How Government Debt Shocks Impact the Economy

Alex Houtz*

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Abstract

I identify exogenous government debt shocks using high-frequency movements in US Treasury futures prices around auction announcements. In a VAR, these shocks raise interest rates across the yield curve while prices increase, output falls, unemployment rises, and the money supply shrinks. I interpret these findings as evidence of fiscal dominance and show that a standard monetary-dominant model cannot replicate the empirical impulse responses. In an estimated business cycle model, I find that debt shocks offset part of the disinflation of the 1980s, contributed to growth in the 1990s, and slowed the recovery from the Great Recession.

Keywords: fiscal dominance; government debt shocks; high-frequency identification; Treasury futures; Treasury auctions; VAR; DSGE; monetary base.

JEL Codes: E31; E43; E62; H63; C32.

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Correspondence: ahoutz@nd.edu | Affiliation: University of Notre Dame

1 Introduction

Since 2008, the United States has experienced two historic surges in government debt. Fiscal stimulus during the Great Recession pushed the year-over-year growth rate of debt-to-GDP to roughly 25%. During the COVID-19 pandemic, that rate climbed even higher to roughly 29%. Both events exceed historical precedent. While debt is typically assumed to be residually determined by the government budget constraint, this paper relaxes that assumption, viewing debt as a fiscal choice variable and studying the causal effects of an unexpected debt issuance with the paths of government spending and taxation fixed - a *debt shock*. As a stock, though, debt is slow to adjust, partly anticipated, and co-moving with spending and taxation, obscuring exogenous variation.

To solve this identification problem, I first identify exogenous government debt shocks using high-frequency movements in US Treasury futures markets around Treasury auction announcements. Second, I analyze their macroeconomic impacts in a proxy VAR. Third, I build a small-scale model in the New Keynesian tradition to explain the empirical results. Lastly, I estimate a quantitative DSGE model and assess both the importance of debt shocks and how their inclusion reshapes the interpretation of historical events.

My empirical strategy exploits the information release structure of US Treasury auctions. Because the issuance amount and maturity of each auction is embargoed until the week before that auction, these announcements act as information shocks to financial markets. I use high-frequency movements in Treasury futures prices around announcement times to identify exogenous shocks to government debt issuance. Because futures markets are highly liquid and regularly traded, the new information from the announcements are incorporated quickly. This approach isolates market responses to news about public borrowing, capturing debt shocks that are plausibly unrelated to concurrent macroeconomic developments.

I then use these shocks as an external instrument in a Bayesian VAR, identifying debt shocks through the secondary market 30-year Treasury yield. My shock series serves as a strong instrument, ensuring the resulting impulse response functions (IRFs) are well-identified. I find that industrial production declines while inflation increases. Debt issuance increases and interest rates rise across the curve. The money supply contracts, while taxes and government spending move negligibly. The Treasury general account balance rises.

I interpret these findings in a small New Keynesian model that reproduces three key movements in the empirical IRFs: (1) falling output, (2) inflation rising, and (3) money supply falling. A standard monetary-dominant model with an active Taylor rule cannot replicate these dynamics. Therefore, I adopt a fiscal-dominance framework in which monetary policy is passive, and the money supply adjusts to absorb new government debt. To preserve the intertemporal government budget constraint, inflation jumps. Interest rates rise to satisfy household money demand.

I then construct a quantitative New Keynesian model similar to that found in Cristiano et al. (2005), Sims & Wu (2021), or Harding et al. (2022). I conduct Bayesian estimation on my model and a standard, monetary dominant version of my model. I confirm that my model delivers qualitatively similar impulse responses to standard business cycle shocks, quantitatively similar variance decompositions, and quantitatively similar historical decompositions as the monetary dominant model. My model is able to match the empirical debt shock IRFs reasonably well. In the historical decomposition, I find that debt shocks countered the disinflation of the 1980s, contributed to the expansion of the 1990s, and stalled the recovery from the Great Recession.

Literature Review

I use high frequency identification for my empirical strategy, linking my paper to Kanzig (2021), Montiel-Olea et al. (2020), Plagborg-Moller & Wolf (2021), and Mertens & Ravn (2013). While I do not use narrative identification or look at monetary policy shocks empirically, the spirit of my paper is similar to the papers identifying monetary policy shocks, including Romer & Romer (2004) and Nakamura & Steinsson (2018). Because I am looking at fiscal policy, my paper similarly relates to the papers empirically identifying fiscal shocks, such as Romer & Romer (2010) and Ramey (2016).

My paper is empirically closely related to Mustafi (2024) and Phillot (2025) . Both papers use high frequency identification to evaluate government debt shocks in the United States. Mustafi (2024) uses a factor model to decompose his identified shocks into maturity and level shocks. Phillot (2025) uses his identified shocks as an instrument in a local projections framework. I differ from both by extending my identification series through the COVID-19 pandemic, which consisted of the largest expansion of debt since at least 1980, and by embedding my shocks into a proxy VAR. In addition, I focus on evaluating the mechanism behind the empirical impulse responses by building a fiscally dominant New Keynesian model, whereas the focus of both Mustafi (2024) and Phillot (2025) is more empirical.

My use of an immediate money supply drop due to debt issuance connects my paper to the recent literature on fiscal dominance, including Leeper & Leith (2016), Cochrane (2023), and Bianchi et al. (2023). This mechanism also connects my paper to an older literature on fiscal dominance, including Sargent & Wallace (1981), Leeper (1991), and Sims (1994). Because my model studies the impact of debt on macroeconomic outcomes, my paper also relates to the HANK literature focused on fiscal policy (see Auclert et al. (2024) or Kaplan et al. (2018)), where government debt impacts the marginal propensities to consume of households.

The rest of the paper proceeds as follows: Section 2 lays out my empirical identification and results from the proxy VAR. Section 3 describes the small New Keynesian Model and demonstrates the necessity of fiscal dominance. Section 4 implements the mechanism from section 3 into a quantitative model, estimates that model, and then discusses the results. Section 5 concludes.

2 Empirical Analysis

In this section, I describe my identification strategy using high frequency Treasury futures prices and Treasury auction announcements. I report the empirical impulse responses of a debt shock in a proxy VAR. I then explore a potential mechanism using a second VAR.

2.1 Identification

Identifying the impact of government debt on the economy is challenging. Debt issuance is tightly intertwined with fiscal policy – if the government increases its consumption or its social program expenditure (transfers), it needs to increase debt issuance, holding tax collection constant. If tax rates decrease, keeping government consumption constant, debt issuance must increase. The problem is that these scenarios are all *not* debt shocks. They are G_t shocks or T_t shocks.[1] A direct debt shock requires the US Treasury to exogenously issue more (or less) debt relative to the government's current expenditure needs and revenue plans. To analyze this, I would need access to internal Treasury tax collection projections and maturity analysis and a high frequency tax data series. Alternatively, I can estimate a debt shock indirectly – through its impact on prices.

Each time the Treasury seeks to raise funds, it conducts security auctions. These auctions occur approximately 325 times a year, with multiple auctions occurring on the same date as others (FRB Services). Before an auction, the Treasury announces the maturity of security being auctioned, the amount offered, the auction date, and other relevant information for investors (see appendix A1 for an example of a Treasury announcement). This announcement date is roughly a week to two days before the actual auction. Auction announcements are tightly controlled and embargoed until 11:00 am Eastern on the announcement date.

In addition to auction announcements, the Treasury releases Quarterly Refunding

[1] Much work has been done on these shocks – see Ramey (2016) for example.

Statements (QFRs). QFRs are released at the beginning of each quarter. These statements indicate the maturities and amounts for each maturity the Treasury plans to borrow over the next quarter. QFRs are more "big picture" than individual auction announcements, with the amounts and maturities subject to revision as the quarter progresses. QFRs too are embargoed until a specific time on release day. Up until May 2013, the release time was 9:00 am Eastern, while after May 2013 the release time has been 8:30 am Eastern.

For prices, I turn to US Treasury futures prices from the Chicago Board of Trade (CBOT). While a secondary market exists for Treasuries, futures markets tend to be more liquid and react to changes in expectations rather than potential cash flow concerns, facilitating efficient price discovery (Moser, 1991). CBOT currently offers eight different futures maturities: 2 year, 3-year, 5 year, 10-year, Ultra 10-year, 20-year, 30-year, and Ultra 30-year, though the 3 and 20-year futures are relatively recent (introduced in 2020 and 2022 respectively). Of these, the 2, 5, 10, and 30-year account for almost all of the trading volume, with the 10-year having the highest trading volume (Johnson et al., 2017).

The contract for each maturity exists on the March quarterly cycle (March, June, September, December). To fulfill the contract, Treasuries within a maturity specific time-window must be delivered by the end of the contract month.[2] The futures have a face amount of $200,000 for the 2 and 3-year futures and $100,000 for the other futures, where prices are quoted in points per $2,000 on the 2 and 3-year futures and points per $1,000 on the other futures. For prices over time, see appendix A2.

To exploit the timing of Treasury auctions, I need intraday trading data on Treasury futures. I use FirstRate Data to get data from 01/01/2008 to 08/23/2024 for the 2, 5, 10, and 30-year securities. I first find only dates where a Treasury announcement was made, excluding dates where Treasury buyback announcements were made at the same date and time as a Treasury auction announcement.[3] Note that I include cross-maturity

[2] The 2-year future deliverable, for example, must be a Treasury with a maturity of 1 3/4 to 2 years.

[3] Treasury buybacks occur when the Treasury repurchases US Treasury securities from the market. These are relatively rare, mostly occurring at the very end of my sample with the stated goals of "liquidity support" and "cash management" (Office of Debt Management, 2024) In practice, these remove some off-the-

auctions in my dataset. For example, if the Treasury announces an auction for a 5-year security, I will include that announcement date for the 2, 5, 10, and 30 year dates. As such, I pick up movements across the yield curve.

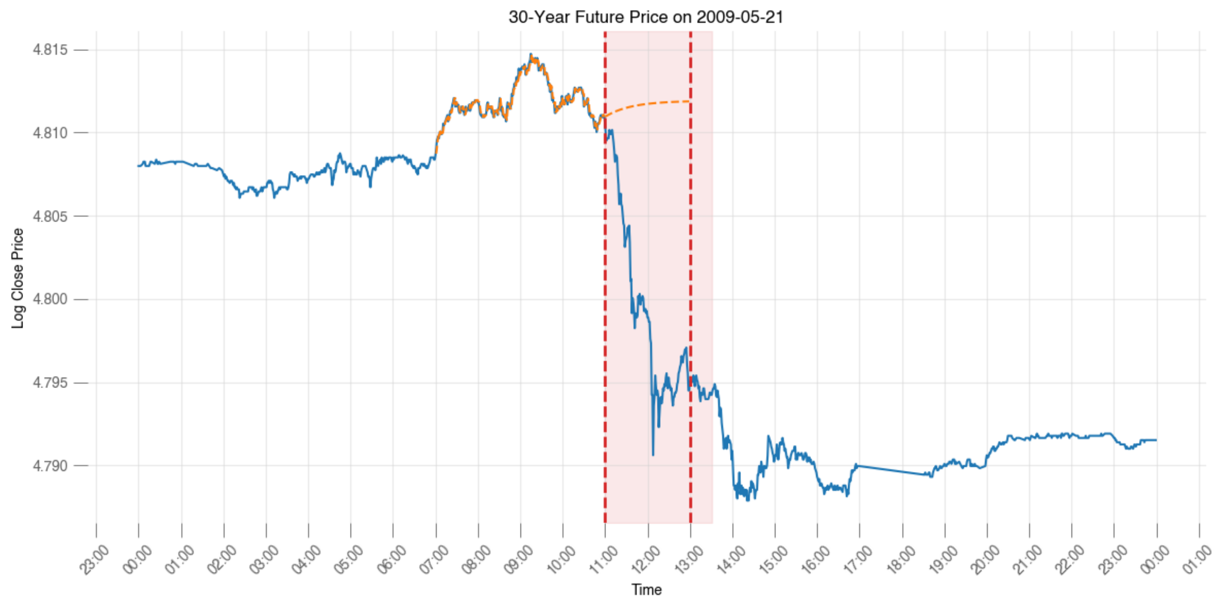

Figure 1: Calculating the shock for a Treasury auction announcement on May 21, 2009. The auction announcement was released at 11:00 am Eastern (left-most red dashed line). The GARCH model determined that volatility returned to pre-shock levels at roughly 1:30 pm (end of shaded red area). I cap the window at 120 minutes, effectively ending the window at 1:00 pm (right-most red dashed line). The ARMA model (orange dashed line) predicts an end log price above the actual log price.

High frequency identification requires a window around the shock time. To build this window, I fit a GARCH(p,q) model to each shock day's log price data to measure volatility, where p and q are determined by finding the values that minimize the AIC. I take the average variance for the 120 minutes preceding the shock time. When the post-shock 15 minute rolling window average variance returns to the pre-shock average, I close the window. To ensure my shock windows encompass enough data, I enforce a minimum of 30 minutes. I also enforce a maximum time of 120 minutes for an 11:00 am shock or 60 minutes for an 8:30/9:00 am shock. These maxima prevent the shock windows from rolling into other potential announcements, such as FOMC announcements or industry

run securities, target specific areas of the yield curve, and can secure more favorable borrowing terms for the federal government. Because buybacks tend to be for more strategic reasons, I exclude them rather than interpret them as negative supply shocks.

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I next need to calculate the size of the announcement shock. To do so, I fit an ARMA(p_1, q_1) model to the logged price data 240 minutes before the shock, where p_1 and q_1 again minimize the AIC. I then use the ARMA model to predict the log price at the end of the shock window. I then take the difference between the predicted price and the actual price at the end of the window. To ensure I have shocks centered at zero, I demean the resulting series, following Phillot (2025). In practice though, the means are close to zero anyway.

As an example, in May and June of 2009, the Treasury announced a sequence of large auctions. Figure 1 demonstrates the shock calculation visually for the 30-year future on May 21, 2009. At 11:00 am, intermediate releases announcing over $100 billion dollars of borrowing total were released for the 7-year, 5-year, 2-year, 26-week, and 13-week maturities. From the figure, prices were relatively stable prior to 11:00 am. At 11:00 am, prices dropped. The GARCH model determines that the variance of prices returned to their pre-shock level at 1:30 pm. In my baseline specification, I cut-off the shock time period to 1:00 pm. I then fit an ARMA model to the data, shown in orange. The ARMA model forecasts a price at 1:00 pm based on the pre-shock prices. I then take the difference between the forecasted price and the actual price as my shock value.

This process leaves me with four individual shock series, one for each maturity. To combine these four separate series into one shock series, I first sum each series by month. I then create weights based on each maturity's share of the total federal debt load. I assign the two-year shock series the portion of federal debt between one and three years, the five year shock series the portion between three and seven years, the 10 year shock series the portion between seven and 15 years, and the 30-year shock series anything over 15 years. This weighting scheme accounts for approximately 70-75% of the federal debt (see appendix A3). I then do a weighted sum. Diagnostic tests following those conducted in Kanzig (2021) are found in appendix A4. Figure 2 displays the resulting shock series, multiplied by negative one so that a positive shock will be correlated with a positive increase in debt.

First, notice the shape of the shock series. There is a cluster of large positive shocks around June 2009. This cluster of shocks reflects a number of large debt issuances similar to the event I used in figure 1. After the Great Recession, shocks generally decrease in magnitude and hover around zero. In 2020, we see a small positive cluster of shocks followed by a cluster of negative shocks. This result suggests that markets actually expected more deficit-financing during the COVID-19 pandemic than actually occurred.

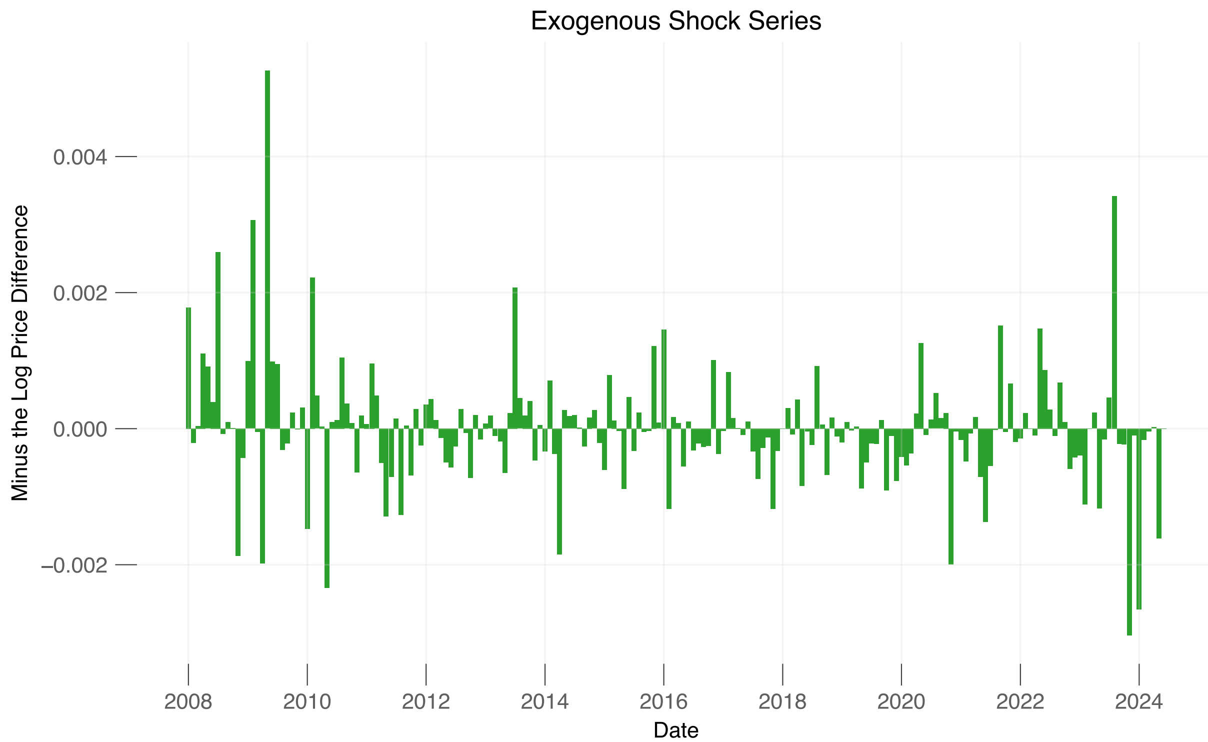

Figure 2: Resulting shock series. Each green bar denotes a monthly shock, where the y-axis is the negative of the log price difference.

Given the scale of the pandemic spending, the publicity fiscal packages received, and the fact that large stimulus spending had recently occurred in the Great Recession, it is not unreasonable to suppose that markets expected large amounts of government spending financed by debt. Lastly, there is a large positive shock late in August of 2023, followed by large negative shocks in November of 2023 and January of 2024. In November 2023, the Treasury released the QFR for Q4. This announcement promised to increase the auction sizes the two, three, five, and seven year securities. In January 2024, the Treasury signaled that it would need substantially less borrowing than initially projected due to a higher than expected cash balance at the beginning of the new quarter.

2.2 VAR

I use my shock series as an external instrument for the secondary market yield on the thirty-year Treasury note inside a proxy VAR. I use the thirty-year Treasury note yield to identify the debt shock due to its long time horizon and sufficient amounts of variation.

My baseline specification consists of 8 variables: the thirty-year, ten-year, and five-year yields, the unemployment rate, industrial production, the PCE price index, the federal funds rate, and monthly outstanding privately held gross par-value debt from the Dallas Fed. I divide the debt series through by the PCE price index and seasonally detrend using the Census's X-13ARIMA-SEATS program. My baseline specification includes 12 lags. Using two lags as suggested by the HQIC, eight lags as suggested by the AIC, or 24 lags does not significantly alter the resulting IRFs (see appendix A5). The final data set runs from 1977M4 to 2024M6.[4] In addition, I include a dummy variable to account for a potential structural break in the covariates around the time of the COVID-19 pandemic. For robustness, I do run the VAR without the dummy and excluding the COVID-19 period. (see appendix A5).

To evaluate the strength of the debt shock series as an instrument, I augment the procedure found in Olea et al. (2021) and estimate a robust Wald statistic. I first recover the residuals from the reduced-form VAR, estimated using standard OLS. I then align the instrument series by date with the right-hand side data, since my shock series is only available from 2008 onward. From there, the steps follow Olea et al. (2021).[5] My main

[4]The reduced form VAR will therefore cover more time than just the period with my debt shock series. This is an advantage of an external instruments approach over an internal instruments approach.

[5]The authors have a Github repository that implements their robust Wald statistic in Matlab. I use this code translated to Python.

specification delivers a robust Wald statistic of 22.6, above the threshold of 10 stated in Olea et al. (2021), meaning I do not need to account for invalid credible set coverage.[6]

I estimate the model using Bayesian techniques. I impose a Normal-Inverse Wishart prior centered around the OLS estimates. I employ the Minnesota prior on the coefficient covariance matrix. For each draw past burn-in, I use the external instrument to identify the shock to the thirty-year yield up to a scaling factor (which I set to be a 1 pp shock). I thus get a distribution of impulse response functions. In figure 3, I report the median and the 68% and 90% credible sets.

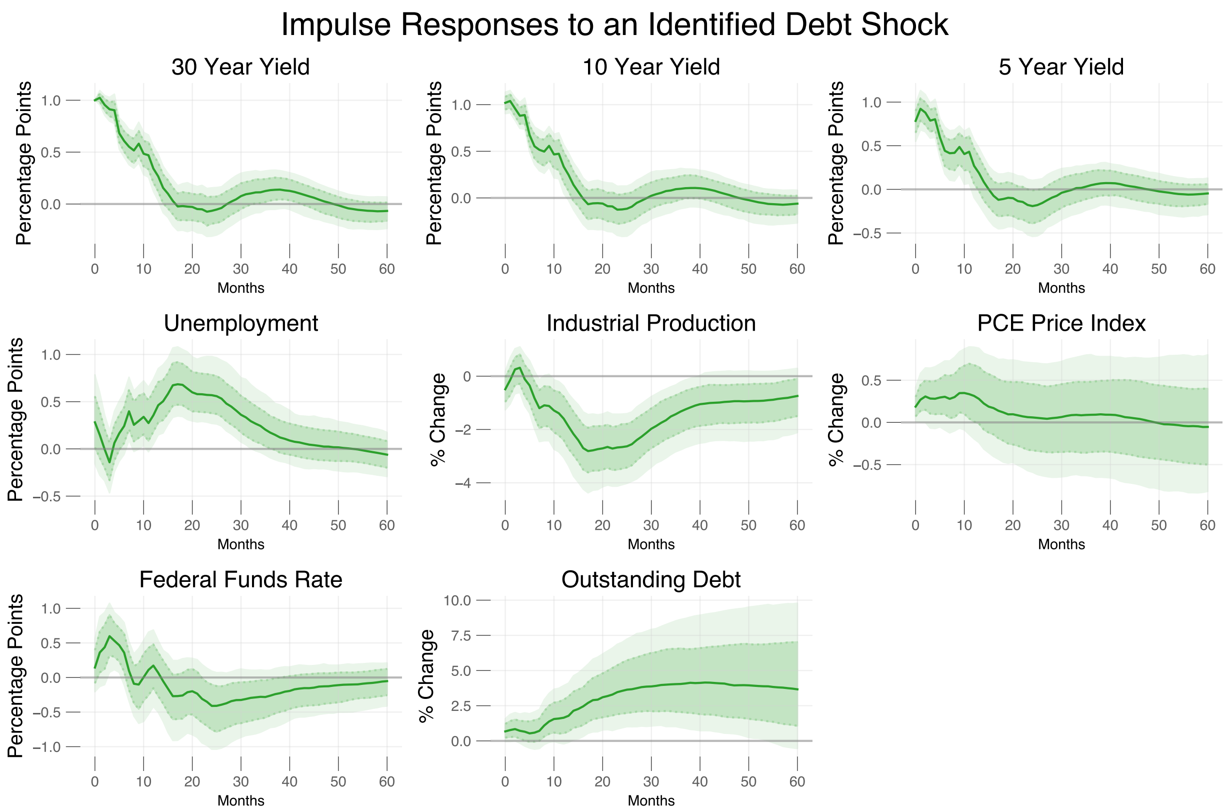

Figure 3: Impulse response functions to a 1 percentage point debt shock identified through the thirty-year yield. The solid green line denotes the median, the dark green area denotes the 68% credible set, and the light green area denotes the 90% credible set.

First, notice that the identified shock does indeed increase the par amount of debt outstanding. This result is important as it indicates that I am identifying a debt shock rather than a maturity, yield, or monetary policy shock. The increase in debt is persistent,

[6]See appendix A5 for the robust confidence intervals using a frequentist approach.

with a positive growth rate for 30 months after the shock. The peak occurs at about a 5% increase in par debt. Second, yields rise across the yield curve, providing further evidence that this shock is not a maturity shock. Third, industrial production decreases gradually, peaking at about a three percentage point drop two years after the shock, and recovering after 60 months. Unemployment follows a similar path, increasing by about half a percentage point after two years and trending back to zero. The PCE price index jumps by about 25 basis points on impact, rises to 50 basis points after a year, and then declines back to steady-state. Lastly, the federal funds rate follows inflation, though the increase is smaller than the increase in the long-term yields; the yield curve therefore steepens.[7]

2.3 Potential Mechanism

If government debt is increasing exogenously, then some variable needs to offset that increase in the government budget constraint. A stylized nominal budget constraint is as follows:

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

where B_t denotes government debt, i_{t-1} denotes the nominal interest rate, G_t denotes government spending, T_t denotes taxes, M_t denotes money balances, and P_t denotes the price level. If B_t increases, then either G_t must increase, T_t must fall, or ΔM_t must fall. I run a second, internal instrument VAR where I order the identified shock from the proxy VAR first to identify potential mechanisms using different variables that do not appear in the first VAR as they are available for a shorter time-frame. As long as the shock is exogenous, this is a valid specification (Plagborg-Moller & Wolf, 2021). I include the balance in the Treasury General Account, M2, taxes, and government consumption/investment.

[7] For IRFs generated by slightly different schemes for calculating the shock, see appendix A6.

The Treasury General Account is essentially the Treasury's bank account at the Federal Reserve. Any extra cash the Treasury has is stored there and, importantly, is not counted as part of the money supply. I construct the last two using the Daily Treasury Statements, which are digitized back to 2008. For details on how I construct taxes and government consumption/investment, see appendix A7. In the main specification, I keep all variables nominal, but I include the specification with real variables in appendix A8 to demonstrate that any movement is not the result of inflation moving the price level. M2 and my fiscal series are seasonally de-trended using X13. I include 12 lags as in the first VAR. The impulse response functions are in figure 4.

M2 falls persistently, concurrent with the initial increase in the Treasury general account. Taxes, though, hardly move, with fluctuations around zero, and if anything, increase slightly. Government consumption and investment falls insignificantly statistically, indicating that if anything, the government does not increase but decreases expenditure.

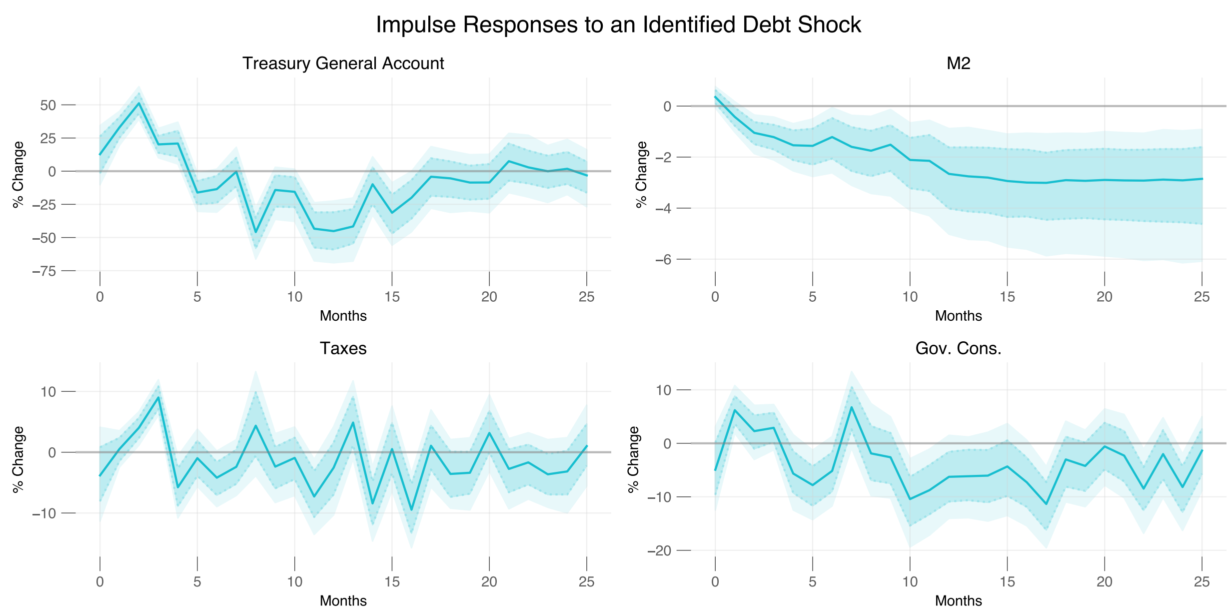

Figure 4: Impulse response functions to an identified debt shock. The solid blue line denotes the median, the dark blue area denotes the 68% credible set, and the light blue area denotes the 90% credible set.

These IRFs give me a potential mechanism for how debt impacts business cycles. When government debt increases, money supply falls. From a pure mechanical perspective, this link makes sense. When a buyer purchases government debt from the Treasury, they trade liquid money for the debt instrument. As such, at least in the short-run, the money supply should fall. In turn, a falling money supply raises interest rates. Increased interest rates slow the economy, putting downward pressure on output.

3 Simple Model

I now introduce a mostly textbook New Keynesian model to explain the empirical results. Instead of assuming the cashless limit, I include money additively in utility. Departures from the standard model include an exogenous rule for government debt, which implements the debt shock, and a process that keeps real debt stationary. I then explore price level determination, implementing two different economies: one where the price level is determined by monetary policy, and one where the price level is determined by the fiscal authority. After briefly laying out model equations and discussing calibration, I finish with an analysis of the impulse response functions to a debt shock.

3.1 Model Environment

Households

Households maximize the following lifetime utility function:

$$\max_{\{C_t,\, A_t,\, M_t,\, L_t\}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma} - 1}{1-\sigma} - \chi \frac{L_t^{1+\eta}}{1+\eta} + \psi_m \frac{M_t^{1-\xi} - 1}{1-\xi} \right) \right]$$

subject to the following real flow budget constraint:

$$C_t + A_t + M_t + T_t = w_t L_t + (1 + i_{t-1}) \Pi_t^{-1} A_{t-1} + \Pi_t^{-1} M_{t-1} + Div_t$$

C_t denotes consumption, L_t denotes labor, M_t denotes real money holdings, A_t denotes a one-period savings/borrowing instrument, T_t denotes lump sum taxes, w_t denotes real wages, i_t denotes the nominal interest rate, Π_t denotes gross inflation, and Div_t denotes firm profits remitted to households. β is the discount factor, σ is the CRRA parameter, η is the inverse Frisch elasticity, and ξ governs the curvature of money demand. χ and ψ_m weight the disutility of labor and the benefit of money holdings, respectively.

The household first-order condition for money is:

$$\psi_m M_t^{-\xi} = C_t^{-\sigma} \frac{i_t}{1 + i_t}$$

This equation links money supply to the nominal interest rate. If the monetary authority sets the nominal interest rate, money supply adjusts to make this equation hold. If instead the money supply is determined by government debt, the nominal rate must adjust to make this equation hold.

Firms

The production side of the economy is textbook. A representative, competitive final goods firm aggregates intermediate firm output using a CES aggregator. Intermediate firms use a production technology with only labor to produce intermediate output. Rotemberg adjustment costs on intermediate firm prices introduce nominal frictions into the economy. Optimization delivers the New Keynesian Phillips curve:

$$\ln(\Pi_t) = \kappa_p \left(mc_t - \frac{\varepsilon_p - 1}{\varepsilon_p} \right) + \mathbb{E}_t \left[\Lambda_{t+1} \frac{Y_{t+1}}{Y_t} \ln(\Pi_{t+1}) \right]$$

mc_t denotes firm marginal cost, Y_t denotes aggregate output, and Λ_t denotes the household stochastic discount factor. κ_p is the Phillips curve slope, and ε_p is the elasticity of substitution between intermediate firm goods.

Government

The government has the following nominal budget constraint:

$$B_t + P_t T_t + P_t M_t = P_t G_t + (1 + i_{t-1}) B_{t-1} + P_{t-1} M_{t-1}$$

where B_t denotes nominal government debt and G_t denotes real government consumption/investment. Dividing through by P_t, the price level, gives:

$$\frac{B_t}{P_t} + T_t + M_t = G_t + (1 + i_{t-1}) \Pi_t^{-1} \frac{B_{t-1}}{P_{t-1}} + \Pi_t^{-1} M_{t-1}$$

Following Schmitt-Grohe & Uribe (2012), define:

$$b_t^x = \frac{B_t}{X_t}$$

with:

$$X_t = X_{t-1}^{\rho} P_{t-1}^{1-\rho}$$

where $0 \leq \rho < 1$. Divide X_t through by the price level for stationarity and define $x_t = X_t / P_t$:

$$x_t = x_{t-1}^{\rho} \Pi_t^{-1}$$

If I plug this into the definition of b_t^x:

$$b_t^x = \frac{B_t}{P_t} x_t^{-1}$$

b_t^x is then real debt with an autoregressive wedge that depends on inflation. This formulation is useful for me, as it removes the unit root from nominal debt B_t, but does not force

b_t^x to be exactly real debt this period. Thus, nominal debt can move without necessarily moving real debt. In steady-state, where the wedge is equal to unity and inflation is set to zero, $b_t^x = \frac{B_{ss}}{P_{ss}}$.

The stationary government budget constraint is then:

$$b_t^x x_t + T_t + M_t = G_t + (1 + i_{t-1})\Pi_t^{-1} b_{t-1}^x x_{t-1} + \Pi_t^{-1} M_{t-1}$$

I introduce a government debt shock into the model imposing an ARMA(1,1) process for b_t^x:

$$\ln(b_t^x) = (1 - \rho_b)\ln(b_{ss}^x) + \rho_b \ln(b_{t-1}^x) + \rho_{\varepsilon^b}\varepsilon_{t-1}^b + \varepsilon_t^b$$

Monetary Dominance

I compare two economies. The first imposes monetary dominance and passive fiscal policy. The monetary authority therefore determines the nominal rate independent of fiscal considerations. I implement this with a Taylor rule that satisfies the Taylor principle ($\phi_\pi > 1$):

$$i_t = (1 - \rho_r)i_{ss} + \rho_r i_{t-1} + (1 - \rho_r)\phi_\pi \ln(\Pi_t)$$

Real money must move to satisfy the household first-order condition for money. So either G_t or T_t, or some combination of the two, must adjust to satisfy the government budget constraint. For simplicity, I run two versions of the monetary dominance economy: one with G_t as the residual and T_t fixed, and the other with T_t as the residual and G_t fixed.

Fiscal Dominance

The second economy imposes fiscal dominance. There is no Taylor rule. Instead, the money supply moves to balance the government budget constraint. The nominal interest rate, i_t, adjusts to satisfy the household money demand equation. T_t and G_t are exogenously determined.

3.2 Parameterization

I use standard values from the literature for the parameters in this model, calibrating to the quarterly frequency. I set σ, the CRRA parameter, and η, the inverse of the Frisch elasticity, to unity. I also set ξ to unity. I set κ_p to 0.1, which corresponds to a Calvo parameter of approximately 0.75. The CES parameter, ε_p is set to 10. The persistence parameters ρ and ρ_b are set to 0.95 to reflect a persistent debt and nominal debt process, while ρ_{ε_b} is set to 0.5 to help generate the hump-shape in debt. The Taylor rule persistence parameter, ρ_r is set to 0.7, while ϕ_π is set to 1.5. The steady-state interest rate is set to 0.01, making β approximately 0.99. I set steady-state debt-to-GDP to 75%, money-to-GDP to 25%, and government spending-to-GDP to 25%. Output, and therefore labor, are normalized to unity.

3.3 IRFs

I now shock government debt. Figure 5 displays the IRFs for the two monetary dominance economies. First, note that in the economy where lump-sum taxes adjust, output, inflation, and the nominal rate do not move. This result occurs because Ricardian equivalence holds. Lump-sum taxes do not enter any first-order condition for household, so offsetting debt increases with taxes does not impact other variables.

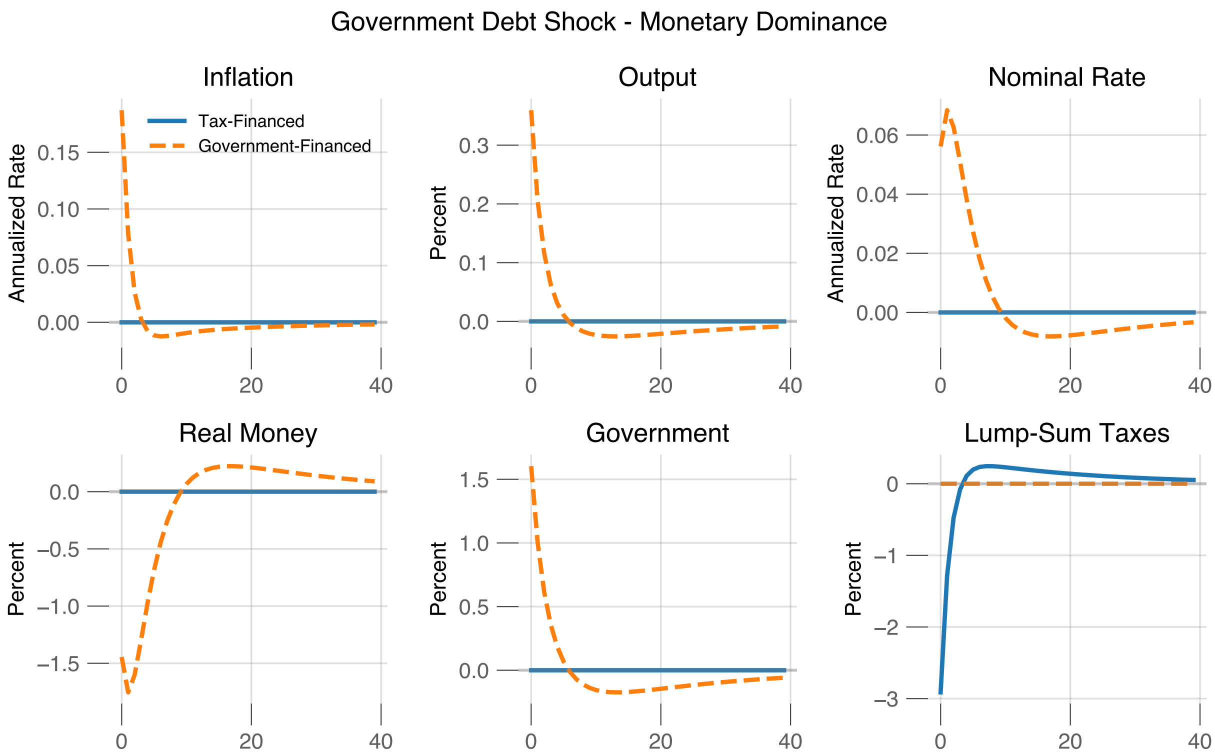

Figure 5: Impulse response functions to a 1% debt shock for the monetary dominance economies. Blue line – scheme where taxes adjust to satisfy the government budget constraint. Orange dashed – scheme where government consumption adjusts to satisfy the government budget constraint.

Offsetting the debt increase with a government spending increase delivers what is effectively a government spending shock. An increase in G_t increases both inflation and output. Higher inflation increases the nominal rate through the Taylor rule. A higher nominal rate leads to less money demand through the household first-order condition.

Neither funding scheme with monetary dominance qualitatively matches the empirical impulse responses. The tax scheme clearly does not match, as the empirical IRFs are not zero. The government spending scheme gets money, inflation, and the nominal rate right, but leads to expanding output rather than declining output.[8]

[8]In a representative agent model like this stylized model, Ricardian equivalence renders the financing mix between debt and lump-sum taxes irrelevant for other variables. In appendix A9, I repeat this stylized model, but with a two-agent model with a hand-to-mouth household so that lump-sum transfers have macroeconomic effects. The results are similar to that of the government-funded scenario.

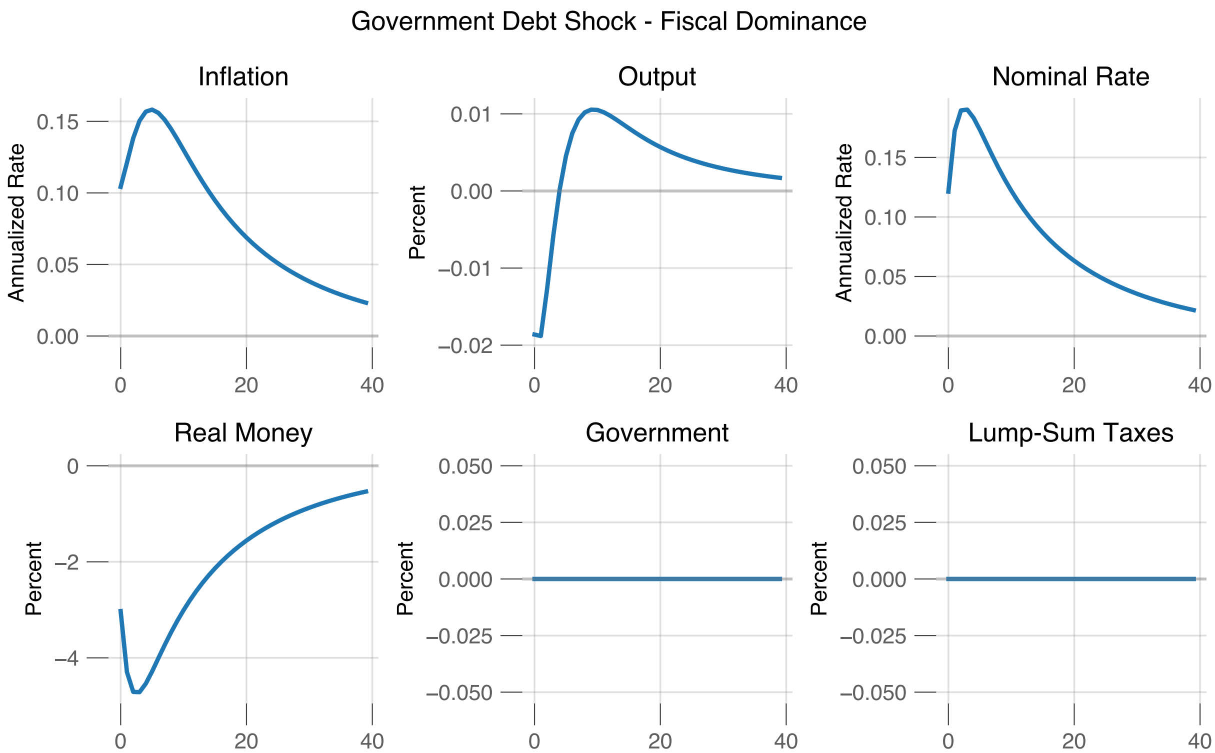

Figure 6: Impulse response functions to a 1% debt shock for the fiscal dominance economy where money moves to satisfy the government budget constraint.

Figure 6 displays IRFs for the fiscal dominance economy with the money financing scheme. This model's IRFs qualitatively match the empirical IRFs. The exogenous increase in debt necessarily leads to a decline in real money. A decrease in money increases the annualized nominal rate through household demand for money. The increase in the nominal rate decreases household consumption today, dropping output. Inflation increases to maintain the intertemporal government budget constraint as in other fiscal dominant DSGE models. While the qualitative match with the empirical IRFs is good, the quantitative match is not so good. The drop in output is small – only two basis points to a one percentage point debt shock – and not persistent.

4 Quantitative Model

The simple model demonstrates that an economy with fiscal dominance and a money supply that adjusts to satisfy the government budget constraint qualitatively matches the empirical IRFs from section 1. In this section, I build a quantitative model with medium-scale frictions. I then estimate this quantitative model with Bayesian MCMC methods and compare the model's performance quantitatively with the VAR results. Finally, I perform a historical decomposition with the fiscal dominance, money-financed model and compare it to a historical decomposition from a standard, monetary dominance model.

4.1 Model Environment

The model features standard medium-scale frictions such as sticky wages and sticky prices as in Calvo (1983). I add real rigidities using a form of the Kimball (1995) aggregator found in Dotsey & King (2005). Capital accumulation is subject to investment adjustment costs and firms optimize over capital utilization. As in the small model, households value money separably. The monetary-fiscal block of the model includes distortionary taxes on labor and consumption, following Bianchi et al. (2023), lump-sum taxes/transfers, and government consumption. Government debt is now long-term as in Cochrane (2023). The money supply clears the government budget constraint in the fiscal dominance version. Below I write out equations with the model mechanism and the equations where shocks enter. A full set of equilibrium conditions can be found in appendix A10.

Households

A representative household seeks to maximize:

$$\max_{\{C_t, A_t, M_t, L_t\}} \mathbb{E}_0 \left[\sum_{s=0}^{\infty} \varepsilon_{t+s}^{s} \beta^s \left(\frac{(C_{t+s} - hC_{t+s-1})^{1-\sigma} - 1}{1-\sigma} - \chi L_{t+s} + \psi_m \frac{M_{t+s}^{1-\xi} - 1}{1-\xi} \right) \right]$$

subject to the real flow budget constraint:

$$(1+\tau_t^C)C_t + Q_tA_t + T_t + M_t = (1+\rho Q_t)\Pi_t^{-1}A_{t-1} \\ + w_t(1-\tau_t^\ell)L_t + div_t + (1+i_{t-1}^{oc})\Pi_t^{-1}M_{t-1}$$

C_t is consumption, Q_t is the price of government debt, A_t is savings held in government debt, T_t is lump-sum taxes, M_t is real money balances, ρ governs the average maturity of the savings instruments, w_t is real take-home wages, L_t is labor, div_t is dividends from firms, τ_t^C is a consumption tax, τ_t^ℓ is an income tax, and i_t^{oc} is interest earned on cash.[9] Π_t is gross inflation. ε_t^s serves as a preference shock. Solving the maximization problem yields a standard Euler equation and a money demand curve:

$$Q_t\lambda_t = \beta\mathbb{E}_t\left[\frac{\varepsilon_{t+1}^s}{\varepsilon_t^s}\lambda_{t+1}(1+\rho Q_{t+1})\Pi_{t+1}^{-1}\right]$$
$$\psi_m M_t^{-\xi} = \lambda_t\frac{i_t - i_t^{oc}}{1+i_t}$$

where i_t is the nominal rate and λ_t is the Lagrange multiplier on the budget constraint. Similarly to the small model, the money supply determines the nominal rate with fiscal dominance.

Labor Markets

I follow Harding et al. (2022) in introducing sticky wages.[10] A competitive labor contractor aggregates household labor inputs $L_t(j)$ into a final labor good L_t. Labor contractors

[9] We can think of i_t^{oc} as interest on reserves. The government will directly pay the interest on cash. I include this interest rate so I can implement a monetary policy shock in the fiscal dominance economy.

[10] Harding et al. (2022) use linear disutility of labor in the household value function to simplify the resulting wage dispersion equations. I follow their precedent.

maximize profits by aggregating labor using a Kimball aggregator:

$$G\left(\frac{L_t(j)}{L_t}\right) = \frac{\omega_t^w}{1+\psi_w}\left((1+\psi_w)\frac{L_t(j)}{L_t} - \psi_w\right)^{\frac{1}{\omega_t^w}} + 1 - \frac{\omega_t^w}{1+\psi_w}$$

where $\omega_t^w = \frac{(1+\psi_w)\phi_t^w}{1+\phi_t^w\psi_w}$. $\phi_t^w \geq 1$ denotes the gross wage-markup. A wage markup shock enters the model through this parameter. $\psi_w \leq 0$ controls the degree of complementarities in wage-setting. If $\psi_w = 0.$, then I recover the standard CES aggregator. Benevolent unions, existing on a measure $j \in [0,1]$, optimize on the household's behalf, maximizing the difference between wages and labor disutility. This union can only update wages each period with a probability of $1 - \phi_c^w$. Otherwise, the union indexes back to steady-state inflation. Because of the nominal pricing friction, a wedge arises between household labor supplied and firm labor demanded, L_t^d:

$$L_t^d = L_t / \tilde{w}_t$$

where $\tilde{w}_t$ denotes aggregate wage dispersion.

Production

Production occurs across four firms. A final goods firm aggregates output from retail firms using a Kimball aggregator of:

$$G\left(\frac{Y_t(j)}{Y_t}\right) = \frac{\omega_t^p}{1+\psi_p}\left((1+\psi_p)\frac{Y_t(j)}{Y_t} - \psi_p\right)^{\frac{1}{\omega_t^p}} + 1 - \frac{\omega_t^p}{1+\psi_p}$$

where $\omega_t^p = \frac{(1+\psi_p)\phi_t^p}{1+\phi_t^p\psi_p}$. $\phi_t^p \geq 1$ denotes the gross markup. A markup shock enters the model through this parameter. $\psi_p \leq 0$ controls the degree of complementarities in price-setting. If $\psi_p = 0.$, then I recover the standard CES aggregator. Retail firms exist on a unit measure, $j \in [0,1]$, and purchase output from a representative wholesale firm. Retailers can change prices each period with a probability of $1 - \phi_c^p$. If a retailer cannot change prices, that retailer indexes prices to steady-state inflation. The wholesale firm purchases capital from a representative capital producer. The wholesaler has production function:

$$Y_t^m = Z_t K_{t-1}^{\alpha} \left(L_t^d\right)^{1-\alpha}$$

where Y_t^m, K_t, and L_t^d denote the wholesaler's output, capital stock, and labor, respectively. Z_t denotes productivity and evolves according to an AR(1) process in logs. Because of price dispersion, a wedge arises between aggregate output and wholesaler output:

$$Y_t = Y_t^m / \tilde{p}_t$$

where $\tilde{p}_t$ denotes aggregate price dispersion.[11] The wholesaler accumulates capital according to:

$$K_t = \hat{I}_t + (1-\delta)K_{t-1}$$

where $\hat{I}_t$ is usable investment purchased from the capital producer and δ is depreciation.

The capital producer constructs raw investment good I_t, but must pay an investment adjust cost $S(I_t, I_{t-1})$ such that:

$$\hat{I}_t = \left[1 - S(I_t, I_{t-1})\right] I_t \varepsilon_t^i$$

where ε_t^i is an investment shock.

[11] We could write the production function as follows: $Y_t = \frac{Z_t K_{t-1}^{\alpha} (L_t)^{1-\alpha}}{\tilde{p}_t \tilde{w}_t}$

Government

The nominal government budget constraint is as follows:

$$\begin{aligned} &Q_t B_t + P_t T_t + P_t \tau_t^{\ell} w_t L_t + P_t \tau_t^C C_t + P_t M_t \\ &\qquad = (1+\rho Q_t)\Pi_t^{-1} B_{t-1} + P_t G_t + (1+i_{t-1}^{oc}) P_{t-1} M_{t-1} \end{aligned}$$

where G_t denotes government consumption and B_t denotes nominal debt. Following the steps from the small model, I can derive a stationary version of the government budget constraint:

$$Q_t b_t^x x_t + T + \tau_t^{\ell} w_t L_t + \tau_t^C C_t + M_t = (1+\rho Q_t)\Pi_t^{-1} b_{t-1}^x x_{t-1} + G_t + (1+i_{t-1}^{oc})\Pi_t^{-1} M_{t-1}$$

where b_t^x and x_t are defined as in the small model. There are five financing instruments: M_t, b_t^x, τ_t^{ℓ}, τ_C and T_t. I impose the following law of motion for b_t^x:

$$\begin{aligned} \ln(b_t^x) &= (1-\rho_b)\ln(b_{ss}^x) + \rho_b \ln(b_{t-1}^x) \\ &\qquad + \gamma_g(\ln(G_{t-1}) - \ln(G_{ss})) - \gamma_T(\ln(TR_{t-1}) - \ln(TR_{ss})) + \varepsilon_t^B \end{aligned}$$

TR_t denotes total tax revenue. The parameter γ_g governs how much of government spending is initially covered by long-term debt issuance , while γ_T governs how much of tax revenue is initially covered by debt issuance. Note that γ_g enters positively indicating that debt increases when G_t increases, while γ_T enters negatively indicating that debt decreases when TR_t increases.

Fiscal vs Monetary Dominance

In the fiscal dominance economy, money adjusts to satisfy the government budget constraint. The long-term interest rate is determined via household demand for money.

Lump sum taxes remain at steady-state. Both models will have a policy rate that follows a Taylor rule:

$$i_t^{oc} = (1-\rho_r)i_{ss}^{oc} + \rho_r i_{t-1}^{oc} + (1-\rho_r)\phi_\pi \ln(\Pi_t) + \varepsilon_t^m$$

where ε_t^m is a monetary policy shock. In the fiscal dominance economy, ϕ_π will be less than one, whereas in the monetary dominance economy, ϕ_π will be greater than one and satisfy the Taylor principle. Lump-sum taxes adjust to satisfy the government budget constraint in the monetary dominance economy.

4.2 Calibration and Estimation

I start by adopting standard values from the literature. β is set to support a steady-state quarterly policy rate of 0.5% with a steady-state inflation rate of zero. The steady-state spread between the policy rate and long-term rate is set to 0.016/4, resulting in an annual long-term bond rate of roughly 4%. Gross firm and wage markups, ϕ_{ss}^p and ϕ_{ss}^w, are both set to 1.1, or a markup of 10%. Following Harding et al. (2022), I set ψ_p to -12.2 and ψ_w to -6. I set the average maturity of government bonds to be 20 quarters, or five years, which corresponds roughly to the average maturity on government debt. Steady-state government debt-to-GDP is set to 90%, the ratio just after the Great Recession. The money supply is set to 20% of GDP, close to the ratio of the monetary base-to-GDP after the Great Recession. The steady-state income tax rate, τ^ℓ, is set to 20% while the consumption tax rate, τ^C, is set to 6%.

I then conduct Bayesian likelihood estimation. I construct nine time series: the PCE deflator, nominal GDP, M2, PCE services plus PCE non-durables, PCE durables plus fixed private investment, average hourly compensation for private production and nonsupervisory employees, hours worked for all workers, total tax revenue, and federal debt held by the public. I divide nominal series by the PCE deflator. I seasonally de-trend federal debt held by the public and keep the trend and cycle components. I replace any instance where the federal funds rate is below 0.25 with the Wu-Xia shadow rate. I log first-difference and demean all time series. The data run from 1970Q2-2020Q1. There are seven shocks held in common between the two economies: technology (Z), markup (ε_t^{cp}), wage markup (ε_t^{w}), investment (ε_t^{i}), preference (ε_t^{s}), monetary policy (ε_t^{m}), and government spending (G_t). In the fiscal dominance economy, debt (ε_t^{b}) and the income tax rate (ε_t^{τ}) serve as the eighth and ninth shocks. All shocks follow an AR(1) process. In the monetary dominance economy, I drop the debt shock due to Ricardian equivalence. I drop the income tax rate shock because it is isomorphic to the wage markup shock, also due to Ricardian equivalence. To prevent stochastic singularity, I omit the time series on debt and money supply from the monetary estimation.

In addition to the shock parameters, I estimate eight common parameters between the two economies: habit, the elasticity of intertemporal substitution for consumption, price and wage stickiness, the capital share of output, the parameter on investment adjustment costs, the Taylor rule weight on inflation, and the Taylor rule smoothing parameter.[12] In the fiscal dominance economy, I estimate the elasticity of intertemporal substitution for money demand, the persistence of the government debt rule, debt's response to government consumption, and debt's response to tax revenue. Table 1 reports the priors I impose and the posterior estimates for the fiscal dominance model.

My estimates are in-line with the existing literature. The inverse EIS parameter on consumption is 1.58, with common values for σ ranging between log-utility ($\sigma = 1$) and 2. Both Calvo parameters hover around 0.80, close to the textbook value of 0.67 (Gali, 2015), and within the ballpark of other estimated fiscal models, such as Bianchi et al. (2023). The Taylor rule weight on inflation is 0.58, while the smoothing parameter is 0.59, indicating mild smoothing. The debt persistence parameter has a median of 0.87, indi-

[12]The priors on the Taylor rule weight on inflation will be different. In the fiscal dominance economy, I will set a prior to prevent the Taylor principle from holding. In the monetary dominance economy, my prior will force the Taylor principle to hold.

cating a moderately persistent debt process. γ_g is 0.30, implying that 30% of government spending deviations from steady-state are funded by debt, while γ_T is 0.06. The value for this parameter is similar to those used by others in the literature for variables like taxes responding to debt deviations from steady-state (see for example Auclert et al. (2020)). The full set of estimated parameters, including the results for the monetary dominance economy, can be found in appendix A11.

Table 1

Estimated Structural Parameter Values

		Prior			Posterior		
Parameter	**Description**	**Mean**	**SD**	**Distr.**	**Median**	**5%**	**95%**
h	Habit	0.600	0.050	Beta	0.6952	0.6317	0.7535
σ	Inverse EIS (C_t)	1.500	0.100	Normal	1.5837	1.4269	1.7186
ξ	Inverse EIS (M_t)	5.000	0.050	Normal	5.7078	4.3057	6.9095
ϕ_c^p	Price stickiness	0.800	0.025	Beta	0.7921	0.7559	0.8285
ϕ_c^w	Wage stickiness	0.800	0.025	Beta	0.7773	0.7518	0.8033
α	K share	0.333	0.050	Normal	0.3176	0.2850	0.3549
κ_I	I adj. costs	0.500	0.200	Normal	1.3132	1.1260	1.4919
ρ_b	Debt persistence	0.950	0.025	Beta	0.8739	0.8518	0.8950
γ_g	b_t^x to G_{t-1}	0.500	0.050	Beta	0.3015	0.2360	0.3668
γ_T	b_t^x to TR_{t-1}	0.500	0.200	Beta	0.0602	0.0252	0.1012
ϕ_π	TR weight on Π	0.500	0.100	Normal	0.5742	0.4229	0.7285
ρ_r	TR persistence	0.750	0.050	Beta	0.5909	0.4900	0.6801

Table 1: Estimation results from Bayesian likelihood estimation on the fiscal dominance model.

4.3 Impulse Response Functions

I verify that the model behaves as expected post-estimation, using the 90% posterior IRFs for each variable. I compare the model's responses to a government debt shock to the empirical IRFs first. I then display the model's IRFs to productivity and cost-push shocks.

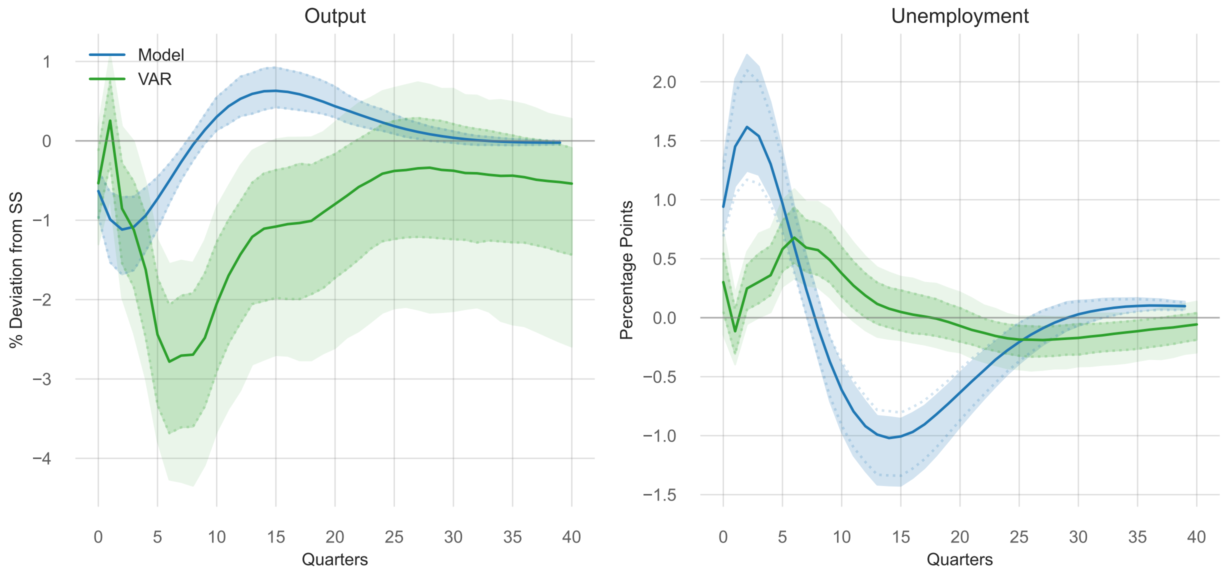

Figure 7: Impulse responses to a government debt shock. Blue – 90% posterior IRFs from the estimated model. Green – 90% posterior IRFs from the proxy VAR.

Government Debt Shock

I shock government debt (ε_t^b), scaled to generate a 1% increase in i, the long-term bond rate. For comparison, I aggregate the empirical IRFs to a quarterly frequency by taking the first observation in each quarter and linearly interpolating to the next quarter. These are displayed in green. First, I look at output and unemployment in figure 7. In the model, colored blue, output falls by approximately one percentage point on impact, decreasing for a few quarters, and then recovers after approximately three years. The quantitative match is close on impact, though the model has output recovering more quickly and not falling as far as the empirics. To compare unemployment in the model with the data, I use a back-of-the-envelope calculation. Assuming hours per worker and the labor force participation rate remains the same, the percentage change in hours per capita is approximately $-\frac{\Delta u}{1-u}$. Unemployment in the model, shown in the right panel of figure 7, jumps by about one percentage point on impact, rises for a few quarters more, and then falls. Considering the model has no mechanism for distinguishing between hours per worker and the labor force participation rate, the match here is reasonable.

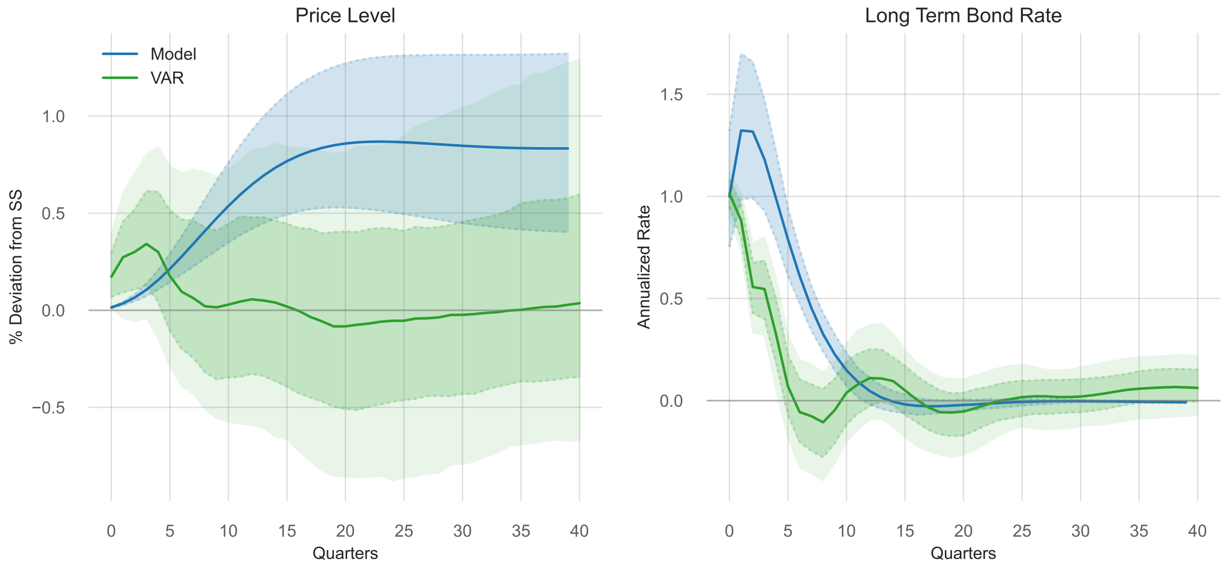

Figure 8: Impulse responses to a government debt shock. I calculate the price level in the model by integrating over inflation. Blue – 90% posterior IRFs from the estimated model. Green – 90% posterior IRFs from the proxy VAR.

Figure 8 shows the response of the price index and the long-term rate. The model generates inflation in a hump-shape, leading to a drawn-out increase in the price index. Only after five years does the price level begin to fall. The empirical IRFs, on the other hand, generate a peak increase in the price level roughly half that of the model and indicate that inflation should occur on impact, with slight deflation over the medium-run. The model simply does not front-load inflation enough. Given that the model takes a relatively standard sticky prices model off-the-shelf, this timing mismatch is understandable, though still an object in need of improvement. Lastly, the long-term bond rate (i in the model notation), jumps one percentage point on impact by construction. After a slight increase, the rate falls back to steady state after approximately three years. The shape and scale are consistent with the empirical IRFs.

5 The Quantitative Implications of Fiscal Dominance

Having established that the quantitative model is reasonably accurate on most margins in response to a government debt shock, I now demonstrate that this model preserves the conclusions of more standard, monetary dominant models. I first demonstrate that the IRFs to productivity and cost-push shocks are quantitatively similar. I then show that a variance decomposition indicates most of the volatility in the model still comes from cost-push and wage-markup shocks, with policy shocks playing small roles. Lastly, a model-implied historical decomposition indicates that while debt shocks do matter historically, the shocks that drive key economic events remain unchanged.

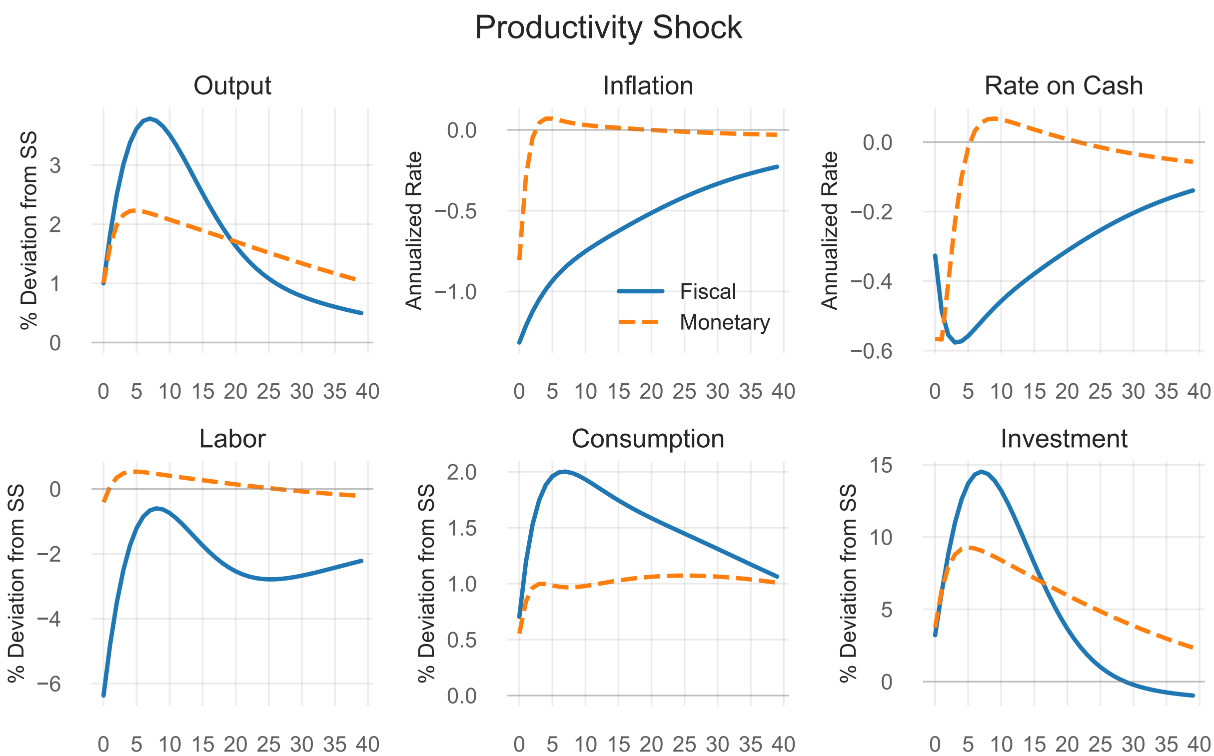

Figure 9: Impulse responses to a productivity shock that causes a 1 percentage point increase in output on impact. Blue – fiscal dominant model. Orange dashed – monetary dominant model.

5.1 Other Shocks

Figures 9 and 10 display the impulse responses for each economy to a productivity shock and cost-push shock, Output, inflation, labor, consumption, and investment all follow similarly shaped paths between the two models. The fiscal dominance economy is more volatile, especially with inflation. This result tracks though, as in the monetary dominance economy, the monetary authority enacts policy specifically to prevent inflation from deviating too far from target. Under fiscal dominance, inflation works to clear the intertemporal government budget constraint; no authority is working to actively tamp down prices.

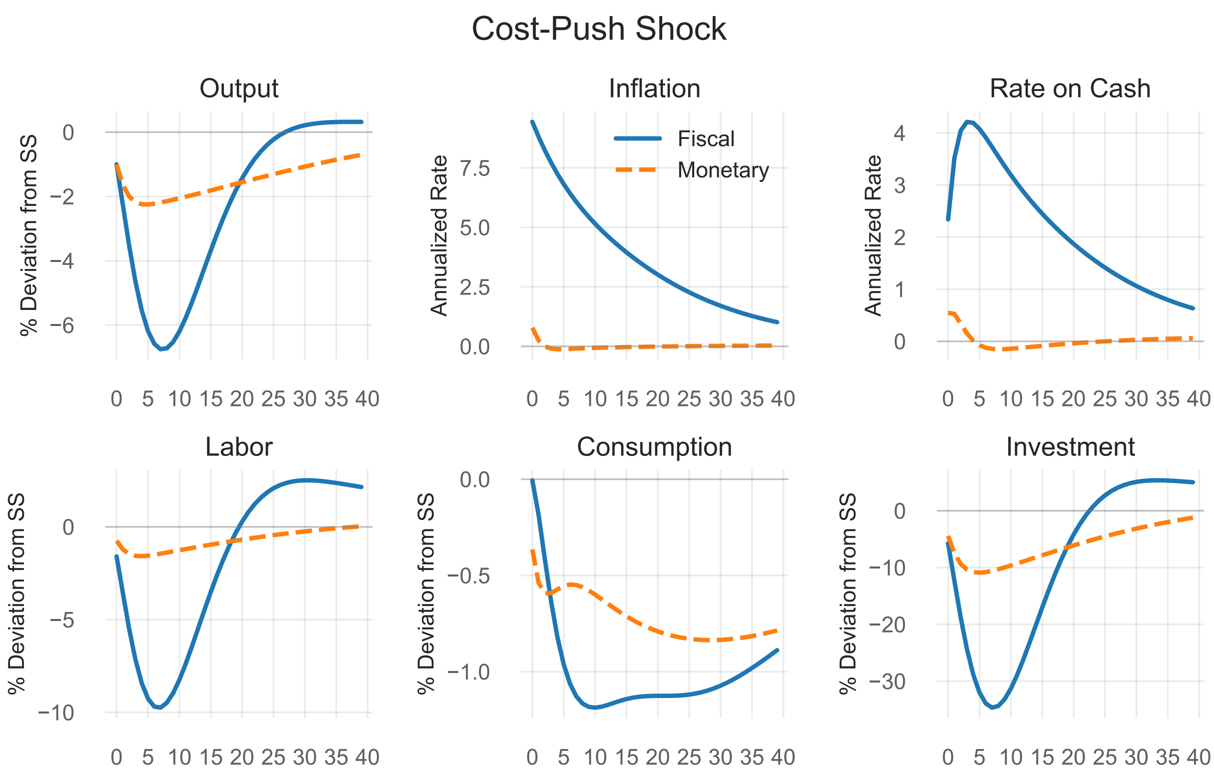

Figure 10: Impulse responses to a cost-push shock that causes a 1 percentage point decrease in output on impact. Blue – fiscal dominant model. Orange dashed – monetary dominant model.

5.2 Variance Decomposition

Figure 11 displays the unconditional variance decompositions for the fiscal and monetary economies, with shocks grouped into "supply", "demand", debt, and monetary policy shocks, following Faria-e-Castro (2024). "Supply" shocks include cost-push, wage markup, investment, and productivity shocks. "Demand" shocks include preference, government spending, and income tax shocks. Under the fiscal dominance model, supply shocks drive about 70% of output, virtually all of inflation, and approximately 25% of the long-term rate. Demand explains about 20% of output, while monetary policy explains about 5% of output and 60% of the long-term rate. Debt explain about 2% of output.

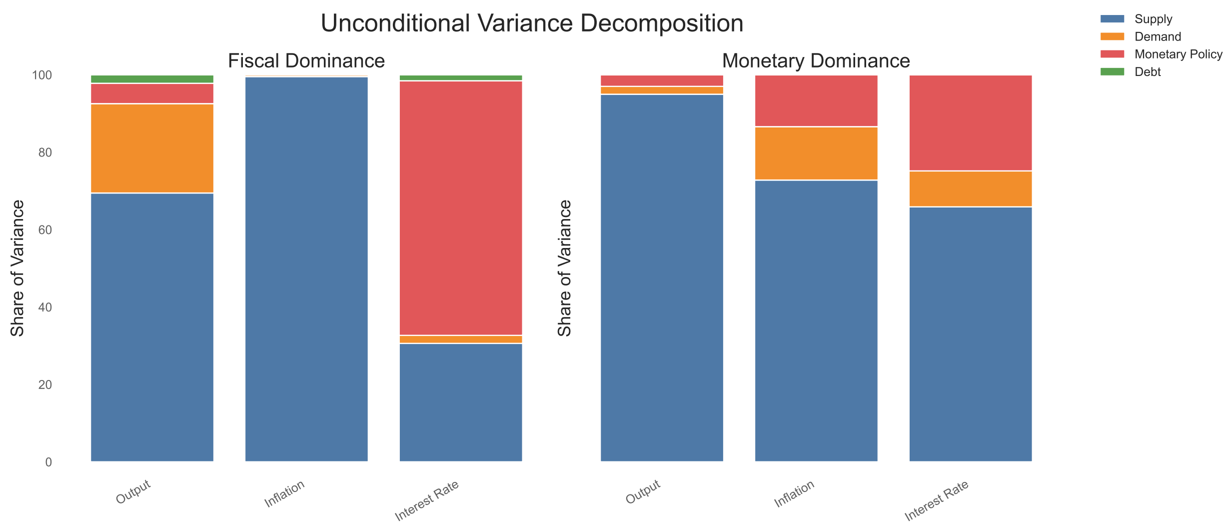

Figure 11: Unconditional variance decomposition for each economy, fiscal dominance on the left and monetary dominance on the right. Each column represents a model variable, while each color represents the share of the variance of that variable the corresponding shock explains. Blue – Supply. Orange – Demand. Red – Monetary policy. Green – Debt.

The monetary dominance model similarly ascribes a large role for supply shocks for output and inflation. Demand and monetary policy shocks now explain little of the variation in output, but roughly 15% each of inflation. The long-term rate, now being driven by a policy rule that reacts strongly to inflation, reflects the shocks that cause variation in inflation. Overall, though, the general shocks driving output and inflation in both models are broadly similar. For a full variance decomposition, see appendix A12.

5.3 Historical Decomposition

In figure 12, I plot the historical decomposition for inflation for each model. I group the shocks into supply and demand shocks again, keeping the policy shocks separate. Supply shocks explain nearly all historical variation in inflation under fiscal dominance, with demand and debt shocks playing small roles in the mid 1980s and in the mid 1990s. The monetary dominance economy delivers a similar result, albeit with a little more color around the edges. Monetary policy shocks contribute during the late 1970s and in the 2000s.

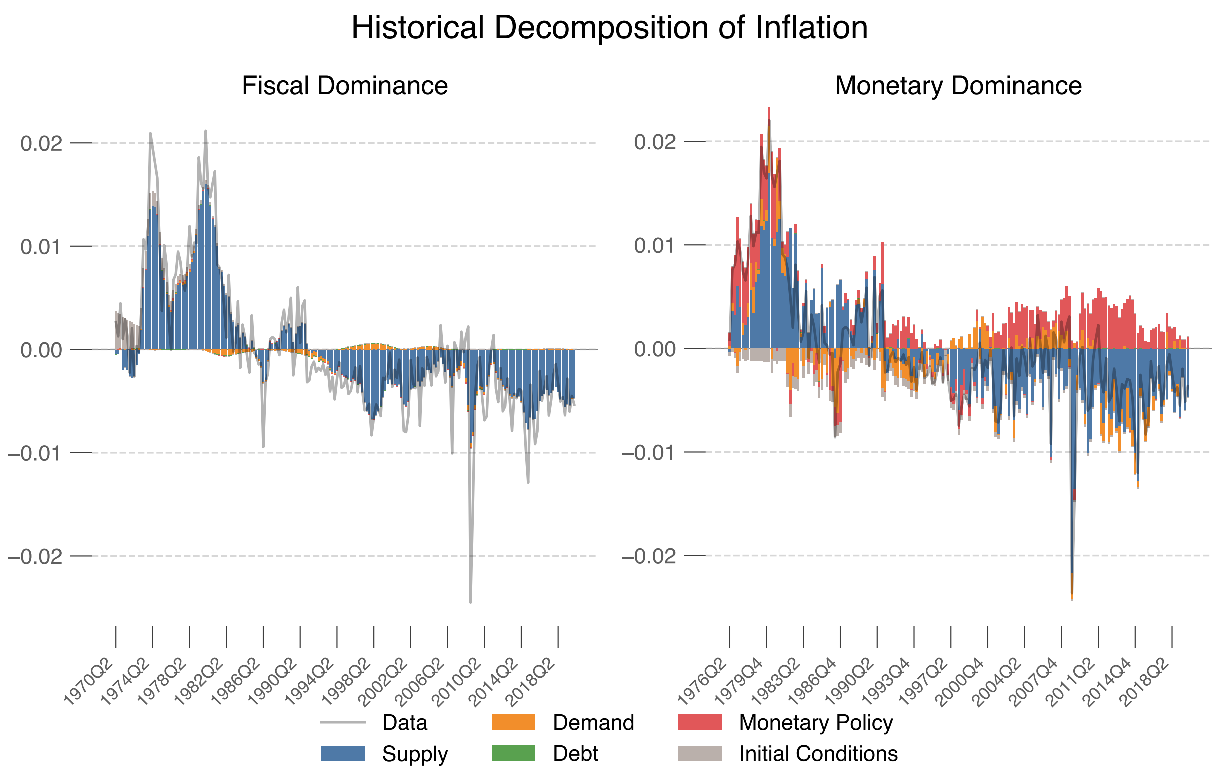

Figure 12: Historical decompositions of inflation under the fiscal dominance economy (left) and the monetary dominance economy (right). The height of each bar represents the time-series contribution of each shock. Blue – supply. Orange – Demand. Red – Monetary Policy. Green – Debt. Gray – Initial Conditions.

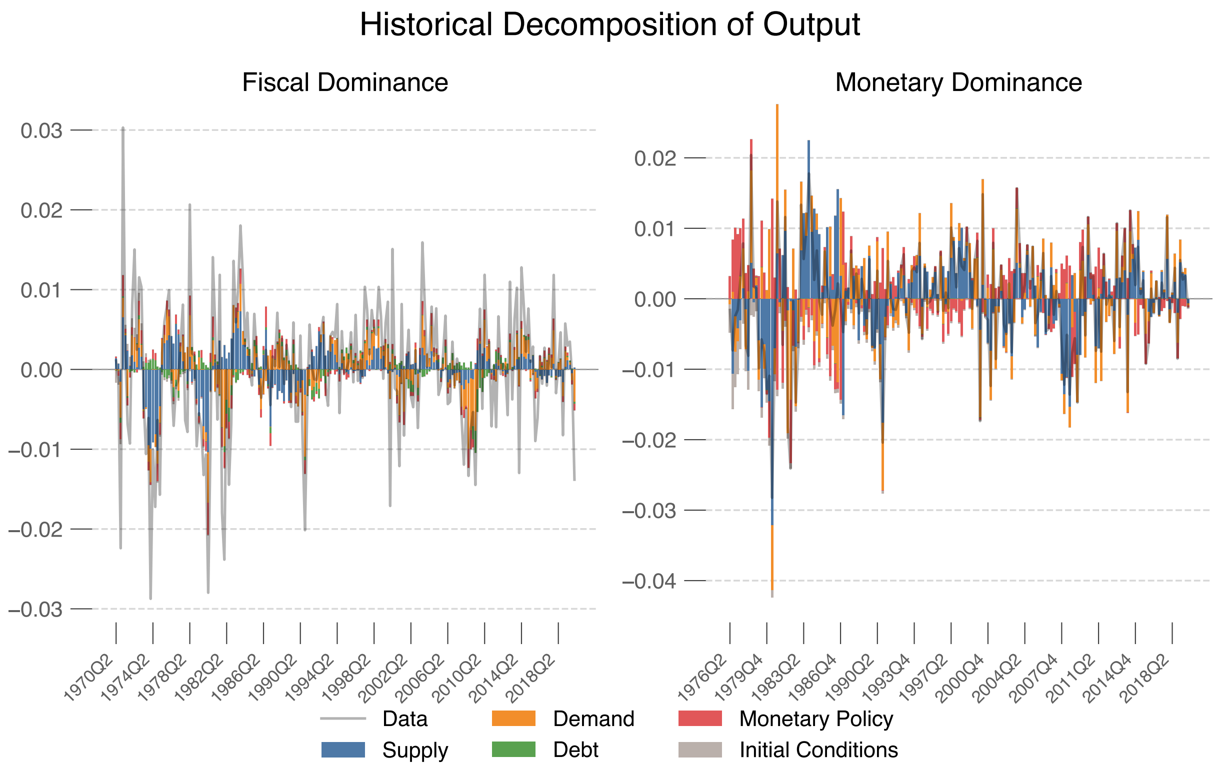

Figure 13: Historical decompositions of output under the fiscal dominance economy (left) and the monetary dominance economy (right). The height of each bar represents the time-series contribution of each shock. Blue – supply. Orange – Demand. Red – Monetary Policy. Green – Debt. Gray – Initial Conditions.

In figure 13, I plot the historical decomposition for output for each model. The key takeaway from these plots is that the variation ascribed to each shock category in the fiscal dominance model is similar to the variance ascribed in the monetary dominance model. For example, supply shocks explain the recession at the end of the 1970s and then also drive the recovery. The biggest difference is the Great Recession, where the fiscal dominance model assigns demand shocks as the cause of the recession (particularly preference shocks) and the monetary dominance model assigns supply shocks as the cause (productivity and cost-push shocks).

5.4 Debt's Contribution

Broadly speaking, fiscal and monetary dominance deliver similar impulse response functions, variance decompositions, and historical decompositions. Then, do debt shocks even matter in DSGE models? In figure 14, I plot the historical contribution from debt shocks, with monetary policy shocks as a reference, to output and inflation. While debt shocks did not drive any major movement in output or inflation, they did contribute meaningfully to output variation. Growth in the early 1980s, for example, was dampened by approximately 0.2 percentage points due to debt shocks. The late 1990s saw a small boost from negative debt shocks. The Great Recession was deepened by debt shocks, with an output penalty of more than 0.4 percentage points. These debt shocks are at least as important as the monetary policy shocks the literature has extensively studied.

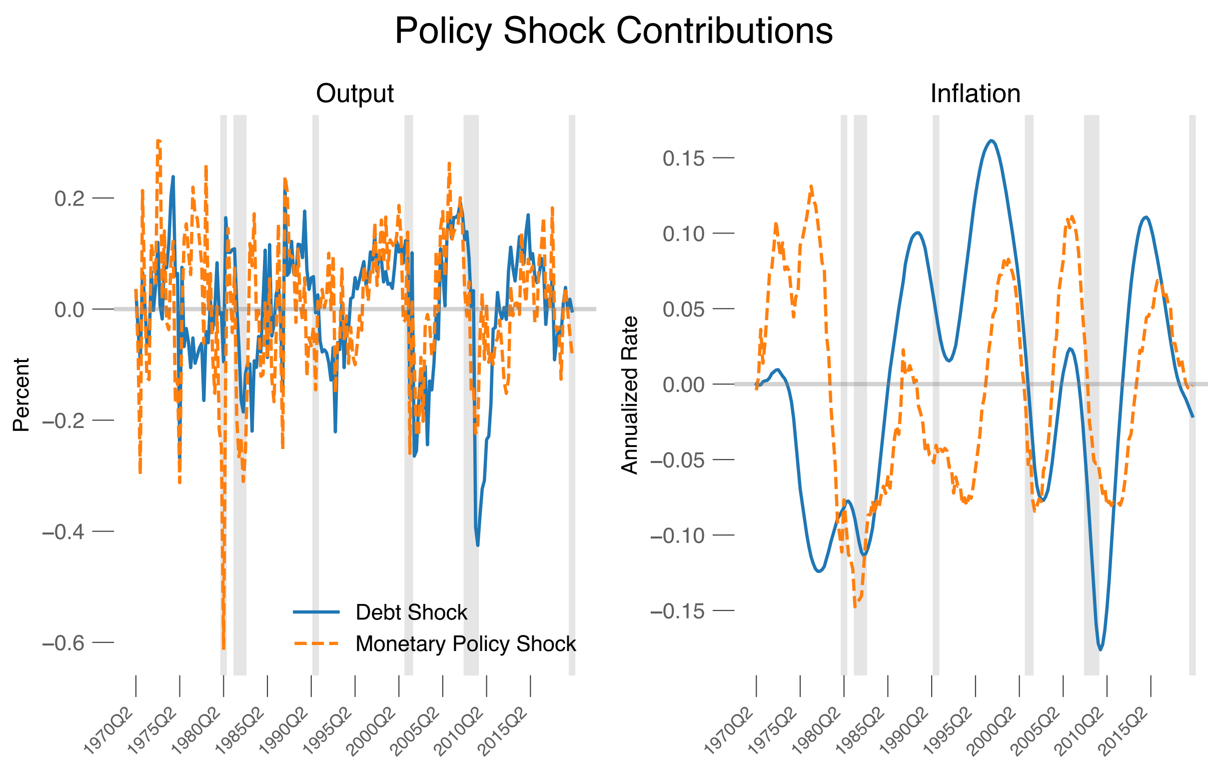

Figure 14: The contribution of policy shocks to output growth (left panel) and inflation (right panel). Blue – debt shocks. Orange dashed – monetary policy shocks

Debt shocks impact inflation as well, albeit in a much smaller way. Debt shocks initially kept inflation lower in the late 1970s and early 1980s. Then, debt shocks fought against the tail of the Volcker disinflation, increasing inflation by 15 basis points in the early 1990s. Debt shocks played little role in the 2000s until the Great Recession, where these shocks cause a 15 basis point decrease in inflation followed by a 10 basis point increase around 2015.

6 Conclusion

In this paper, I empirically identify government debt supply shocks using Treasury futures markets. I then use a proxy VAR to study the macroeconomic implications of these shocks. A small New Keynesian model with fiscal dominance can qualitatively match the empirical IRFs while the same model with monetary dominance cannot. A medium-scale New Keynesian model explains the main empirical results reasonably well quantitatively, but future work should focus on increasing the fall in output and the short-run burst in inflation. I then demonstrate that the this fiscal dominance model interprets the data similarly to a monetary dominance model, but that debt shocks nevertheless explain historically important variations in output.

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A Appendix

A1 Treasury Announcement

TREASURY NEWS

Department of the Treasury • Bureau of the Fiscal Service

Embargoed Until 11:00 A.M.
May 14, 2024

CONTACT: Treasury Auctions
202-504-3550

TREASURY OFFERING ANNOUNCEMENT [1]

Term and Type of Security	28-Day Bill
Security Description	4-Week Bill
Offering Amount	$80,000,000,000
Currently Outstanding	$135,590,000,000
CUSIP Number	912797KF3
Auction Date	May 16, 2024
Original Issue Date	February 20, 2024
Issue Date	May 21, 2024
Maturity Date	June 18, 2024
Maximum Award	$28,000,000,000
Maximum Recognized Bid at a Single Rate	$28,000,000,000
NLP Reporting Threshold	$28,000,000,000
NLP Exclusion Amount	$47,300,000,000
Minimum Bid Amount and Multiples	$100
Competitive Bid Rate Increments [2]	0.005%
Maximum Noncompetitive Award	$10,000,000
Eligible for Holding by Treasury Retail	Yes
Estimated Amount of Maturing Bills Held by the Public	$212,949,000,000
Maturing Date	May 21, 2024
SOMA Holdings Maturing	$674,000,000
SOMA Amounts Included in Offering Amount	No
FIMA Amounts Included in Offering Amount [3]	Yes
Noncompetitive Closing Time	11:00 a.m. ET
Competitive Closing Time	11:30 a.m. ET

[1]Governed by the Terms and Conditions set forth in The Uniform Offering Circular for the Sale and Issue of Marketable Book-Entry Treasury Bills, Notes, and Bonds (31 CFR Part 356, as amended), and this offering announcement.

[2]Must be expressed as a discount rate with three decimals in increments of 0.005%, e.g., 7.100%, 7.105%.

[3]FIMA up to $2,000 million in noncompetitive bids from Foreign and International Monetary Authority not to exceed $500 million per account.

A2 Treasury Future Prices

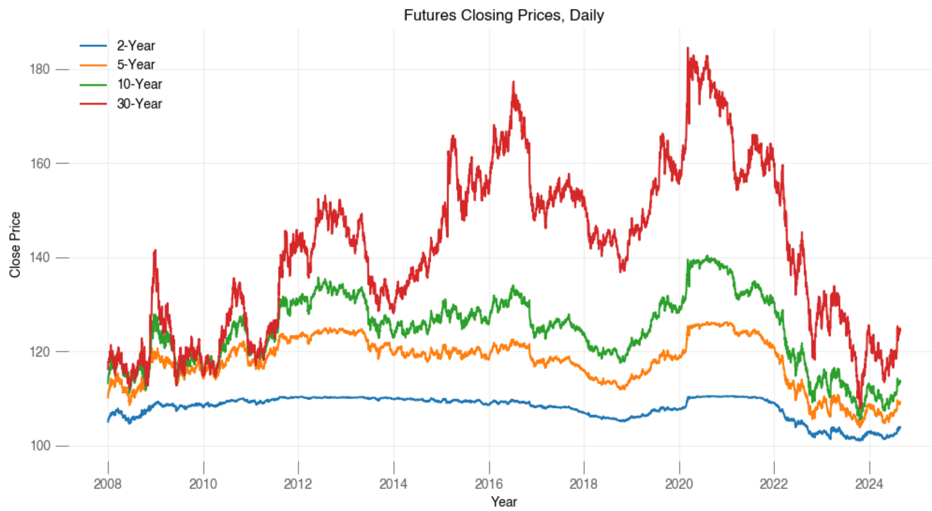


Figure A1: Evolution of Treasury futures prices from 2008 to 2024.

A3 Weighting Scheme

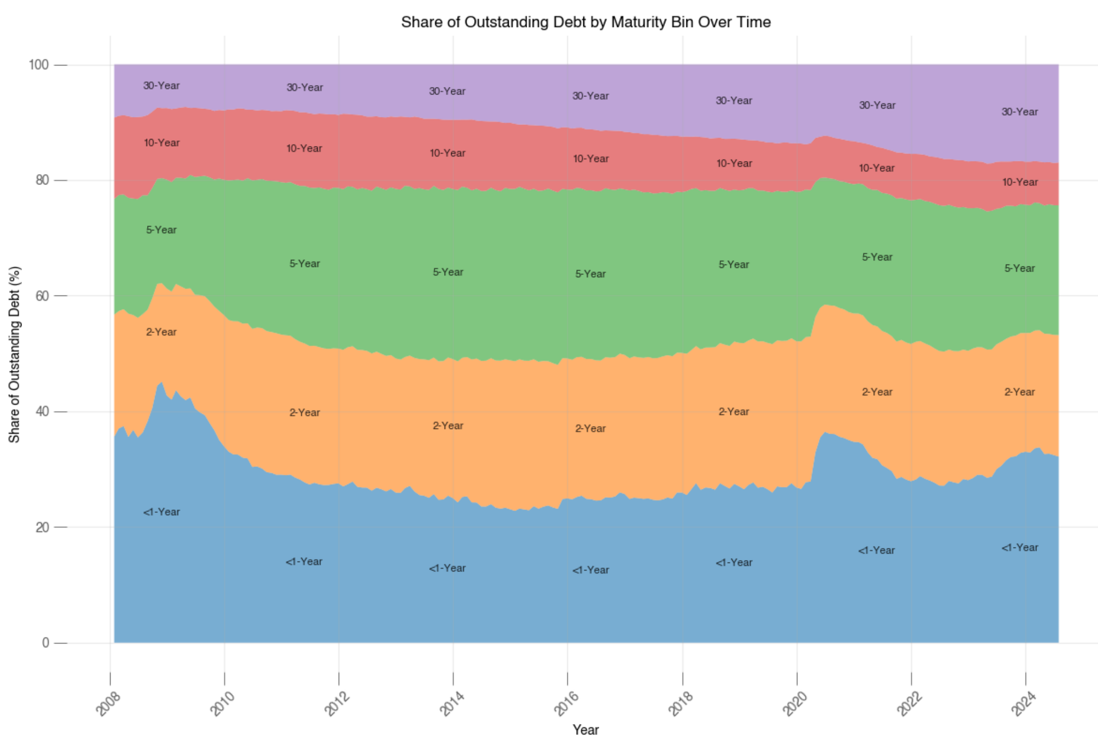


Figure A2: Proportion of outstanding debt by maturity bin.

A4 Diagnostic Tests

Autocorrelation

The first diagnostic test I run is an autocorrelation test. Ideally, a shock should not be forecasted by itself. As shown by the autocorrelation plot below, my shock series is not autocorrelated. Only one lag length, 13, is statistically significant out of 20 tested lag lengths.

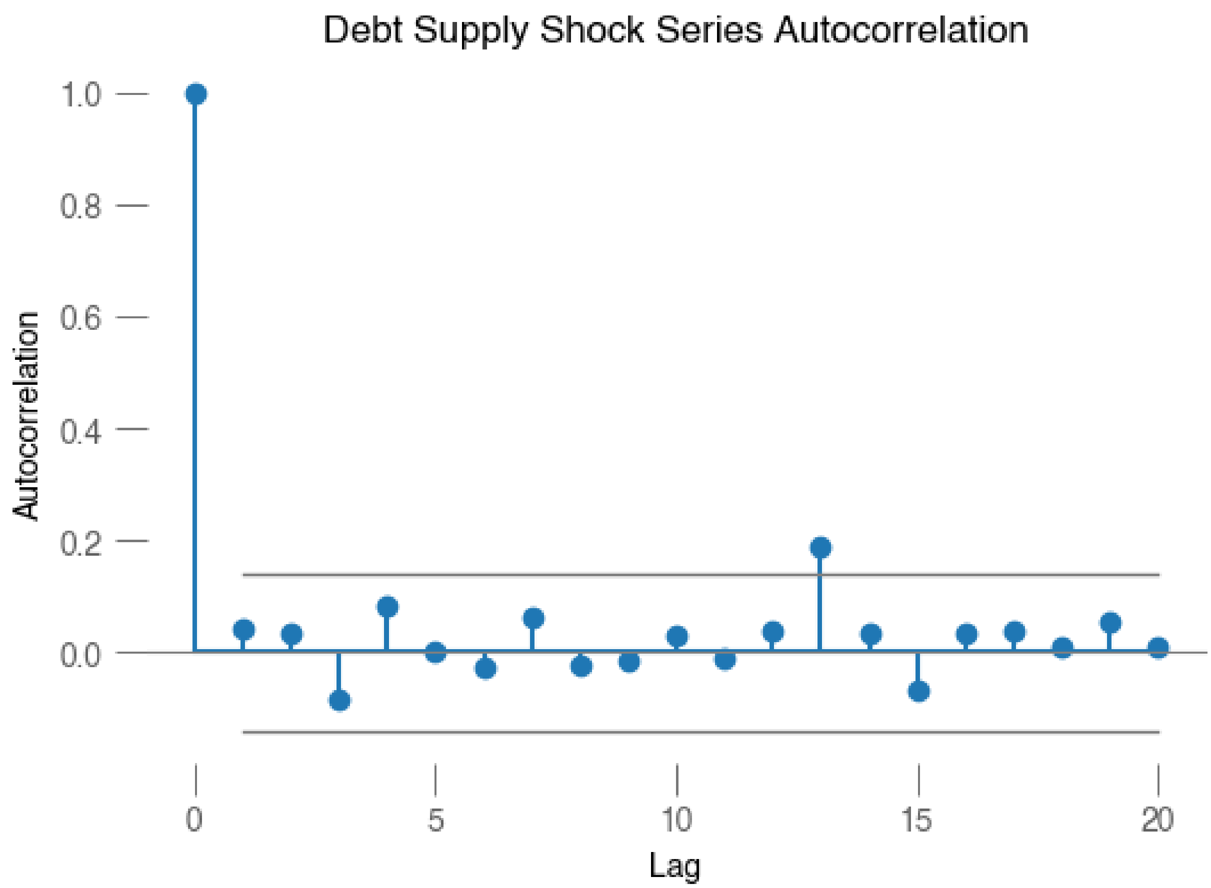


Figure A3: Debt supply shock series correlation with lags of itself. With the exception of lag 13, the series does not forecast itself.

Correlation with Other Shocks

I take other shock series that run at least part-way through my shock series and calculate the correlation coefficient with my shock. Table A1 summarizes the results. No shock series is statistically correlated with my debt shock series.

Table A1
Correlation Analysis of Shock Series

Shock Series	Type of Shock	Corr.	p-value	Time Period
Nakamura & Steinsson (2018)	Monetary Policy	-0.06	0.37	2008M1-2024M7
GSW (2005) Target	Monetary Policy	-0.08	0.26	2008M1-2024M7
GSW (2005) Path	Monetary Policy	-0.02	0.79	2008M1-2024M7
Ramey (2016)	Gov. Spending News	0.29	0.17	2008Q1-2013Q4
Gilchrist & Zakrajsek (2012)	Financial	-0.03	0.79	2008M1-2015M12
Baker, Bloom, & Davis (2016)	Uncertainty	0.06	0.52	2008M1-2017M12

Table A1: Correlation between my debt shock series and other relevant shock series. The monetary policy shock series are taken from Acosta et al. (2024). Ramey's government spending news shock series comes from her website. Gilchrest & Zakrajsek (2012) and Baker, Bloom, & Davis (2016) both come from Kanzig (2021).

Granger Causality

I lastly conduct Granger causality tests between my shock series and a number of macro-financial time series. Table A2 displays the results. The results here generally support the exogeneity of my shock series. While over the whole sample the VIX and industrial production index are statistically significant, they become insignificant if I start the shock series after the Great Recession. The federal funds rate, while insignificant at the 5% level over the whole sample, becomes statistically significant when excluding the Great Recession.

Table A2
Granger Causality Tests

Time Series	F-stat	p-value	Time Period
Self	0.93	0.52	2008M1-2024M7
Fed Funds Rate	1.64	0.09	2008M1-2024M7
	2.71	0.003	2010M1-2024M7
PCE Inflation	1.17	0.31	2008M1-2024M7
Unemployment	0.95	0.49	2008M1-2024M7
VIX	2.01	0.03	2008M1-2024M7
	0.92	0.53	2010M1-2024M7
Corporate Tax Receipts	1.29	0.23	2008M1-2024M7
Other Tax Receipts	0.88	0.57	2008M1-2024M7
Outlays	0.74	0.72	2008M1-2024M7
Transfers	0.74	0.71	2008M1-2024M7
Currency Component of M1	1.34	0.20	2008M1-2024M7
Industrial Production	1.9	0.04	2008M1-2024M7
	0.66	0.79	2010M1-2024M7

Table A2: Granger causality tests between my shock series and various macro-financial time series. Each test includes a constant and 12 lags. Non-stationary series are log first-differenced before running the test. Tax receipts, outlays, and transfers are data series I constructed from Daily Treasury Statements. See appendix A7 for details on those series.

A5 Specification Robustness

Varying Lag Length

My main specification uses 12 lags. I now show that if I go up to 24 lags, or down to 8 lags (AIC) or 2 lags (HQIC), the results are qualitatively similar. .

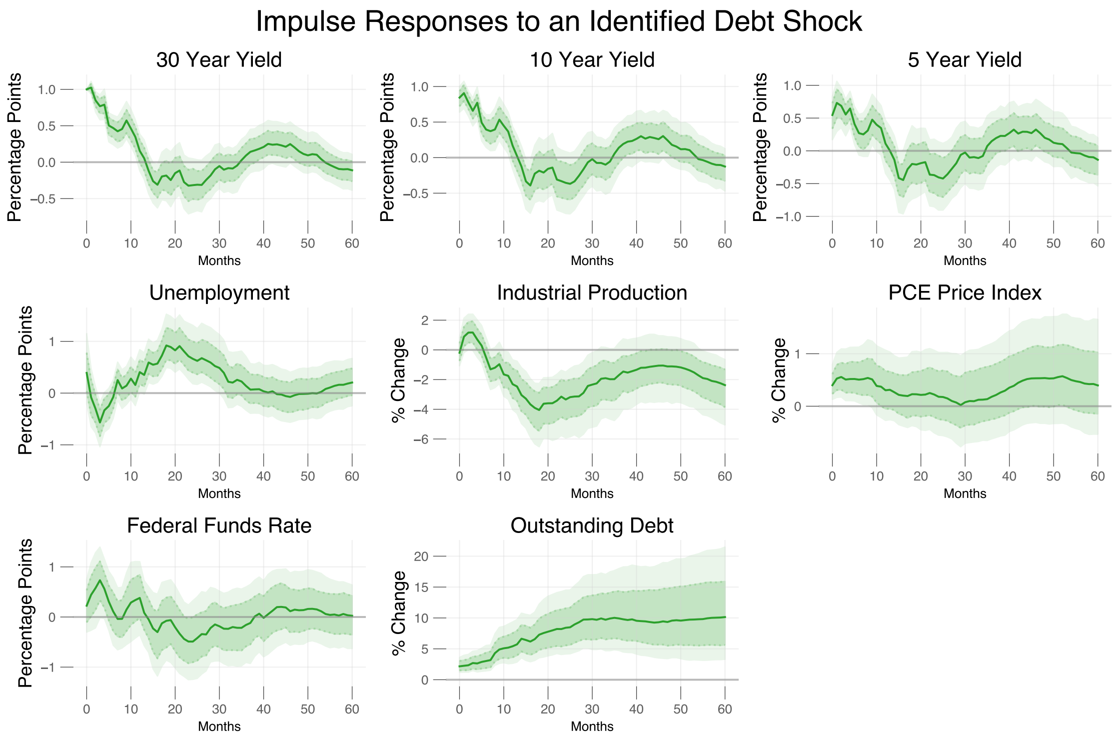


Figure A4: Impulse response functions to an identified 1 percentage point shock to the thirty year yield. The solid green line denotes the median, the dark green area denotes the 68% credible set, and the light green area denotes the 90% credible set. This specification has 24 lags instead of 12.

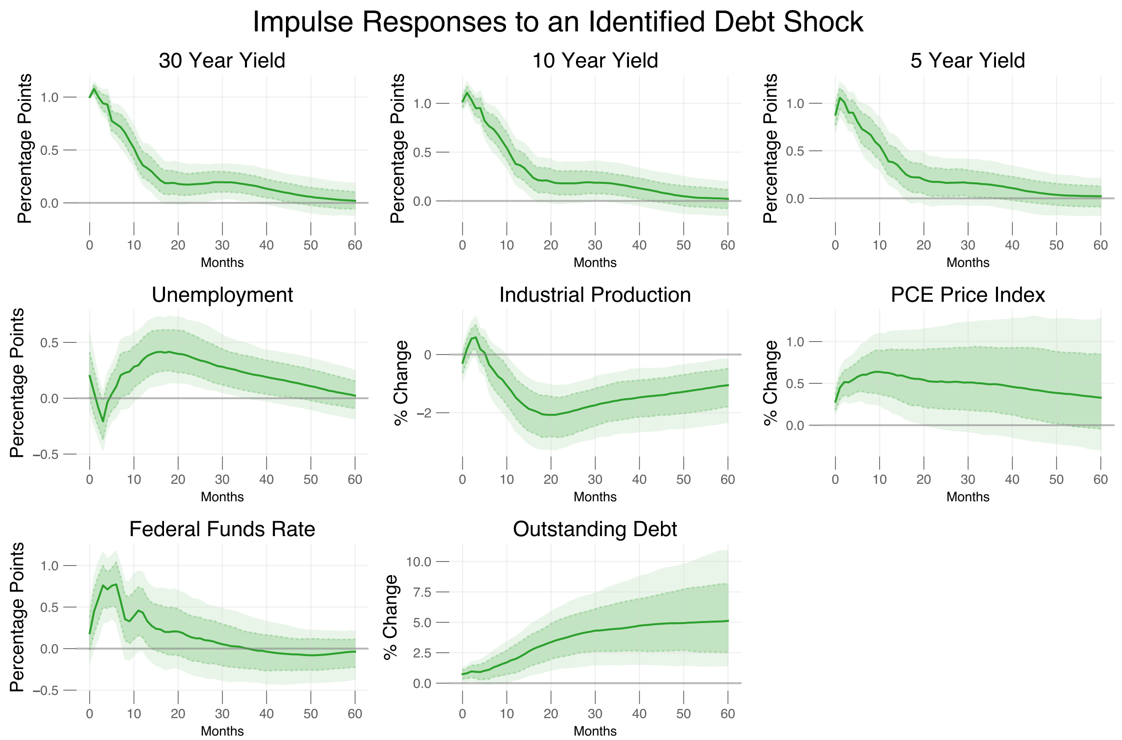


Figure A5: Impulse response functions to an identified debt shock. This specification has 8 lags as suggested by the AIC instead of 12.

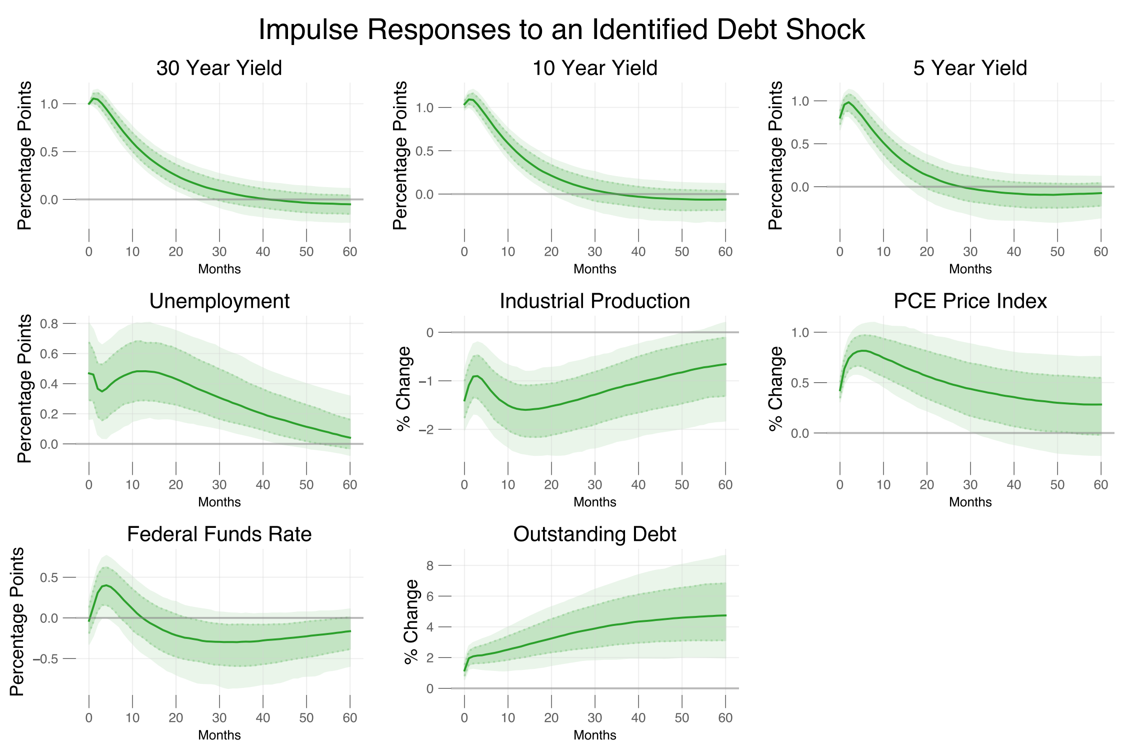


Figure A6: Impulse response functions to an identified debt shock. This specification has 2 lags as suggested by the HQIC instead of 12.

Dummy Variable

My main specification uses a dummy variable, set to true from 2020M1 to 2021M12, to account for the COVID-19 pandemic. Here, I demonstrate that neither the inclusion of the dummy or of the COVID-19 pandemic in the dataset are critical to the qualitative argument. Figure A5 demonstrates that dropping the dummy negligibly changes the IRFs. Figure A6 demonstrates that dropping the COVID time period also negligibly changes the IRFs.

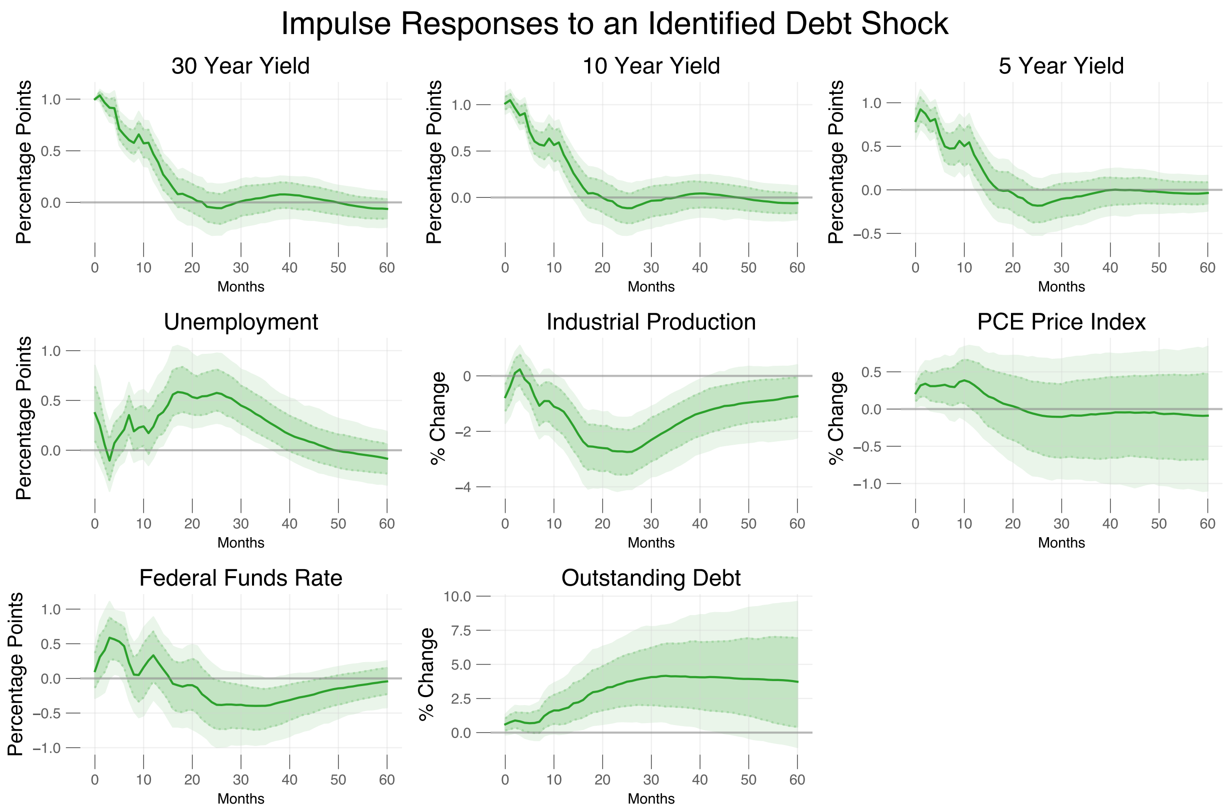


Figure A7: Impulse response functions to an identified debt shock. This specification does not include a dummy during the COVID pandemic.

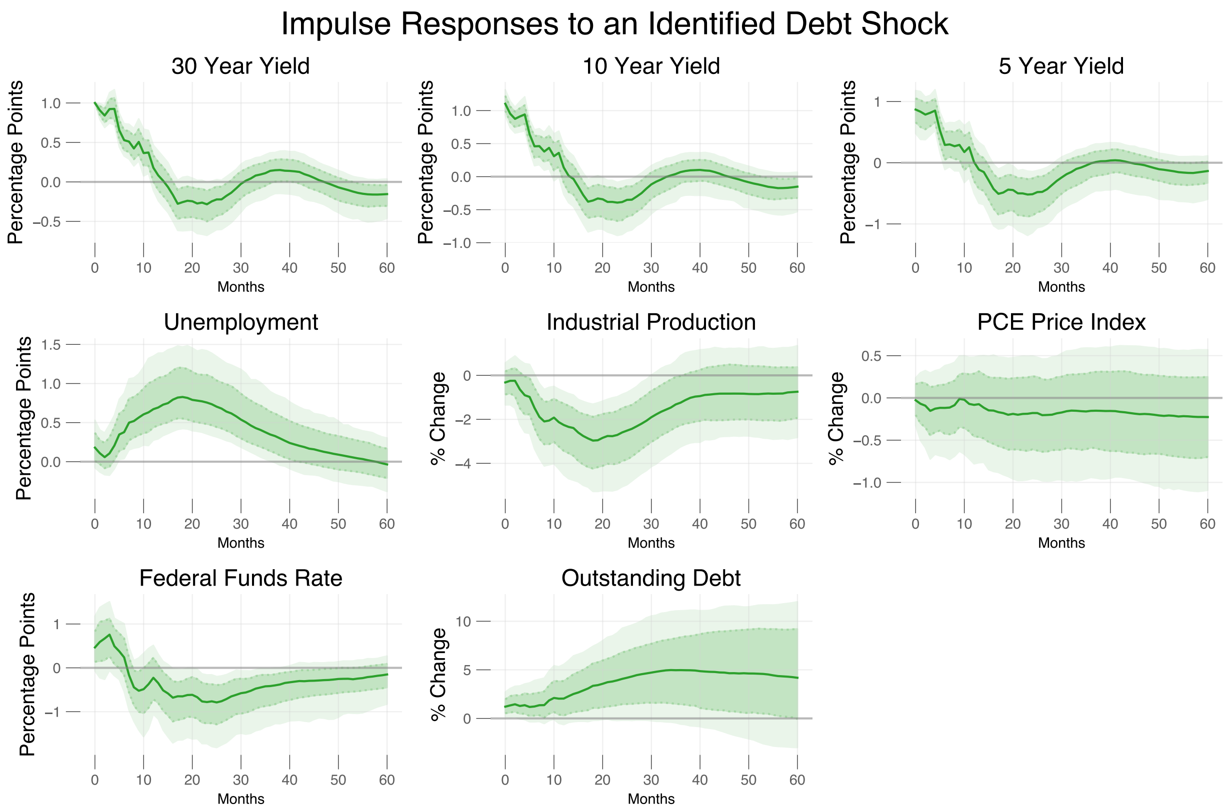


Figure A8: Impulse response functions to an identified debt shock. This specification drops the years 2020 onward.

Frequentist VAR with MSW Robust Confidence Intervals

Monteil Olea et al. (2020) build robust confidence intervals for external instrument VARs. If their robust Wald statistic is less than 10, then the instrument is weak and standard asymptotic confidence intervals will not be wide enough. While my robust Wald statistic is above this threshold at 22.6, I run the VAR with the frequentist robust confidence intervals to demonstrate that my Bayesian VAR is comparable to the frequentist VAR. The major difference is in the width of the confidence intervals for unemployment and outstanding par debt.

Figure A9: Impulse response functions to an identified debt shock. The solid green line denotes the point estimate, while the dark green area denotes the 68% confidence interval and the light green area denotes the 90% confidence interval.

A6 Different Shock Identification Schemes

In my main specification, I identify shocks using a GARCH($p,\ q$) model to build the shock window, enforce a minimum and maximum timeframe, and then use an ARMA($p,\ q$) model to predict what the Treasury futures price should have been at the end of that window. There are many different ways to calculate the shocks though. The following IRFs are the impulse responses to three alternative shock identification schemes: (1) No maximum cutoff to the shock window, (2) Simple mean before and after, (3) Simple mean before and after with no maximum cutoff to the shock window. In the captions for each figure I include the MSW robust Wald statistic.

No Maximum Cutoff

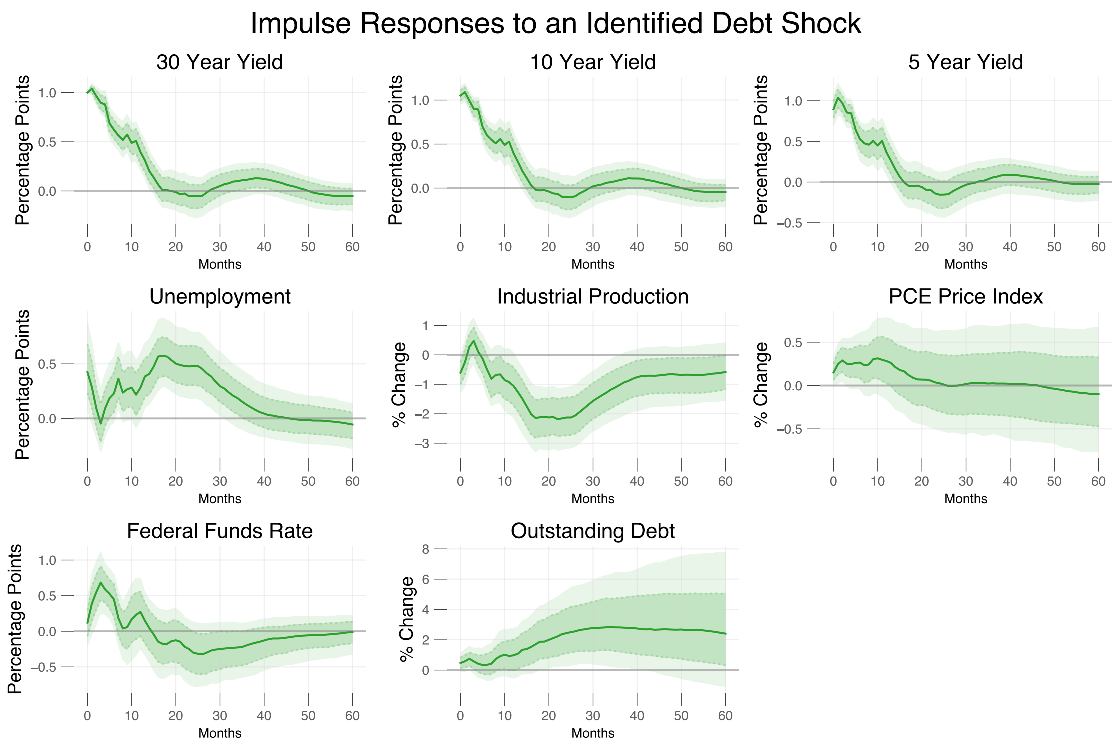


Figure A10: No maximum window cutoff. MSW robust Wald: 17.4

Difference in Means, with and without a Cutoff

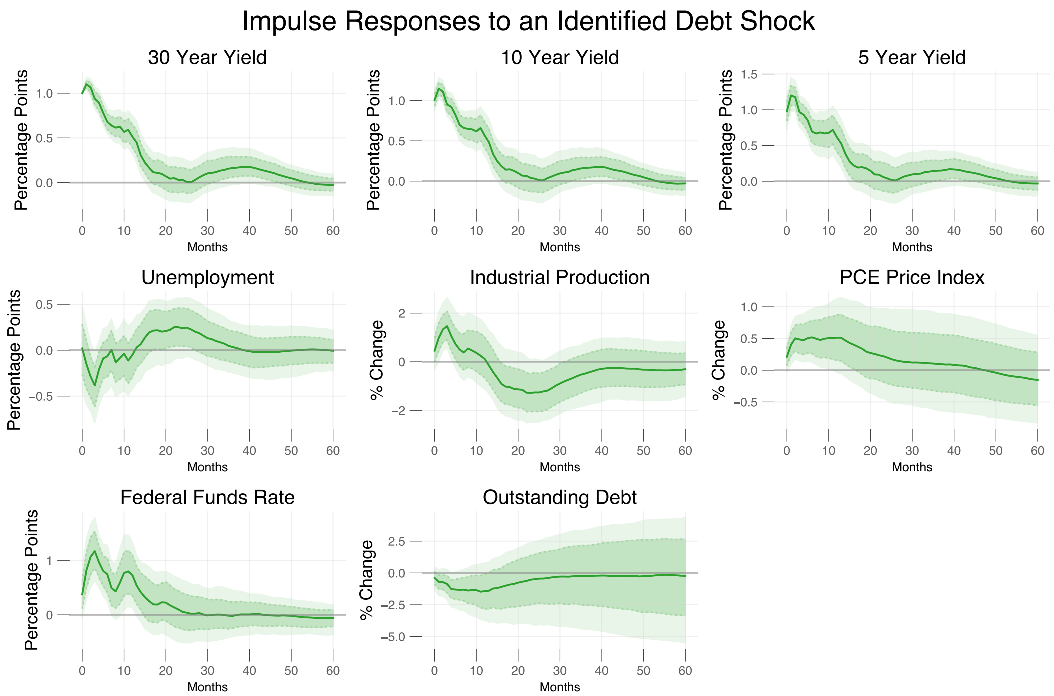


Figure A11: Difference in means with a maximum window cutoff. MSW robust Wald: 16.56

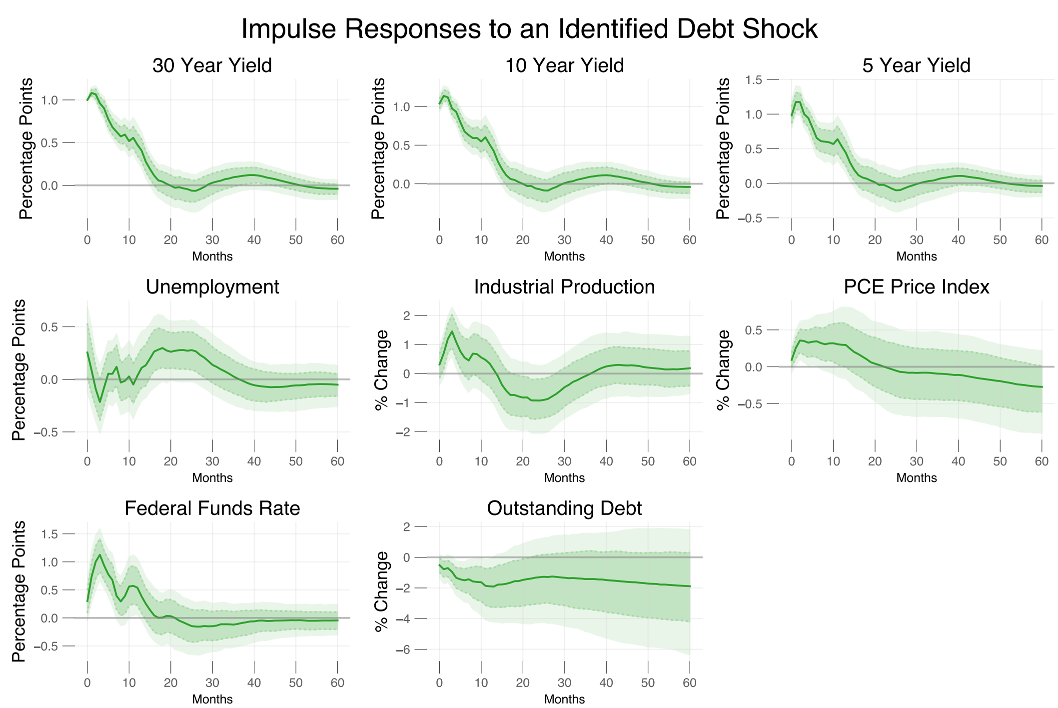


Figure A12: Difference in means without a maximum window cutoff. MSW robust Wald: 13.97

Identification through Par Debt Outstanding

Instead of identifying the debt shock through the thirty-year yield, I identify the debt shock through par debt outstanding. The qualitative shape of the median IRFs remain the same, but the confidence bands increase dramatically due to how weakness of the instrument – The MSW robust Wald statistic is 0.52.

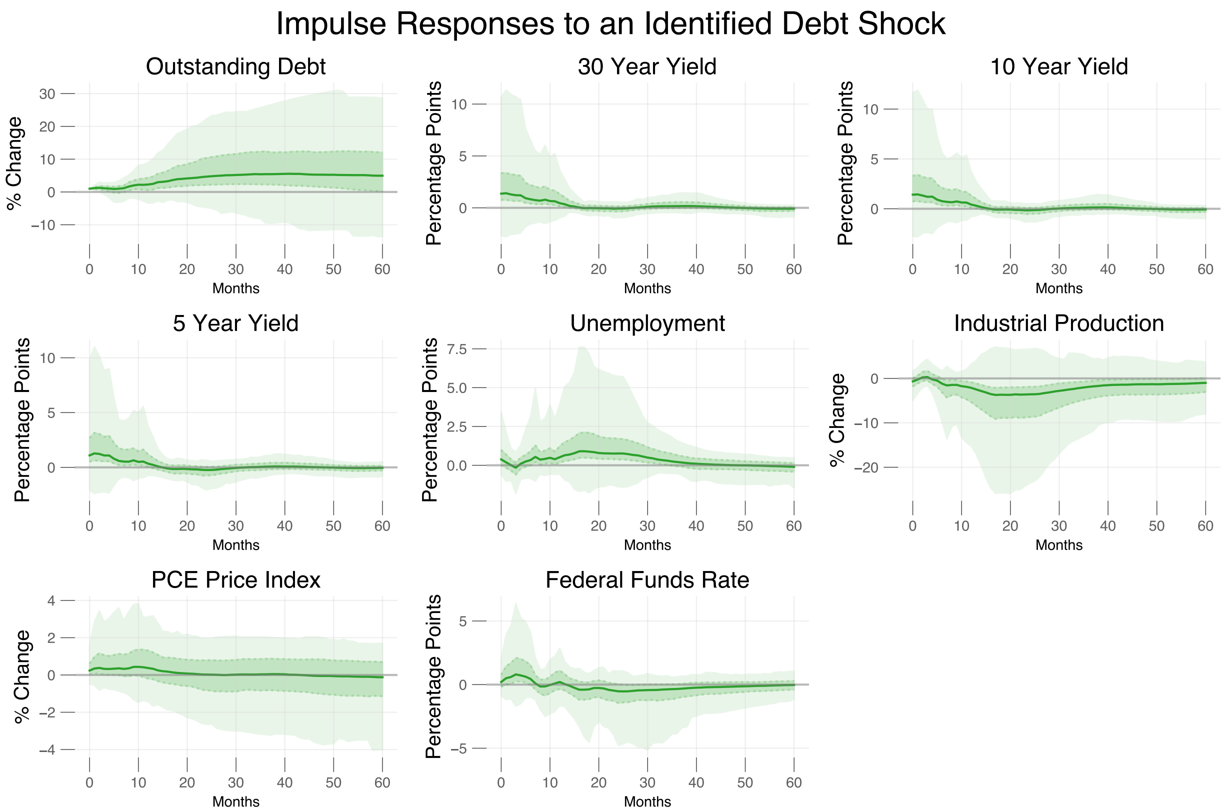


Figure A13: Using par debt outstanding through which to incorporate the debt shock. MSW robust Wald: 0.52

A7 Constructing Fiscal Policy Time Series

I use the Daily Treasury Statement (DTS) to construct monthly time series for taxes, government consumption/investment, and transfer payments. The DTS is a cash-basis accounting document the Treasury releases each day detailing amounts of spending that come into the Treasury and amounts that are withdrawn.

Taxes

Before 02/14/2023, the DTS reported taxes slightly differently. I select the following categories subcategories from the “Deposits” category in the Operating Cash table:

Taxes - Estates and Gift	Taxes - Miscellaneous Excise
Taxes - Federal Unemployment	Taxes - Non Withheld Ind/SECA Electronic
Taxes - IRS Collected Estate, Gift, msc	Taxes - Non Withheld Ind/SECA Other
Taxes - Railroad Retirement	Taxes - Withheld Individual/FICA
Taxes - Corporate Income	

I group all taxes except for corporate income into “Other Taxes.” I then take data from before 02/14/2023 and select the following subcategories from the “Federal Tax Deposits Today” category:

Withheld Income and Employment Taxes	Excise Taxes
Individual Income Taxes	Federal Unemployment Taxes
Railroad Retirement Taxes	Estate and Gift Taxes & Misc IRS Rcpts.
Corporation Income Taxes	Change in Balance of Unclassified Taxes

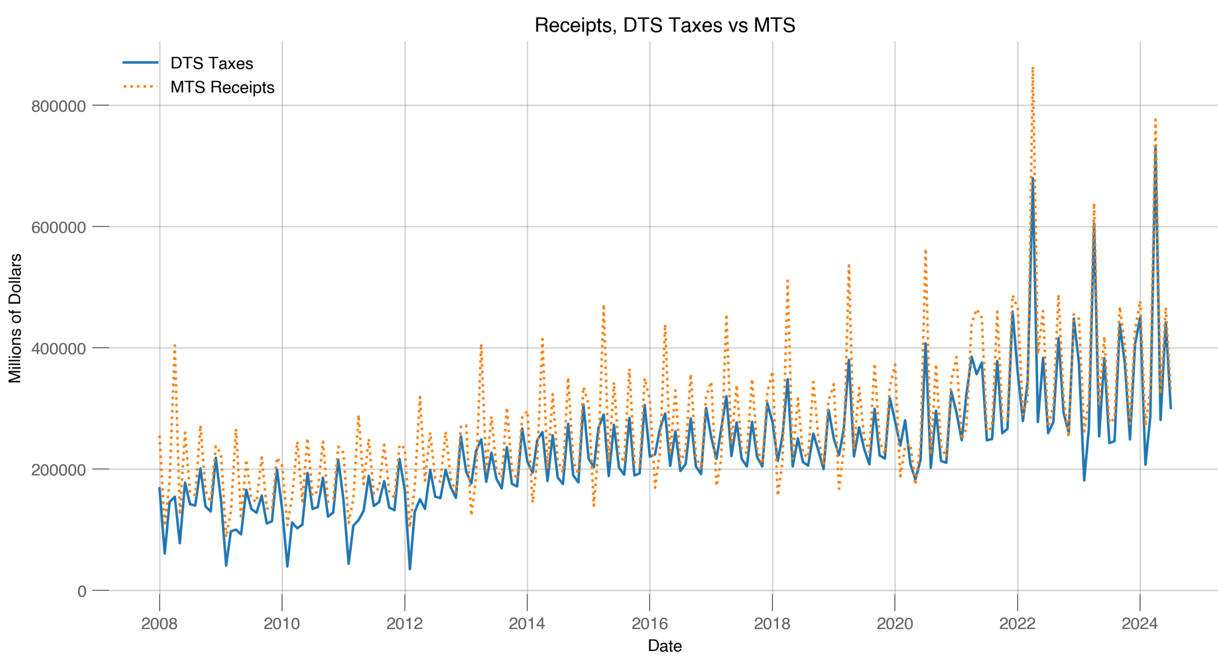


Figure A14: Plotting tax income constructed from the Daily Treasury Statement (blue solid) and receipts the Monthly Treasury Statement (orange dotted).

This process gives me a time series for corporate taxes, all other taxes, and total taxes (when added together). I also subtract COVID tax credits from my series, since I am looking at income generated through taxes. While not all federal government receipts are counted in my tax measure, taxes make up most of federal government receipts. As such, I can compare my time series to the Monthly Treasury Statement receipts series from FRED, seen in figure A14.

Outlays

I then group "Withdrawals" together into two categories: transfers and government consumption/investment. I exclude transfers from the Treasury to various accounts, public debt redemption, and tax refunds. The specific categories excluded are:

ShTransfersCtohFederalmReserve Account (Table V)
Transfers to Federal Reserve Account (Table V)
Transfers to TGA (Table V)
Transfers to Depositaries
Sub-Total Withdrawals
Public Debt Cash Redemp. (Table IIIB)
Taxes - Individual Tax Refunds (EFT)
Taxes - Business Tax Refunds (EFT)
Other Withdrawals
TREAS - Federal Financing Bank
Interest on Treasury Securities
Public Debt Cash Redemp. (Table III-B)

I then go through the left-over categories and determine which categories are transfer payments. The following categories are classified as transfers:

USDA - Supp Nutrition Assist Prog (SNAP)
USDA - Supp Nutrition Assist Prog (WIC)
HHS - Grants to States for Medicaid
HHS - Medicare Prescription Drugs
HHS - Payments to States
HHS - Temp Assistance for Needy Families
DOL - Unemployment Benefits
SSA - Benefits Payments
SSA - Supplemental Security Income
IRS - Advanced Child Tax Credit (EFT)
IRS - Economic Impact Payments (EFT)
Social Security Benefits (EFT)
Medicaid
Medicare and Other CMS Payments
Medicare Advantage - Part C&D Payments
Temporary Assistance for Needy Families (HHS)
Food Stamps
USDA - Child Nutrition
USDA - Commodity Credit Corporation
USDA - Federal Crop Insurance Corp Fund
Railroad Retirement Board (RRB) - Benefit Payments
Federal Retirement Thrift Savings Plan
IRS - Business Tax Refunds (EFT)
IRS - Individual Tax Refunds (EFT)
Unemployment Assist - FEMA Lost Wage Pmt
Housing and Urban Development programs
Emergency Capital Investment Program
Unemployment Insurance Benefits
IRS Tax Refunds Business (EFT)
IRS Tax Refunds Individual (EFT)
RRB - Benefit Payments
ESF - Economic Recovery Programs
TREAS - IRS Refunds for Puerto Rico
DoD - Military Retirement
Medicare
HHS - Federal Hospital Insr Trust Fund
HHS - Federal Supple Med Insr Trust Fund
Supple. Nutrition Assist. Program (SNAP)
VA - Benefits
Federal Employees Insurance Payments
Coronavirus Relief Fund
Airline Worker Support Extension
HHS - Othr Cent Medicare & Medicaid Serv
Food and Nutrition Service (misc)
Labor Dept. prgms (excl. unemployment)
HHS - Other Public Health Services
OPM - Civil Serv Retirement & Disability
OPM - Federal Employee Insurance Payment
IAP - Agency for Int'l Development (AID)
Dept of Housing & Urban Dev (HUD) - misc
Health and Human Services Grants (misc)
Veterans Affairs programs
Commodity Credit Corporation programs
Air Carrier Worker Support
HHS - Marketplace Payments

The rest of the categories are classified as government consumption/investment. By adding transfers and government consumption/investment together, I obtain a time series similar to the MTS outlays series (see figure A15).

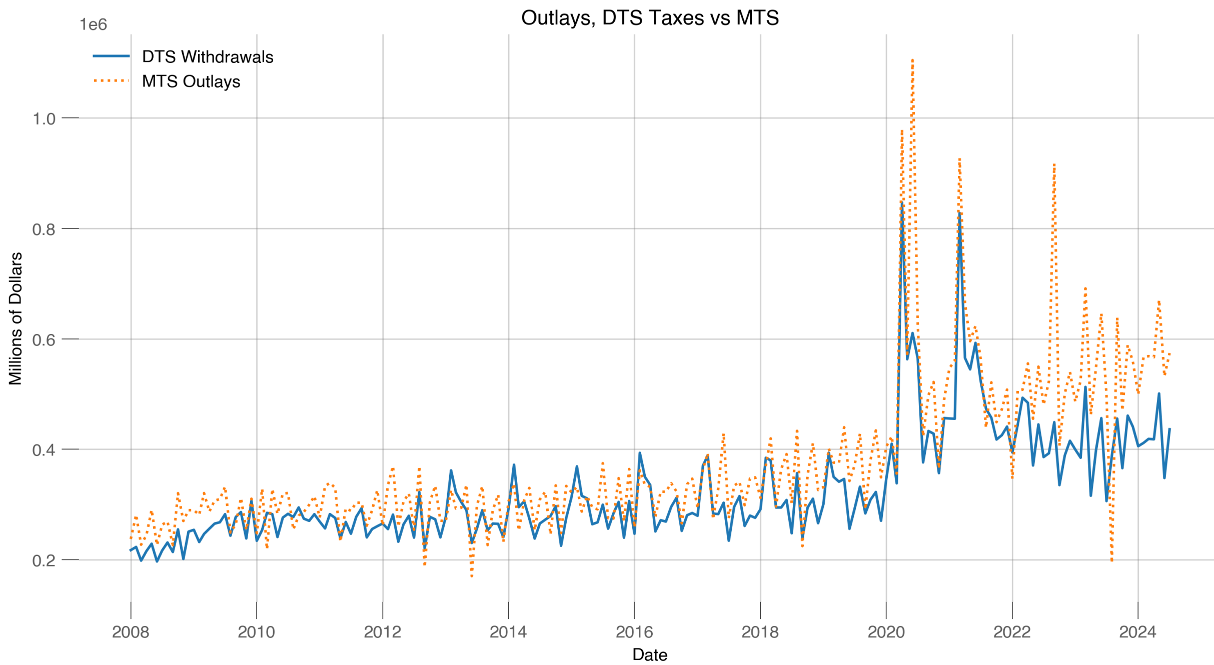
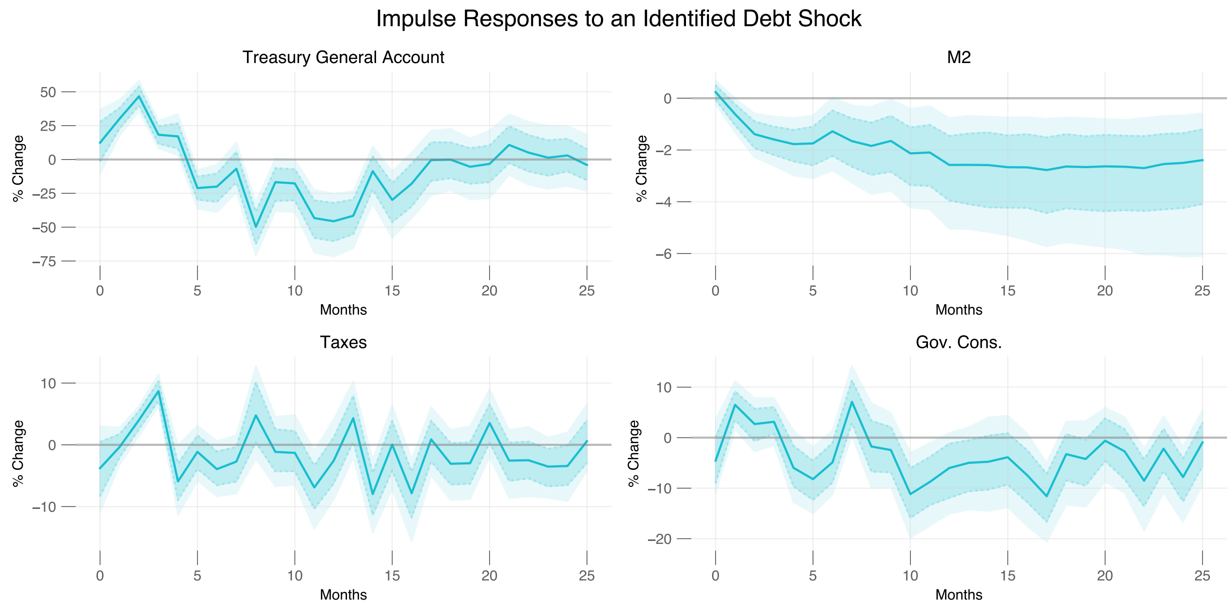


Figure A15: Plotting withdrawals constructed from the Daily Treasury Statement (blue solid) and outlays from the Monthly Treasury Statement (orange dotted).

A8 Second VAR – Real Variables

In the main specification, I run the second VAR with nominal variables to more directly align with the nominal budget constraint I presented. Here, I run the second VAR with real variables. The results do not change much. This result makes sense though, as the inflation response in the first VAR is only 50 basis points.



A9 Two Agent Model

Instead of supposing an economy with only a Ricardian household, I extend the stylized model to include a hand-to-mouth household. The hand-to-mouth household cannot save, so it does not have access to either one-period bonds, A_t, or money holdings, M_t. This household's problem is:

$$\max_{\{C_t^H,\, L_t^H\}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{\left(C_t^H\right)^{1-\sigma} - 1}{1-\sigma} - \chi^H \frac{\left(L_t^H\right)^{1+\eta}}{1+\eta} \right) \right]$$

subject to the following real flow budget constraint:

$$C_t^H = w_t L_t^H + \frac{z_t}{1-\mu}$$

where C_t^H and L_t^H denote hand-to-mouth consumption and labor, respectively, and z_t denotes aggregate lump-sum transfers. μ is the share of Ricardian households, so $1-\mu$ is the share of hand-to-mouth households. Only hand-to-mouth households receive transfers, so z_t is scaled by the share of hand-to-mouth households. Out of this problem comes two equilibrium conditions:

$$C_t^H = w_t L_t^H + \frac{z_t}{1-\mu}$$
$$\chi^H \left(L_t^H\right)^{\eta} = \left(C_t^H\right)^{-\sigma} w_t$$

The Ricardian household problem becomes:

$$\max_{\{C_t^S,\, A_t,\, M_t,\, L_t^S\}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{\left(C_t^S\right)^{1-\sigma} - 1}{1-\sigma} - \chi^S \frac{\left(L_t^S\right)^{1+\eta}}{1+\eta} + \psi_m \frac{M_t^{1-\xi} - 1}{1-\xi} \right) \right]$$

subject to the following real flow budget constraint:

$$C_t^S + \frac{A_t}{\mu} + \frac{M_t}{\mu} + \frac{T_t}{\mu} = w_t L_t^S + (1+i_{t-1})\Pi_t^{-1} \frac{A_{t-1}}{\mu} + \Pi_t^{-1} \frac{M_{t-1}}{\mu} + \frac{Div_t}{\mu}$$

where C_t^S and L_t^s denote Ricardian consumption and labor, respectively. The optimality conditions are the same as in the representative agent stylized model. Aggregation requires two additional equations:

$$C_t = \mu C_t^S + (1-\mu) C_t^H$$
$$L_t = \mu L_t^S + (1-\mu) L_t^H$$

The real government budget constraint becomes:

$$b_t^x x_t + T_t + M_t = G_t + z_t + (1 + i_{t-1})\Pi_t^{-1} b_{t-1}^x x_{t-1} + \Pi_t^{-1} M_{t-1}$$

The resulting impulse response functions to a government debt shock with transfers, z_t, serving as the government budget constraint residual are in figure A14. The shock now acts as a transfer shock in the standard two-agent setup. Output, inflation, and the nominal rate all increase.

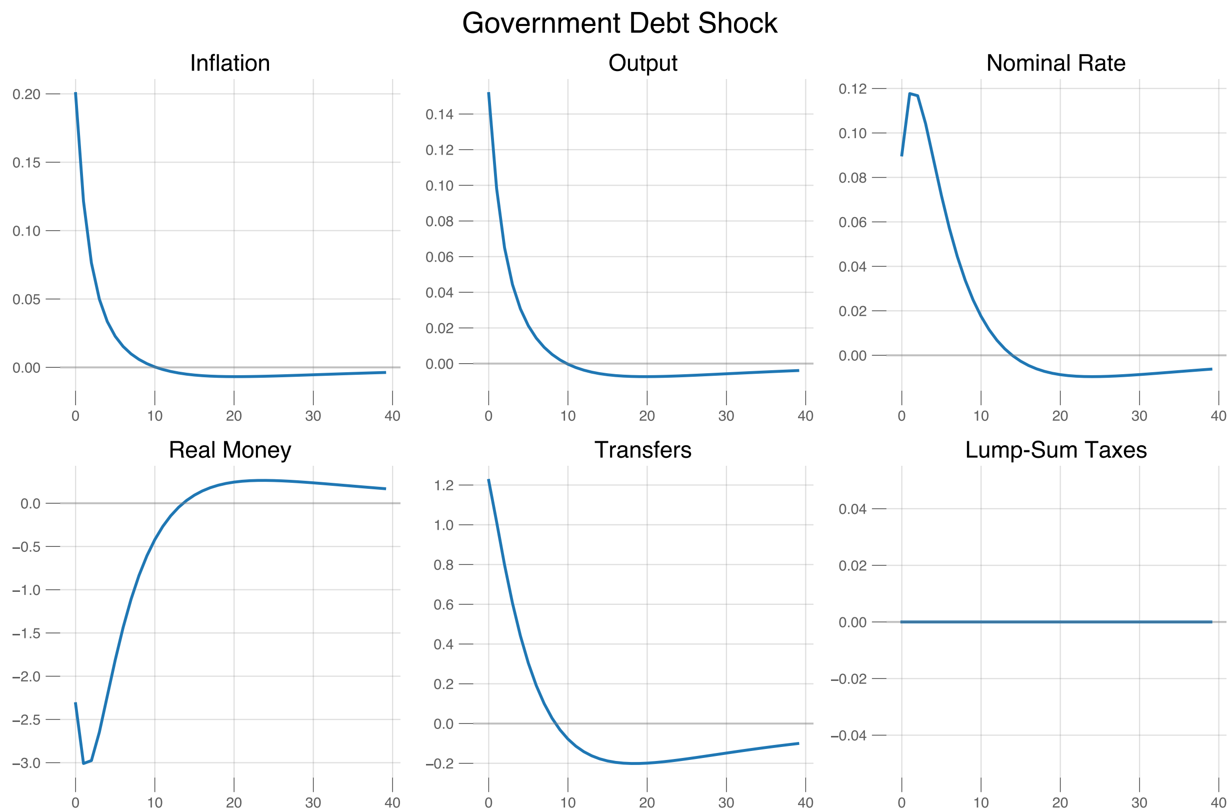


Figure A16: Impulse response functions to a 1% debt shock for the monetary dominance economy where lump-sum transfers to the hand-to-mouth household move to satisfy the government budget constraint.

A10 Equilibrium Conditions

Below are the equilibrium conditions for the quantitative model:

$$(1+\tau^c)\lambda_t = (C_t - hC_{t-1})^{-\sigma} - \beta h \mathbb{E}_t\left[\delta_{t+1}(C_{t+1} - hC_t)^{-\sigma}\right] \tag{A1}$$

$$Q_t\lambda_t = \beta \mathbb{E}\left[\delta_{t+1}(1+\rho Q_{t+1})\Pi_{t+1}^{-1}\lambda_{t+1}\right] \tag{A2}$$

$$\psi_m M_t^{-\xi} = \lambda_t \frac{i_t - i_t^{oc}}{1+i_t} \tag{A3}$$

$$\Lambda_t = \delta_t \beta \frac{\lambda_t}{\lambda_{t-1}} \tag{A4}$$

$$\tilde{p}_t = \frac{\psi_p}{1+\psi_p} + \frac{1}{1+\psi_p}\left(\lambda_t^p\right)^{\frac{(1+\theta_t^p)(1+\psi_p)}{\theta_t^p}}\left(v_t^{p,1}\right)^{\frac{-(1+\theta_t^p)(1+\psi_p)}{\theta_t^p}} \tag{A5}$$

$$v_t^{p,1} = \left[(1-\phi_c^p)(p_t^*)^{\frac{-(1+\theta_t^p)(1+\psi_p)}{\theta_t^p}} + \phi_c^p\left(\Pi_t^{-1}v_{t-1}^{p,1}\right)^{\frac{-(1+\theta_t^p)(1+\psi_p)}{\theta_t^p}}\right]^{\frac{-\theta_t^p}{(1+\theta_t^p)(1+\psi_p)}} \tag{A6}$$

$$v_t^{p,2} = (1-\phi_c^p)p_t^* + \phi_c^p\Pi_t^{-1}v_{t-1}^{p,2} \tag{A7}$$

$$v_t^{p,3} = \left[(1-\phi_c^p)\left(p_t^*\right)^{\frac{-(1+\psi_p+\psi_p\theta_t^p)}{\theta_t^p}} + \phi_c^p\left(\Pi_t^{-1}v_{t-1}^{p,3}\right)^{\frac{-(1+\psi_p+\psi_p\theta_t^p)}{\theta_t^p}}\right]^{\frac{-\theta_t^p}{1+\psi_p+\psi_p\theta_t^p}} \tag{A8}$$

$$\lambda_t^p = v_t^{p,3} \tag{A9}$$

$$\lambda_t^p = 1 + \psi_p - \psi_p v_t^{p,2} \tag{A10}$$

$$S_t^p = \frac{(1+\theta_t^p)(1+\psi_p)}{1+\psi_p+\theta_t^p\psi_p}\lambda_t Y_t p_t^m\left(\lambda_t^p\right)^{\frac{1+\theta_t^p}{\theta_t^p(1+\psi_p)}} + \phi_c^p\beta\mathbb{E}_t\left[\delta_{t+1}\Pi_{t+1}^{\frac{(1+\theta_t^p)(1+\psi_p)}{\theta_t^p}}S_{t+1}^p\right] \tag{A11}$$

$$F_t^p = \lambda_t Y_t\left(\lambda_t^p\right)^{\frac{(1+\theta_t^p)(1+\psi_p)}{\theta_t^p}} + \phi_c^p\beta\mathbb{E}_t\left[\delta_{t+1}\Pi_{t+1}^{\frac{1+\psi_p+\psi_p\theta_t^p}{\theta_t^p}}F_{t+1}^p\right] \tag{A12}$$

$$A_t^p = \frac{\psi_p\theta_t^p}{1+\psi_p+\psi_p * \theta_t^p}Y_t\lambda_t + \phi_c^p\beta\mathbb{E}_t\left[\delta_{t+1}\Pi_{t+1}^{-1}A_{t+1}^p\right] \tag{A13}$$

$$S_t^p = F_t^p p_t^* - A_t^p\left(p_t^*\right)^{\frac{1+(1+\psi_p)(1+\theta_t^p)}{\theta_t^p}} \tag{A14}$$

$$w_t = (1-\alpha)p_t^m Z_t K_{t-1}^{\alpha}(L_t^d)^{-\alpha} \tag{A15}$$

$$Y_t^m = Z_t K_{t-1}^{\alpha}(L_t^d)^{1-\alpha} \tag{A16}$$

$$Y_t = \frac{Y_t^m}{p_t^*} \tag{A17}$$

$$1 = p_t^k(1+\varepsilon_t^x)\left(1 - \frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - \kappa\left(\frac{I_t}{I_{t-1}} - 1\right)\left(\frac{I_t}{I_{t-1}}\right)\right) + \mathbb{E}_t\left[(1+\varepsilon_{t+1}^x)\Lambda_{t+1}p_{t+1}^k\kappa\left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right] \tag{A18}$$

$$q_t = \mathbb{E}_t\left[\Lambda_{t+1}\left(\alpha p_{t+1}^m Z_{t+1} K_t^{\alpha-1}(L_{t+1}^d)^{1-\alpha} + q_{t+1}(1-\delta)\right)\right] \tag{A19}$$

$$K_t = \hat{I}_t + (1-\delta)K_{t-1} \tag{A20}$$

$$\hat{I}_t = (1+\varepsilon_t^x)\left[1 - \frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right] I_t \tag{A21}$$

$$\Pi_t^w = \frac{w_t}{w_{t-1}}\Pi_t \tag{A22}$$

$$mrs_t = \chi/\lambda_t \tag{A23}$$

$$\tilde{w}_t = \frac{\psi_w}{1+\psi_w} + \frac{1}{1+\psi_w}\left(\lambda_t^w\right)^{\frac{(1+\theta_t^w)(1+\psi_w)}{\theta_t^w}}\left(v_t^{w,1}\right)^{\frac{-(1+\theta_t^w)(1+\psi_w)}{\theta_t^w}} \tag{A24}$$

$$v_t^{w,1} = \left[(1-\phi_c^w)\left(w_t^*\right)^{\frac{-(1+\theta_t^w)(1+\psi_w)}{\theta_t^w}} + \phi_c^w\left(\frac{v_{t-1}^{w,1}}{\Pi_t^w}\right)^{\frac{-(1+\theta_t^w)(1+\psi_w)}{\theta_t^w}}\right]^{\frac{-\theta_t^w}{(1+\theta_t^w)(1+\psi_w)}} \tag{A25}$$

$$v_t^{w,2} = (1-\phi_c^w)w_t^* + \phi_c^w\frac{v_{t-1}^{w,2}}{\Pi_t^w} \tag{A26}$$

$$v_t^{w,3} = \left[(1-\phi_c^w)\left(w_t^*\right)^{\frac{-(1+\psi_w+\psi_w\theta_t^w)}{\theta_t^w}} + \phi_c^w\left(\frac{v_{t-1}^{w,3}}{\Pi_t^w}\right)^{\frac{-(1+\psi_w+\psi_w\theta_t^w)}{\theta_t^w}}\right]^{\frac{-\theta_t^w}{1+\psi_w+\psi_w\theta_t^w}} \tag{A27}$$

$$\lambda_t^w = v_t^{w,3} \tag{A28}$$

$$\lambda_t^w = 1 + \psi_w - \psi_w v_t^{w,2} \tag{A29}$$

$$S_t^w = \frac{(1+\theta_t^w)(1+\psi_w)}{1+\psi_w+\psi_w\theta_t^w}\lambda_t L_t \tilde{w}_t^{-1} mrs_t\left(\lambda_t^w\right)^{\frac{(1+\theta_t^w)(1+\psi_w)}{\theta_t^w}} + \phi_c^w\beta\mathbb{E}_t\left[\delta_{t+1}\left(\Pi_{t+1}^w\right)^{\frac{(1+\theta_t^w)(1+\psi_w)}{\theta_t^w}} S_{t+1}^w\right] \tag{A30}$$

$$F_t^w = \lambda_t L_t \frac{w_t}{\tilde{w}_t} \left(\lambda_t^w\right)^{\frac{(1+\theta_t^w)(1+\psi_w)}{\theta_t^w}} + \phi_c^w \beta \mathbb{E}_t \left[\delta_{t+1} \left(\Pi_t^w\right)^{\frac{1+\psi_w+\psi_w\theta_t^w}{\theta_t^w}} F_{t+1}^w \right] \tag{A31}$$

$$A_t^w = \frac{\psi_w \theta_t^w}{1+\psi_w+\psi_w\theta_t^w} \lambda_t L_t \frac{w_t}{\tilde{w}_t} + \phi_c^w \beta \mathbb{E}_t \left[\delta_{t+1} \left(\Pi_{t+1}^w\right)^{-1} A_{t+1}^w \right] \tag{A32}$$

$$S_t^w = F_t^w w_t^* - A_t^w \left(w_t^*\right)^{\frac{1+(1+\psi_w)(1+\theta_t^w)}{\theta_t^w}} \tag{A33}$$

$$L_t^d = \frac{L_t}{\tilde{w}_t} \tag{A34}$$

$$\begin{aligned}(1+\rho Q_t) b_{t-1}^x x_{t-1} \Pi_t^{-1} + G_t + \left(1+i_{t-1}^{oc}\right) \Pi_t^{-1} M_{t-1} = \\ \tau_t^\ell w_t L_t + \tau^c C_t + Q_t b_t^x x_t + M_t + T_t\end{aligned} \tag{A35}$$

$$x_t = x_{t-1}^{\rho_x} \Pi_t^{-1} \tag{A36}$$

$$b_t = b_t^x x_t \tag{A37}$$

$$i_t = \frac{\mathbb{E}_t[1+\rho Q_{t+1}]}{Q_t} - 1 \tag{A38}$$

$$\begin{aligned}\ln(b_t^x) = (1-\rho_b)\ln(b_{ss}^x) + \rho_b \ln(b_{t-1}^x) + \gamma_g \left[\ln(G_{t-1}) - \ln(G_{ss})\right] + \\ \gamma_g \left[\ln(TR_{t-1}) - \ln(TR_{ss})\right] + \varepsilon_t^b\end{aligned} \tag{A39}$$

$$TR_t = T + \tau_t^\ell w_t L_t + \tau^C C_t \tag{A40}$$

$$i_t^{oc} = (1-\rho_r) i_{ss}^{oc} + \rho_r i_{t-1}^{oc} + (1-\rho_r)\phi_\pi \ln(\Pi_t) + \varepsilon_t^m \tag{A41}$$

$$\delta_t - 1 = \rho_d(\delta_{t-1} - 1) + \varepsilon_t^d \tag{A42}$$

$$\ln(Z_t) = \rho_z \ln(Z_{t-1}) + \varepsilon_t^z \tag{A43}$$

$$\ln(G_t) = (1-\rho_g)\ln(G_{ss}) + \rho_g \ln(G_{t-1}) + \varepsilon_t^g \tag{A44}$$

$$\theta_t^w = (1-\rho_w)\theta_{ss}^w + \rho_w \theta_{t-1}^w + \varepsilon_t^w \tag{A45}$$

$$\theta_t^p = (1-\rho_{cp})\theta_{ss}^p + \rho_{cp} \theta_{t-1}^p + \varepsilon_t^p \tag{A46}$$

I allow ε_t^b, ε_t^i, and ε_t^m to follow AR(1) processes. I also use the identities $\phi^w = 1 + \theta^w$ and $\phi^p = 1 + \theta^p$, where θ^w is the net wage markup and θ^p is the net price markup.

A11 Calibration and Estimation

Table A3 displays all the parameters estimated in the fiscal dominance model.

Table A3

Estimated Parameter Values – Fiscal Dominance

		Prior			Posterior		
Parameter	**Description**	**Mean**	**SD**	**Distr.**	**Median**	**5%**	**95%**
h	Habit	0.600	0.050	Beta	0.6952	0.6317	0.7535
σ	Inverse EIS (C_t)	1.500	0.100	Normal	1.5837	1.4269	1.7186
ξ	Inverse EIS (M_t)	5.000	1.000	Normal	5.7078	4.3057	6.9095
α	Capital share	0.333	0.050	Normal	0.3176	0.2850	0.3549
κ_I	I adj. cost	0.500	0.200	Normal	1.3132	1.1260	1.4919
ϕ_c^p	Price stickiness	0.800	0.020	Beta	0.7921	0.7559	0.8285
ϕ_c^w	Wage stickiness	0.800	0.020	Beta	0.7773	0.7518	0.8033
γ_g	Debt to G	0.500	0.050	Beta	0.3015	0.2360	0.3686
γ_T	Debt to TR	0.500	0.200	Beta	0.0602	0.0252	0.1012
ρ_r	Taylor smoothing	0.750	0.050	Beta	0.5909	0.4900	0.6801
ϕ_π	Taylor rule to Π	0.500	0.150	Beta	0.5742	0.4229	0.7285
ρ_b	Persistence in b	0.850	0.015	Beta	0.8739	0.8518	0.8950
Shock Standard Deviations							
σ_z	TFP	0.050	0.100	Inv. Gam.	0.0059	0.0053	0.0066
σ_{cp}	Cost-push	0.010	0.100	Inv. Gam.	0.0282	0.0158	0.0590
σ_w	Wage-markup	0.010	0.100	Inv. Gam.	0.0097	0.0036	0.0382
σ_d	Preference	0.050	0.100	Inv. Gam.	0.0110	0.0087	0.0143
σ_g	Gov. spending	0.050	0.100	Inv. Gam.	0.0070	0.0060	0.0082
σ_I	Investment	0.050	0.100	Inv. Gam.	0.0105	0.0087	0.0126
σ_b	Debt	0.025	0.100	Inv. Gam.	0.0026	0.0023	0.0029
σ_τ	Income Tax	0.010	0.100	Inv. Gam.	0.0022	0.0018	0.0027
σ_m	Monetary policy	0.025	0.100	Inv. Gam.	0.0051	0.0040	0.0066
Shock Persistence Parameters							
ρ_z	TFP	0.900	0.050	Beta	0.9682	0.9518	0.9795
ρ_{cp}	Cost-push	0.800	0.100	Beta	0.9553	0.9292	0.9731
ρ_w	Wage markup	0.800	0.100	Beta	0.8375	0.7861	0.8884
ρ_d	Preference	0.800	0.050	Beta	0.6385	0.5700	0.6974
ρ_g	Gov. spending	0.800	0.100	Beta	0.8655	0.8156	0.9078
ρ_i	Investment	0.800	0.100	Beta	0.8251	0.7469	0.8925
ρ_τ	Labor tax	0.800	0.100	Beta	0.7962	0.7285	0.8649
ρ_m	Money	0.250	0.100	Beta	0.1056	0.0493	0.1757
Measurement Error							
M	Money growth	0.005	0.001	Inv. Gam.	0.0051	0.0040	0.0063
B	Debt	0.005	0.001	Inv. Gam.	0.0160	0.0147	0.0175
TR	Tax revenue	0.005	0.001	Inv. Gam.	0.0206	0.0191	0.0224
Π	Inflation	0.005	0.001	Inv. Gam.	0.0031	0.0027	0.0034
w	Wages	0.005	0.001	Inv. Gam.	0.0040	0.0036	0.0043
Y	Output	0.005	0.001	Inv. Gam.	0.0055	0.0049	0.0061
C	Consumption	0.005	0.001	Inv. Gam.	0.0053	0.0047	0.0058
I	Investment	0.005	0.001	Inv. Gam.	0.0070	0.0053	0.0086
L	Hours	0.005	0.001	Inv. Gam.	0.0035	0.0029	0.0042

Table A4 displays all the parameters estimated in the monetary dominance model. There are a few points worth elaborating. First, I find very low price stickiness. This is a direct result of imposing the Kimball real rigidities parameters which flatten the Phillips curve. If the Phillips curve becomes too flat, the monetary authority must act unrealistically strongly to satisfy Blanchard-Kahn conditions. Second, I do not include measurement error in the monetary dominance estimation to facilitate comparison with benchmark estimation like in Smets & Wouters (2007).

Table A4

Estimated Parameter Values – Monetary Dominance

		Prior			Posterior		
Parameter	**Description**	**Mean**	**SD**	**Distr.**	**Median**	**5%**	**95%**
h	Habit	0.600	0.050	Beta	0.5994	0.5490	0.6460
σ	Inverse EIS (C_t)	1.500	0.100	Normal	1.5949	1.4439	1.7316
κ_I	I adj. costs	0.500	0.200	Normal	1.4245	1.2049	1.6528
α	Capital share	0.333	0.050	Normal	0.4253	0.3891	0.4640
ϕ_c^p	Price stickiness	0.500	0.100	Beta	0.2015	0.1643	0.2441
ϕ_c^w	Wage stickiness	0.500	0.100	Beta	0.8196	0.7499	0.8551
ϕ_π	i^{oc} Weight on Π	2.000	0.050	Normal	1.9978	1.9183	2.0719
ρ_r	i^{oc} persistence	0.750	0.050	Beta	0.6518	0.6075	0.6907
Shock Standard Deviations							
σ_d	preference	0.050	0.100	Inv. Gam.	0.0140	0.0108	0.0191
σ_g	G	0.050	0.100	Inv. Gam.	0.0263	0.0241	0.0288
σ_{cp}	cost-push	0.010	0.100	Inv. Gam.	0.0132	0.0115	0.0156
σ_m	monetary policy	0.001	0.100	Inv. Gam.	0.0058	0.0052	0.0063
σ_z	TFP	0.050	0.100	Inv. Gam.	0.0075	0.0069	0.0082
σ_w	w markup	0.010	0.100	Inv. Gam.	0.1402	0.0732	0.2270
σ_i	I	0.050	0.100	Inv. Gam.	0.0218	0.0193	0.0248
Shock Persistence Parameters							
ρ_d	preference	0.800	0.050	Beta	0.6518	0.5938	0.7077
ρ_g	G	0.800	0.100	Beta	0.9029	0.8634	0.9354
ρ_{cp}	cost-push	0.800	0.100	Beta	0.9503	0.9273	0.9692
ρ_m	monetary policy	0.250	0.100	Beta	0.0637	0.0277	0.1173
ρ_z	TFP	0.900	0.050	Beta	0.9761	0.9680	0.9829
ρ_w	w markup	0.800	0.100	Beta	0.8261	0.7747	0.8745
ρ_i	I	0.800	0.100	Beta	0.8907	0.8510	0.9237

Calibration

Table A5 displays the calibrated values I impose in the model.

Table A5
Calibrated Values

Parameter	Description	Target
Π_{ss}	Trend inflation	1.00
i^{oc}_{ss}	Steady-state Policy Rate	0.005
i_{ss}	Steady-state long-term rate	$i^{oc}_{ss} + \frac{0.016}{4}$
L_{ss}	Steady-State Labor	1.00
β	Discount Factor	$\frac{1}{1+i_{ss}}$
ρ	Maturity of Debt	20 quarters
χ	Labor disutility	$mrs_{ss}\lambda_{ss}$
ψ_m	Money utility	$\lambda_{ss} M^{\xi}_{ss} \frac{i_{ss}-i^{oc}_{ss}}{1+i_{ss}}$
τ^c	Consumption tax	0.06
τ^{ℓ}_{SS}	Steady-state income tax	0.20
G_{ss}	Steady-state G	$\frac{G_{ss}}{Y_{ss}} = 0.20$
M_{ss}	Steady-state M	$\frac{M_{ss}}{Y_{ss}} = 0.20$
b_{ss}	Steady-state b	$\frac{Q_{ss}b_{ss}}{Y_{ss}} = 0.9$ p.a.
ρ_{ε_b}	Debt shock persistence	0.5
δ	Constant depreciation	0.05/4
ψ_p	Kimball price curvature	-12.2
ψ_w	Kimball wage curvature	-6
θ^p_{ss}	Net price markup	0.1
θ^w_{ss}	Net wage markup	0.1

A12 Full Decompositions

Figure A17 displays the full unconditional variance decompositions for each model. In general, the importance of each shock is roughly the same across the two models. The largest differences are in the importance of cost-push shocks in the fiscal model compared to the importance of wage markup and investment shocks in the monetary dominance model.

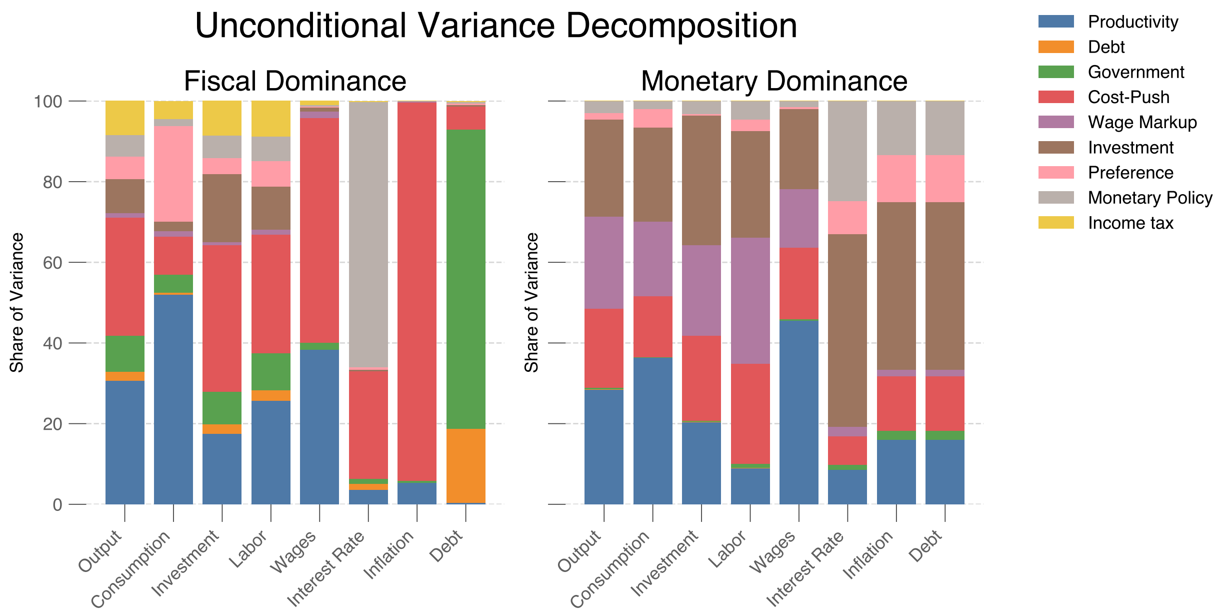


Figure A17: Full unconditional variance decomposition of both the fiscal dominance (left) and monetary dominance (right) economies. Blue – productivity. Orange – Debt. Green – Government spending. Red – Cost push. Purple – Wage markup. Brown – Investment. Pink – Preference. Gray – Monetary policy. Yellow – Income tax.

Figure A18 displays the full historical decompositions for each model. The monetary dominance model gives more importance to investment shocks, especially in driving inflation, whereas the fiscal dominance model places a high emphasis on cost-push shocks.

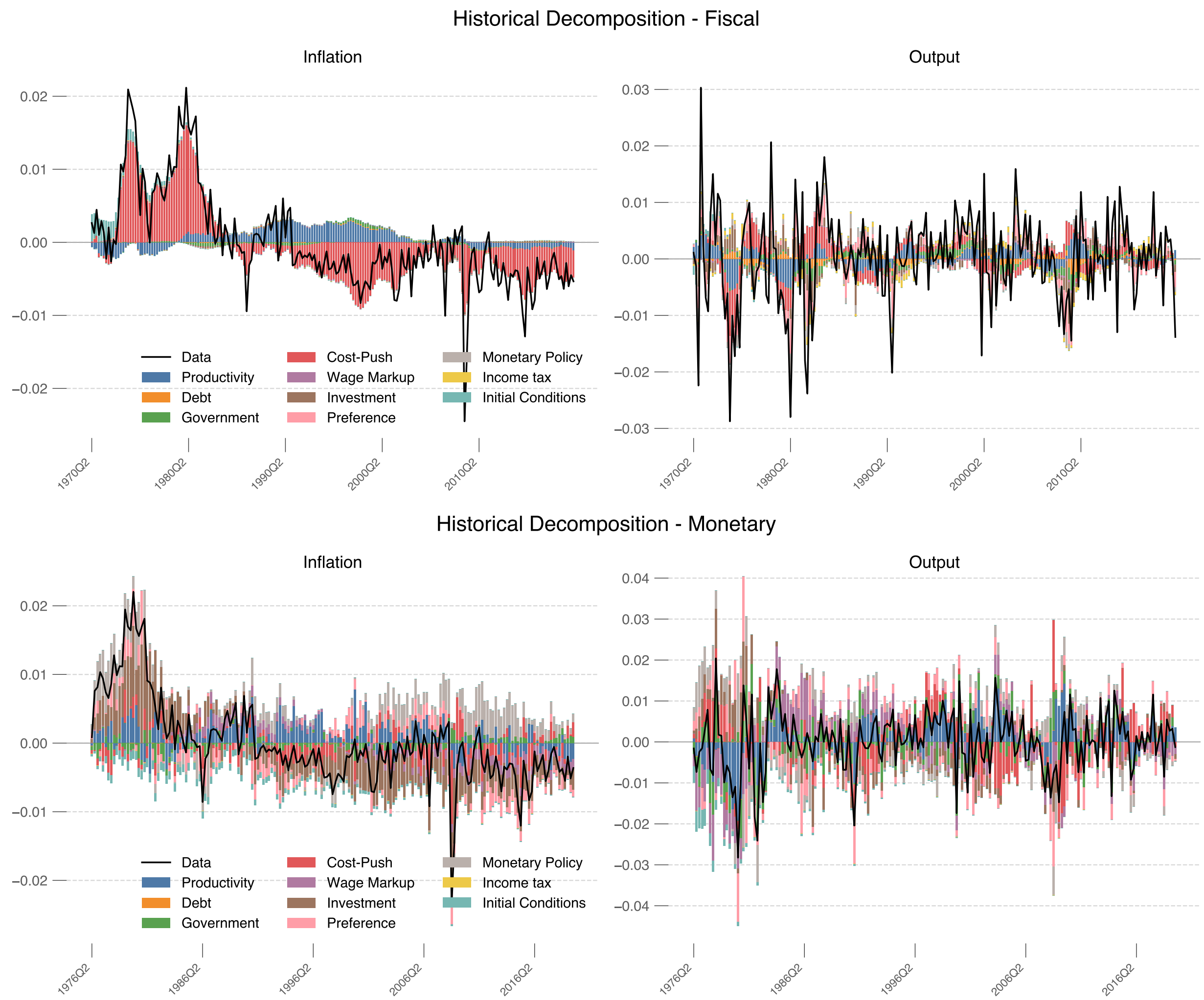


Figure A18: Full unconditional historical decomposition of both the fiscal dominance (top) and monetary dominance (bottom) economies. Blue – productivity. Orange – Debt. Green – Government spending. Red – Cost push. Purple – Wage markup. Brown – Investment. Pink – Preference. Gray – Monetary policy. Yellow – Income tax.