parameter κ so that the term spread is 75 bps per annum. Lines with crosses set the term premium equal to 50 bps. As usual STF is blue lines and LTF is red lines.

B.6 An alternative calibration of the share of short over long.

As we discussed in text, short maturity debt in our model is of one quarter duration, however, in the empirical exercise we defined short term debt to be any debt that is of maturity less than a year. We now experiment with an alternative definition of the share of short over long in our model which includes debt which is of maturity 2, 3 and 4 quarters.

To do so we define as short term debt, the coupon payments of the long term asset that have duration less than or equal to one year. Recall that a long term bond issued in t pays coupons that decay at rate δ. Then the payments 1, δ, δ^2, δ^3 which are to be paid in $t+1, t+2, ..., t+4$ can essentially be counted as short bonds at the end of period t. Consequently, the face value of short debt becomes $b_{S,t} + b_{L,t}(1+\delta+\delta^2+\delta^3) = b_{S,t} + b_{L,t}\frac{1-\delta^4}{1-\delta}$ and analogously the value of long debt is $b_{L,t}\frac{\delta^4}{1-\delta}$.

The share (in levels) of short term over long term debt is:

$$\widetilde{R}_t = \frac{b_{S,t} + b_{L,t}\frac{1-\delta^4}{1-\delta}}{b_{L,t}\frac{\delta^4}{1-\delta}}$$

In log deviations we obtain:

$$\hat{\widetilde{R}}_t = \frac{1}{\overline{\widetilde{R}}}\frac{\overline{b}_S}{\overline{b}_L\frac{\delta^4}{1-\delta}}\left(\hat{b}_{S,t} - \hat{b}_{L,t}\right).$$

We now solve the model setting $\hat{\widetilde{R}}_t = \varrho \hat{G}_t$ and ϱ equal to 0.6 (-0.6) for a short term (long term) financed spending shock.

We calibrate the model as follows: First, we keep $\delta = 0.96$ as in the baseline calibration. Then we set the average share $\overline{\widetilde{R}}$ such the model produces an average debt maturity roughly equal to our baseline (5 years). This implies that the share of short over long term debt is roughly 0.30.[12] Furthermore, to calibrate the parameters of F_θ we repeated the steps reported in text, that is requiring that the model matches the empirical evidence of Greenwood et al. (2015). The remaining parameters of the model assume the values we reported in text.

Figure 32 repeats the main exercises we considered in text, in this new calibration of the model. Notice that now the differences in the fiscal multipliers across STF and LTF are even larger than in our baseline experiments. For example, we obtain a strong positive effect of the fiscal shock on consumption under STF even when we assume a simple Taylor rule (left panels). The corresponding cumulative multiplier then exceeds one for all values ϕ_π considered. The STF multipliers for the inertial rule (middle panels) and the passive monetary policy (right panels) are also larger than their baseline counterparts.

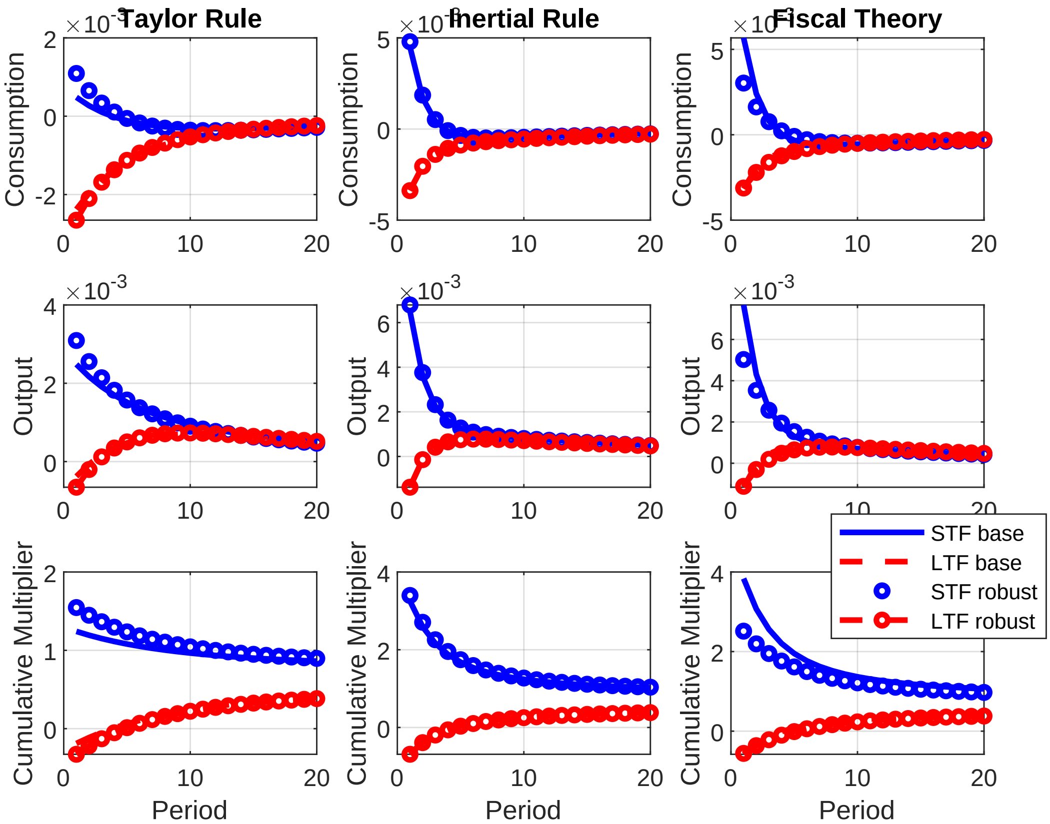
It is of course not difficult to explain these differences. Under the new calibration the quantity of short bonds needs to increase more sharply in the STF regime, when the elasticity of the share with respect to the spending shock is 0.6. Thus financing short term, induces a bigger consumption boom now than in the baseline calibration. Analogously, the quantity of short debt drops more sharply in the LTF scenario when the elastisticity is -0.6, leading to a tightening of the liquidity constraint.

[12] Unfortunately, with this alternative modeling of the share, a target of 12.5 percent is too low, and fixing $\delta = 0.96$ implies that the quantity of quarterly bonds in steady state turns negative!

A 12.5 percent target is also not consistent with the data. Faraglia, Marcet, Oikonomou, and Scott (2019) report that in post world war II US data, the average share of short term debt (in their case also defined as all debt of maturity less than or equal to one year, including the coupons of long term bonds) over total debt was roughly 40 percent. If we calibrate $\overline{b}_S, \overline{b}_L$ to match this number we get a share of short over long term debt equal to 70 percent. But this calibration also does not correspond to our empirical exercise since in the empirical model we did not count coupon payments as short term debt.

Therefore, we compromise with $\overline{\widetilde{R}} = 0.3$ in our calibration to target average maturity.

Figure 32: Responses to a spending shock under an alternative definition of the share Short/Long.



Notes: We recalibrate the share of short over long as discussed in paragraph B.6. The Figure shows the impulse responses of consumption, output and the output multiplier for the same numerical experiments considered in the baseline model in text.

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