Treasury Supply Shocks: Propagation Through Debt Expansion and Maturity Adjustment *

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Abstract

Historically high debt-to-GDP levels in the U.S. have raised concerns about future financial market stability and fiscal sustainability. We use high-frequency data to identify debt supply shocks by considering Treasury futures price changes within narrow windows around auction announcements. We identify two distinct Treasury supply shocks: debt volume shocks that capture changes in the level of public debt, and maturity adjustment shocks that reflect changes in the maturity structure. We find that debt expansion shocks raise yields across the curve by increasing term premia and lowering the convenience yield of Treasuries, leading to tighter financial conditions. These shocks crowd out private sector activity by reducing investment and production, particularly during periods of rapid debt growth. In contrast, maturity extension shocks steepen the yield curve while easing credit and fiscal risks. By increasing the supply of long-duration safe assets and lowering the excess bond premium, these shocks stimulate near-term investment and production, while increases in long-term borrowing costs weigh on longer-term investment. We also show that the Treasury debt management policy can meaningfully interact with the Federal Reserve's asset purchase programs.

JEL Classification: E44, E63, H63

Keywords: Treasury supply shocks, debt maturity, term premium

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1 Introduction

U.S. federal debt has risen to historically high levels, fueling concerns about fiscal sustainability and financial market stability. Jerome Powell, Chair of the Federal Reserve, has noted that while debt is not yet unsustainable, it is on an unsustainable path. Elevated debt burdens can raise borrowing costs and crowd out private investment, yet Treasury securities also serve as the world's preeminent safe and liquid asset. These dual roles highlight that the macro-financial effects of Treasury issuance depend not only on the amount of debt but also on its maturity structure. Short- and long-term securities provide different safety and liquidity services, and their issuance decisions can carry informational content about fiscal risks. Overall, this suggests potentially distinct channels through which Treasury issuance and its maturity structure can impact the financial market and the economy at large.

In this paper, we employ a high-frequency identification strategy that uses Treasury futures price movements within narrow windows around Treasury auction announcements to examine how Treasury supply shocks affect financial and macroeconomic conditions. A key innovation of our analysis is to distinguish between two types of Treasury supply shocks, those that capture changes in the overall level of public debt and those that reflect adjustments in the maturity structure of issuance. We show that both types of shocks have significant and persistent effects on financial conditions and borrowing costs, which in turn translate into substantial macroeconomic effects on investment and industrial production. These dynamics operate primarily through the crowding-out, safe-asset, and at times signaling channels. Importantly, the relative strength of these mechanisms differs sharply across the two shocks: the crowding-out channel dominates in response to debt expansion shocks, particularly during periods of rapid debt growth such as the one the U.S. is currently experiencing, whereas the safe-asset channel is more prominent for longer-term securities and plays a central role in the transmission of maturity adjustment shocks. Finally, we demonstrate that Treasury maturity adjustments can meaningfully interact with the Federal Reserve's asset purchase programs, as both influence long-term yields and broader financial conditions.

We leverage the strategy of Phillot (2025) to identify Treasury supply shocks. Despite the routine and predictable nature of Treasury auctions, announcements about upcoming auctions may convey new information about the size and maturity structure of Treasury issuance. We use Treasury futures contracts, which provide a near-instantaneous measure of market reactions to Treasury market, to isolate futures price movements across different maturities within a short window around Treasury auction announcements, for a time period spanning October, 1998 and February, 2025. We use a factor model and identify two distinct types of supply shocks: debt volume shocks and maturity adjustment shocks. These components each reflect distinct aspects of government debt management and have different implications for financial markets and macroeconomic conditions.

First, debt expansion shocks tend to tighten financial conditions and dampen economic activity through the crowding out channel. Unexpected increases in Treasury issuance raise yields and term premia across all maturities, generating a broad tightening of financial conditions. A Treasury supply shock that leads to a surprise increase in net issuance of notes and bonds of $1 billion

increases the 10-year Treasury yield by 0.7 basis point on impact and 1.4 basis points at the peak, with a large fraction of it driven by the 10-year term premium, that rises by about 1 basis point at the peak. Treasury convenience yields decline, indicating a reduction in the scarcity value of safe assets. Corporate bond markets respond with higher yields and wider spreads, especially between BAA and AAA-rated bonds, reflecting more elevated credit risks. Those responses are particularly strong during high-debt growth periods. While the safe asset channel posits that greater supply of Treasuries should lower credit risks, our findings suggest this channel plays only a limited role in the response to debt expansion shocks, especially during high-debt growth periods when concerns over fiscal sustainability may undermine the perceived safety of additional Treasury supply. Instead, the crowding-out channel prevails. Higher Treasury yields raise borrowing costs for firms and households, leading to reductions in investment, production, and consumption. The contraction is most severe for construction activity, which is especially sensitive to long-term interest rates.

Second, maturity adjustment shocks influence financial and macroeconomic outcomes through a combination of safe asset, crowding-out and signaling channels, with their relative strength depending on the direction of the maturity shift. First, a maturity extension shock, that shifts issuance toward longer-term securities, raises long-term yields and steepens the yield curve. Business loans and construction spending see a sustained decline, consistent with the crowding-out channel, due to higher long term yields. However, a greater supply of longer-term Treasuries also reduces credit risks with lower excess bond premium. The easing credit conditions support economic activity, leading to sustained gains in short-horizon investment such as equipment spending and industrial production. In addition, the shift toward longer maturities reduces debt rollover risk and, thus, fiscal policy uncertainty, further reinforcing the safe asset channel in the financial system. Maturity extension shocks are also interpreted by the markets as confidence signals, dampening concern about rollover risk, so they tend to raise expected future short rates without a rise in risk premia. Second, maturity compression shocks, which tilt issuance toward shorter-term bills, are read by the markets as signals of fiscal stress as they lead to a fall in stock prices and a rise in uncertainty, consistent with governments relying on short-term financing under strain. But these effects are dominated by a crowding-in channel, through which maturity compression shocks reduce long-term yields, ease borrowing costs and boost construction and broader investment.

The contrast between maturity extension and compression shocks highlights an asymmetry in the transmission of maturity adjustment shocks: maturity extension shocks propagate primarily through the safe asset channel, while maturity compression shocks lead to expansionary effects mainly through lower long-term yields. These distinctions underscore that changes in the maturity structure of debt issuance can shape the balance between risk absorption and crowding-out, with important macro-financial consequences.

We also document that the impact of Treasury supply shocks depends on the fiscal stance. When government debt-to-GDP ratios are relatively stable, announcements on the size and maturity of Treasury issuance have muted impact on financial markets and the macroeconomy. This is consistent with Treasury's switch to "regular and predictable" debt management strategy after

1982 to minimize market disruptions, see Garbade (2007b). However, during periods of rapid debt growth when concerns about fiscal sustainability are heightened, Treasury supply shocks have important implications for financial markets and the broad economy. The effects of debt expansion shocks intensify as the crowding-out channel dominates: Treasury yields and term premia rise more persistently, credit spreads widen, and private investment, especially construction, contracts sharply. At the same time, the safe asset channel weakens as markets interpret rising issuance as a signal of fiscal risk rather than a supply of safe collateral. As a result, financial conditions tighten more severely and real activity declines more substantially than in periods of stable debt growth.

The effects of maturity adjustment shocks also become more pronounced during periods of high debt growth, with both the safe asset channel and the crowding-out channel intensifying. A shift toward longer-term issuance reduces fiscal rollover risk and lowers credit spreads, improving financial conditions and supporting short-horizon investment and industrial production. However, the associated rise in long-term yields raises borrowing costs for interest-sensitive sectors like construction, which contracts more sharply. The macroeconomic responses thus reflect both greater support from reduced risk and steeper tradeoffs from tighter long-term financing.

Treasury issuance decisions also have important interactions with monetary policy, as changes in the size and maturity of debt supply can reinforce or offset the Federal Reserve's actions in shaping interest rates. Notably, we show how Treasury's issuance decisions interact with Federal Reserve policy through their maturity adjustment. Quantitative Easing (QE) by the Federal Reserve in recent years compressed long-term yields by removing duration risk from the market, but contemporaneous maturity extension by Treasury leaned in the opposite direction. We estimate that Treasury's actions offset roughly one-third of the average QE effect on long-term yields over 2008-2020. This provides direct evidence of monetary-fiscal interplay operating through the maturity structure of government debt.

Our findings carry important implications for fiscal and monetary policymakers. To sum up, we show that debt expansion shocks lead to a rise in Treasury yields, particularly through increases in the term premium. This aligns with recent studies documenting similar effects of debt expansion on yields and convenience premia, though our identification approach is distinct. One of our key contributions is to demonstrate that such Treasury supply shocks tighten financial conditions and raise borrowing costs, translating into significant macroeconomic effects with clear crowding-out implications for private investment and activity. Another major contribution of the paper is to identify maturity adjustment shocks and uncover their distinct propagation mechanisms, highlighting the importance of Treasury debt management decisions and the communication surrounding them. Lastly, we show that these maturity adjustments can either offset or amplify the effects of monetary policy, as both have the potential to shape long-term yields and broader financial conditions. Moreover, our findings take on heightened relevance in the current environment of rapid debt accumulation, as we show that in periods of rapid debt growth, Treasury's decisions over issuance volume and maturity structure exert especially strong and persistent effects on financial conditions and the broader economy. Overall, these results provide important insights in guiding discussions

on the the effects of rising debt levels and optimal debt management strategies for the Treasury.

Related literature: This paper contributes to a large literature that employs high-frequency identification (HFI) methods to obtain policy surprises from financial market reactions. In monetary policy, Kuttner (2001) pioneered the use of Fed funds futures to disentangle anticipated from unanticipated policy rate changes, and Gürkaynak, Sack, and Swanson (2005) showed that policy surprises affect both current rates and future rate expectations. More recently, HFI approach has been extended beyond monetary policy. Ray, Droste, and Gorodnichenko (2024) capture the intraday change in Treasury yields before and after the close of Treasury auctions to construct Treasury demand shocks. Gomez Cram, Kung, and Lustig (2025) exploit market responses to Congressional Budget Office's cost estimate releases to show how fiscal announcements about future revenue/expenditure plans shift Treasury yields. Similarly, Weigand (2025) documents high-frequency yield movements to fiscal policy news revealed during the budget appropriation process. Hartley and Rigon (2025) estimate the impact of surprises in the Treasury supply on yields within a short window following the Treasury's Quarterly Refunding announcements.

Phillot (2025) is the first to apply HFI to Treasury auction *announcements* and uses intraday price changes to identify Treasury supply shocks. Our paper extends Phillot (2025) by disentangling shocks to the level of debt issuance from those to its maturity structure. Joyce and Lengyel (2024) study the reaction of yields to UK government debt auction announcements and quantify the potential impact of quantitative tightening through both duration risk and local supply channels. In addition, our paper is closely related to concurrent work by Mustafi (2025), who uses heteroskedasticity-based restrictions tied to a narrative classification of announcements and finds that both volume and maturity shocks raise yields across the curve. Instead, we estimate a factor model, and the identified shocks align closely with yield curve dynamics as the volume factor resembles a level shift and the maturity factor a slope twist.[1]

This paper also relates to the broader macro-financial literature on the effects of Treasury supply. Treasury securities provide safety and liquidity services that may stimulate economic activity, as argued in Longstaff (2004), Krishnamurthy and Vissing-Jorgensen (2012b), Nagel (2016), Du, Im, and Schreger (2018), and Choi, Kirpalani, and Perez (2025) among others. Fleckenstein and Longstaff (2024) estimate Treasury convenience premia across the term structure and find that credit safety seems to play a less important role than near-money liquidity. An increase in government debt, however, can also raise interest rates and crowd out private investment, see Laubach (2009) and Cecchetti, Mohanty, and Zampolli (2011) among others. More recently, Li, Ma, and Zhao (2023), and Choi and Robatto (2024) identify the crowding out channel in banking sector, as Treasury supply crowds out bank deposits, curtails bank lending, and reduces firm investment. Vayanos and Vila (2021), Greenwood and Vayanos (2014), Greenwood, Hanson, Rudolph, and

[1]Moreover, while we both use Treasury futures for identification, Mustafi (2025) includes 3-month Eurodollar futures to capture short-term maturities. We omit these, as they reflect monetary policy expectations rather than Treasury issuance. In Mustafi (2025), the Eurodollar contract is needed to reject the one-factor hypothesis, whereas we reject it using Treasury futures alone. Finally, our sample extends through 2025, including the post-COVID period when Treasury issuance faced significant market scrutiny.

Summers (2015) all emphasized the importance of maturity structure for yield curve dynamics, with changes in the supply of long-term Treasuries affecting yields across maturities through portfolio rebalancing effects and preferred habitat models Our focus is on documenting causal effects of Treasury supply shocks, both debt volume and maturity structure, and their distinct transmission channels.

A growing macro-finance literature has developed theoretical models with rich financial and fiscal sectors to study the impact of government debt on financial markets and macroeconomy, see Nguyen (2021) and Bretscher, Hsu, and Tamoni (2020) among others. Using a general equilibrium asset pricing model, Liu, Schmid, and Yaron (2021) evaluate a fiscal risk channel that limits the safety benefits of Treasury securities, and find that the risk channel is exacerbated in times of fiscal stress. Our causal empirical analysis complements their theoretical investigations.

The remainder of this paper is structured as follows. Section 2 provides an overview of the U.S. Treasury auction process and details the high-frequency identification strategy used to measure Treasury supply shocks. Section 3 presents the effects of debt expansion shocks. Section 4 analyzes the financial and macroeconomic implications of maturity adjustment shocks. Section 5 explores heterogeneity across fiscal regimes and monetary policy stances. Finally, Section 6 concludes with a discussion of policy implications and directions for future research.

2 Method and Data

2.1 U.S. Treasury Auction Process: Institutional Details

The U.S. Treasury finances government spending and manages debt by selling Treasuries through public auctions. These securities include Treasury bills, notes, bonds, Treasury inflation-protected securities (TIPS), and floating rate notes (FRN). The Treasury aims at following a *regular* and *predictable* debt issuance policy.[2] The Treasury auction process consists of three steps:

- **Announcement:** The Treasury announces auction details, including security type, maturity, offered amounts, auction date, issue date, and, for coupon securities, the coupon rate.
- **Auction:** Investors submit competitive and noncompetitive bids. Competitive bidders (i.e., primary dealers) specify the yield they are willing to accept, while noncompetitive bidders agree to accept the yield determined at auction.
- **Issuance:** Winning primary dealers as well as noncompetitive bidders receive their securities in exchange for payment.

In this paper, we focus on the first step of announcements, and these announcements have come with a report published on the same day.

Figure 1 presents an example of a Treasury announcement for a 10-year Treasury note auction dated November 1, 2023. It discloses important details about the security being issued, including

[2]See Garbade (2007a) for a historical account of U.S. Treasury debt management policies.

Figure 1: U.S. Treasury Announcement: November 1, 2023

TREASURY NEWS

Department of the Treasury • Bureau of the Fiscal Service

Embargoed Until 08:30 A.M.
November 01, 2023

CONTACT: Treasury Auctions
202-504-3550

TREASURY OFFERING ANNOUNCEMENT [1]

Term and Type of Security	10-Year Note
Offering Amount	$40,000,000,000
Currently Outstanding	$0
CUSIP Number	91282CJJ1
Auction Date	November 08, 2023
Original Issue Date	November 15, 2023
Issue Date	November 15, 2023
Maturity Date	November 15, 2033
Dated Date	November 15, 2023
Series	F-2033
Yield	Determined at Auction
Interest Rate	Determined at Auction
Interest Payment Dates	May 15 and November 15
Accrued Interest from 11/15/2023 to 11/15/2023	None
Premium or Discount	Determined at Auction
Minimum Amount Required for STRIPS	$100
Corpus CUSIP Number	912821NP6
Additional TINT(s) Due Date(s) and	None
CUSIP Number(s)	None
Maximum Award	$14,000,000,000
Maximum Recognized Bid at a Single Yield	$14,000,000,000
NLP Reporting Threshold	$14,000,000,000
NLP Exclusion Amount	$0
Minimum Bid Amount and Multiples	$100
Competitive Bid Yield Increments [2]	0.001%
Maximum Noncompetitive Award	$10,000,000
Eligible for Holding by Treasury Retail	Yes
Estimated Amount of Maturing Coupon Securities Held by the Public	$102,174,000,000
Maturing Date	November 15, 2023
SOMA Holdings Maturing	$32,629,000,000
SOMA Amounts Included in Offering Amount	No
FIMA Amounts Included in Offering Amount [3]	Yes
Noncompetitive Closing Time	12:00 Noon ET
Competitive Closing Time	1:00 p.m. ET

the offering amount ($40 billion), auction date (November 8, 2023), issuance date (November 15, 2023), and maturity date (November 15, 2033). The announcement specifies that the yield and interest rate will be determined at auction, and it outlines bidding rules like competitive and noncompetitive bid limits, the minimum bid amount ($100), and yield increments (0.001%). It contains additional information about maturing securities, System Open Market Account (SOMA) holdings, and Foreign and International Monetary Authority (FIMA) participation.

Treasury auction announcements are made either standalone or together with the Quarterly Refunding Statement (QRS). Four times a year, the Department of the Treasury issues QRS and holds a quarterly refunding press conference to discusses Treasury marketable security auctions. This usually happens on the first Wednesday in February, May, August, and November. Through the QRS, the Treasury communicates a broad range of topics, including fiscal outlook, issuance

strategy and sizes for upcoming quarters, and factors influencing its debt management decisions. It usually gives the tentative auction schedule for the next six months.

The U.S. Treasury's primary objective, in their own words, is to minimize debt issuance costs, as interest expenses represent a significant component of the federal budget. For a given level of debt issuance, the expected relative cost of issuing at different maturities over time matters. The Treasury also aims to be "regular and predictable" in its debt issuance, which discourages an opportunistic approach to issuance.

The issuance experience, complemented by surveys of the primary dealers, informs the Treasury's view on the speed of any adjustment to auction sizes.[3] Their considerations include the fact that greater liquidity reduces Treasury's funding costs over the long-run. However, limiting the speed of issuance adjustment means the Treasury may be slow to respond to shifts in expected borrowing costs. The evolution of auction sizes, as shown in Figure A2, shows that the Treasury is cautious in changing auction size. Changes in Treasury auction sizes are rarely one-offs; instead, once the Treasury decides to alter auction sizes, it is most likely to continue changing issuance in the same direction for a consecutive period of time.

2.2 Treasury Supply Shocks: High Frequency Identification

For our identification of shocks, we rely on Treasury futures contracts. These futures contracts on U.S. Treasuries, available on the Chicago Board of Trade (CBOT) since 1977, specify a settlement price at which the buyer agrees to take delivery of eligible securities on settlement month. We focus on 2-, 5-, 10-year T-notes, and 30-year T-bonds, for which we have data available for a long enough sample. Because these futures do not bear coupon payments and are acquired for speculative or hedging purposes, they represent an ideal "synthetic" metric of expectations about Treasury prices. Figure A3 in the Appendix plots the evolution of these Treasury futures prices.

Under the efficient market hypothesis following Fama (1970), Treasury futures prices reflect market expectations about interest rates and government debt supply. As such, price movements in Treasury futures around U.S. Treasury auction announcements provide natural experiments to study market reactions to surprises in debt issuance. Auction announcements convey new information about the volume and maturity of Treasury securities, potentially differing from prior market expectations. Gürkaynak, Kisacikoğlu, and Wright (2020) show that macroeconomic news announcements are elaborate and multi-dimensional. By analyzing price changes within tight windows around these announcements, we can identify the effects of unexpected Treasury supply changes on futures prices that goes beyond the headline auction numbers.

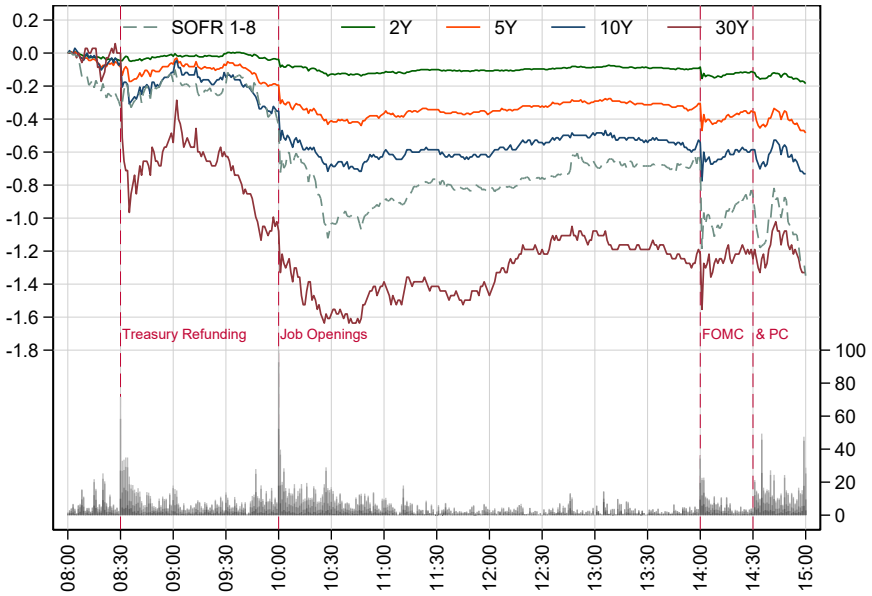
But do financial markets closely monitor U.S. Treasury auction announcements? One interesting example to address this question is the November 2023 quarterly refunding announcement, which included the offering announcement depicted in Figure 1 as part of a broader issuance plan.[4] As

[3] Section A.1 provides an overview of the primary dealer survey that the Treasury conduct prior to each Quarterly Refunding meeting.

[4] Several other studies have demonstrated that communications related to debt management policies, including the quarterly refunding announcements, significantly move markets.

reported by the Wall Street Journal, "Stocks and bonds both staged rallies last week, getting a boost when the Treasury increased the size of longer-term debt auctions by a smaller amount than many had expected".[5] The article further notes that the Treasury also indicated greater flexibility in short-term bill issuance, which investors interpreted as a shift in funding strategy.

Figure 2: Movements of Treasury Futures on November 1, 2023



Note: The solid lines represent the Treasury futures inverse price change in percentage points relative to 8:00 AM, serving as a proxy for Treasury yield movements, while the dotted lines capture shifts in monetary policy expectations through the first principal component of futures-implied SOFR rates. The vertical dotted lines mark the precise timing of four key events on that day: the Treasury quarterly refunding announcement, the release of job openings data, the FOMC policy announcement, and the subsequent press conference. The gray bars are the volumes of traded Treasury futures (right-hand scale), min-max normalized over that day.

Figure 2 provides direct evidence that Treasury auction announcements cause immediate market reactions, comparable to other major macroeconomic events. The solid lines represent the Treasury futures inverse price change in percentage points relative to 8:00 AM, serving as a proxy for Treasury yield movements, while the dotted lines capture shifts in monetary policy expectations through the first principal component of futures-implied SOFR rates. The vertical dotted lines mark the precise timing of four key events on that day: the Treasury quarterly refunding announcement, the release of job openings data, the FOMC policy announcement, and the subsequent press conference. The gray bars are the volumes of traded Treasury futures (right-hand scale), min-max normalized over that day.

The intraday dynamics reveal that the Treasury announcement led to an immediate increase in volumes and measurable shift in yields, similar in magnitude to the reactions following the macroe-

[5]Goldfarb, S. (2023, November 5). *Markets got an unexpected boost from Washington. Will it mark a turning point?* The Wall Street Journal.

conomic release and the FOMC decision. This reaction highlights how, despite the Treasury's policy framework that prioritizes regularity and predictability, deviations from market expectations have important consequences for financial conditions. We provide additional examples of different types of Treasury announcements and market movements in Figure A4 in the Appendix.

Figure 2 further underscores the importance of focusing on price changes in a narrow time window, in order to ensure that the observed movements reflect the Treasury announcement itself rather than unrelated market developments later in the day. We build on these insights and the strategy employed in Phillot (2025) for our identification of Treasury supply shocks which we describe next.

Let ΔP_t^k be the k-year Treasury futures return in a narrow time-window around announcements by the Treasury. We have:

$$\Delta P_t^k = P_t(+)^k - P_t(-)^k$$

where $P_t(-)^k$ is the log-price of the k-year Treasury futures contract just before the auction announcement at time t, and $P_t(+)^k$ is the log-price just after the announcement.[6] Note that a positive price change for maturity k implies that the supply for that maturity is lower than expected. Hence, we switch the sign of $\xi_t^k = -\Delta P_t^k$ to reflect a k-year Treasury supply surprise. We use a 30 minute window. The window selection is based on our identification assumptions that there is a fixed demand for debt securities in a short time window around the announcement. Also, we need to ensure that there is no other market-moving news during this time. We consider announcements about bonds with maturities of 2, 3, 5, 7, 10, 20 and 30-years. Our data spans October 1998-February 2025.[7]

2.3 Factor Analysis

There are two crucial dimensions in debt management strategy:

1. **Debt Volume**: Reflecting the Treasury's need for refinancing in response to time-varying deficits, which are unpredictable due to fiscal policy changes, uncertain macroeconomic conditions, and other shocks.

2. **Maturity Structure**: The Treasury's objective is to minimize debt servicing costs while balancing the risks associated with rollover. Issuing short-term debt reduces interest costs but increases refinancing risks, particularly under uncertain interest rate paths. Therefore, the choice of short-term vs. long-term issuance is discretionary and conveyed during announcements.

[6] Treasury futures traded on the Chicago Board of Trade (CBOT) reflect market expectations of future interest rates for U.S. government bonds with maturities of 2, 5, 10, and 30 years. Treasury futures are cash-settled or can be physically delivered at contract maturity, with settlement based on the price of the cheapest-to-deliver (CTD) bond in the delivery basket. They provide exposure to Treasury yields without holding the actual bonds. Log-price differentials in futures contracts reflect percentage point returns, which proxy changes in implied yields. For small windows around auction announcements, these returns capture surprises in Treasury supply. Appendix B shows that converting prices variations into CTD yield changes makes no material difference to our results.

[7] Relative to the data considered in Phillot (2025), we additionally consider announcements about bonds with 3, 7 and 20 year maturities. We also extend the sample until 2025 to include the fiscal expansion during the COVID period and subsequent years, while Phillot (2025) used data until 2020.

While each Treasury supply shock ξ_t^k obtained at high frequency reflects a supply surprise for an individual maturity, the distribution of these surprises across maturities provides insights into shifts in the expected U.S. debt maturity structure. Thus, in order to effectively capture these two dimensions, we estimate a factor model in which the observed surprises ξ_t^k are expressed as a linear combination of two latent factors $\tilde{F}_1$ and $\tilde{F}_2$:

$$\xi_t^k = \lambda_1^k \tilde{F}_1 + \lambda_2^k \tilde{F}_2 + \epsilon_t^k$$

where λ_1^k and λ_2^k are the loadings on the two factors, and ϵ_t^k is a mean-zero idiosyncratic error term.

Table 1: Factor Loadings - Volume and Maturity of Treasury Supply Shocks

Maturity k shock	Factor loading on F_1	Factor loading on F_2
ξ_t^2	0.8110	-0.2674
ξ_t^5	0.9399	-0.0777
ξ_t^{10}	0.8709	0.1398
ξ_t^{30}	0.7596	0.2620

To interpret the factors, we apply an oblique rotation, allowing for potential correlations between them. The rotation transforms the unrotated factors $\tilde{F}_1$ and $\tilde{F}_2$ into rotated factors F_1 and F_2, as follows:

$$F_1 = \mathbf{R}_{11}\tilde{F}_1 + \mathbf{R}_{12}\tilde{F}_2 \quad \text{and} \quad F_2 = \mathbf{R}_{21}\tilde{F}_1 + \mathbf{R}_{22}\tilde{F}_2$$

The rotation matrix $\mathbf{R}$ is chosen to simplify interpretation and align the factors with the economic meaning of debt volume and maturity.[8]

Table 1 presents the loadings of F_1 and F_2 on the ξ_t^k's. We find that F_1 loads positively and similarly across all ξ_t^k, reflecting an overall shift in debt volume (i.e., a parallel shift in yields due to unexpected changes in the total debt issued). Conversely, F_2 loads positively on longer maturities and negatively on shorter ones, reflecting changes in the maturity structure (i.e., a steepening or flattening of the yield curve due to shifts in the issuance of long-term vs. short-term debt).[9]

2.4 Interpreting the Factors: Debt Expansion and Maturity Extension The top panel of Figure 3 shows the first factor, F_1, which we cumulated to monthly frequency to improve readability. As indicated in the figure, the spikes coincide with major fiscal events. Notably, some of the large positive spikes coincide with fiscal expansionary events such as significantly higher borrowing needs during the Global Financial Crisis (04/2008), the Emergency Economic

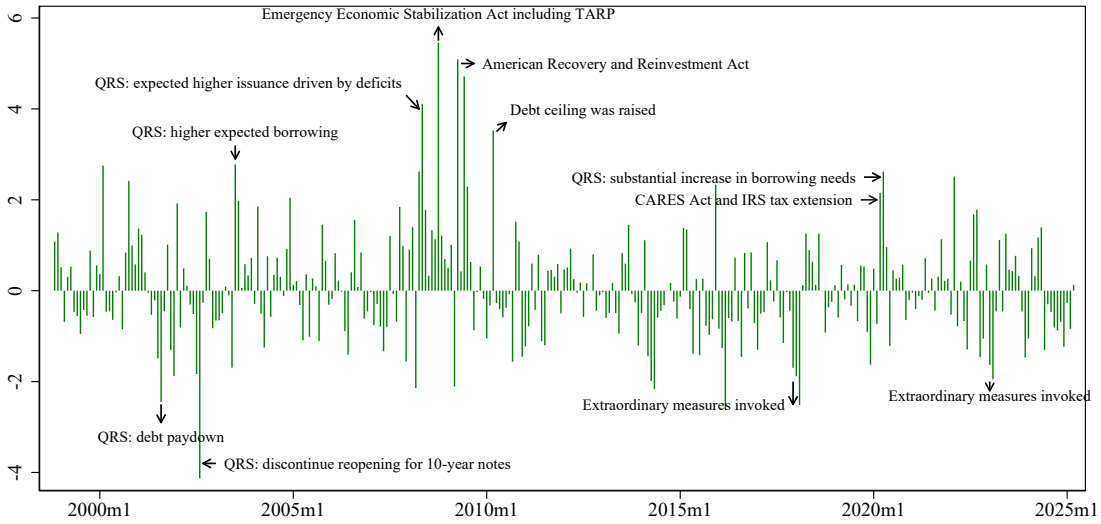
[8] We assess whether the observed variation in high-frequency futures price changes can be adequately captured by a limited number of latent by performing a Cragg and Donald (1997) rank test. The test rejects the null hypothesis of one or fewer factors, so we retain two factors. These factors jointly account for almost all of the common variation in the surprise matrix. See Appendix B for details.

[9] While we allow the factors to be correlated, they are estimated to be orthogonal, with a correlation of 0.01 which is not statistically significant. We also test the robustness of our factors to considering the first two principal components of our Treasury surprises, which have a very high correlation of 0.99 and 0.98 with our estimated first and second factors, respectively.

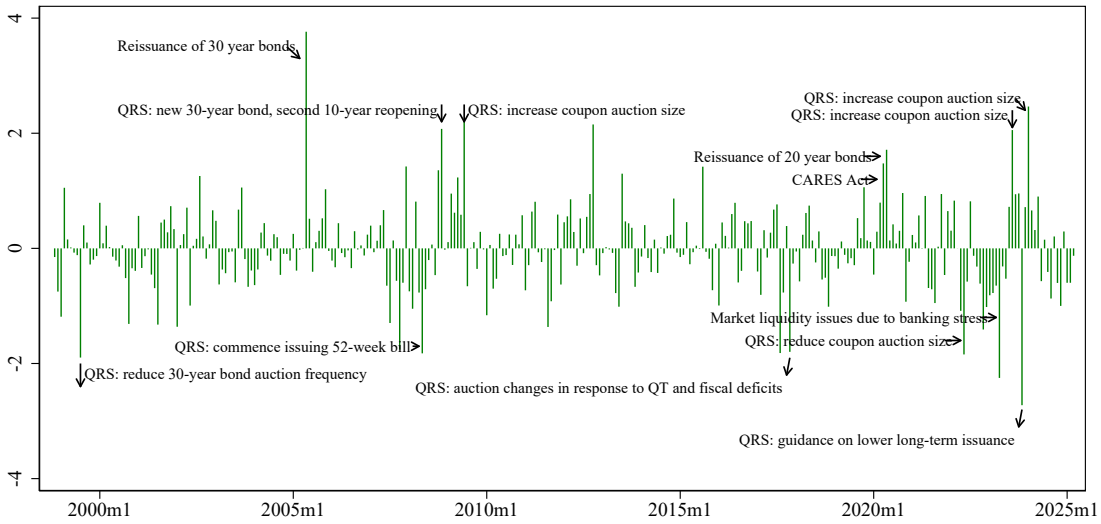
Stabilization Act (10/2008), the American Recovery and Reinvestment Act (04/2009), and the Coronavirus Aid, Relief, and Economic Security Act as well as extension of IRS tax payments (03/2020). Some of the large negative spikes coincide with fiscal contractions or a stop in fiscal expansions, such as notable debt pay down (8/2002), hitting the debt limit with extraordinary measures being used to finance the government on a temporary basis (12/2017), and similarly being subject to debt limit related constraints (01/2023 and 02/2023).

Figure 3: Narrative Events around Large Treasury Supply Shocks

a. Debt Expansion Factor



b. Maturity Extension Factor



The bottom panel of Figure 3 shows the second factor, F_2, aggregated analogously to the monthly frequency. As indicated in the figure, the spikes coincide with events of a slightly different nature, that is, those that have mainly to do with the maturity structure of the issued debt. Notably,

some of the large positive spikes coincide with events such as re-issuance of 30 year bonds (5/2005), the re-issuance of the 20 year bonds (5/2020), additional reopening of 30 year bonds (6/2009) and the announcement of an increase in long-term issuance (8/2023). Some of the large negative spikes coincide with guidance on a slower pace in long-term issuance (11/2023) and market liquidity issues due to banking stress (3/2023).

To gain further insight into what the two factors capture, Figure 4 shows the factors together with additional variables. The left-hand plot shows volume expansion shocks (green spikes) on the left-hand scale, alongside the cumulative volume shocks (grey area) and detrended debt-to-GDP (purple line, right-hand scale). Debt volume shocks series (F1) account well for the evolution of the debt supply in the U.S. between 1998 and 2024. Notably, they do a reasonably good job at capturing the large increases in public debt to GDP during the Great Recession and then during the Covid period.

The right-hand plot shows the maturity extension shocks (F2) against the (demeaned) share of long-term debt over this period, which is given by the share of notes and bonds in total marketable debt. The cumulated maturity extension shocks capture the fall in the long-term debt share in 2008-2009, and the subsequent reversal. The cumulated factor also accounts for the evolution of long-term debt share around and post-Covid period. Note that since the shocks capture news about the debt volume and maturity issuance, there is a lag between it showing up in the relevant macroeconomic series.

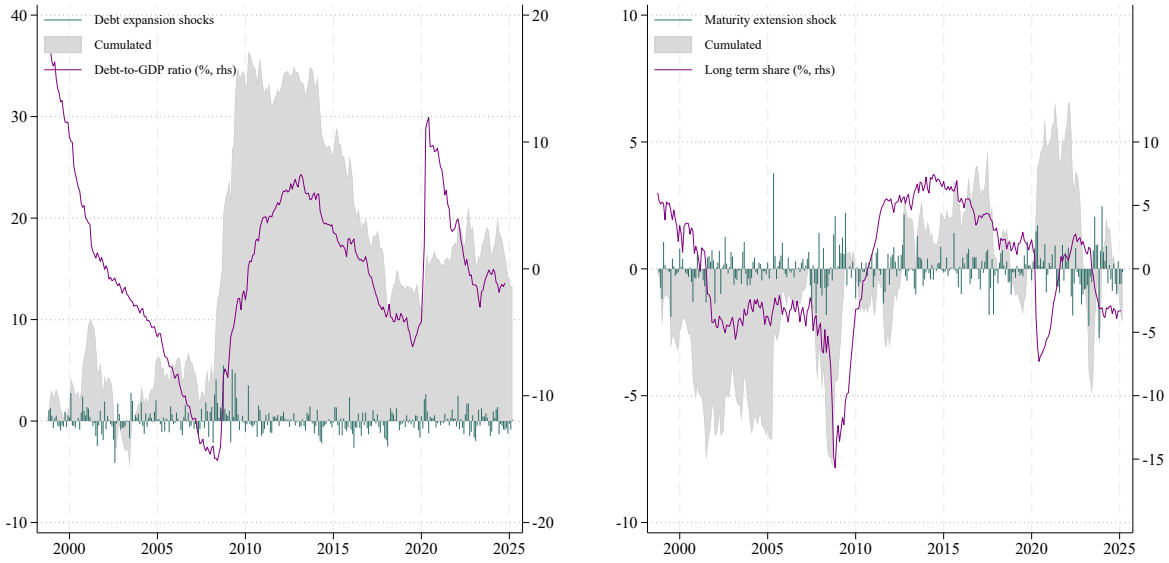
2.5 Further Validation of the Treasury Supply Shocks

In order to assess whether our Treasury supply shocks are exogenous, we consider the contemporaneous correlation of both F1 and F2 surprises with other structural shocks identified in the literature that might be related, including high frequency monetary policy shocks capturing surprises to the federal funds rates, forward guidance and LSAPs from Swanson (2023) and shocks to Treasury demand from Ray, Droste, and Gorodnichenko (2024), who capture the intraday change in Treasury yields before and after the close of a Treasury auction. We find no significant correlation with these shocks. In order to test whether these shocks are predictable, we provide further evidence that we can reject the null that financial variables Granger-cause our shocks. These exercises are shown in Appendix B.

3 Financial and Macroeconomic Effects of Treasury Supply Shocks

There are various potential mechanisms for propagation of Treasury supply shocks through the economy. Firstly, an increase in the supply of Treasury securities or change in the composition can affect the economy through a *portfolio re-balancing/ crowding-out channel*. Higher government Treasury issuance can crowd out private sector funding by raising Treasury yields and increasing excess returns across various asset classes (see Greenwood, Hanson, and Vayanos (2024), Croce, Nguyen, Raymond, and Schmid (2019), among others). The tightening of financial conditions can raise borrowing costs for the private sector. As financial intermediaries face balance sheet

Figure 4: Debt Expansion and Maturity Extension Treasury Supply Shocks



Note: The left-hand plot shows volume expansion shocks (green spikes) on the left-hand scale, alongside the cumulative volume shocks (grey area) and detrended debt-to-GDP (purple line, right-hand scale), between 1998 and 2025. Similarly, the right-hand plot shows the maturity extension shocks (green spikes) on the left-hand scale, alongside the cumulative volume shocks (grey area) against the demeaned share of long-term debt (purple line, right-hand scale) over this period over the same period.

constraints, a higher Treasury supply may crowd out business lending and reduce investment, consistent with models that incorporate financial frictions (see Gertler and Karadi (2011), among others).

On the other hand, if safety is a valued attribute of Treasury securities, a *safe asset channel* suggests that an expansion in the supply of safe assets can accommodate investors' demand, lowering liquidity premium and credit risk and potentially stimulating economic activity. The safe asset channel of Treasury supply might also be a function of the composition of the Treasury securities being issued, as long term Treasuries have stronger attributes of safety (see Krishnamurthy and Vissing-Jorgensen (2012b), among others).

Lastly, Treasury announcements about the amount and maturity structure of Treasury issuance might bring new information to bear to the markets. While short-term Treasuries may behave more like cash equivalents, long-term bonds has better hedging. If there is asymmetric information between the Treasury and the private sector in terms of government financing risks, then Treasury supply shocks might also transmit through the economy via a *signaling channel*. In addition to information about fiscal and tax risks, the maturity adjustment announcements by the Treasury might also signal concern over interest rate rollover risk, or views about the future path of the economy.

In the following subsections, we examine which of these transmission mechanisms are empirically relevant in the transmission of the two types of Treasury supply shocks we consider.

3.1 Debt Expansion Shocks

In this section, we study the impact of debt volume expansion shocks (F_1) on financial markets and the broader macroeconomy, and explore the associated transmission mechanisms.

3.1.1 Financial Market Impact of Debt Expansion Shocks: Daily Regressions

We use daily regressions to explore the effects of debt expansion shocks on financial markets.

$$y_{t+h} - y_{t-1} = \alpha_{1,h} + \beta_{1,h} F_{1,t} + \sum_{j=1}^{J} \theta_{1,h}^{j} X_{t-j} + \epsilon_{1,t+h}, \text{ for } h = 0, 1, 2, ... \tag{3.1}$$

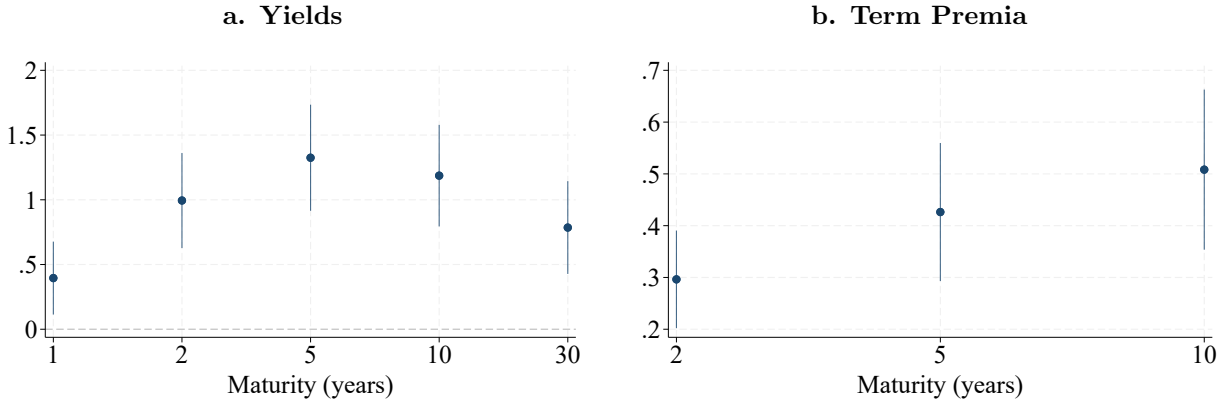
Here y_t is the financial variable of interest. F_1 is the Treasury supply shock that captures volume expansion. The coefficient $\beta_{1,h}$ represents the impulse response of the variable of interest to the shock F_1 at the horizon h. The impulse responses are constructed as a sequence of $\beta_{1,h}$'s estimated in a series of separate regressions for each horizon. In addition, we include J lags of the Treasury supply factor variable and various yields and term premia in the set of control variables, X_t, in order to account for spillovers from other financial variables. We consider $J = 1$ in our baseline specification. $\alpha_{1,h}$ is the fixed effect to control for time-invariant factors. $\varepsilon_{1,t+h}$ is an idiosyncratic error term. Because the error terms in the local projection regressions are serially correlated across horizons, we compute heteroskedasticity and autocorrelation consistent (HAC) standard errors. We run our regression for a sample period that covers October 28, 1998 to February 22, 2025.

Figure 5 shows the impact responses of yields and term premium following a debt volume expansion shock.[10] The left panel shows that Treasury yields increase across all maturities, leading to an upward shift in the yield curve. The impact on yields is hump shaped: the greatest effect is on the intermediate maturity of 5-10 year term, while the impact is smaller with both longer as well as shorter maturities. The right panel shows that higher than expected debt supply raises term premium across the curve. The longer the maturity, the higher the term premium. Term premium counts for a nontrivial share of the yield increase.

Both responses of yields and term premium are consistent with predictions from preferred-habitat models, see Greenwood, Hanson, and Vayanos (2024). The intuition is that following a supply shock, the term premium increases more for longer-term bonds because their prices are more sensitive to changes in supply, as shown in the right panel. Unless a supply shock is permanent, the risk premium is expected to decline at some point and remains elevated over only a fraction of the life of a longer-term bond. Therefore, the maximum impact is on intermediate-term Treasuries, and the impact on yields is hump-shaped.

[10] Figure C9 in the appendix provides impulse responses for a range of variables over time. The responses of yields and term premium peak at day 4, while Figure 5 highlights the impact effect immediately following the shock.

Figure 5: Impact Responses to a Debt Expansion Shock (F_1)



Note: Impact responses of yields (left) and term premia (right) with 90% confidence bands. The x-axis shows maturities and the y-axis is in terms of basis points.

In terms of magnitude, a one-standard deviation shock on Treasury issuance, which signals a surprise $1.7 billion in Treasury issuance, raises the 10-year Treasury yield by 1.2 basis point on impact and a little more than 2 basis points at peak.[11] The same shock also increases the 10-year term premium by about 0.5 basis point on impact and 1.5 basis point at the peak, counting for 40 to 75 percent of the 10-year yield increase. Figure 3 shows that the Emergency Economic Stabilization Act passed after the 2008 financial crisis represents a 5-standard deviation shock, while the higher than expected outlays around the Coronavirus Aid, Relief, and Economic Security Act in 2020 is around a 2-standard deviation shock.[12]

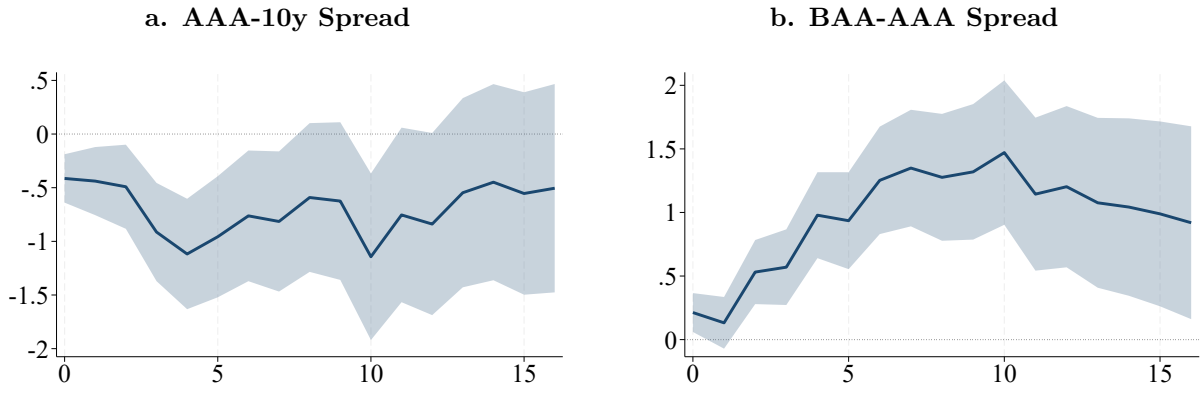
It is important to note that a surprise change in Treasury issuance means a much larger shift in Treasury debt level, because changes in auction sizes are persistent and sticky. Figure A2 shows that changes in Treasury auction sizes are rarely one-offs; instead, once the Treasury decides to alter auction sizes, it is most likely to continue changing issuance in the same direction for a consecutive period of time. In addition, outside those periods, the auction sizes tend to remain very stable, in particular at longer maturities. A surprise increase of $1 billion in Treasury issuance can meaningfully shift the debt-GDP ratio. Thus, there is likely a *signaling channel* at play, as the markets read information about the future fiscal outlook in a surprise issuance shock. The magnitude of the effects of a surprise Treasury issuance shock we find are also consistent with information in the Treasury's primary dealer survey, which suggests a surprise additional issuance of $1 billion 10-year bond would raise 10-year yield by 3 basis points, see discussion in Section A.1.

Higher than expected Treasury issuance also has implications for the private bond market. The

[11] We get this mapping of the shock in terms of debt expansion by regressing the shock on net volume issuance in Treasuries, which is given in terms of billions of dollars. This net issuance is constructed by considering the total amount of issuance announced by the Treasury on dates we are exploiting and subtracting off maturing amounts by that date.

[12] Since the speed at which Congress passed the CARES Act in March 2020 was widely viewed as unprecedented, our Treasury supply shocks, which are constructed based on Treasury auction announcement dates, may not capture the full scope of changes in the Treasury supply associated with the CARES act.

Figure 6: IRFs to a Debt Expansion Shock (F_1): daily frequency



Note: The x-axis shows days after the shock hits. The y-axis gives the response in terms of basis points. 90% confidence bands are shown for all IRFs.

spread between AAA bond and 10-year Treasury yields, known as the convenience yield, reflects the payoff that investors are willing to forego in order to hold highly liquid and safe assets. As shown in panel (a) of Figure 6, we find that as the supply of U.S. Treasuries increases, the convenience yield declines, in line with Krishnamurthy and Vissing-Jorgensen (2012b). Yields for AAA corporate bonds also rise, as the increase in 10-year Treasury yield is more significant than the decline in the spread between AAA and 10-year Treasury bonds. Thus, a greater supply of Treasury securities raises funding costs for firms.

Importantly, a debt expansion shock raises credit risk of corporate bonds, reflected in the sustained increase in the spread between BAA and AAA bonds, as shown in panel (b) of Figure 6. A higher supply of Treasury securities can potentially affect credit risks through two opposing channels: *safe asset channel* and *crowding-out channel*. If safety is a price attribute for Treasury securities, then increases in the Treasury supply would lower credit risks (see Krishnamurthy and Vissing-Jorgensen (2012b)). On the other hand, some papers find evidence that a rising supply of Treasuries lead to rising excess returns and credit spread in many asset classes (see Croce, Nguyen, Raymond, and Schmid (2019) and Liu, Schmid, and Yaron (2021)). Using our high frequency identification approach, our analysis contributes to the debate and shows that the channel of tightening financial conditions dominates on average for our data sample. We further explore the two channels in Sections 3.2.3 and 5, and find that the safety attribute of Treasury securities is more pronounced for longer-term securities and more relevant when government debt level is stable.

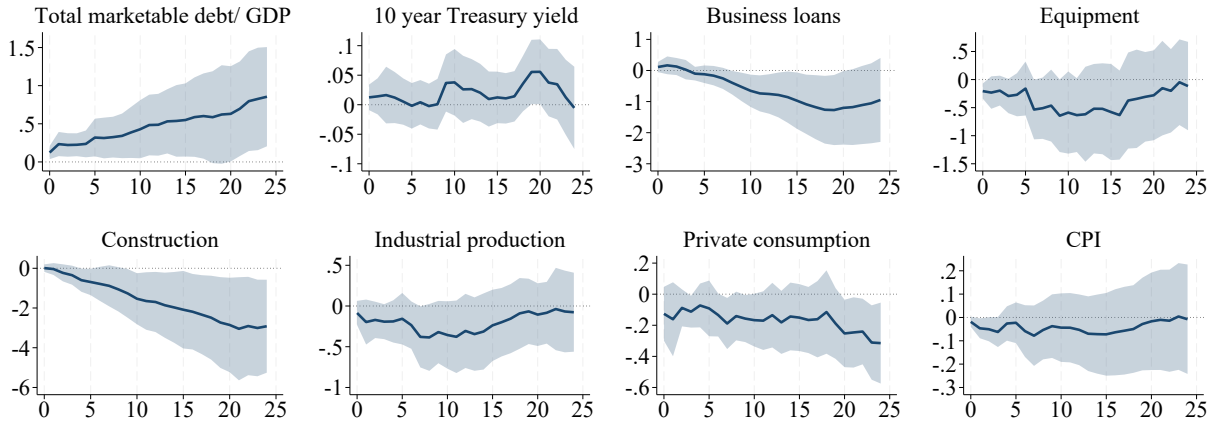
In this section we have shown that debt expansion shocks have clear financial consequences. They raise Treasury yields and term premia, reduce convenience yields, and widen corporate credit spreads. The resulting increase in borrowing costs tightens financial conditions, with the crowding-out channel dominating over any safe asset effects. In short, higher debt issuance translates into more expensive financing for both the government and the private sector.

3.1.2 Macroeconomic Impact of Debt Expansion Shocks: Monthly Regressions

Next, we study the effects of Treasury supply shocks on the broad macroeconomy at monthly frequency using Equation (3.1), the same framework as in the daily analysis. In the monthly regressions, the set of controls X_t include the lags of federal funds rate, industrial production and CPI to control for macroeconomic and monetary conditions as well as the lags of variable of interest. We also add lags of the Treasury supply shock to account for any autocorrelation in the Treasury supply shock as a result of aggregation to monthly frequency. We use 2 lags in our baseline specification.[13]

Figure 7 shows that a debt expansion shock increases the government debt level steadily over time. The one-standard deviation shock raises the debt-to-GDP ratio by 0.9 percent after 2 years. Higher Treasury supply also raises the 10-year Treasury yield.

Figure 7: IRFs to a Debt Expansion Shock (F_1): monthly frequency



Note: The x-axis shows months after the shock hits. The y-axis gives the response in percentage points for debt-GDP ratio and 10-year Treasury yield, and percent deviations for other variables. 90% confidence bands are shown for all IRFs.

We find that the crowding-out channel dominates the macroeconomic effects on average over our data sample, as a surprise increase in Treasury issuance crowds out private economic activity. A higher level of government debt reduces private investment. Business loans, which include commercial and industrial loans extended by all commercial banks, decline notably and reach close to 1.5 percent at the trough. As a result, both real equipment spending and construction expenditure decline. The impact on construction is particularly notable, as it steadily declines in the next 20 months and reaches a loss of 3 percent. The debt expansion shock reduces industrial production in the first year while lowering private consumption expenditure throughout the projection horizon. In addition, the deceleration in economic activity reduces inflation, although the impact isn't statistically significant.

[13] As shown in Figure A5 in the Appendix, Treasury announcements can be on different days of the month, which can potentially introduce temporal aggregation bias. We follow the approach of Gertler and Karadi (2015) to aggregate high-frequency Treasury supply shocks to a monthly frequency.

The macroeconomic results show that the tighter financing conditions identified in the daily regressions translate into meaningful declines in real activity. Higher yields and borrowing costs reduce business lending, which in turn dampens investment and lowers industrial production. These responses underscore how debt expansion shocks crowd out private sector activity.

3.2 Maturity Adjustment Shocks

Next, we study the impact of maturity adjustment shocks (F_2) on the financial market and the broad macroeconomy, as the Treasury tilts its issuance towards short- or long-term securities.

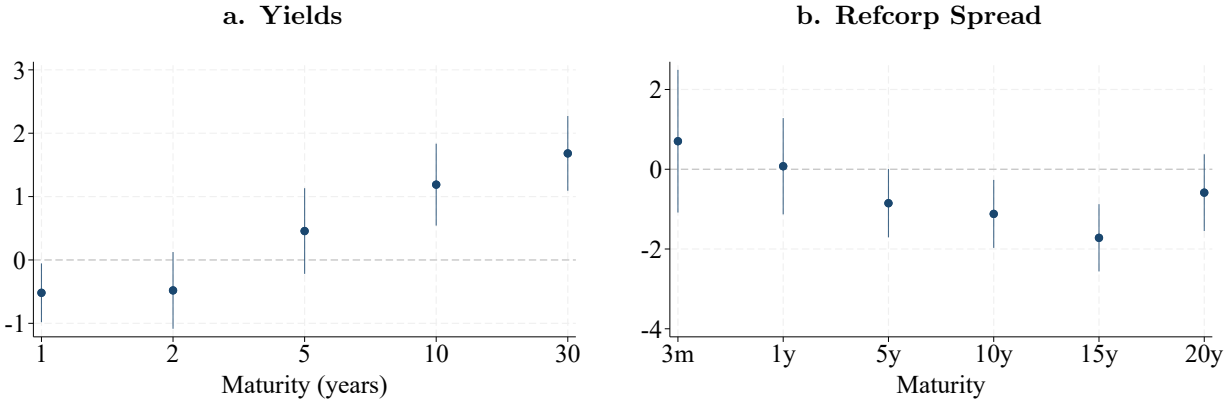
3.2.1 Financial Market Impact of Maturity Adjustment Shocks: Daily Regression

We use daily regressions in a similar way as in Section 3.1.1. F_2 is the maturity adjustment shocks that we have constructed. A positive shock value means maturity extension, as Treasury announces the issuance of more bonds at the long end which are offset by lower issuance at the short end.

$$y_{t+h} - y_{t-1} = \alpha_{2,h} + \beta_{2,h} F_{2,t} + \sum_{j=1}^{J} \theta_{2,h}^{j} X_{t-j} + \epsilon_{2,t+h}, \text{ for } h = 0, 1, 2, ... \tag{3.2}$$

In response to a maturity adjustment shock, Treasury yield declines at the short end, while increasing at the long end. The left panel of Figure 8 shows the impact responses of yields across different maturities.[14] The one-standard-deviation shock reduces 1- and 2-year Treasury yields by 0.5 basis points on impact, while raising 30-year yield close to 2 basis points. The steepening yield curve reflects Treasury issuance unexpectedly shifting from the short to the long end. It may crowd out private credit at the long end, but crowd in at the short end.

Figure 8: Responses to a Maturity Adjustment Shock (F_2): daily frequency



Note: (Left) Impact responses of yields across maturities. (Right) Responses of Refcorp spreads across maturities at day 8 following the shock. The x-axis shows maturities and the y-axis is in terms of basis points. 90% confidence bands are shown.

The impact of a maturity adjustment shock on liquidity premia also varies across maturity. The

[14] Figure C10 in the appendix provides impulse responses for a range of variables over time, while Figure 8 highlights the impact responses of yields and term premia across different maturities.

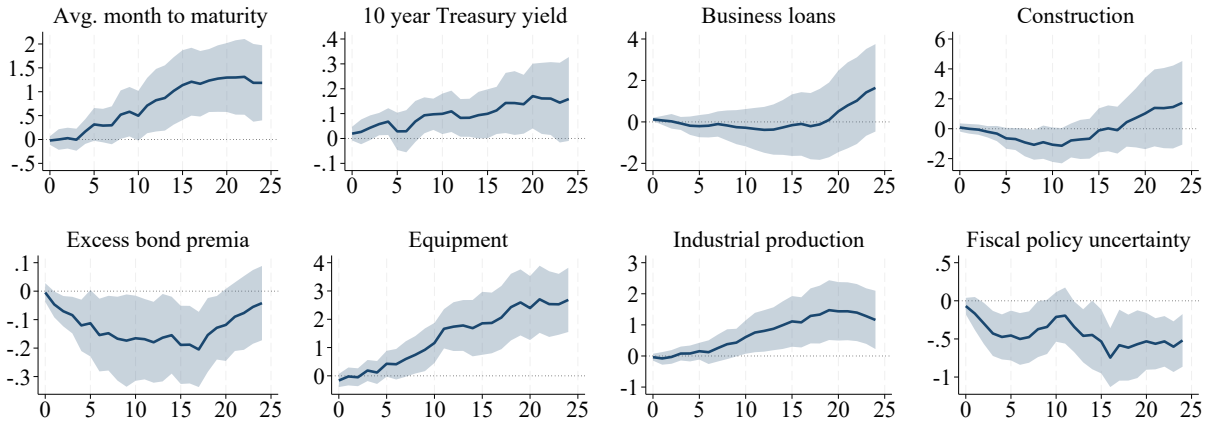
right panel of Figure 8 highlights that the spread between Refcorp bonds and Treasury securities, following Longstaff (2004), increases for 3-month security, as a lower issuance at the short end raises Treasury liquidity premium. The impact declines with maturity and turns negative for 5-, 10- and 15-year securities as issuance at the long end increases.[15] The U-shape impact on liquidity premium reflects the safety attribute of Treasuries, as higher issuance at the long end reduces the convenience yields for long-duration Treasuries.

Finally, more abundant issuance at the long end also reduces credit risk premium and the market expectation of volatility. In appendix Figure C11, we show that a maturity adjustment shock leads to a decline in BAA-AAA bond spread. The narrowing spread suggests lower economic uncertainty and reduced perceived risk in the corporate market. Similarly, there is also evidence that VIX declines in the days following the shock, consistent with a risk-on sentiment. Here both the safety channel as well as the signaling channel may be at play. Since Treasury coupons are a better hedge against future economic and fiscal shocks than bills, shifting issuance from the short to the long end may reduce credit and volatility risks.

3.2.2 Macroeconomic Impact of Maturity Adjustment Shocks: Monthly Regressions

Next, we turn to the effects of maturity adjustment shocks on the broad macroeconomy at the monthly frequency as shown in Figure 9. Following a maturity adjustment shock, the average maturity of Treasury securities increases by 1.3 months in 2 years, and the share of Treasury bonds over the total marketable debt also increase steadily over time as shown in Figure C13.

Figure 9: IRFs to a Maturity Adjustment Shock (F_2): monthly frequency



Note: The x-axis shows months after the shock hits. The y-axis gives the response in percentage points for excess bond premium and 10-year yield, and it is in percent deviations for other variables. 90% confidence bands are shown for all IRFs.

We find that shifting issuance from short- to long-term securities reduces credit risks in the financial market, supporting production and near-term investment. Figure 9 shows that in response

[15] Figure C12 in the appendix shows impulse responses for a range of liquidity measures over time across maturities.

to a maturity adjustment shock, the excess bond premium, constructed by Gilchrist and Zakrajšek (2012), declines steadily within the first 15 months, implying higher risk-bearing capacity of the financial sector, and lower funding costs for firms.[16] These results support the view that the safety attribute is particularly relevant for Treasury coupons. In addition, the channel of lower credit risks is supported by evolving fiscal risks. The bottom right panel shows that in response to a maturity shock, fiscal policy uncertainty declines, indicating that longer-term Treasury securities may be a better instrument than short-term bills in hedging fiscal and rollover risks.[17] The channel of easing credit risks supports near-term investment and production. Real equipment spending increases by about 3 percent after 2 years, while industrial production rises by 1.5 percent at the peak.

At the same time, Figure 9 also presents evidence on the offsetting channel of crowding out. As the Treasury issues more longer-term securities, the 10-year Treasury yield increases over time, weighing on business loans and longer-term investment, such as construction expenditure. In the appendix, Figure C13 shows that the response of private consumption is slightly negative on impact and remains muted in the near term, but then increases over time supported by easing credit risks.

3.2.3 Maturity Extension versus Maturity Compression Shocks

The analysis in the previous section suggests that the relative importance of the two competing channels, *safety* versus *crowding out*, is potentially different for short- versus long-term Treasury securities. Therefore, maturity adjustment shocks may have an asymmetric impact on the economy. In this section, we differentiate maturity extension shocks from compression shocks and run the following state-dependent local projection regression:

$$y_{t+h} - y_{t-1} = \alpha_{2,h} + \beta^P_{2,h} F^+_{2,t} + \beta^N_{2,h} F^-_{2,t} + \sum_{j=1}^{J} \theta^j_{2,h} X_{t-j} + \epsilon_{2,t+h}, \text{ for } h = 0, 1, 2, ... \tag{3.3}$$

where $F^+_{2,t}$ is a positive maturity adjustment shock, and $F^-_{2,t}$ is a maturity adjustment shock that takes a negative value. Thus, the coefficient β^P captures the response to maturity extension shocks and β^N represents the response to compression shocks.

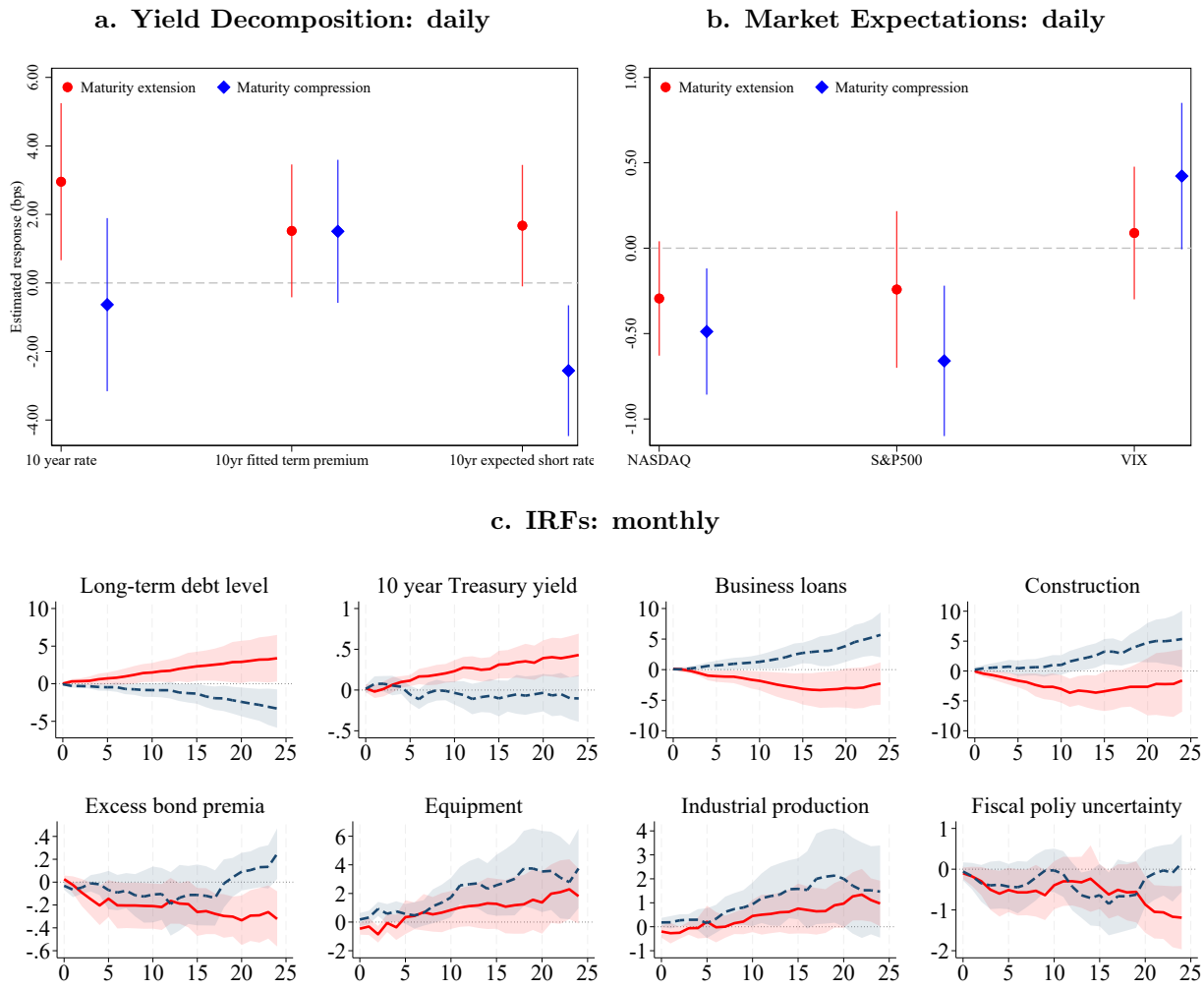
Top panel of Figure 10 shows how the two types of maturity adjustment shocks affect financial variables at a daily frequency. We consider the response of 10-year Treasury yield and its decomposition into a fitted term premium and 10-year ahead expected short term rates, based on the model of Christensen and Rudebusch (2012). For both types of shocks, the adjustment in the 10-year yield operates primarily through changes in expectations about the path of short-term interest rates, rather than through shifts in the compensation for bearing duration risk. In terms of signaling effects, the two types of shocks are perceived very differently by the market.

Maturity compression shocks seem to be interpreted as signals of fiscal stress. They trigger stock market declines and heightened uncertainty given by a rise in the VIX (Panel (b) in Figure

[16] Figure C13 in the appendix shows that alternative credit risk measures, such as the spread between BAA and AAA corporate bonds, show a similar decline as the excess bond premium.

[17] Fiscal Policy uncertainty is measured by the Economic Policy Uncertainty Index for the Categorical Index: Fiscal Policy (Taxes OR Spending), i.e. EPUFISCAL, from Baker, Bloom, and Davis (2016).

Figure 10: IRFs to Maturity Extension vs. Compression Shocks



Note: Red dots/lines represent responses to a maturity extension shock, while blue dots/lines show responses to a maturity compression shock. 90% confidence bands are shown. (Top left) Response of the 10 year Treasury rate, and based on the model of Christensen and Rudebusch (2012), the 10 year fitted term premium and 10 year ahead expected short rate, all in terms of basis points. (Top right) Response of NASDAQ Composite Index, S&P 500 and the VIX uncertainty index in percent. (Bottom) IRFs at monthly frequency with the x-axis showing months after the shock hits. The y-axis is in percentage points for debt-GDP ratio, yields, and excess bond premia, and percent deviations for the rest.

10), consistent with the historical pattern that the government under fiscal strain relies on large short-term issuance to meet financing needs.

In contrast, maturity extension shocks raise expected future short rates, consistent with markets interpreting them either as a precaution against rollover risk or as a reflection of stronger future economic prospects. This more positive interpretation is also consistent with the stock market valuations and VIX responses which don't move in the same direction as for maturity compression shocks (though not in a statistically significant way).

The bottom panel of Figure 10 shows the macroeconomic responses to the two types of maturity adjustment shocks. We see that both safety and crowding out channels are at play in response to a maturity extension shock. A one standard deviation shock increases the level of Treasury bonds steadily by 3.5 percent within 2 years. The higher Treasury supply at the longer end reduces credit risks in the financial market. Excess bond premia decline steadily throughout the horizon. Fiscal policy uncertainty is also lower as longer-term Treasury securities are a better instrument in hedging fiscal and rollover risks. Lower credit risks imply higher risk-bearing capacity in the financial market and support near-term investment and production, as equipment spending and industrial production rise over time. On the other hand, the maturity extension shock raises 10-year Treasury yield consistently. Higher funding costs at the long end crowd out business loans and weigh on construction investment throughout the horizon.

With a maturity compression shock, Treasury tilts issuance towards more short-term securities. Excess bond premia declines, reflecting lower credit risks. The scope of the decline, however, is smaller than what we observe in the maturity extension shock. The contrast highlights that the safety attribute is more pronounced for longer-term Treasuries. In addition, the lower supply of longer-term securities also reduces 10-year Treasury yield. Both lower long-term yield and lower credit risk premia boost economic activity, as reflected in higher industrial production. Investment expenditure is higher with rising equipment and construction spending.

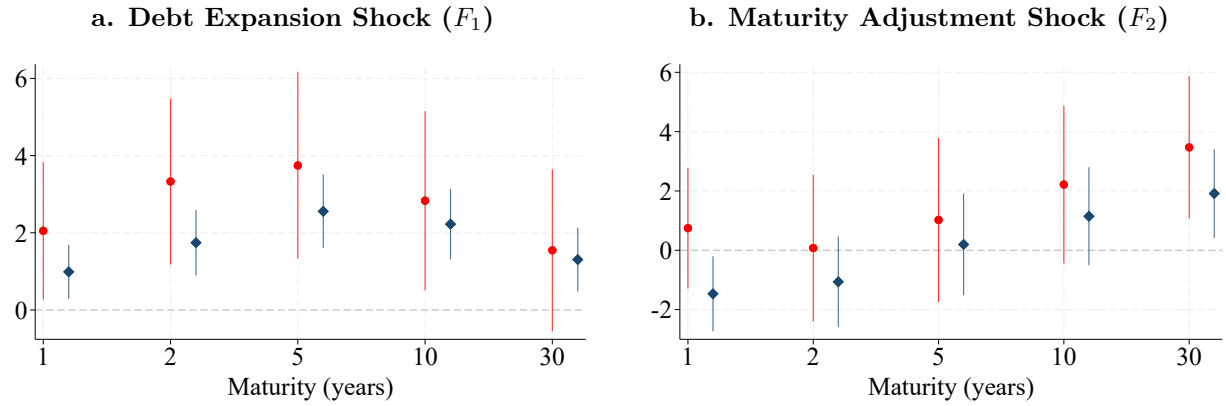
By differentiating maturity extension shocks from maturity compression shocks, our analysis highlights that the safe asset channel is more pronounced for longer-term Treasury securities. The easing credit risks, together with lower fiscal uncertainty, help to mitigate the crowding out channel associated with higher borrowing costs at the long end.

3.3 Role of Quarterly Refunding Statements

As discussed in Section 2.1, the Treasury auction announcements are made either standalone or together with the Quarterly Refunding Statement (QRS). Compared to the standalone auction announcements, the QRS contains broader communications from the Treasury, including near-term fiscal outlook, issuance strategy and sizes for upcoming quarters, and factors influencing its debt management decisions. For this reason, some of the literature has focused exclusively on information released on those days (see Haddad and Muir (2024), Hartley and Rigon (2025), and Wang and Zhao (2025)). We contribute to the literature by leveraging both types of auction announcements.

We leverage the differentiation between QRS and non-QRS announcements by splitting the Treasury supply shocks into two groups. Figure 11 shows the effects of Treasury supply shocks on and outside QRS dates on Treasury yields of various maturities. We find that both debt expansion (left panel) and maturity adjustment (right panel) shocks coinciding with QRS announcements generate larger yield responses than shocks on non-QRS dates, reflecting either a signaling channel or the greater salience of these announcements to market participants. Importantly, however, our identification strategy shows that standalone Treasury auction announcements also convey meaningful information, as the associated yield effects move in the same direction as those on QRS dates. Importantly, the impact on non-QRS dates are more precisely estimated, albeit smaller in

Figure 11: Yield Responses to Treasury Supply Shocks: QRS vs. non-QRS



Note: Peak responses of yields with 90% confidence bands. The x-axis shows maturities and the y-axis is in terms of basis points. The figures show the daily response of yields to shocks that coincide with the Quarterly Refunding Statement (QRS) given by blue dots, and otherwise given by red diamonds.

magnitude.

Examining the distribution of shocks, we find that some of the largest debt expansion (F_1) shocks occur on non-QRS dates, whereas many of the largest positive and negative maturity adjustment (F_2) shocks coincide with QRS announcements (Appendix Figure B7). In particular, several major maturity adjustment shocks, linked to news about the re-issuance or discontinuation of specific maturities, are made in the QRS.

In examining their macroeconomic effects, aggregation at the monthly level inevitably combines QRS and non-QRS shocks within the same month. For debt expansion shocks, those occurring on QRS dates have little impact on monthly aggregates, whereas F_1 shocks outside QRS dates largely drive the macro results, consistent with crowding-out/portfolio-rebalancing effects reflecting, in part, the distribution of shocks. By contrast, for F_2 shocks the macroeconomic effects are broadly similar- and sizable regardless of whether they coincide with QRS announcements (shown in Figure C14 in the appendix).

These results highlights that relying only on QRS events may underestimate the information content of Treasury announcements, and exploiting the broader set of issuance communications provides a more comprehensive picture of how debt management decisions affect yields and financial conditions.

4 Quantitative Easing and Treasury Maturity Adjustments

One of the contributions of this paper is to identify Treasury supply shocks not only in terms of the overall level of debt issuance but also in terms of the maturity structure of issuance, an aspect that has received relatively less attention in the prior literature. This distinction matters because the maturity composition of debt supply interacts directly with the Federal Reserve's large-scale asset purchases (LSAPs), which alter the demand for long duration Treasuries and thereby the maturity

profile of securities available to the public. As Greenwood, Hanson, Rudolph, and Summers (2014) emphasize, "Treasury's decision to lengthen the average maturity of the debt (to mitigate fiscal risks associated with the government's growing debt) has partially offset the Federal Reserve's attempts to reduce the supply of long-term bonds held by private investors through its policy of quantitative easing."

We build on this insight to provide quantitative estimates of this effect, by examining high-frequency market responses to QE-related announcements between November 25, 2008 and April 9, 2020. We consider the policy announcements on QE1, QE2, the Maturity Extension Program, QE3, and the pandemic-era interventions along with associated time stamps, as shown in Table A3. Following our identification approach on Treasury supply shocks, we measure Treasury futures price changes in a 30-minute window around these announcements. With the exception of QE1, which triggered unusually large responses, the magnitude of futures movements around QE announcements is broadly comparable to those observed around Treasury issuance announcements. Consistent with the portfolio balance channel, the largest futures price changes occur at the long end, with 30-year and 10-year contracts responding more strongly than shorter maturities.

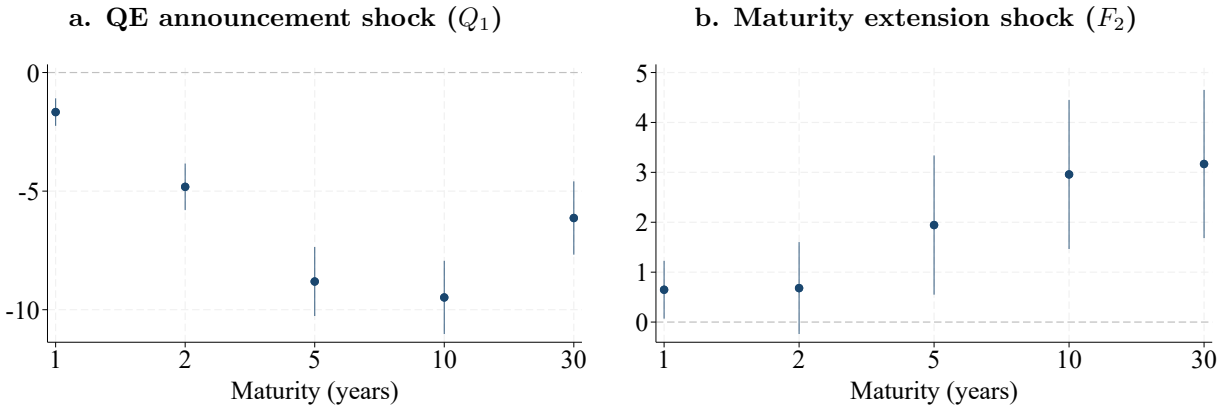
To summarize these comovements, we extract a factor from the 2-, 5-, 10-, and 30-year futures contracts. This first factor, which we denote Q_1, explains about 90 percent of the variation and loads positively across maturities. Yet, once we consider the effects on yields, it is clear that Q_1 primarily shifts the slope of the yield curve. The left panel of Figure 12 shows that on average, a one standard deviation Q_1 shock lowers the 10-year Treasury yield by about 10 basis points and steepens the 10-year minus 2-year spread by 6 basis points on impact.[18] Restricting ourselves to the same sample period, our Treasury maturity extension shock (F_2) on average raises the 10-year yield by about 3 basis points and steepens the spread between the 10-year and 2-year Treasury yields by 2 basis points, as shown in the right panel of Figure 12.

Taken together, these results imply that Treasury maturity adjustment shocks offset roughly one third of the average effects of QE on long-term yields during the 2008-2020 period. In other words, while QE announcements compressed long rates by shifting duration risk onto the central bank's balance sheet, Treasury's simultaneous decision to extend the maturity of issuance leaned in the opposite direction, undoing a material share of those effects. This finding provides direct evidence of monetary-fiscal interaction operating through the maturity structure of government debt.

Our results contribute to the existing literature by leveraging the maturity structure. Gomez Cram, Kung, and Lustig (2025) show that Treasury yields rise substantially in response to projected deficit news, as revealed in CBO cost releases, for the period 1997-2022, while monetary policy offsets much of these fiscal news with yields declining sharply on FOMC days. Our evidence adds another dimension to this story by focusing on the maturity structure of debt. Not only does monetary policy drive long yields at high frequency, but debt management decisions by the Treasury also

[18] The effect on the 10-year yield is consistent with the findings of Swanson (2021), who, using a slightly different sample (2009-2015) and methodology, finds that a one-standard-deviation LSAP shock lowers the 10-year yield between 6 and 7 basis points.

Figure 12: Yield Responses: daily frequency



Note: Responses of yields with 90% confidence bands. The x-axis shows maturities and the y-axis is in terms of basis points.

have significant effects in shaping how fully monetary easing transmits to long-term rates. In this sense, we highlight and quantify an additional channel of monetary-fiscal interplay in determining the behavior of Treasury yields.

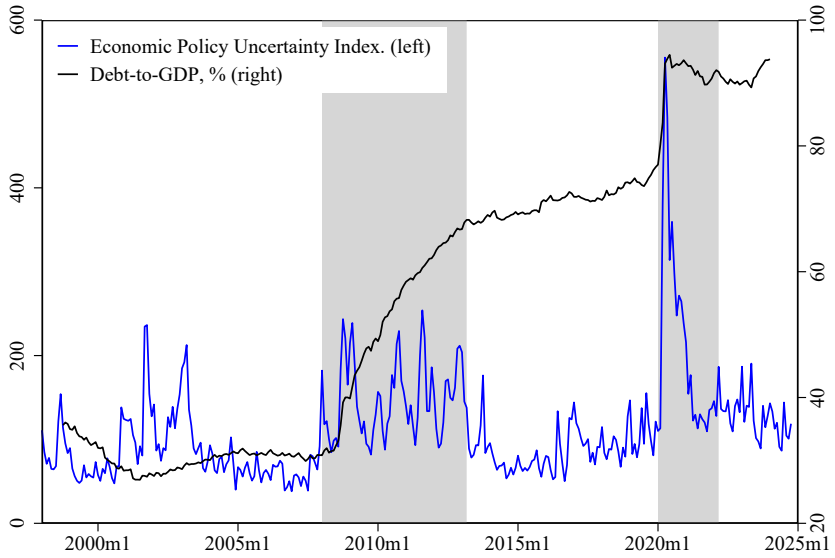
5 Effects of Treasury Supply Shocks under High Debt Growth

The impact of debt expansion shocks may be sensitive to the pace of government debt growth. In this section, we explore whether the transmission channels depend on the underlying fiscal stance. When debt is growing rapidly, an additional increase in Treasury issuance may have a larger impact on financial market and the macroeconomy than it would have when government debt level is stable. Bräuning and Stein (2024) highlight that shocks to primary dealers' risk-bearing constraints have significant effects on the U.S. Treasury market. Compared to a steady debt level, rapid government debt growth can tighten dealer constraints and impairs financial intermediation, amplifying the crowding out channel.

The federal government debt as a share of GDP has seen large changes since 1998, which marks the start of our sample. As shown in Figure 13, government debt fluctuated around 40 percent of GDP prior to the Global Financial Crisis. Lower tax revenue collections as well as higher government spending between 2008 and 2013 led to a steady increase of government debt by more than 30 percent of GDP. In the following years, the debt level remained around 80 percent of GDP until the Covid pandemic which brought a sharp rise in government debt. Figure 13 highlights the two periods of high debt growth. Notably, these periods also coincide with crisis and heightened economic policy uncertainty, as measured by the Policy Uncertainty Index of Baker, Bloom, and Davis (2016).[19] This is another reason to expect salience of Treasury announcements to market

[19]If we look at the distribution of shocks across high and low debt growth periods, we see that on average the debt expansion shocks tend to be larger and more positive during high debt growth periods (shown in Figure B8 in the Appendix.)

Figure 13: Federal Debt/GDP ratio and Economic Uncertainty



Note: The figure show federal debt held by the public as a percent of GDP (black line, right axis). It also shows the Economic Policy Uncertainty Index (blue line, left axis).

participants during these periods of high debt growth.

In order to test whether the responses to debt expansion shocks differ across high and low debt growth periods, we run the following state-dependent local projection regression:

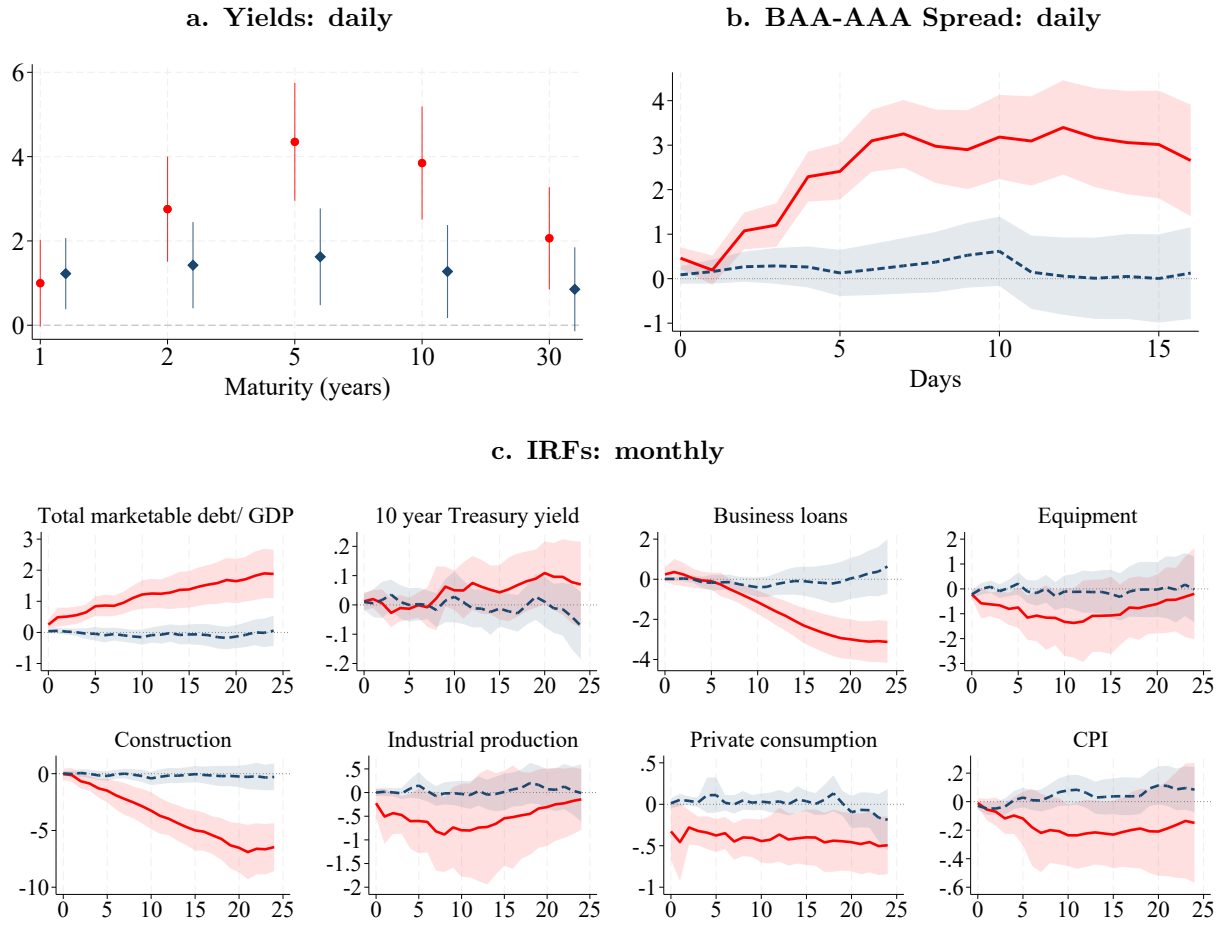
$$y_{t+h} - y_{t-1} = \alpha_{i,h} + I_t \beta^H_{i,h} F_{i,t} + (1 - I_t)\beta^L_{i,h} F_{i,t} + \sum_{j=1}^{J} \theta^j_{i,h} X_{t-j} + \epsilon_{i,t+h}, \text{ for } h = 0, 1, 2, ... \quad (5.1)$$

where F_i with $i = 1, 2$ are debt expansion and maturity extension shocks, respectively. I_t takes a value of 1 during high debt growth periods, which we classify to extend from January 2008 to April 2013, and from January 2020 to April 2022. Thus the coefficient β^H captures the response to the shock F_i during high debt growth periods and β^L captures the response during low debt growth periods.

5.1 Effects of Debt Expansion Shocks based on Debt-to-GDP Growth We start with debt expansion shocks F_1. Figure 14 shows that in response to a debt expansion shock, the crowding out channel is amplified while the safe asset channel is diminished during high debt growth periods. Panel (a) shows that a shock to Treasury debt issuance raises yield across all maturities on impact, but the increases are more pronounced in the high debt-growth regime.[20] This shock raises the 10-year yield by about 1 basis points when debt-to-GDP ratio is stable, but 4 basis points in high debt growth periods.

[20]Panel (a) in Figure 14 shows responses at day 4 following the shock, which coincides with the peak response for 10-year Treasury yields.

Figure 14: Responses to Debt Expansion Shock (F1): Debt-to-GDP Growth



Note: Red dots/lines represent the case of high-debt growth periods, while blue dots/lines are when debt-to-GDP ratios are stable. 90% confidence bands are shown. (Top left) Responses of yields across maturities at day 4 following the shock with the x-axis showing maturities and the y axis in basis points. (Top right) IRFs of BAA and AAA corporate bond spreads with the x-axis showing days after the shock and the y axis in basis points. (Bottom) IRFs at monthly frequency with the x-axis showing months after the shock hits. The y-axis is in percentage points for debt-GDP ratio and yields, and percent deviations for the rest.

On the other hand, the safe asset channel is less pronounced in the high debt growth regime. Panel (b) shows that the response of spread between BAA and AAA corporate bond yields reaches 3 basis points, while the responses are muted when debt-to-GDP ratio is stable. It indicates that the Treasuries' safety attribute depends on government's fiscal stance, and that markets value Treasuries more as safe assets when the government debt share is stable.

Turning to the macro effects, an amplified crowding out channel as well as a diminished safe asset channel during high debt growth periods play a key role. Panel (c) of Figure 14 shows that when debt-to-GDP ratio is stable, a debt expansion shock causes subdued macroeconomic responses. If government debt has already grown at a fast pace, however, a one-standard deviation shock in Treasury issuance steadily increase the government debt level, reaching 2 percent of GDP

after 2 years. Higher government debt crowds out private production, consumption and investment throughout the projection horizon. The impact on construction investment is substantial.

5.2 Effects of Maturity Extension Shocks based on Debt-to-GDP Growth Next we explore maturity extension shocks F_2. Figure 15 shows that in response to a maturity adjustment shock, both the crowding out and the safe asset channels are more pronounced during high debt growth periods.

A shift from short- to long-term Treasury securities reduces the convenience yield at the long end, driven largely by the high debt growth periods. The liquidity premium, measured by the spread between Refcorp bonds and Treasuries, are largely unchanged when debt-GDP ratios are steady. In a high debt growth regime, on the other hand, the measure declines sharply at the longer-end maturity. For instance, the liquidity spread declines by 4 basis points for 15-year bond during the high debt growth periods, but remains unchanged when debt-GDP ratio is stable.

In addition, the safe asset channel is more pronounced in the high debt growth regime. When the government issues more long- rather than short-term debt, the spread between BAA and AAA bonds declines in the high debt growth regime, but remains muted when debt-to-GDP is stable.

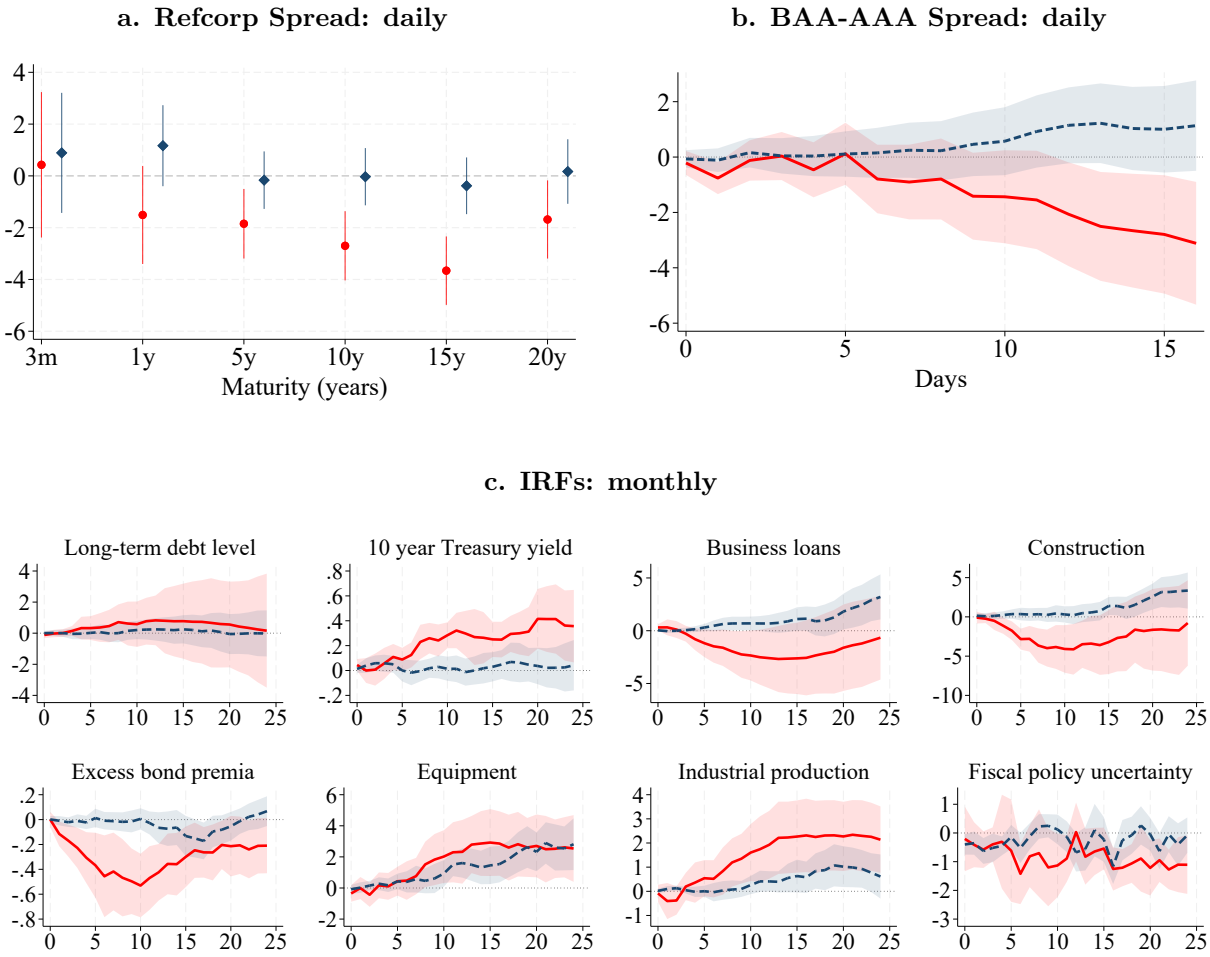
Turning to the macroeconomic impact, panel (c) of Figure 15 highlights that both the safe asset channel and the crowding out channel are amplified during the high debt growth regime. A relatively higher issuance in longer-term securities reduces the excess bond premium more significantly during the high debt growth regime. It is consistent with the stronger safety attribute that we find in the daily regressions. In addition, fiscal policy uncertainty also declines, as longer-term Treasury securities provide a better hedging instrument for fiscal risks. The lower credit and fiscal risks lead to higher economic activity, as equipment spending and industrial production see more sustained increases. On the other hand, the crowding out channel is also stronger in the high debt growth regime. 10-year Treasury yield sees a more sustained increase. As a result, business loans and construction spending experience more notable declines.

6 Conclusion

This paper provides new evidence on how Treasury debt management affects financial conditions and real activity by distinguishing between debt expansion and maturity adjustment shocks. We use a high-frequency identification approach that exploits movements in Treasury futures within narrow windows around Treasury announcements. We find that Treasury issuance decisions, both in scale and composition, play an important macro-financial role, especially during periods of rapid debt growth.

Debt expansion shocks, which raise the overall level of public debt, tighten financial conditions by increasing Treasury yields and term premia, lowering convenience yields, and widening corporate spreads. The resulting rise in borrowing costs crowds out private investment and dampens economic activity, particularly in interest-sensitive sectors such as construction. These effects are amplified when debt is already growing rapidly, as the safe-asset properties of Treasuries weaken

Figure 15: Responses to Maturity Adjustment Shock (F_2): Debt-to-GDP Growth



Note: Red dots/lines represent the case of high-debt growth periods, while blue dots/lines are when debt-to-GDP ratios are stable. 90% confidence bands are shown. (Top left) Responses of Refcorp spread across maturities at day 8 following the shock with the x-axis showing maturities and the y axis in basis points. (Top right) IRFs of BAA and AAA corporate bond spreads with the x-axis showing days after the shock and the y axis in basis points. (Bottom) IRFs at monthly frequency with the x-axis showing months after the shock hits. The y-axis is in percentage points for debt-GDP ratio, yields, and excess bond premia, and percent deviations for the rest.

amid heightened fiscal concerns.

By contrast, maturity adjustment shocks, changes in the maturity structure of issuance, operate through a richer set of mechanisms. Maturity extension shocks steepen the yield curve while easing credit and fiscal risk. By increasing the supply of long-duration safe assets and lowering the excess bond premium, these shocks stimulate short-term investment and production through improved financial conditions, despite modest increases in long-term borrowing costs which depresses some sectors like construction. Maturity compressions, in turn, ease financing conditions by lowering long yields, though they may signal short-term funding stress. This asymmetry underscores that the composition of Treasury issuance can shift the balance between crowding-out and safe-asset

channels in opposite directions.

We also show that Treasury issuance interacts meaningfully with monetary policy. Treasury's maturity choices can either reinforce or offset the Federal Reserve's actions: during 2008-2020, maturity extensions by Treasury are estimated to have undone roughly one-third of the yield-lowering effects of the Fed's quantitative-easing programs. This highlights a direct fiscal-monetary linkage operating through the maturity structure of government debt.

Overall, our results suggest that Treasury debt management has significant macro-financial consequences. When debt levels are high, issuance decisions, both in volume and maturity, can materially shape risk premia, financial stability, and the transmission of monetary policy. Understanding these interactions is crucial for designing coordinated fiscal and monetary strategies that preserve market functioning and mitigate future debt-related vulnerabilities.

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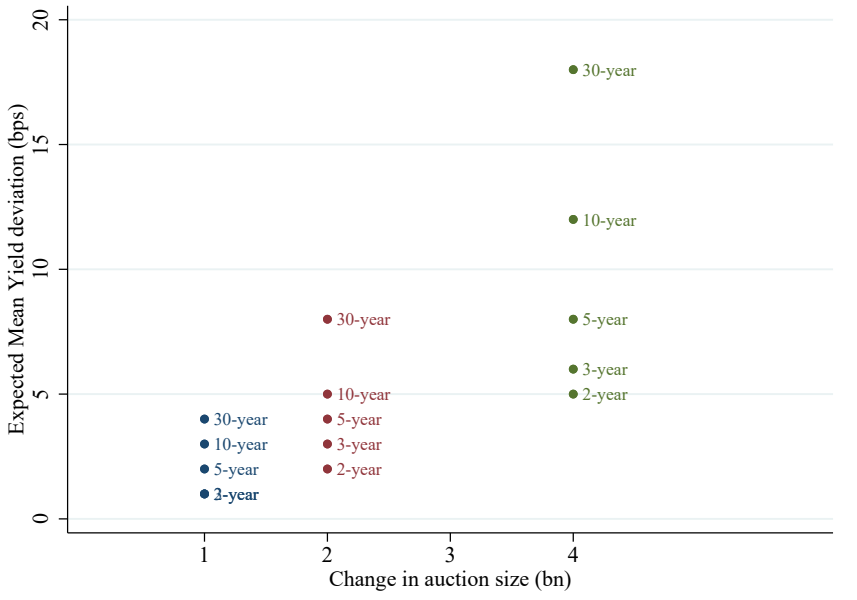
A Data

A.1 Primary Dealers Surveys During the quarterly refunding process, the Treasury solicit views from the primary dealers, and those market participants provide their estimates on issuance sizes for the upcoming auctions. The Treasury publishes the primary dealer auction size survey twice a year (the second and fourth quarters) for the period since 2015.

Between 2015 and 2017, the Treasury conducted the survey to gauge the maximum and minimum auction sizes for maintaining steady market functioning. Since 2018, the Treasury has changed their survey and explicitly asked about primary dealers' estimates on auction sizes for the current and next two fiscal years.

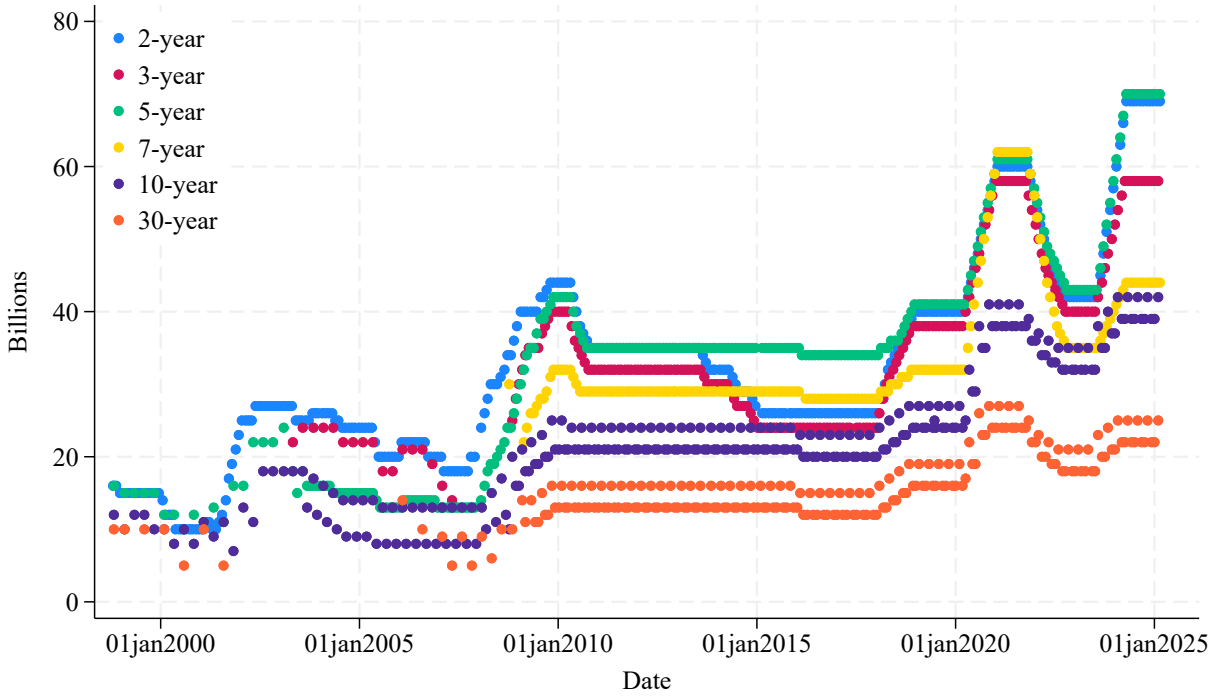
In 2016 Q4, the survey questionnaire solicited estimates on alternative scenarios: "All else equal, estimate the changes in auction stop out rates given small, intermediate and large changes in auction offering amounts. For purposes of these estimates, assume that the change values in the table below represent consecutive monthly increases in offering amounts for a particular tenor relative to current auction sizes and that those increases would be applied for one year. For each tenor, estimate the changes in the stop out rates at the end of 1 year relative to where stop out rates would have been absent any changes to issue sizes." Figure A1 summarizes the responses published by the Treasury. Primary dealers expected that an addition issuance of $1 billion 2-year Treasury note would raise 2-year yield by 1 basis point and the same increase for 10-year coupon would raise 10-year yield by 3 basis points. Similarly, a larger increase in the issuance would lead to a larger rise in yields.

Figure A1: Primary Dealer Auction Survey (2016 Q4)



A.2 Auction Data Figure A2 plots the historical Treasury auction amounts across maturities during our data sample period. A few observations stand out. First, outside of economic recessions, the auction sizes remain remarkably stable for the most part, in particular at longer maturities. For instance, the auction sizes remained entirely unchanged between September 2010 and February 2016 for coupons with maturities of 5 years and longer. Second, once the Treasury decides to alter auction sizes, it is most likely to continue change issuance in the same direction for a consecutive period of time, instead of one-off changes. During recession, the auction sizes usually increase steadily, as higher fiscal spending and lower tax revenue prompt the Federal government to issue more debt. Even outside of recessions, changes are rarely one-off, for instance the sequence of changes during the recalibration in 2023. Third, the Treasury almost never reverse its changes on auction sizes. That is, if it decides to increase issuance, it is very rare to see auction size decline in the following period.

Figure A2: Auction amounts for various maturities



A.3 Treasury Futures Prices

Figure A3 plots the historical price of the four financial instruments we use in this paper.

Figure A3: Treasury futures prices for various maturities

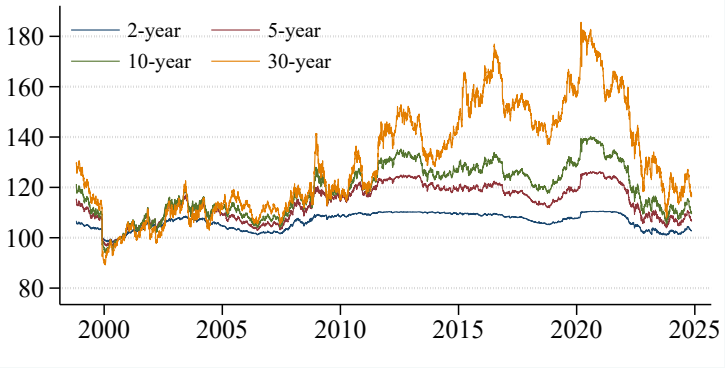
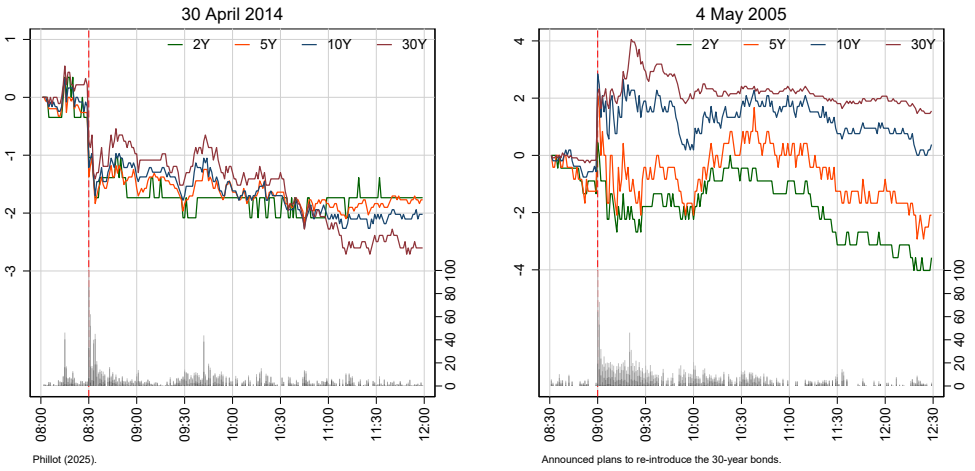


Figure A4 illustrates the two types of Treasury supply shocks that we aim at identifying in this paper. The left panel shows an announcement about debt volume primarily on April 30, 2014, where the Treasury trimmed the size of debt auctions, as the fiscal outlook brightened. The right panel shows an announcement on May 4, 2005 affecting maturity structure primarily, where they announced plans to re-introduce the 30 year bonds.

Figure A4: Treasury Announcement Effects on Treasury Futures



Note: The left panel shows an announcement about debt volume primarily on April 30, 2014 where Treasury trimmed the size of debt auctions, as the fiscal outlook brightened. The right panel shows an announcement on May 4, 2005 affecting maturity structure primarily, where they announced plans to re-introduce the 30 year bonds

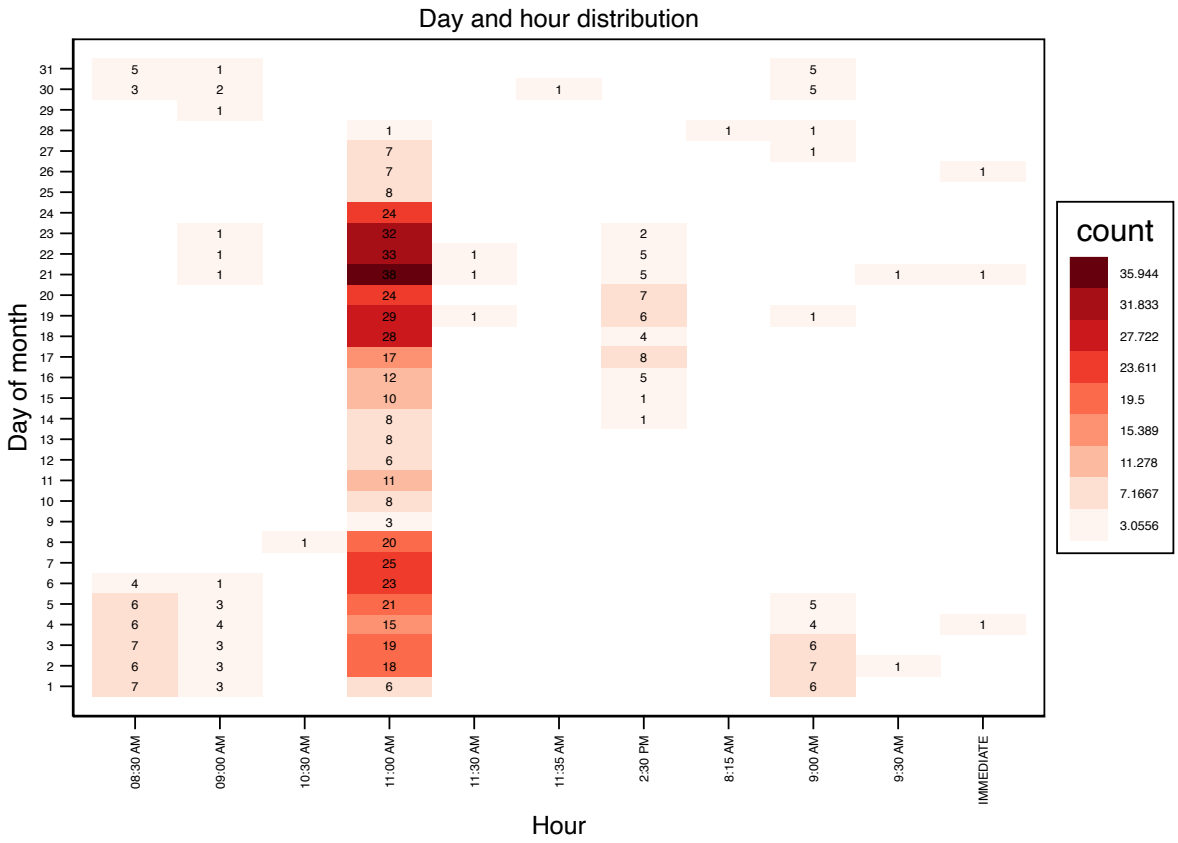
A.4 Major Data Release Treasury futures market may respond to other data releases besides Treasury announcements. If those data releases overlap with Treasury announcements within the 30-minute window, then the constructed Treasury supply shocks can be potentially contaminated. Therefore, we parse through the Treasury supply shocks according to major data release times.

Table A1 lists major macroeconomic data releases that can potentially move the Treasury futures market. For Treasury announcements in our dataset, Figure A5 summarizes the times when announcements were made. Most of announcements took place at 11:00am EST. For the construction window of 30 minutes, the possible overlapping announcements would be ones at 8:15am, 8:30am, and 9:00am. We find that the only overlapping incidents include 1) July 31, 2013, 2) April 30, 2014, 3) Jan 30, 2019, and 4) October 30, 2019, when Treasury announcements coincided with GDP data release.

Table A1: Major Macroeconomic Data Releases

Data Release	Time
GDP, Personal income and outlays, Retail sales Employment situation, CES report, Initial unemployment claims Housing starts, Trade balance, PPI, CPI	8:30am EST
Industrial production & capital utilizations	9:15am EST
Durable goods orders, New home sales, Construction spending Manufacturers' shipments, inventories, and orders University of Michigan consumer sentiment Conference Board consumer confidence, ISM manufacturing	10:00am EST
Government deficits	2:00pm EST
Consumer credit	3:00pm EST

Figure A5: Times of Treasury Announcements



A.5 Data definitions and sources

Table A2 displays the data definitions and sources.

Table A2: Data Definitions and Sources

Variable Name	Definition	Source
a. Intraday Futures		
Treasury futures	Minute-level price data for continuous quarterly U.S. Treasury futures at 2-, 5-, 10-, and 30-year maturities, rolling from front-month to second-month contracts after the 5th calendar day of the delivery month [TUc1, TUc2, FVc1, FVc2, TYc1, TYc2, USc1, USc2]	LSEG Tick History
SOFR futures	Minute-level price data for continuous quarterly SOFR futures, for the first eight listed contracts [SRAcm1-SRAcm8]	LSEG Tick History
Stock market futures	Minute-level price data for S&P 500 E-mini futures (front-month) [ESc1]	LSEG Tick History
b. Daily Financial Market Variables		
Treasury bond yields	Yield on U.S. Treasury Securities at Constant Maturity for 1-, 2-, 5-, 10-, and 30-Year maturities [DGS1, DGS2, DGS5, DGS10, DGS30]	FRED
Corporate bond yields	Moody's Seasoned AAA and BAA Corporate Bond Yields [DAAA, DBAA]	FRED
Inflation expectations	5- and 10-Year Breakeven Inflation Expectations [T5YIE, T10YIE]	FRED
Term premium	Term Premium on 2-, 5-, and 10-Year Zero-Coupon Treasury Bonds [THREEFYTP2, THREEFYTP5, THREEFYTP10]	Federal Reserve Board via FRED
Refcorp spread	Spread between Refcorp Bond Yield and Treasury Zero-Coupon Bond Rate of the same maturity	Bloomberg
CIP spread	Covered Interest Parity (CIP) deviations for given maturity	Du, Im, and Schreger (2018)
Swap spread	Spread between Overnight Indexed Swap (OIS) rates and Treasury Zero-Coupon yields of the same maturity	Bloomberg
DV01	Sensitivity of Treasury futures price to changes in the CTD yield (Dollar value of a basis point)	Bloomberg
c. Monthly Macroeconomic and Financial Variables		
Industrial Production	Industrial Production Index [INDPRO]	FRED
Consumption	Nominal PCE deflated by the PCE price deflator [PCE / PCEPI]	FRED
Equipment	Manufacturer Shipments of Non-defense Capital Goods deflated by the PPI for Capital Equipment for Manufacturing Industry	FRED
Construction	Private Non-residential Construction Spending deflated by the PPI of Finished Goods	FRED
Business Loans	Commercial and Industrial Loans, All Commercial Banks, deflated by CPI	FRED
Commercial Paper	Non-financial Commercial Paper Outstanding, seasonally adjusted, deflated by CPI	FRED
Inflation expectations (model-based)	5- and 10-year model-based inflation expectations	Cleveland Fed via FRED
Short term share	Ratio of Treasury bills to total marketable debt	U.S. Treasury
Long-term share	Ratio of Treasury notes and bonds to total marketable debt	U.S. Treasury
Total ratio	Total marketable Treasury debt divided by GDP	U.S. Treasury / BEA

A.6 Quantitative Easing Dates and Times These are the dates and timestamps used in our analysis.

Date	Time	Event	Source
25-Nov-08	8:15 AM ET	QE1 launch: buy up to $100b agency debt, $500b MBS	KVJ-BPEA
1-Dec-08	1:45 PM ET	Bernanke speech	KVJ-BPEA
16-Dec-08	2:15 PM ET	FOMC mentions large-scale asset purchases	KVJ-BPEA
28-Jan-09	2:15 PM ET	FOMC ready to expand MBS, agency debt, LT Treasuries	KVJ-BPEA
18-Mar-09	2:15 PM ET	QE1 expansion: $1.25t MBS, $200b agency debt, $300b Treasuries	KVJ-BPEA
12-Aug-09	2:15 PM ET	Gradual slowdown of Treasury purchases, completion by Oct 2009	NY Fed
23-Sep-09	2:15 PM ET	Plan to slow agency debt and MBS purchases, end Q1 2010	NY Fed
4-Nov-09	2:15 PM ET	Agency debt target reduced from $200b to $175b	NY Fed
10-Aug-10	2:15 PM ET	Reinvest MBS/agency debt principal into Treasuries	KVJ-BPEA
21-Sep-10	2:15 PM ET	Statement (no detail)	KVJ-BPEA
3-Nov-10	2:15 PM ET	QE2: buy $600b Treasuries by mid-2011	KVJ-BPEA
12-Sep-11	2:15 PM ET	Operation Twist: $400b long-term Treasuries, sell short-term	NY Fed
20-Jun-12	2:15 PM ET	Extend maturity program through year-end	NY Fed
13-Sep-12	12:35 PM ET	QE3: buy $40b/month MBS until labor market improves	NY Fed
12-Dec-12	12:30 PM ET	QE3 extension: add $45b Treasuries per month	NY Fed
18-Dec-13	2:00 PM ET	Taper: reduce MBS to $35b, Treasuries to $40b	NY Fed
29-Oct-14	2:00 PM ET	End QE: conclude asset purchases	NY Fed
16-Dec-15	2:00 PM ET	First rate hike since crisis, reinvestment policy maintained	NY Fed
14-Jun-17	2:00 PM ET	Fed expects to begin balance sheet normalization	NY Fed
20-Sep-17	2:00 PM ET	Balance sheet normalization to start Oct 2017	NY Fed
3-Mar-20	10:00 AM ET	Emergency 50bp rate cut (unscheduled)	Collins & Gagnon
9-Mar-20	7:40 AM ET	Increased repo offerings by $75b	Collins & Gagnon
11-Mar-20	2:32 PM ET	Repo offerings increased further	Collins & Gagnon
12-Mar-20	1:10 PM ET	Extended maturity distribution, $1t repo operations	Collins & Gagnon
17-Mar-20	10:45 AM ET	Announced Commercial Paper Funding Facility	Collins & Gagnon
18-Mar-20	11:30 PM ET	Announced Money Market Mutual Fund Facility	Collins & Gagnon
19-Mar-20	9:00 AM ET	Dollar swap lines with more central banks	Collins & Gagnon
20-Mar-20	10:00 AM ET	Coordinated CB action on USD liquidity	Collins & Gagnon
20-Mar-20	11:00 AM ET	Expanded MMF Facility to muni funds	Collins & Gagnon
23-Mar-20	8:00 AM ET	Unlimited QE, new corporate/MBS/TALF/Main Street facilities	Collins & Gagnon
1-Apr-20	4:45 PM ET	Exclude Treasuries/deposits from bank leverage ratios	Haddad et al. (2021)
9-Apr-20	8:30 AM ET	$500b muni facility, extend corporate/MBS/TALF and loans	Haddad et al. (2021)

Table A3: List of QE related announcements.

Source: KVJ:BPEA refers to Krishnamurthy and Vissing-Jorgensen (2012a). The other sources mentioned above are Federal Reserve Bank of New York (2023), Collins and Gagnon (2020) and Haddad, Moreira, and Muir (2021).

B Properties of the F1 and F2 shocks

B.1 Factor Number Selection To determine the number of latent Treasury supply shocks underlying high-frequency futures price changes, we apply the Cragg and Donald (1997) minimum-distance rank test. This test assesses whether the symmetric matrix of average Treasury futures price reactions, denoted $\hat{A} = X'X/T$, can be approximated by a matrix of rank less than or equal to r_0, where X is the matrix of surprises across T announcements and N futures. The null hypothesis $H_0 : \text{rank}(\hat{A}) \leq r_0$ is tested against the alternative $H_1 : \text{rank}(\hat{A}) > r_0$ using a minimum-distance statistic constructed as the quadratic form:

$$\text{MD}_{r_0} = T \cdot \Big(\text{vech}(\hat{A}) - \text{vech}(A_{r_0})\Big)' \hat{V}^{-1} \Big(\text{vech}(\hat{A}) - \text{vech}(A_{r_0})\Big)$$

where A_{r_0} is the best rank-r_0 approximation to $\hat{A}$, obtained via truncated singular value decomposition, and $\hat{V}$ is the estimated asymptotic variance-covariance matrix of $\text{vech}(\hat{A})$. The test statistic follows a χ^2 distribution with degrees of freedom given by $\frac{(N-r_0)(N-r_0+1)}{2} - N$. We implement the test using an analytical (plug-in) estimator of $\hat{V}$ derived from the sample distribution of $x_t x_t'$, where x_t denotes the cross-section of futures price change on announcement t.

Table B4: Cragg–Donald Rank Test Results

Rank r_0	Statistic	DF	p-value	Decision
0	172.23	6	0.0000	Reject H_0
1	191.85	2	0.0000	Reject H_0
2	185.30	–	–	Not testable
3	54.86	–	–	Not testable

The results displayed in Table B4 indicate that the null hypothesis of one or fewer latent factors can be rejected at conventional significance levels. Specifically, the test rejects $H_0 : \text{rank}(\hat{A}) \leq 0$ and $H_0 : \text{rank}(\hat{A}) \leq 1$, suggesting that at least two underlying Treasury supply shocks are necessary to explain the systematic variation in Treasury futures price movements on announcement days. Tests for higher ranks ($r_0 = 2$ and $r_0 = 3$) are not identified, as the associated degrees of freedom are negative. We therefore conclude that two factors sufficiently capture Treasury supply shocks in our data.

B.2 Futures Price Variations & CTD Yield Changes Treasury futures contracts settle on the cheapest-to-deliver (CTD) bond within the delivery basket, adjusted by its conversion factor. A variation in the futures price consequently reflects a change in the implied value of the CTD bond. By contrast, the yield of the underlying CTD encompasses duration risk and yield curve exposure.

Relying on changes in futures prices for identification may theoretically skew the assessment of shocks. The sensitivity of the futures price to changes in the CTD yield depends on the CTD's duration, which fluctuates over time and across contracts. Changes in the CTD or its conversion

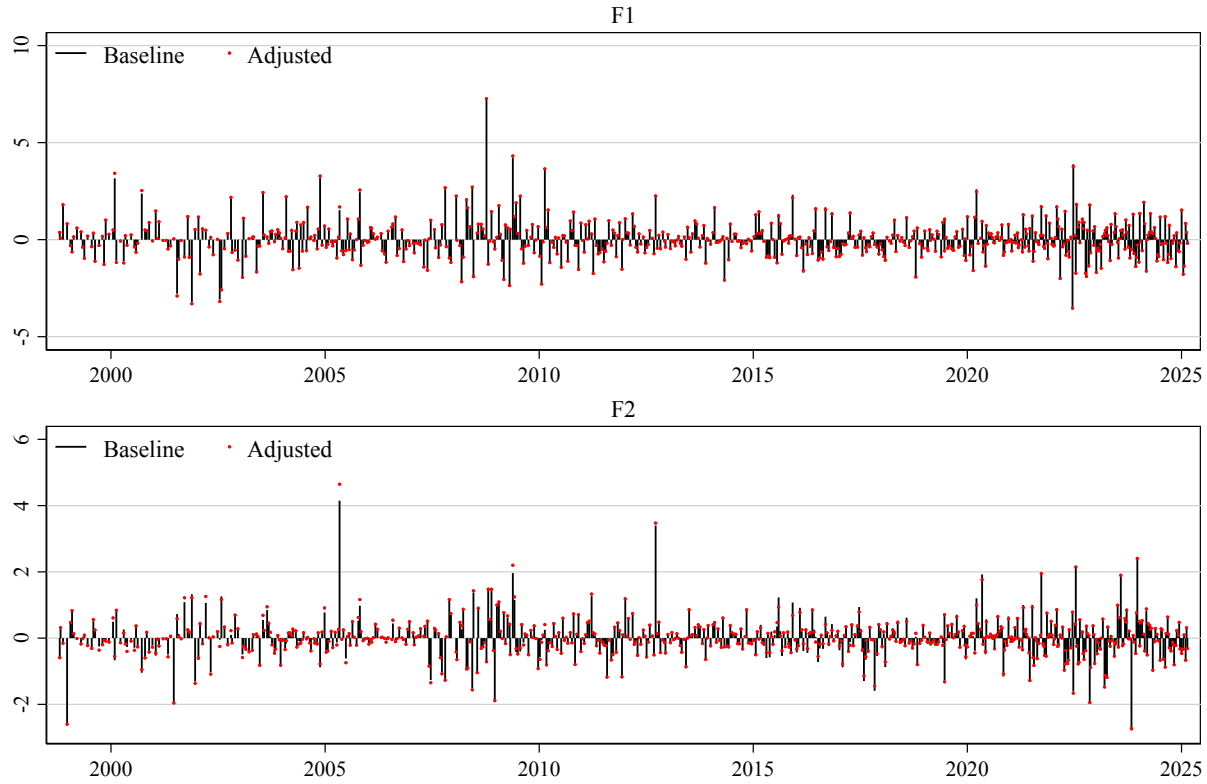
factor can result in shifts in the dollar value of a basis point (DV01). Neglecting these shifts may result in shocks that are not entirely comparable over time or across maturities.

The link between futures price and yield changes can be formalized via the CTD's basis point value (BPV, also known as DV01):

$$\Delta \text{yield}_t^k = -\frac{\Delta P_t^k}{\text{BPV_CTD}_t^k},$$

where ΔP_t^k is the time-t change in k-year futures price (in points), and BPV_CTD_t^k is the change in price (in points) associated with a 1 basis point change in the corresponding CTD yield. For example, suppose the CTD 10-year Treasury security has a BPV of 0.22 points per basis point. Then a 10-year futures price decline of 1.1 points ($\approx 1\%$ at a price of 110) corresponds to a yield increase of –1.10/0.22 = 5 basis points. This calculation scales intraday futures price moves into yield changes that are directly comparable across contracts and over time.

Figure B6: Shock Robustness to Converting Futures Price Changes into CTD Yield Changes



We obtain from Bloomberg daily CTD BPVs for the 2-, 5-, 10-, and 30-year Treasury futures, starting in 2004. To extend the series back to 1998, the beginning of our sample, we regress these daily BPV values on daily settlement prices and employ the fitted values to extrapolate backwards. The intuition is that both BPV and settlement price are driven by the CTD's duration, allowing

us to approximate BPV for earlier years. Using this extrapolated series, we re-scale the 30-minute futures price returns around Treasury auction announcements into yield changes of the CTD. We then re-estimate the two-factor model with an otherwise identical methodology.

Figure B6 compares the baseline factors (based on price changes) with the adjusted factors (based on yield changes). All factors overlap almost exactly: divergences are small and limited to certain periods, and are unlikely to materially affect the results of the paper. Quantitatively, the factor loadings are nearly identical across specifications, and the correlations between the baseline and adjusted factors are virtually 1. These results confirm that using futures price changes as a proxy for yield changes is valid in practice.

B.3 Granger Causality Tests We estimate a VARX(p) that treats both z_t and y_t as endogenous, and the other controls, which include time fixed effects, as exogenous. We then test the null hypothesis that the coefficients on the lagged values of y_t and z_t are jointly zero in the equations of z_t. Table B5 collects the p-values for the test that the row variable Granger-cause the column shock. The results support the lead-lag exogeneity assumption, as we can reject the null hypothesis at the 95% level in the vast majority of cases. Note, this is done with daily data, with lag length, p, selection based on HBIC.

Table B5: Granger causality results

	F1	F2
F1		0.98
F2	0.93	
1 year rate	0.01	0.63
2 year rate	0.20	0.45
5 year rate	0.69	0.21
10 year rate	0.15	0.47
30 year rate	0.44	0.13
2 year term premium	0.47	0.12
5 year term premium	0.49	0.13
10 year term premium	0.41	0.16
Moody's AAA yield	0.04	0.02
BAA-AAA spread	0.27	0.43
S&P 500	0.69	0.29
NASDAQ Composite Index	0.64	0.37
VIX	0.38	0.67

Notes: Each cell displays the p-values for the test that the row variable Granger-causes the column shock.

B.4 Correlations with Other Structural Shocks We consider the contemporaneous correlation of both F1 and F2 surprises with other structural shocks identified in the literature that might be related, including high frequency monetary policy shocks capturing surprises to the federal funds rates, forward guidance and LSAPs from Swanson (2023) and shocks to Treasury

demand from Ray, Droste, and Gorodnichenko (2024), who capture the intraday change in Treasury yields before and after the close of a Treasury auction. In Table B6 and B7, we find no significant correlation with these shocks.

Table B6: Correlation with other shock measures from the literature - daily frequency

	FFR shock	FG shock	-LSAP shock	Treasury demand
F1	-0.039 (0.002)	0.037 (0.003)	0.017 (0.186)	0.000 (0.993)
F2	0.014 (0.269)	-0.008 (0.500)	-0.017 (0.178)	-0.002 (0.898)
Sample	Oct 1998- Dec 2023	Oct 1998- Dec 2023	Oct 1998- Dec 2023	Oct1998 - Dec 2017

Note: The shocks refer to the federal funds rate (FFR), forward guidance (FG), and large-scale asset purchase (LSAP) shocks from Swanson (2023). Eric Swanson kindly provided the data. Treasury demand shocks are from Ray, Droste, and Gorodnichenko (2024), and capture the intraday change in Treasury yields before and after the close of an auction. Sample period is based on overlapping data available for the two series under consideration.

Table B7: Correlation with other shock measures from the literature - monthly

	FFR shock	FG shock	LSAP shock	Treasury demand
F1	-0.168 (0.003)	0.112 (0.046)	0.054 (0.335)	-0.063 (0.265)
F2	-0.004 (0.940)	-0.033 (0.559)	0.094 (0.094)	0.061 (0.279)
Sample	Oct 1998- Dec 2023	Oct 1998- Dec 2023	Oct 1998- Dec 2023	Oct1998 - Dec 2017

Note: The shocks refer to the federal funds rate (FFR), forward guidance (FG), and large-scale asset purchase (LSAP) shocks from Swanson (2023). Eric Swanson kindly provided the data. Treasury demand shocks are from Ray, Droste, and Gorodnichenko (2024), and capture the intraday change in Treasury yields before and after the close of an auction. Sample period is based on overlapping data available for the two series under consideration.

B.5 Distribution of F_1 and F_2 In Figure B7, we plot the distribution of Treasury supply shocks by separating QRS and non-QRS dates. Larger shocks, in particular for F_2, tend to coincide with QRS announcements. Given the report and press conference, the QRS provides a venue for the Treasury to communicate the issuance strategy and is likely to contain richer information. In addition, Figure B8 split the distributions based on the debt-GDP growth. The two sets of distributions overlap with each other, suggesting no systematic differences in issuance surprises.

Figure B7: Conditional Distribution of F_1 and F_2: QRS dates (blue) vs. non QRS (red)

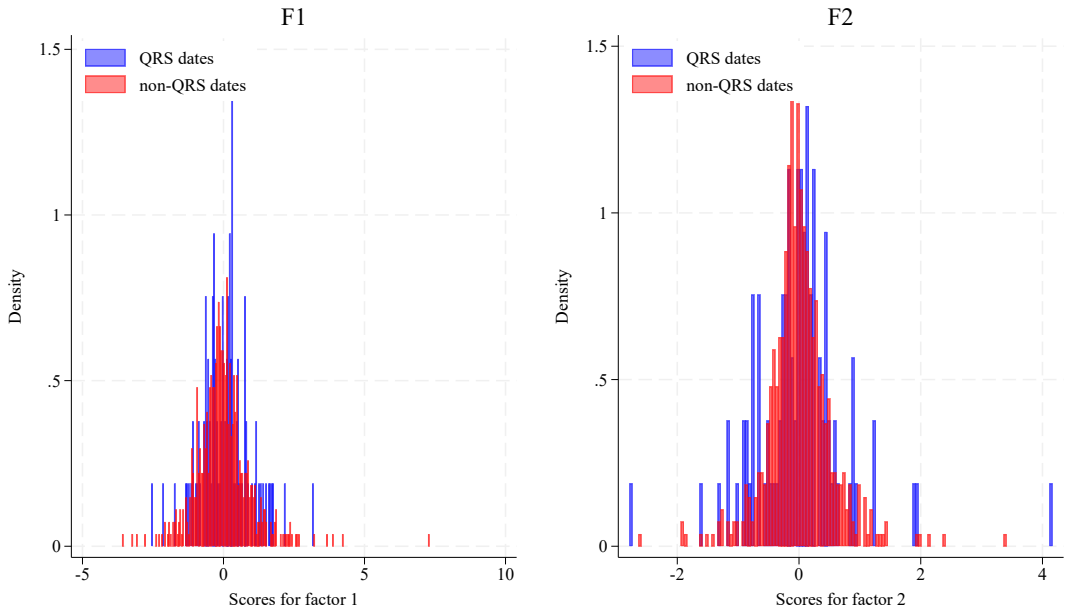
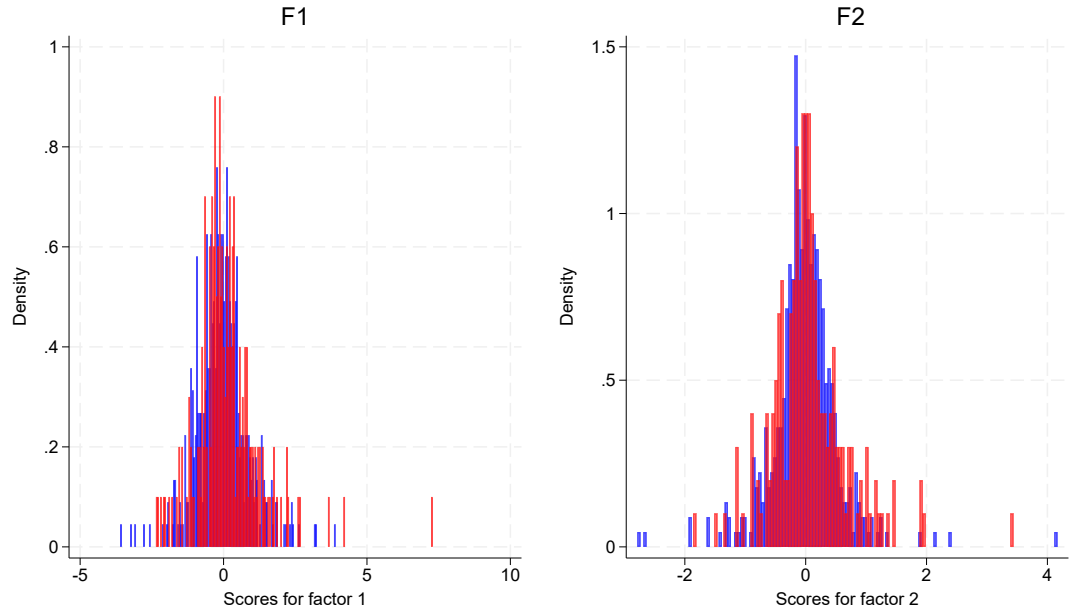


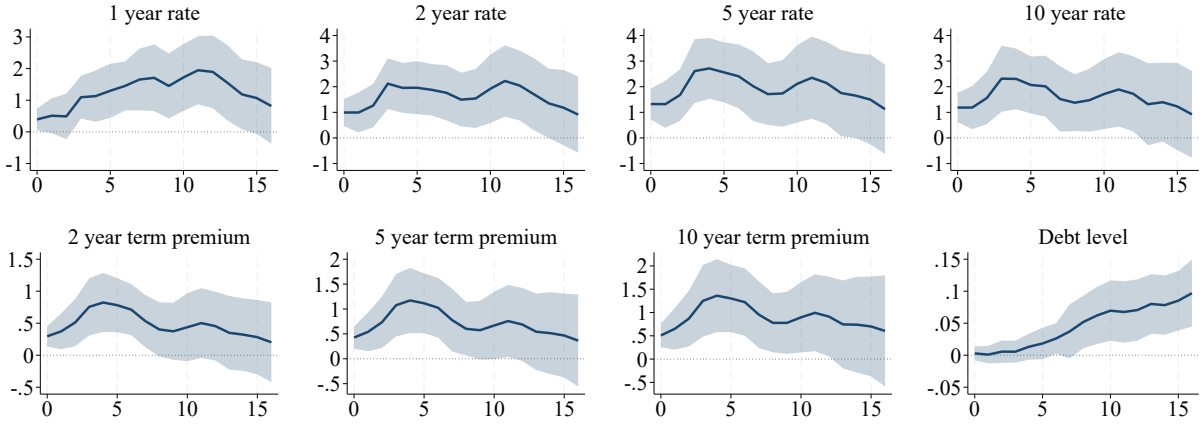
Figure B8: Conditional Distribution of F_1 and F_2: High-debt (red) vs. Low-debt (blue)



C Additional Impulse Responses

C.1 Daily Responses to F_1 Figure 6 shows that a debt volume expansion shock leads to a gradual but sustained increase in the level of government debt. The initial muted response is consistent with the fact that Treasury announcements are usually made days before the auctions. With a higher supply, Treasury yields increase across all maturities, leading to an upward shift in the yield curve. In addition, higher than expected debt issuance puts upward pressure on the Treasury market, and investors demand a higher term premium for compensation.

Figure C9: IRFs to a Debt Expansion Shock (F_1): daily frequency

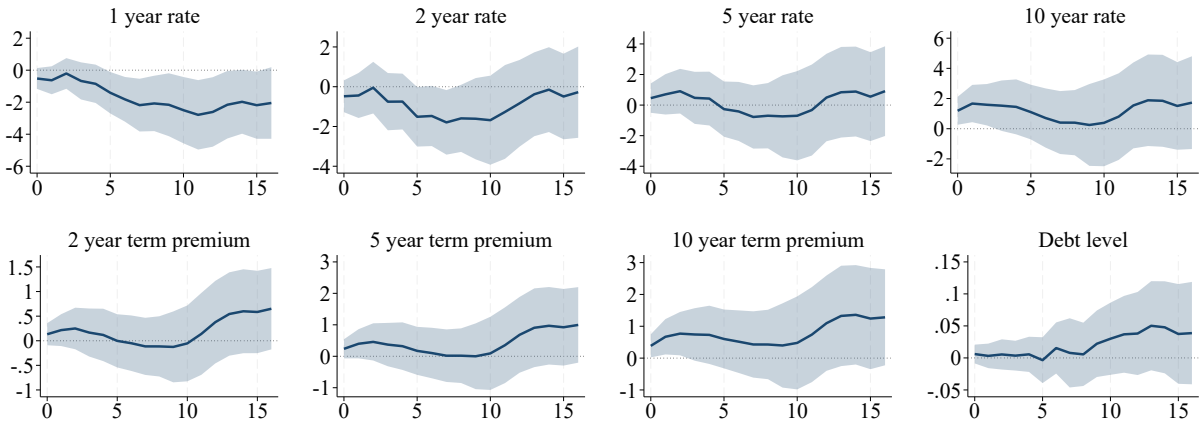


Note: The x-axis shows business days after the shock hits. The y-axis gives the response in terms of basis points for the yields, term-premia and spreads. 90% confidence bands are shown for all IRFs.

C.2 Daily Responses to F_2 Figure C10 shows the average responses of financial markets to a maturity extension shock of one standard deviation. A lower bill supply reduces 1-year Treasury yield by 2 to 3 basis points, while a higher bond supply raises 30-year yield by about 2 basis points. The steepening yield curve reflects Treasury issuance unexpectedly shifting from the short to the long end. Following the announcement, term premium rises for 10-year Treasury, while the response is largely muted for 2-year notes. In addition, the response of debt level is also muted, as F_2 shock captures a lengthening in the issuance maturity rather than an increase in the issuance volume.

Turning to corporate bonds, Figure C11 shows that the spread between BAA and AAA bonds declines, reflecting lower credit risks in the financial market. The easing credit conditions are consistent with the safe asset channel (see Krishnamurthy and Vissing-Jorgensen (2012b)). Our result indicates that the safety attribute may be particularly relevant for longer-term Treasury securities, as the relative abundance of long-term safe assets helps to reduce corporate credit risks. Similarly, VIX declines in the days following the shock, consistent with a risk-on sentiment. Here both the safety channel as well as the signaling channel may be at play. Since Treasury coupons are a better hedge against future economic and fiscal shocks than bills, shifting issuance from the

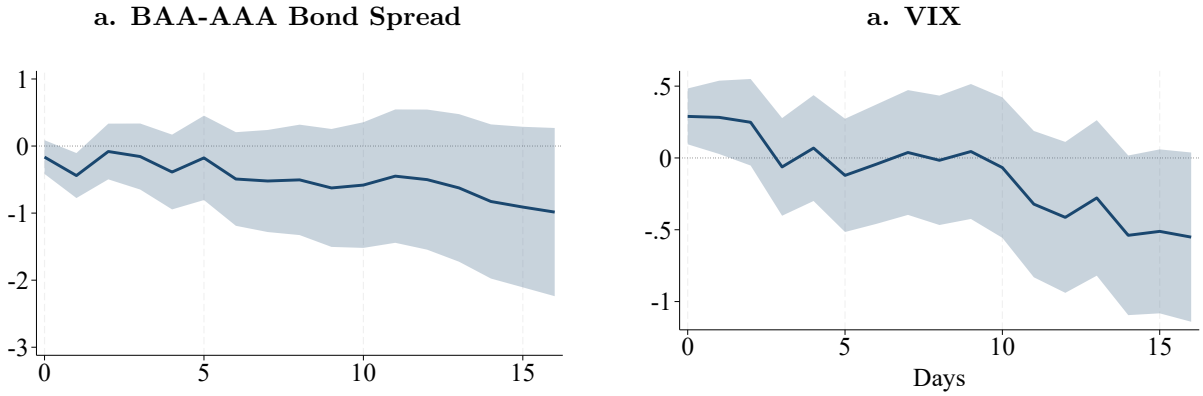
Figure C10: IRFs to a Maturity Extension Shock (F_2): Daily Frequency



Note: The x-axis shows business days after the shock hits. The y-axis gives the response in terms of basis points for the yields, term-premia and spreads. 90% confidence bands are shown for all IRFs.

short to the long end may reduce credit and volatility risks.

Figure C11: IRFs to a Maturity Adjustment Shock (F_2): daily frequency

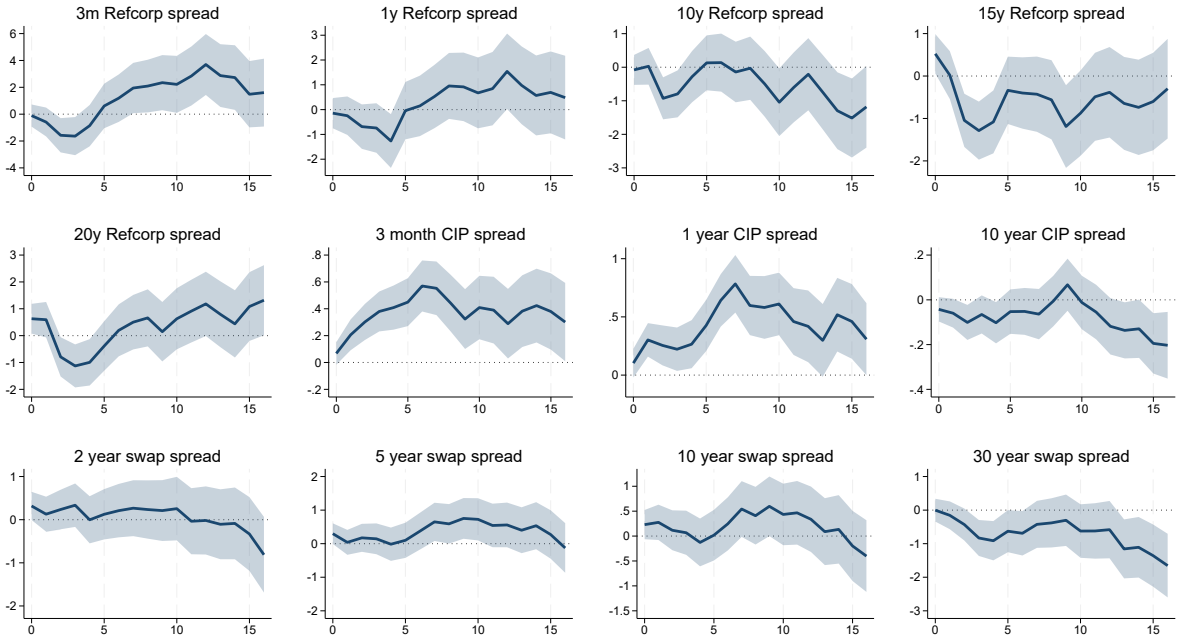


Note: (Left) IRFs of BAA and AAA corporate bond spreads with the y-axis in basis points. (Right) IRFs of VIX with the y-axis in percent deviations. In both panels, the x-axis shows business days after the shock and 90% confidence bands are displayed.

Using a range of liquidity measures, Figure C12 highlights that a maturity extension shock raises liquidity premia at the short end while reducing it at the long end. The first five panels show the response of spreads between Refcorp bonds and Treasury securities, following Longstaff (2004). We see an increase for 3-month and 1-year securities shortly after the announcement, as lower issuance at the short end raises Treasury liquidity premium. But they decline for 10-year and 15-year securities as issuance at the long end increases. Convenience yields constructed as covered interest parity (CIP) deviations such as in Du, Im, and Schreger (2018) increase for 3-month and 1-year securities while declining for 10-year bonds. Swap spreads, capturing the difference between

OIS rates and zero-coupon Treasury yields of a given maturity, are also lower at the long end.

Figure C12: IRFs to a Maturity Extension Shock (F_2): Liquidity Measures

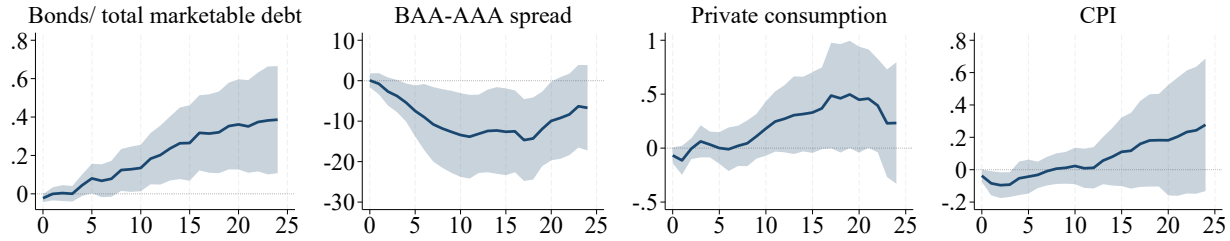


Note: The x-axis shows business days after the shock hits. The y-axis gives the response in terms of basis points for the yields, term-premia and spreads. 90% confidence bands are shown for all IRFs.

C.3 Monthly Responses to F_2 Figure C13 provides additional IRFs to a maturity adjustment shock. Long-term bonds as a share of total market debt increases steadily following a positive F_2 shock. Consistent with the response of excess bond premia, the spread between BAA and AAA spread also declines, reflecting easing credit constraint in the corporate bond market. Private consumption follows a similar dynamics as industry production.

C.4 Monthly Responses: QRS vs. non-QRS Figure C14 shows the responses to the two types of Treasury supply shocks, based on whether they coincide with the QRS announcement or not.

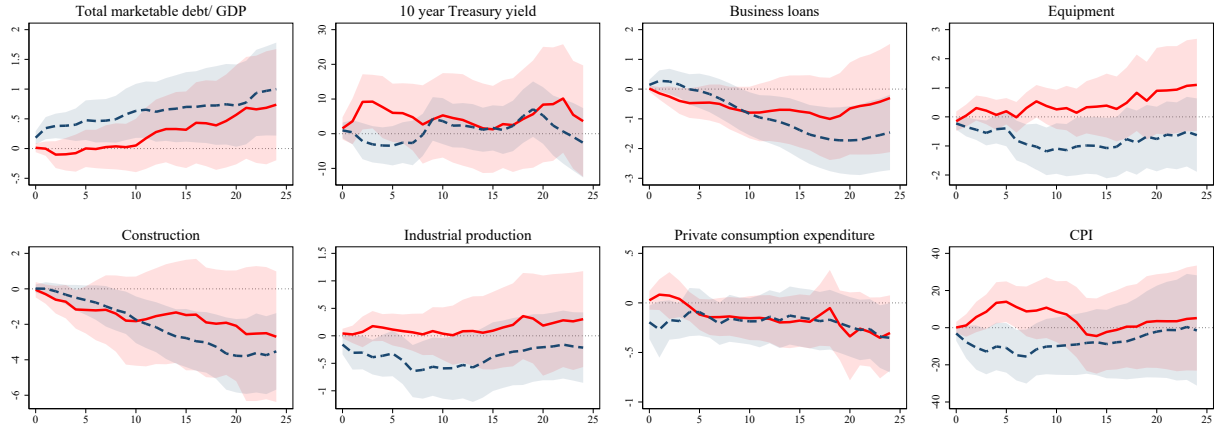
Figure C13: IRFs to a Maturity Shock (F_2): monthly frequency



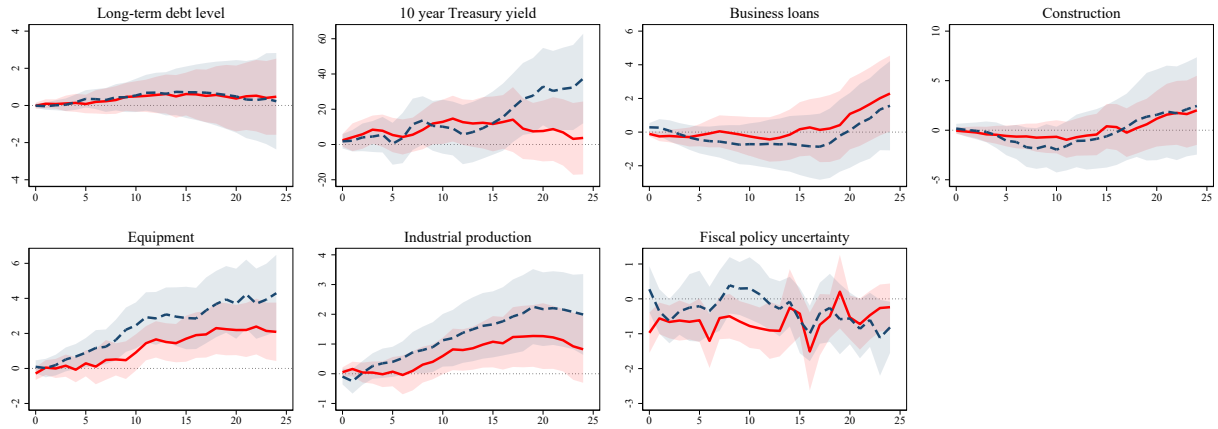
Note: The x-axis shows months after the shock hits. The y-axis gives the response in basis points for BAA-AAA spread, in percentage points for bonds/debt ratio, and in percent deviations for other variables. 90% confidence bands are shown for all IRFs.

Figure C14: IRFs to Treasury Supply Shocks: : QRS vs. non QRS dates

a. Debt Expansion Shock (F_1)



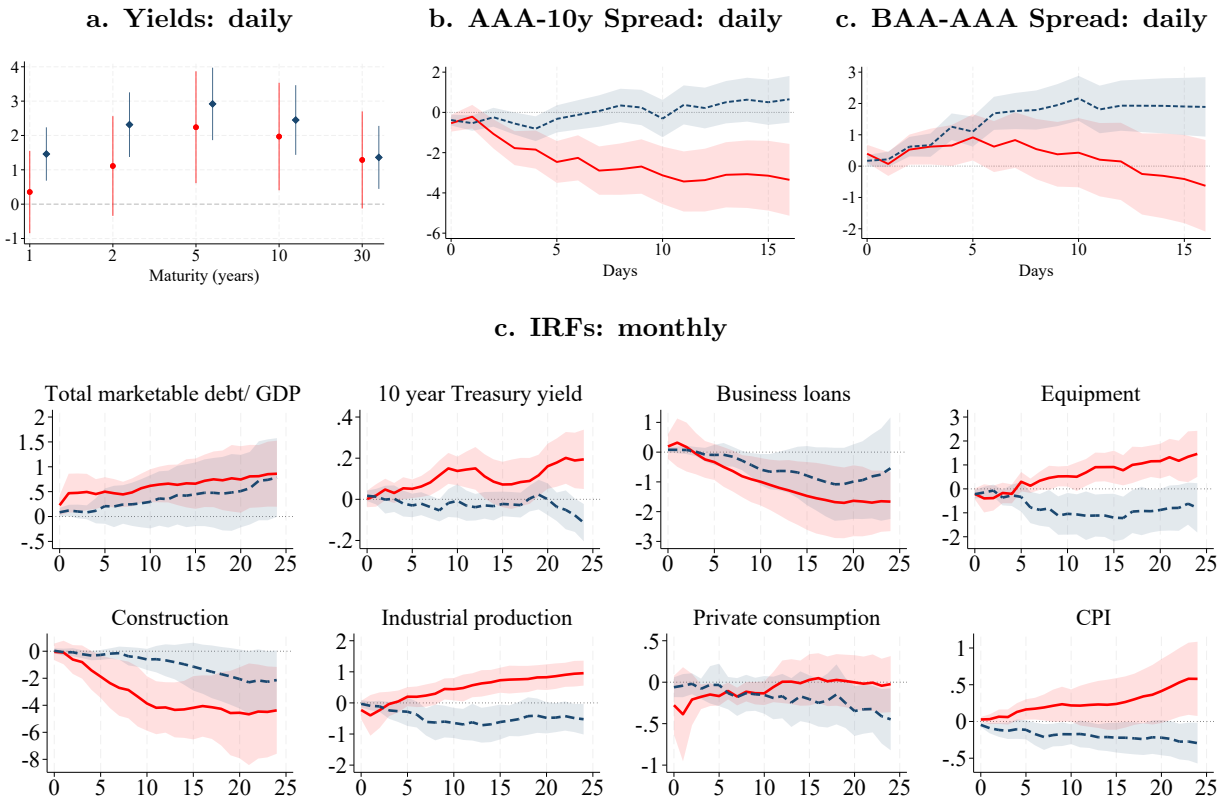
b. Maturity Extension Shock (F_2)



Note: The x-axis shows months after the shock hits. Red solid lines represent responses for debt expansion shocks that coincide with QRS, and dashed blue lines show responses for debt expansion shocks that do not coincide with QRS. 90% confidence bands are shown for all IRFs.

C.5 Zero Lower Bound Periods There is a vast literature on the interaction between fiscal and monetary policy. One natural question is whether the prevailing stance of monetary policy has consequences for the propagation of Treasury supply shocks. Notably, during the time frame we consider in our analysis, monetary policy was subject to the zero lower bound. We now consider Equation 5.1 and define I_t to take a value of 1 when the economy was subject to ZLB.[21]

Figure C15: Responses to Debt Expansion Shock (F1): ZLB



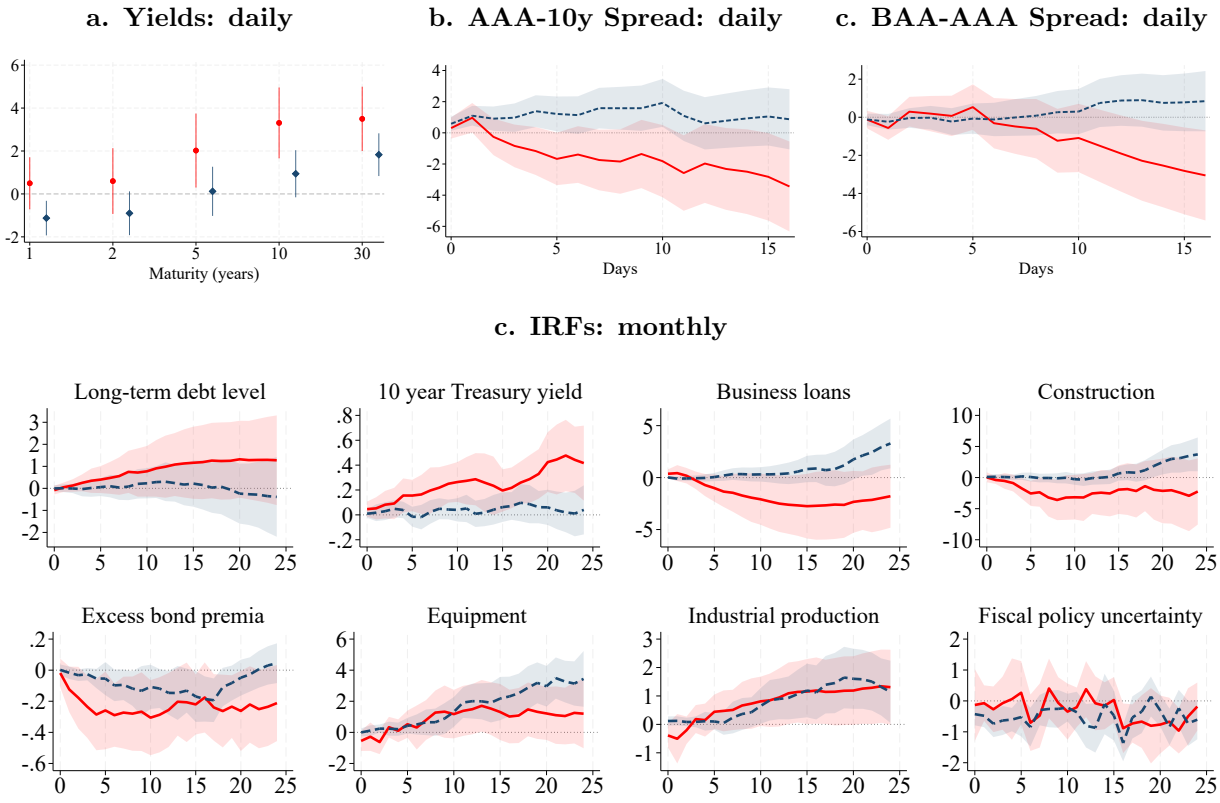
Note: Red dots/lines represent responses during ZLB periods, while blue dots/lines are outside of ZLB periods. 90% confidence bands are shown. (Top left) Responses of yields across maturities at day 4 following the shock with the x-axis showing maturities and the y axis in basis points. (Top middle/right) IRFs of AAA and 10-year Treasury spread as well as BAA and AAA corporate bond spreads with the x-axis showing days after the shock and the y axis in basis points. (Bottom) IRFs at monthly frequency with the x-axis showing months after the shock hits. The y-axis is in percentage points for debt-GDP ratio, basis points for yields, and percent deviations for the rest.

Panel (a) of Figure C15 shows the responses from the daily regressions. We see that during ZLB periods (red solid), the short-term yields do not respond but rise for longer maturities particularly on impact. In non-ZLB periods, conversely, we see a rise in yields across all maturities, which is statistically significantly positive. We also see a fall in the convenience yield given by the AAA-10Y spread during ZLB periods, while it is flat outside of ZLB periods. Importantly, the safe asset

[21] These periods are defined as from January 1, 2009 to November 30, 2015 and from March 15, 2020 to March 15, 2022.

channel is more pronounced during the ZLB periods, as the BAA-AAA spread increases less and even start to decline after 10 days.

Figure C16: Responses to Debt Expansion Shock (F2): ZLB



Note: Red dots/lines represent responses during ZLB periods, while blue dots/lines are outside of ZLB periods. 90% confidence bands are shown. (Top left) Responses of yields across maturities at day 4 following the shock with the x-axis showing maturities and the y axis in basis points. (Top middle/right) IRFs of AAA and 10-year Treasury spread as well as BAA and AAA corporate bond spreads with the x-axis showing days after the shock and the y axis in basis points. (Bottom) IRFs at monthly frequency with the x-axis showing months after the shock hits. The y-axis is in percentage points for debt-GDP ratio, yields, and excess bond premia, and percent deviations for the rest.

When we consider responses of macroeconomic variables at the monthly frequency, we find significant differences across the two regimes. A debt expansion shock leads to a notable decline in excess bond premia and a rise in industrial production, while it has the opposite impact outside of the ZLB period.[22] The crowding out of consumption is also muted during ZLB. This positive impact on private economic activity is consistent with the findings in the literature that consider fiscal multipliers at the ZLB (see, for instance, Christiano, Eichenbaum, and Rebelo (2011) for a theoretical framework and Ramey and Zubairy (2018) for empirical evidence). At the ZLB, theory suggests that since short rates do not respond, then the real interest rate do not rise as much or even fall, and thus lead to a rise in private activity. Here we find that the expansionary impact from

[22] A debt expansion shock also increases equipment spending during the ZLB regime.

the safe asset channel is also stronger during the ZLB periods. On the other hand, we observe a crowding-out of construction during the ZLB period, suggesting its sensitivity to long-term interest rates. This also aligns with the rise in 10-year Treasury yields to the debt expansion shock during ZLB.

For maturity extension shocks, at the daily level we see differences in the responses of yields: shorter maturity yields have a flat response during ZLB periods, and longer maturities tend to rise more. During non-ZLB periods, we see a fall in the short-term maturities and a rise in longer-term maturities, which is smaller than the ZLB periods. Thus, overall the slope of the yield curve seems to move to the same degree across ZLB and on-ZLB periods. At the macroeconomic level, we do not find significant differences in responses to a maturity extension shock across ZLB and non-ZLB periods, as the two competing channels are largely offset, as shown in Figure C16.