Can U.S. Treasury Markets Add and Subtract?[*]

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Abstract

The CBO cost releases of U.S. spending and tax proposals contain valuable news about future primary surpluses priced in by U.S. Treasury markets. Using daily event windows, we find that cost releases with large negative cash flow projections have lowered the valuation of all outstanding Treasurys by more than 20% between 1997 and 2022. The Treasury valuation effects of adverse fiscal news are concentrated at longer maturities, with an overall increase of 4% in long-term nominal yields driven by an increase in nominal term premia and inflation expectations and a decrease in convenience yields that offset higher inflation expectations. We account for these valuation effects of large bills in a model with Bayesian bond investors who use the cost releases to learn about the long-run dynamics of U.S. deficits, not just the cost of the bill. Using the estimated model, we infer that a one percentage point surprise increase in the supply of Treasurys, expressed as a fraction of GDP, corresponds to an increase of the 10-year nominal yield by 31 bps and a drop in the convenience yield of 7.5 bps.

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All federal taxation and spending requires legislation enacted by Congress. Therefore, the federal government's primary surplus –revenues minus expenditures– is the outcome of a collection of legislative bills. The Congressional Budget Office (CBO) is an important source of news about the budget process. The CBO is an independent agency created by the Congressional Budget Act of 1974 to provide detailed communication about the federal budget process to the public.

Each year, the CBO provides hundreds of real-time cost estimates for legislative proposals at horizons of up to ten years. We collect the cost releases for all bills introduced by Congress from 1997 to 2022, totaling 15,533 unique cost projections. The CBO has an informational edge because CBO analysts have direct access to the legislators of the bill to gather specific details of the scale and implementation of the bill used to prepare the estimates. We examine how the bond market processes the release of these individual cost estimates.

We focus on the response of aggregate Treasury valuations around the cost releases of individual proposals. Suppose the cost releases are a systematic news source about the individual proposal's cash flows or aggregate surplus policy. In that case, this news should be reflected in Treasury valuations since the government budget identity equates the market value of public debt to the present value of future surpluses. In daily event windows, we find that cost releases of large proposals expected to increase future deficits (e.g., tax cuts or spending) significantly lower the Treasury valuations.

The consistent negative bond price responses to large negative cost releases are difficult to rationalize in a standard full information rational expectations (FIRE) framework. Instead, we interpret our findings in a framework where Treasury investors use these cost releases to learn about the entire path of future surpluses and the underlying policy parameters governing surplus dynamics rather than only inferring the cost impact of an individual proposal.

We construct a measure of a proposal's budgetary impact by aggregating the cash flow estimates for each CBO cost release. We use this measure as a conditioning variable in our empirical tests. The fiscal news in cost releases over our sample is concentrated on large proposals with a negative budgetary impact that exceeds the median. On days with large negative proposals, the cost release causes bond market investors to decrease

Treasury valuations by -1.84 basis points (bps) or -0.88 bps of GDP. We assume that the news content of the cost release dominates the high-frequency change in the Treasury valuation on these days.

The cumulative change in the valuation of the Treasury portfolio on large negative proposal days exhibits a smooth downward trend that sums to approximately -21% over our sample covering 1997 to 2022. The smooth trend implies that the effects on large negative days are attributed to a consistent flow of news and not a few large observations. In contrast, we do not find significant effects on large positive proposal days. In this sample, large negative proposals reveal budgetary news about the path of future surpluses that are relevant to bond investors.

We next explore whether the cost releases convey budgetary news beyond government cash flows by examining the responses of nominal government discount rates and expected inflation. We decompose the nominal government discount rate into the convenience yield, default risk, and nominal term premia components at the aggregate Treasury portfolio level and the nominal short rate. We evaluate market expectations of inflation across different horizons.

On the large negative proposal days, nominal term premia increases by 0.18 bps while convenience yields decrease by 0.09 bps. The cumulative effect is 2% for nominal term premia and -0.8% for convenience yields on these days. The impact on convenience yields is consistent with the downward-sloping demand for the convenience services of Treasurys (Krishnamurthy and Vissing-Jorgensen, 2012). Short rates and Treasury default risk do not respond. The increase in nominal term premia and decrease in convenience yields on large negative proposal days both contribute to higher nominal government discount rates.

We find market expectations of inflation also increase across horizons in daily event windows around large negative proposal days, particularly at long horizons. For example, the average daily change in the 10-year inflation swap is 0.21 bps, and the cumulative effect is 1.64%. The expected inflation response is consistent with models of the fiscal theory featuring long-term government debt if the cost releases revealed news about higher deficits or nominal discount rates (e.g., Cochrane (2001) and Corhay, Kind, Kung, and Morales (2023)).

The increase in expected inflation and nominal term premia give rise to an increase in long-term nominal yields around large negative proposal days. The average daily change in the 10-year nominal yield is 0.38 bps, with a cumulative increase of 4.33% on these days. Interestingly, Fed policy imputed a secular downward drift to long-term bond yields over this period (Hillenbrand, 2021). The cumulative change of the 10-year nominal yield on FOMC meeting days is -3.18%, effectively offsetting the cumulative effect of large negative proposals. Most of the FOMC-induced yield changes accelerated after the Fed's large-scale asset purchases at the start of the Financial Crisis in 2008, suggesting that the Fed may have been leaning against the fiscal wind.[1]

We use the intertemporal government budget identity to relate changes in Treasury values around large negative proposals to cash flow news about the individual proposal in the cost release, cash flow news about aggregate surpluses (excluding the proposal), and government discount rate news. We provide evidence that large negative proposal days can be predicted using the text in the proposal's summary when introduced (usually available 150 days before the cost release) and that these days are not correlated with bond pricing factors.

We then argue that the negative Treasury value responses to large negative proposals are inconsistent with investors having full information and rational expectations (FIRE) about the processes driving surpluses and discount rates. In other words, it is unlikely that rational bond investors are consistently underestimating the direct costs of proposals, aggregate surpluses, or discount rates on large negative proposal days for over two decades. The positive responses of nominal discount rate components and market expectations of inflation on large negative proposal days further corroborate the deviations from FIRE.

A plausible deviation from full information is that bond investors at the start of our sample in 1997 did not fully know the true model governing the drift in policy toward rising deficits and indebtedness in the subsequent decades, especially since it contrasts with the fiscal consolidation of the 1990s. Rational bond investors would have gradually learned about the increasing trend in deficits as new data came in. Over 80% of the proposals in our sample have negative future cash flows up to 10 years ahead, which

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[1] Hall and Sargent (2022) compare U.S. fiscal and monetary policy during the pandemic and the world wars.

could provide valuable information about the future path of fiscal policy. Given the persistence of the policy reversal, bond investors would gradually revise their beliefs about the loosening stance of policy as the cost estimates are released.

We formalize the narrative of bond investor learning by assuming that rational Bayesian investors use incoming cost releases with past realized surpluses and bond prices to revise their beliefs about the persistent components of the aggregate surplus policy, government discount rates, and future debt in a present value framework. The model operates on a monthly frequency to align with the aggregate realized surplus data sampled at the highest frequency available. If investors observe an increasing frequency of large negative proposals, this could reveal policymakers' willingness to run persistent deficits. Absent long-run expectations of Ricardian policy to offset these persistent deficits in the future, bond investors would lower Treasury valuations.

We find that the large negative cost releases generate significant parameter revisions in the learning model, leading to a gradual increase in the investor's estimates of the persistence and declining unconditional mean governing the surplus processes over a 10-year horizon, capturing how the investor updated their beliefs about the deepening deficits unfolding throughout our sample. The parameter revisions help explain the negative systematic Treasury value changes on days with large negative cost releases. The model also explains why small cost releases and large positive cost releases do not generate significant bond price responses since they are less helpful for the investor to learn about and predict the trend component in surpluses.

We use our estimated model to decompose the news content in the large negative cost releases. At monthly frequencies, we find the majority (57%) of the surplus news from large negative cost releases is passed on to Treasury valuations. The remaining 43% is absorbed by an increase in investors' expectations of future outstanding debt. The effect on real discount rates is small, partly reflecting the offsetting responses of expected inflation and nominal discount rate components. In addition, Fed policiescc with long-term interest rate targets may offset the effects on nominal discount rates within the month. According to our estimates, the negative Treasury value responses to large negative cost releases primarily reflect investors updating their beliefs about the aggregate surplus process and the parameters governing it.

We relate to the empirical literature linking government debt valuations to surplus news using budget identities (e.g., Berndt, Lustig, and Yeltekin (2012), Jiang, Lustig, Van Nieuwerburgh, and Xiaolan (2019), Cochrane (2022), Hilscher, Raviv, and Reis (2022), Campbell, Gao, and Martin (2023), and Collin-Dufresne, Hugonnier, and Perazzi (2023)). We distinguish our paper by exploiting high-frequency and granular data about the cash flows of individual legislative proposals to isolate when bond investors learn about future surpluses, evidenced by the significant response of Treasury valuations to cost releases in daily event windows.

Jiang, Lustig, Van Nieuwerburgh, and Xiaolan (2021) do not find evidence that Treasury values respond to news about future surpluses using aggregate data at a quarterly frequency. We provide suggestive evidence that the actions of the Fed may have been counteracting the effects of these fiscal shocks over our sample, making it challenging to identify the effect of surplus news on Treasury values at lower frequencies.

Our approach to measuring surplus news at the bill level and extracting relevant information from cost projections builds on the narrative approach to constructing fiscal shocks (e.g., Romer and Romer (2010), Ramey (2011), Mertens and Ravn (2012), Guajardo, Leigh, and Pescatori (2014), Alesina, Favero, and Giavazzi (2019), Drautzburg (2020), and Bianchi, Gomez-Cram, and Kung (2021)). We contribute by showing that the CBO cost projections at the bill level reveal fiscal news with significant pricing implications.

In our model, bond investors learn about long-run dynamics in macroeconomic data (e.g., see Croce, Lettau, and Ludvigson (2015), Collin-Dufresne, Johannes, and Lochstoer (2016), Kozlowski, Veldkamp, and Venkateswaran (2020), Farmer, Nakamura, and Steinsson (2021), and Giacoletti, Laursen, and Singleton (2021)). We build on this literature by showing that Bayesian investors who are learning about the persistent trend in deficits through incoming cost releases in a present value framework can generate bond price drifts.

In traditional macro models, monetary policy has a small influence on long-term real rates. To anchor short rates, central bankers rely on measures of the equilibrium real rate that are assumed to be invariant with respect to monetary policy (See, e.g., work by Laubach and Williams, 2003; Holston, Laubach, and Williams, 2017, on rstar). Recently, there has been more evidence that monetary policy impacts long-term real rates (Hanson and Stein, 2015; Hillenbrand, 2021; Bianchi, Lettau, and Ludvigson, 2022). Our findings suggest that the Fed may have been actively neutralizing the effect of fiscal news on long-term real rates, especially after the Financial Crisis in 2008.

1 Data and Measurement

This section first describes the information provided by the cost estimates of individual legislative proposals from Congress. We then provide a present value framework for interpreting the news content in the cost estimates. The final part outlines the construction of the aggregate Treasury values.

1.1 *CBO cost estimates*

The Congressional Budget Act of 1974 (CBA) established centralized budgeting with revenue and spending targets specified in the budget resolution. The CBA also created the Congressional Budget Office (CBO), which is a non-partisan agency that provides hundreds of cost estimates of legislative proposals and other budgetary information each year. The CBO is legally required to provide cost estimates for a legislative proposal after committee approval but before it is voted on by the full Senate and House.[2] These cost estimates are designed to calculate the impact of legislative proposals on the federal budget across multiple years. The CBO promotes transparency by posting cost estimates on its website (`cbo.gov`), granting access to members of Congress, their staff, and the public. Congress can use these estimates to enforce budget rules.

The CBO gets a unique glimpse of the legislative path of a given proposal before the public cost release.[3] For example, CBO analysts have direct access to the legislators of the bill to gather specific details of the scale and implementation of the bill used to prepare the estimates. The analysts also provide confidential cost estimates of alternative legislative options in the early stages of the bill and before the public cost release to help

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[2] On average, the cost estimates occur 60 days before the congressional vote on the proposal and 150 days after the proposal is introduced.

[3] See, for example, "How CBO Prepares Cost Estimates" (`www.cbo.gov/publication/53519`).

guide the congressional committee in selecting the legislative path for the bill. In sum, the CBO has private information about the legislative process that is embedded in the public cost release.

We analyze all legislative proposals introduced by Congress covering the 105th Congress (1997-1998) to the 117th Congress (2021-2022), yielding 15,050 unique proposals. Our sample started in 1997 because that is when the cost releases began to comprehensively cover all proposed legislation. For each bill, we obtained the corresponding CBO published cost estimates, which show how federal outlays and revenues would change if the legislation was implemented as proposed. Occasionally, the CBO revises existing cost estimates in a public release due to new material information. In total, we collected 15,533 unique cost estimates, with a median bill having one unique cost estimate. Figure B.1 illustrates that there is significant coverage by major media outlets in the days following the cost releases.

Each cost estimate is presented in a pdf format detailing the projected cash flow effects of the proposed legislation on three key components of the federal budget for the current year and the subsequent five to ten years: discretionary spending, mandatory (or direct) spending, and federal revenues.[4] The cost estimates of small bills are described as text in a paragraph, while the estimates for large bills are typically detailed in a table format. Appendix A.2 provides examples of the cost estimate format for a small and large bill. From each cost estimate document, we extract the cash flows by year, bill number, title, legislative status, and publication date. We augment the data gathered from the cost estimate document with key legislative actions and corresponding dates (i.e., when the bill was first introduced in the House and Senate, committee meetings, congressional vote, and if the bill was signed into law by the president) from `congress.gov`.

We focus on the budgetary effects of legislative actions as a source of surplus news because they are the most important driver of the CBO's aggregate surplus revisions reported in the Budget and Economic Outlook documents. Legislative changes account for 56% of the variance observed in the revisions to the aggregate surplus projections. The

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[4] For bills authorizing discretionary activities or programs (requiring subsequent funding), cost estimates typically offer budgetary details for a 5-year period as directed by the Budget Act. Alternatively, for bills that affect mandatory spending or revenues, provisions in other laws stipulate a 10-year period.

remaining 44% of the variance in surplus changes is equally accounted for by economic changes and technical changes. Economic changes arise from revisions made to the agency's economic forecast, which includes adjustments to incorporate the macroeconomic effects of recently enacted legislation. Technical changes serve as a residual category, capturing revisions to projections that are neither legislative nor economic in nature. Appendix A.3 provides details of this aggregate decomposition of surplus revisions.

1.2 Cash flow contributions from individual proposals

We relate the expected cash flows of individual bills to the aggregate Treasury value using the intertemporal government budget equation.

We start with the budget identity at time t,

$$B_t + S_t = R_{gt} B_{t-1}, \tag{1}$$

where B_t is the market value of the aggregate Treasury portfolio held by the public, R_{gt} is the corresponding gross portfolio return and S_t is the aggregate surplus. Appendix C shows how this identity can be expressed in terms of face values and market prices of individual treasuries and how the identity can account for partial default risk.

We normalize the variables in the identity by nominal GDP (Y_t)

$$\hat{B}_t + \hat{S}_t = R_{gt}/(\Pi_t \Delta\hat{Y}_t)\hat{B}_{t-1}, \tag{2}$$

where $\hat{B}_t \equiv B_t/Y_t$ is debt to GDP, $\hat{S}_t \equiv S_t/Y_t$, $\Pi_t \equiv P_t/P_{t-1}$ is inflation, and $\Delta\hat{Y}_t \equiv \hat{Y}_t/\hat{Y}_{t-1}$ is real GDP growth. Taking logs of the equation (2) at $t+1$, we obtain

$$\log\left(e^{b_{t+1}} + \hat{S}_{t+1}\right) = \hat{r}_{gt+1} + b_t, \tag{3}$$

where $\hat{r}_{gt} \equiv r_{gt} - \pi_t - \Delta y_t$ is the log inflation and growth-adjusted return, $r_{gt} \equiv \log(R_{gt})$, $\pi_t \equiv \log(\Pi_t)$, $\Delta y_t \equiv \log(\Delta\hat{Y}_t)$, and $b_t \equiv \log(\hat{B}_t)$.

We linearize equation (3) with respect to log debt to GDP and the level of surplus to GDP around the steady state as in Jiang et al. (2021) and Cochrane (2022) to get the approximate identity as

$$\alpha + \nu b_{t+1} + \gamma \hat{S}_{t+1} = \hat{r}_{gt+1} + b_t, \tag{4}$$

where α, ν, and γ are constants of the linearization. Details of the approximation and the expressions for the constants are contained in Appendix C.

We iterate equation (4) forward, impose the transversality condition, and then take the bond investor's expectations of the dynamic identity to get

$$b_t = \alpha^\star + \mathbb{E}_t \sum_{j=1}^{\infty} \nu^{j-1} \gamma \hat{S}_{t+j} - \mathbb{E}_t \sum_{j=1}^{\infty} \nu^{j-1} \hat{r}_{gt+j}, \tag{5}$$

where $\alpha^\star \equiv \alpha/(1-\nu)$ and $\mathbb{E}_t(\cdot)$ is the bond investor's conditional expectations operator that we assume respects the government budget identity. Equation (5) links the current market value of the government debt-to-GDP ratio to future surplus-to-GDP ratios and government discount rates adjusted for expected growth and inflation.

We relate the market value of debt to the expected cash flows of individual proposals and enacted bills by using an identity that decomposes the expected aggregate surplus at horizon j into the contributions from current proposals and enacted bills, and future proposals as

$$\mathbb{E}_t \hat{S}_{t+j} = \underbrace{\mathbb{E}_t \sum_{k \in N_t} \mathbb{1}^{(k)}_{\geq t} \hat{S}^{(k)}_{t+j}}_{\text{current policy}} + \underbrace{\mathbb{E}_t \sum_{l \in N_{>t}} \iota^{(l)}_{>t} \hat{\mathbb{S}}^{(l)}_{t+j}}_{\text{future policy}}, \tag{6}$$

where N_t is the set of current bills enacted or proposed before or at t, $\mathbb{1}^{(k)}_{\geq t}$ is an indicator variable that takes on the value of 1 if the bill k is enacted, $\hat{S}^{(k)}_{t+j} \equiv S^{(k)}_{t+j}/(Y_{t+j})$ is the cash flow contribution of bill k at time $t+j$ normalized by nominal GDP conditional on being enacted, $N_{>t}$ corresponds to the set of new legislation proposed or amended after t, $\iota^{(l)}_{>t}$ is an indicator variable that is equal to 1 if the future proposed bill or amendment l is enacted in the future, and $\hat{\mathbb{S}}^{(l)}_{t+j} \equiv \mathbb{S}^{(l)}_{t+j}/(Y_{t+j})$.

We can plug equation (6) into equation (5) to obtain a present value relation linking the cash flow contribution from current policy (enacted and proposed bills today), cash flow contribution from future policy (future proposals), and government discount rates according to

$$b_t = \alpha^\star + \underbrace{\gamma \mathbb{E}_t \sum_{k \in N_t} \sum_{j=1}^{T} \nu^{j-1} \mathbb{1}_{\geq t}^{(k)} \hat{S}_{t+j}^{(k)}}_{\substack{\text{cash flow contribution from} \\ \text{current policy}}} + \underbrace{\gamma \mathbb{E}_t \sum_{l \in N_{>t}} \sum_{j=1}^{\infty} \nu^{j-1} \iota_{>t}^{(l)} \hat{\mathbb{S}}_{t+j}^{(l)}}_{\substack{\text{cash flow contribution from} \\ \text{future policy}}} - \underbrace{\mathbb{E}_t \sum_{j=1}^{\infty} \nu^{j-1} \hat{r}_{gt+j}}_{\text{discount rates}}, \tag{7}$$

where T corresponds to the time horizon of the CBO forecasts.

Suppose that the CBO cost estimate of a current proposal z is released at time $t + \Delta t$, providing cash flow projections $\{\widetilde{\mathbb{E}}_{t+\Delta t} S_{t+j}^{(z)}\}_{j=1}^{T}$ conditional on the proposed legislation being enacted, where $\widetilde{\mathbb{E}}_{t+\Delta t}[\cdot]$ is the CBO's expectation operator, which could be different than the bond investor's expectations. The cost estimate could contain direct news about the cash flows of proposal z or convey new information about the stance of aggregate surplus policy or discount rates. Any new information relevant to bond investors would be reflected in the change in the Treasury portfolio value based on equation (7), rewritten in news terms as

$$\begin{aligned} \Delta b_{t+\Delta t} \quad &= \quad \gamma(\mathtt{cf}_{t+\Delta t}^{(z)} - \mathtt{cf}_t^{(z)}) + \Delta \mathtt{CF}_{t+\Delta t}(\mathtt{current\ bills} \backslash z) + \Delta \mathtt{CF}_{t+\Delta t}(\mathtt{future\ bills}) \\ & \quad\quad - \Delta \mathtt{DR}_{t+\Delta t}, \end{aligned} \tag{8}$$

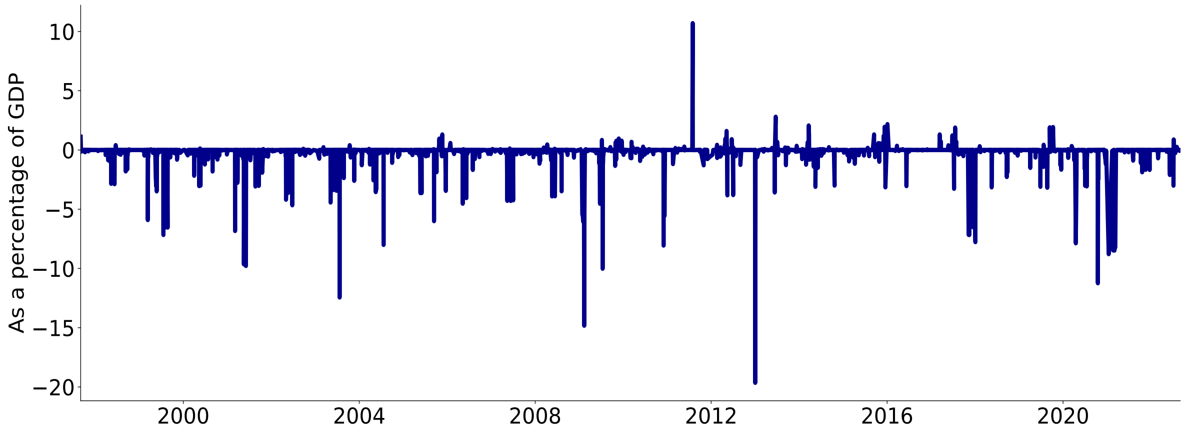
where $\Delta b_{t+\Delta t} \equiv b_{t+\Delta t} - b_t$ and we separated out the cash flow component of proposal z from equation (7), which we define as

$$\Delta \mathtt{cf}_t^{(z)} \equiv \mathbb{E}_t \sum_{j=1}^{T} \nu^{j-1} \mathbb{1}_{\geq t}^{(z)} \hat{S}_{t+j}^{(z)}, \tag{9}$$

and $\mathtt{CF}_{t+\Delta t}(\mathtt{current\ bills} \backslash z)$ is cash flow news from current policy, $\Delta \mathtt{CF}_{t+\Delta t}(\mathtt{future\ bills})$ is cash flow news from future policy, and $\Delta \mathtt{DR}_{t+\Delta t}$ is government discount rate news.

A natural conditioning variable for evaluating the news content of the cost releases is to compute an empirical measure of proposal size and sign by aggregating the cash flow

Fig. 1. **Bill-level cash flow contributions**



Notes: This figure shows the aggregate cash flow contribution of proposal z at time $t+\Delta t$, expressed as $\mathtt{cbo}^{(z)}_{t+\Delta t} \equiv \widetilde{\mathbb{E}}_{t+\Delta t}\sum_{j=1}^{T}\nu^{j-1}\hat{S}^{(z)}_{t+j}$. The subscript $t+\Delta t$ indicates the release date of the cost estimate. The figure aggregates the cost estimates at the daily level by summing the costs of each bill reported on the same day. The steady-state annual discount rate, denoted by $\nu = 0.96$, is calculated as the average annual return of the nominal government debt portfolio, adjusted for growth and inflation. The dataset encompasses 15,533 unique cost estimates, spanning from the 105th Congress (1997-1998) to the 117th Congress (2021-2022).

contribution of proposal z at time $t+\Delta t$ implied by the CBO forecasts according to

$$\mathtt{cbo}^{(z)}_{t+\Delta t} \equiv \widetilde{\mathbb{E}}_{t+\Delta t}\sum_{j=1}^{T}\nu^{j-1}\hat{S}^{(z)}_{t+j}, \tag{10}$$

where $\nu \equiv e^{-\hat{r}_g}$ is the steady-state discount rate adjusted for growth and inflation, and we use the nominal GDP forecast, $\widetilde{\mathbb{E}}_t[Y_{t+j}]$, from the most recent CBO Budget and Economic Outlook report before the cost estimate of proposal z to normalize the cash flow projections.[5]

Figure 1 plots the cash flow contributions ($\mathtt{cbo}^{(z)}_{t+\Delta t}$) to the aggregate surplus of all proposals extracted from the 15,533 unique cost releases. We sum the cash flow contributions of cost releases reported on the same day. The vast majority of the proposals (81%), if enacted, would increase deficits, reflecting the large reversal in fiscal policy starting in the late 1990s toward less fiscal discipline in the most recent two decades. The average size of a proposal is -0.175% of GDP with a standard deviation of 0.99% of GDP. Around 20% of these proposals are subsequently enacted as law.

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[5] Our empirical measure of $\mathtt{cbo}^{(z)}_{t+\Delta t}$ uses the approximation $\mathbb{E}_{t+\Delta t}\hat{S}_{t+j} \equiv \mathbb{E}_{t+\Delta t}[S_{t+j}/Y_{t+j}] \approx \mathbb{E}_{t+\Delta t}S_{t+j}/\mathbb{E}_t[P_{t+j}Y_{t+j}]$.

We next provide intuition for how information embedded in the cost releases ($\texttt{cbo}^{(z)}_{t+\Delta t}$) could affect the news terms in the present value relation depicted in equation (8). To help fix ideas, consider a simple example where the CBO and bond investor expectations are similar ($\widetilde{\mathbb{E}}_t[\cdot] \approx \mathbb{E}_t[\cdot]$) and the event that the proposal gets enacted is independent of the cash flows realizations. We can then express equation (8) as

$$\begin{aligned}\Delta b_{t+\Delta t} \;=\;& \underbrace{\gamma(p^{(z)}_{t+\Delta t}\texttt{cbo}^{(z)}_{t+\Delta t} - \texttt{cf}^{(z)}_{t})}_{\text{direct news about proposal } z} \\ & \underbrace{+\Delta \texttt{CF}_{t+\Delta t}(\texttt{current bills}\backslash z) + \Delta \texttt{CF}_{t+\Delta t}(\texttt{future bills}) - \Delta \texttt{DR}_{t+\Delta t}}_{\text{indirect news about the stance of fiscal policy}},\end{aligned} \tag{11}$$

where $p^{(z)}_t \equiv E_t[\mathbb{1}^{(z)}_{\geq t}]$ is the conditional probability that the proposal gets enacted.

The cost release at $t + \Delta t$ could contain direct news about proposal z, either due to a revision in the conditional probability that the bill is enacted ($p^{(z)}_{t+\Delta t}$) or the expected cash flow conditional on being enacted ($\texttt{cbo}^{(z)}_{t+\Delta t}$), relative to the investor expectations before the cost release at time t given in $\texttt{cf}^{(z)}_t$. The cost releases could also reveal news about the future path of fiscal policy, which would be reflected in the remaining three news terms relating to aggregate cash flows and discount rates. For example, a recent increase in the frequency and magnitude of bills proposing higher spending could convey that the government is drifting toward fiscal profligacy. The news terms would generate changes in the log Treasury values ($\Delta b_{t+\Delta t}$) according to the present value relation. Our subsequent empirical analysis tests each of these channels presented in equation (11).

1.3 Measuring aggregate Treasury values

We compute daily aggregate Treasury values as in Hall and Sargent (2011). Let B_t denote the aggregate market value of nominal government debt held by the public at time t as in equation (1). We can calculate B_t by stripping all coupon and principal payments from outstanding treasuries and pricing them as the discounted sum of future cash flows according to $B_t = \sum_{j=1}^{n} q^t_{t+j} f^t_{t+j}$, where f^t_{t+j} represents the total nominal debt payment committed for j years from time t. This includes all principal and coupon payments to be paid by the government at time $t + j$. The price of a one-dollar zero-coupon bond maturing at time $t+j$ is denoted by q^t_{t+j}.

We obtain daily prices and quantities of US Treasuries from the Center for Research in Security Prices (CRSP). We compute f^t_{t+j} for each government note and bond by relying on the publicly held outstanding amount (`tdpubout`) and collect other pertinent bond characteristics such as coupon rates and maturity dates. We compute q^t_{t+j} by fitting a zero-coupon forward curve using coupon bond prices, following the approach of Gürkaynak, Sack, and Wright (2007). For maturities of less than one year, we use market yields of US Treasury securities at constant maturities of one, three, and six months and linear interpolate for the remaining maturities.

The present value relation characterized in equation (8) implies that if a cost release at time $t+\Delta t$ contained cash news about the proposal or revealed aggregate cash flow or discount rate news, then it would generate a revision in log debt to GDP. In our empirical analysis, we use a narrow event window around the cost release ($t+\Delta t \in [t, t+1]$). We assume that the response of log debt to GDP to a cost release is dominated by changes in the Treasury market value; that is,

$$\Delta b_{t,t+1} \equiv \log\left(\frac{B_{t+1}}{Y_{t+1}}\right) - \log\left(\frac{B_t}{Y_t}\right) \approx \log(B_{t+1}) - \log(B_t) \tag{12}$$

for narrow event windows. We use the log Treasury market value changes to test if there is news embedded in the cost releases. Additional details regarding the construction of aggregate Treasury values are contained in Appendix A.

2 News in Cost Projections

Motivated by the present value relation, we examine daily aggregate Treasury value responses around the cost releases to see if they reveal news about the federal budget. We condition our tests on the measure of proposal sign and size given by the cash flow contribution measure, $\texttt{cbo}^{(z)}_{t+\Delta t}$.

Table 1. **Bill cost estimates and Treasury values**

	(1)	(2)
$\texttt{cbo}^{(z)}_{t+\Delta t}$	1.64	1.67
t-statistic	[2.13]	[2.09]
R^2 in %	0.10	4.93
Observations	2,990	2,990
Controls	No	Yes

Notes: This table presents regression results for the equation:

$$\Delta b_{t,t+1} = a + b \cdot \texttt{cbo}^{(z)}_{t+\Delta t} + \epsilon_{t+1},$$

where $\Delta b_{t,t+1}$ is the daily change in the value of the government debt portfolio computed using procedures similar to Hall and Sargent (2011). $\texttt{cbo}^{(z)}_{t+\Delta t}$ denotes the aggregate surplus of each proposal, where we sum the cash flow contributions of cost releases reported on the same day. In column (2), we use various controls. We use news announcements of the top 50 macroeconomic indicators as contemporaneous controls. We also control for lagged daily returns from $t-6$ to $t-1$, and the following lagged macro variables available at the daily frequency: CBOE Volatility Index, 10-Year Treasury Constant Maturity Minus 2-Year Treasury Constant Maturity, Federal Funds Effective Rate, 10-Year Breakeven Inflation Rate, Term premia on a 10 Year Zero Coupon Bond. The daily return $\Delta b_{t,t+1}$ is in basis points, while $\texttt{cbo}^{(z)}_{t+\Delta t}$ is in percent (as a percentage of GDP). t-statistics are in squared brackets.

2.1 Regression evidence

Our first pass at the data regresses the log Treasury value changes on our cash flow contribution measure of legislative proposals

$$\Delta b_{t,t+1} = a + b \cdot \texttt{cbo}^{(z)}_{t+\Delta t} + \epsilon_{t+1}, \tag{13}$$

where $\Delta b_{t,t+1}$ denotes the change in the log Treasury market value between two consecutive business days t and $t+1$, around the cost release date. We aggregate the cash flow contributions on days with multiple proposals. The error term is denoted by ϵ_{t+1}, while a and b are parameters. If the CBO cost release did not contain any news about government cash flows or discount rates, the slope coefficient, b, would be zero.

Column 1 of Table 1 presents our regression evidence. We find that the coefficient for $\texttt{cbo}_{t+\Delta t}$ is positive and statistically significant. The estimated value indicates that a 1% increase in a legislative proposal's cash flow contributions corresponds to an average increase of about 1.64 basis points in the value of the government bond portfolio (t-statistic = 2.13). Hence, cost releases of increasing deficits lower Treasury values.

Our previous regression specification computes Treasury value changes in a daily event window around the CBO cost releases. The rationale is that the cost releases reveal substantial news about the federal budget highlighted in equation (8) within this window, enabling a high-frequency identification strategy. However, one concern is that other news affecting bond prices might systematically occur within this tight event window. We next incorporate a comprehensive set of controls in the regression to address potential concerns about these confounding effects.

We collect announcement dates for the top 50 macroeconomic indicators (e.g., FOMC announcements, Non-Farm Payrolls, and Consumer Price Index) from Bloomberg Professional Service to control for news coinciding with the CBO cost releases. For each indicator, we calculate the news component by computing the difference between the actual and the median forecasted values and standardizing this difference using its standard deviation.

Bond prices at the start of the event window should already reflect all public information. However, we control for the cumulative bond price change to address concerns about price drifts preceding the cost releases (e.g., bond investors processing other news outside the event window potentially correlated with $\texttt{cbo}_{t+\Delta t}^{(z)}$). This is computed over a weekly event window starting seven days before the cost release and ending the day before.

We also control for the previous day's aggregate market return, the slope of the yield curve (calculated as the difference between the 10-year and 2-year yields), the CBOE Volatility Index, the nominal short rate, the term premium for a 10-year zero-coupon bond, and the 5-year breakeven inflation rate. In addition, we add dummy variables for NBER recession periods and the party affiliation of presidential tenures.

Column 2 of Table 1 shows that introducing these controls in equation (13) minimally affects the point estimate of b. The estimate increases slightly from 1.64 to 1.67, with a t-statistic of 2.09.

2.2 *Economic relevance*

The regression evidence suggests that there is systematic news revealed in the cost estimates about individual proposals. This subsection evaluates the economic relevance of the estimated effects.

We classify legislative proposals based on the sign and size according to the cash flow contribution measure. We first categorize proposals with `negative` and `positive` values of $\texttt{cbo}^{(z)}_{t+\Delta t}$. Within each category, we then select the proposals with the largest cash flow impact in absolute value (i.e., $|\texttt{cbo}^{(z)}_{t+\Delta t}|$). We then define `large` proposals as those exceeding the median absolute value, based on a rolling 3-month window within each sign category, yielding `large negative` and `large positive` subsets of proposals. Using a rolling window avoids lookahead bias in our selection criteria. Our identification assumption is that the change in Treasury values on days when there is a `large` proposal is dominated by the news content of the cost release.

We compute the average daily Treasury value changes conditioning on the `large negative` and `large positive` proposals in Table 2. Panel A shows that the average daily change on days with large negative proposals is -1.84 basis points (t-statistic =-2.20), while on other days, the average daily effect is 0.57 (t-statistic = 1.34). The average Treasury value change on all days is close to zero and lacks statistical significance (0.07, t-statistic =0.20), reflecting how the significant negative price effect on large negative proposal days (comprising 20% of the trading days) offsets the positive effect on the remaining trading days.

We also measure the economic relevance of the daily estimates by summing the Treasury value changes over our sample in Panel A of Table 2. The cumulative change on large negative proposal days is approximately -21%. In contrast, the cumulative change is 25% on other days. We assess the statistical significance of these cumulative effects by generating 10,000 samples, each randomly selecting 1,125 and 4,372 days to align with the number of large negative proposal days and the other days in our sample, respectively. We then calculate the cumulative changes in the Treasury values for each random sample. We find that less than 1% of the simulations have cumulative effects below the actual realization of -21% on large negative proposals days. The table reports these one-tailed

Table 2. **Changes in Treasury values**

A. Large negative proposal days	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	-1.84	0.57	0.07
t-statistic	[-2.20]	[1.34]	[0.20]
p-value	(0.02)	(0.92)	–
Cumulative change in %	-20.70	24.75	4.06
p-value	(0.00)	(0.98)	–
Observations	1,125	4,372	5,497

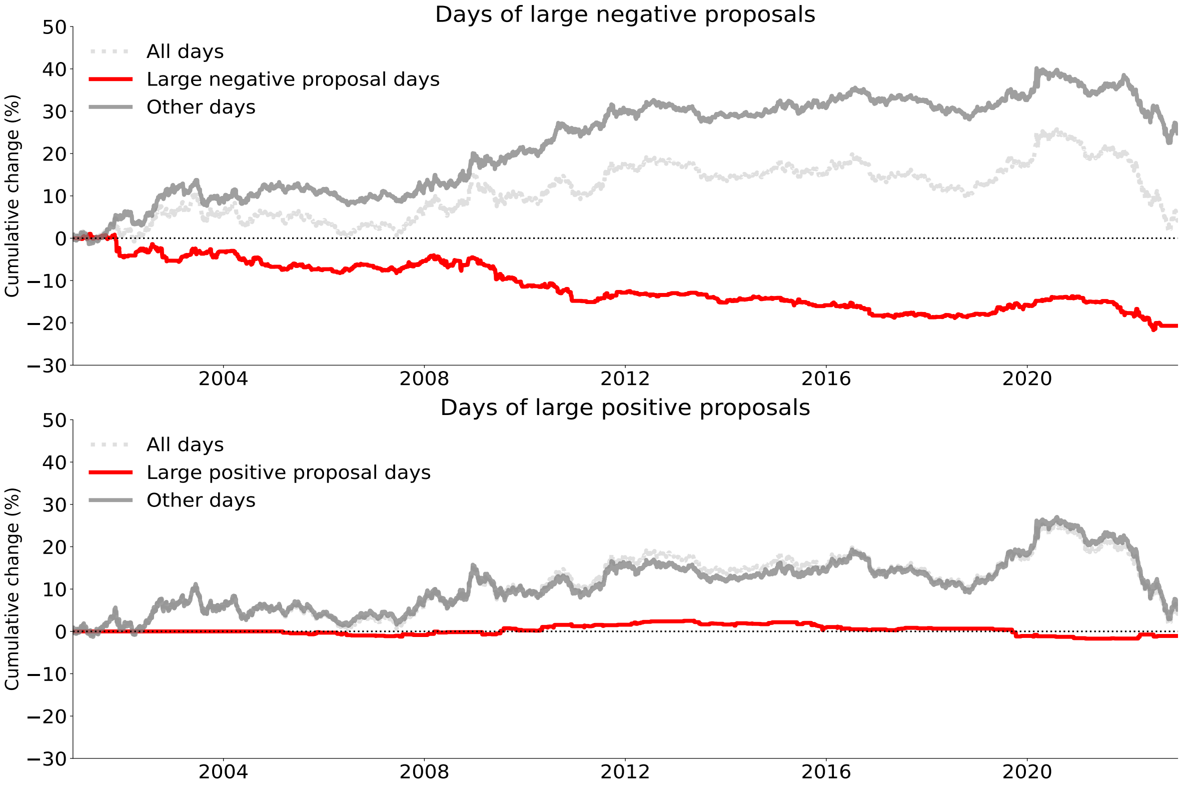
B. Large positive proposal days	Large positive proposal days (1)	Other days (2)	All days (3)
Mean bps	-0.64	0.10	0.07
t-statistic	[-0.34]	[0.25]	[0.20]
p-value	(0.38)	(0.54)	–
Cumulative change in %	-1.08	5.14	4.06
p-value	(0.34)	(0.61)	–
Observations	170	5,327	5,497

Notes: This table presents the average daily and cumulative changes in Treasury values, organized across three different sets of days. In Panel A, column 1 reports changes on days with large negative proposals, specifically excluding those that overlap with FOMC meeting days. Correspondingly, in Panel B, Column 1 reports changes on days with large positive proposals, also excluding any day coinciding with FOMC meeting days. Column 2 in both panels reports changes on other trading days, and column 3 reports changes across all trading days. t-statistics are in squared brackets. In parentheses, we report the percentage of simulated Treasury value changes that fall below the actual realizations. To determine these percentiles, we generate 10,000 samples. Each sample randomly selects without replacement 1,125 days and 170 days, corresponding to the number of observations in our actual sample for large negative and positive proposals, respectively. Then, for each of these samples, we calculate the average daily and cumulative changes in the Treasury values.

p-values in parenthesis. Figure B.3 in the Appendix plots the distribution of simulated statistics and actual realization.

The red line in the top panel of Figure 2 plots the cumulative daily changes on days with large negative proposals and sets the change to zero on days without. The dark grey line shows the cumulative change on the other days without large negative proposals. The light grey line corresponds to the cumulative changes using all trading days in our sample. The red line illustrates a smooth downward trend in the change of Treasury values on large negative proposal days, highlighting that our estimated effects are attributed to a

Fig. 2. **Cumulative change in Treasury values**



Notes: This figure shows the cumulative change in Treasury values on three different sets of days. In both panels, the light gray line displays the cumulative change using all trading days. The red line in the top (bottom) panel shows the cumulative change using the large negative (positive) proposal days that do not coincide with FOMC meeting days. The dark gray lines in both panels show the cumulative change using all remaining trading days. The sample period runs from January 2000 to December 2022.

steady flow of news lowering Treasury values and not to a few large observations.

Panel B of Table 2 reports the average and cumulative change in Treasury values on large positive proposal days. The average daily change on these days is close to zero and statistically insignificant (t-statistic = -0.38). The red line in the bottom panel of Figure 2 indicates that the cumulative changes on large positive proposal days remain near zero throughout the sample period.

2.3 Nominal discount rates and expected inflation

We next explore whether the cash flow projections for large negative proposals reveal news about the nominal government discount rate or expected inflation. These are two potential adjustment margins to fiscal news in the intertemporal government budget equation highlighted in equation (5) through the growth and inflation-adjusted nominal discount rate, $\mathbb{E}_t[\hat{r}_{gt+j}] = \mathbb{E}_t[r_{gt+j}] - \mathbb{E}_t[\pi_{t+j}] - \mathbb{E}_t[\Delta y_{t+j}]$, where $\mathbb{E}_t[r_{gt+j}]$ is the nominal government discount rate and $\mathbb{E}_t[\pi_{t+j}]$ is expected inflation.

We start by analyzing how nominal government discount rate components respond to cost releases of large negative proposals. We show that in a framework with a representative investor that derives utility from holdings of nominal government bonds (e.g., Krishnamurthy and Vissing-Jorgensen (2012)) and accounting for partial government default, the consumption-savings Euler equation implies an approximate expected nominal return decomposition given by

$$E_t[r_{gt+1}] \approx \underbrace{i_t}_{\substack{\text{nominal}\\ \text{short rate}}} - \underbrace{\theta_t}_{\substack{\text{convenience}\\ \text{yield}}} + \underbrace{\gamma_t \delta_{t+1}}_{\substack{\text{expected}\\ \text{default loss}}} \underbrace{- \frac{1}{2}\mathrm{Var}_t(r_{gt+1}) - \mathrm{Cov}_t(m^{\$}_{t+1}, r_{gt+1}),}_{\text{bond risk premium}} \tag{14}$$

where i_t is the nominal short rate, θ_t is the convenience yield on treasuries, $\gamma_t \delta_{t+1}$ captures the expected default loss next period, and the final two terms represent the bond risk premia of the Treasury portfolio. The Treasury portfolio risk premium depends on nominal term premia and the credit risk premia of future default events. Appendix D provides the derivations for the return decomposition above.

Table 3 reports how empirical measures of these four nominal discount rate components respond to `large negative` cost releases. Panel A considers a composite nominal term premia measure ($\mathtt{ctp}_t$) using the maturity weights given by

$$\mathtt{ctp}_t = \sum_j \omega_t^{(j)} \cdot \mathtt{tp}_t^{(j)}, \tag{15}$$

where $\mathtt{ctp}_t^{(j)}$ represents the term premium of a zero-coupon bond with maturity j. We use the term premia estimates from the affine model of Adrian, Crump, and Moench (2013) as a proxy for $\mathtt{tp}_t^{(j)}$. The portfolio weight assigned to each maturity j, defined as $\omega_t^{(j)} \equiv \frac{q^t_{t+j-1} f^t_{t+j-1}}{\sum_j q^t_{t+j-1} f^t_{t+j-1}}$, is the market value of the treasuries for the given maturity j on day t, scaled by the total market value of all treasuries on day t.

We find that the average daily change in the composite nominal term premium around days with large negative proposals is around 0.2 bps (t-statistic = 1.82). The cumulative

Table 3. **Changes in nominal discount rate components**

A. Composite term premia

	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	0.18	-0.06	-0.01
t-statistic	[1.82]	[-1.16]	[-0.25]
p-value	(0.95)	(0.13)	–
Cumulative change in %	2.05	-2.70	-0.65
p-value	(0.99)	(0.03)	–
Observations	1,125	4,371	5,496

B. Composite convenience yield

	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	-0.09	0.02	-0.00
t-statistic	[-1.63]	[0.19]	[-0.01]
p-value	(0.13)	(0.45)	–
Cumulative change in %	-0.81	0.75	-0.05
p-value	(0.10)	(0.45)	–
Observations	924	3,830	4,754

C. Credit risk

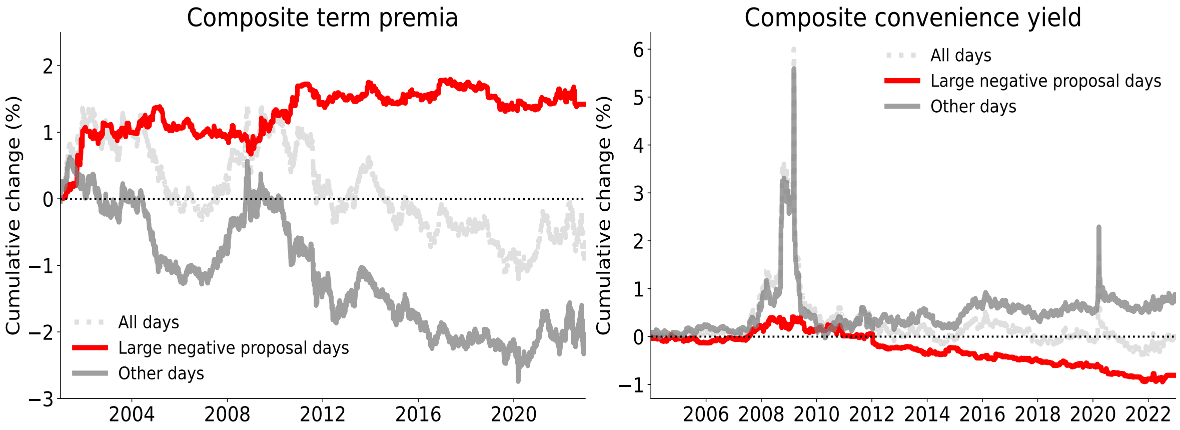
	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	-0.03	-0.00	-0.01
t-statistic	[-0.51]	[-0.11]	[-0.28]
p-value	(0.32)	(0.68)	–
Cumulative change in %	-0.12	-0.04	-0.17
p-value	(0.32)	(0.68)	–
Observations	484	2,646	3,130

D. Nominal short rate

	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	0.11	-0.17	-0.11
t-statistic	[0.74]	[-2.56]	[-1.82]
p-value	(0.65)	(0.21)	–
Cumulative change in %	0.57	-5.65	-5.08
p-value	(0.88)	(0.00)	–
Observations	1,119	4,377	5,496

Notes: Panel A presents the average daily and cumulative changes in the composite nominal term premia, categorized across three distinct sets of days. Column 1 reports changes on days with large negative proposals that do not coincide with FOMC meeting days. Column 2 reports changes on other trading days, and column 3 reports changes across all trading days. Panels B, C and D use the same day classifications, but compute changes in the composite convenience yields, expected default loss, and nominal short rate, respectively. t-statistics are presented within square brackets. We report the percentage of simulated changes that fall below the actual realizations in parentheses.

Fig. 3. **Changes in the composite term premia and the composite convenience yields**



Notes: The light gray lines show the cumulative change in the composite nominal term premium (left plot) and the composite convenience yields (right plot) over the sample period. The red line shows the cumulative change on large negative proposal days that do not coincide with FOMC meeting days. The dark gray line denotes the cumulative changes around the remaining days.

effect over our sample period is 2% and statistically significant (p-value = 0.99). The red line in the left panel of Figure 3 illustrates that the cumulative effects on term premia follow a smooth upward trend, indicating a consistent increase in term premia on days associated with large negative proposals. On the other days, the composite nominal term premium exhibits a downward trend, reflecting the average daily change of -0.06 bps (t-statistic = -1.16) and a cumulative effect of -2.7%.

Column 1 of Panel B shows the average daily change in the composite convenience yield of the government debt portfolio around the large negative proposal days. We measure the composite convenience yield of the government debt portfolio, denoted as θ_t, using the maturity weights according to

$$\theta_t = \sum_j \omega_t^{(j)} \cdot \theta_t^{(j)}, \tag{16}$$

where $\theta_t^{(j)}$ denotes the convenience yield at maturity j. We use the spread between intermediate Aaa-rated corporate bonds and five-year Treasury yields as a proxy for the convenience yields of maturities five years and less, and the spread between long-term Aaa-rated corporate bonds and ten-year Treasury yields as a measure of convenience yields above five years.[6]

Panel B shows that the composite Treasury convenience yield decreases on large negative proposal days. The average daily change of θ_t on these days is -0.09 bps (t-statistic = -1.63). The right panel of Figure 3 plots the cumulative change in the convenience yield during our sample period. The red line in the figure illustrates a steady decrease in the convenience yield on days with large negative proposals. This decrease is particularly pronounced after 2009, as shown in Figure B.5 in the Appendix. By the end of 2022, the cumulative decline in θ_t reaches -0.81% (one-tailed p-value = 0.1). In contrast, there is an observed increase in the convenience yield on other days with a cumulative effect of 0.75%.

Panel C analyzes CDS rates on Treasuries. A CDS rate reflects the annual insurance premium, expressed as a percentage of the face value, paid to hedge against defaults or debt restructurings on any Treasury security over a given horizon. We use five-year CDS contracts because they are the most traded. We use the CDS rate to proxy for the credit risk terms in the return decomposition. Our CDS dataset spans December 2007 to December 2022. We do not find statistically significant effects in the daily changes in the CDS rate on the large negative proposal days. The point estimate is near zero, and the t-statistic is well below one. The cumulative effects on CDS Rates are also insignificantly different from zero on these days.

Panel D reports the average daily change in the nominal short rate on days with large negative proposals. We measure the nominal short rate using the three-month Treasury bill rate. Although the point estimate is positive, the effects are not statistically significant, with the t-statistic well below one. The average daily change in short rates on the other days is significantly negative, partly reflecting the extended period of monetary policy easing in the second half of our sample. While the large negative proposal days have a negligible impact on short-term interest rates, we show that they have a considerable impact on long-term rates in Section 2.4.

A takeaway from Table 3 is that the significant increase in nominal term premia and decrease in convenience yields around large negative proposal days both contribute to

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[6] We follow Krishnamurthy and Vissing-Jorgensen (2011, 2012), Acharya and Laarits (2023), and Cieslak, Li, and Pflueger (2023) by using these spreads as proxies for convenience yields.

Table 4. **Changes in inflation expectations**

Changes in 10-year inflation swaps	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	0.21	-0.05	-0.00
t-statistic	[1.52]	[-0.75]	[-0.06]
p-value	(0.95)	(0.05)	–
Cumulative change in %	1.65	-1.81	-0.16
p-value	(0.95)	(0.05)	–
Observations	800	3,635	4,435

Notes: This table presents the average daily and cumulative changes in 10-year inflation swaps categorized across three distinct sets of days. Column 1 reports changes on days with large negative proposals that do not coincide with FOMC meeting days. Column 2 reports changes on other trading days, and column 3 reports changes across all trading days. t-statistics are presented within square brackets. We report the percentage of simulated changes that fall below the actual realizations in parentheses.

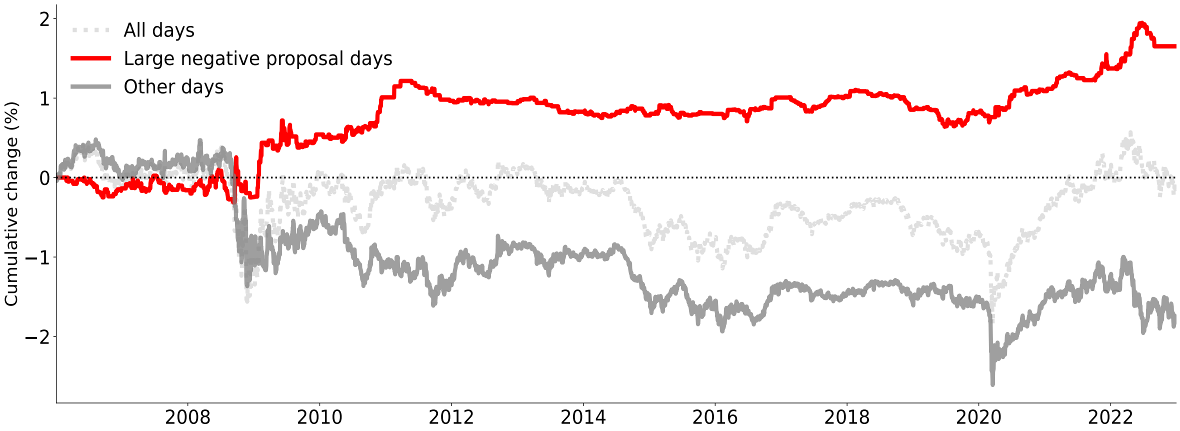
higher government discount rates. We next investigate how expected inflation contributes to Treasury value responses.

We use zero-coupon inflation swaps to back out inflation expectations at different horizons. These swaps are executed between two counterparties at predetermined dates, where one party agrees to exchange fixed payments for floating ones. The floating payment is tied to the cumulative inflation realized over the duration of the contract, using the consumer price index as the benchmark. If the risk premia component in the swap contract is small, the fixed-rate payment can serve as a market-based proxy of inflation expectations over the contract's maturity. Our inflation swaps dataset covers January 2005 to December 2022 and encompasses tenors of one, three, five, and ten years.

We find that inflation expectations increase across horizons in daily event windows around large negative proposal days. Table 4 reports the results for the 10-year inflation expectation while Table B.5 in the Appendix provides the evidence from the one, three, and five-year horizons. The average daily change in the 10-year inflation expectation is 0.21 bps on the large negative proposal days, with a t-statistic of 1.52.

Although the daily changes in 10-year inflation expectation changes are not statistically significant, the cumulative effect over the sample period is economically large, as shown in Figure 4. The red line in the figure shows that 10-year inflation expectations increased by approximately 1.64% on days with large negative proposals. Only 5% of 10,000 sample

Fig. 4. **Changes in inflation expectations**



Notes: The light gray lines show the cumulative change in 10-year inflation swaps over the sample period. The red line shows the cumulative change on large negative proposal days that do not coincide with FOMC meeting days. The dark gray line denotes the cumulative changes around the remaining days.

simulations result in a cumulative change in 10-year inflation swaps that exceeds the observed value of 1.64%.

The expected inflation response is consistent with models of the fiscal theory featuring long-term government debt if the cost releases revealed news about higher deficits or nominal discount rates (e.g., Cochrane (2001) and Corhay et al. (2023)). We presented evidence of higher nominal discount rates in Table 3, and we will provide evidence for the cash flow news margin in Section 4. Moreover, the increase in expected inflation and nominal term premia at long maturities on large negative proposal days suggest that long-term nominal yields should also increase.[7] The next section investigates how the cost releases relate to the secular trend in nominal interest rates.

2.4 Long-term nominal yields

We previously showed that short-term nominal interest rates do not respond significantly to the large negative cost releases. In light of our evidence on long-horizon expected inflation and nominal term premia, we should expect long-term nominal yields to increase around the cost releases of large negative proposals. We provide evidence of this pattern in Table 5.

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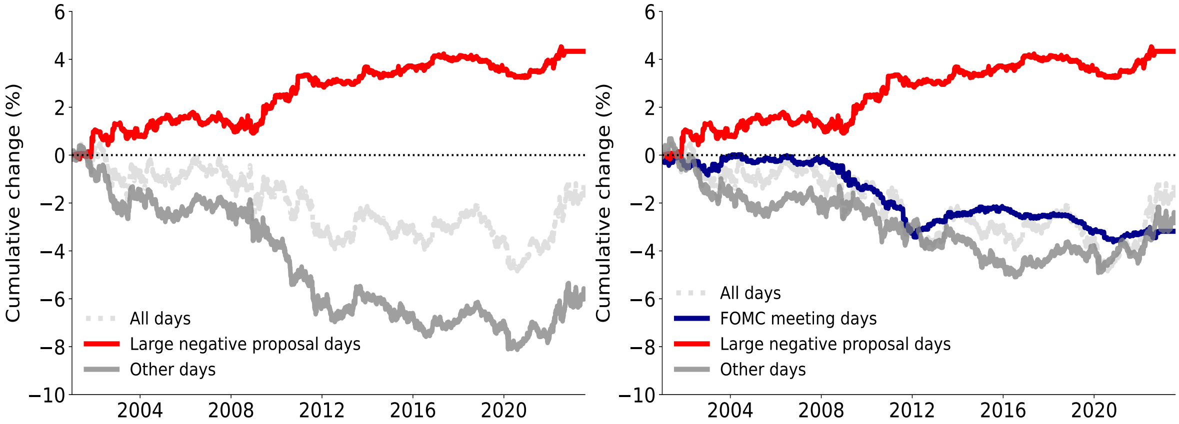
[7] Appendix B.7 provides the maturity decomposition of the response of the composite nominal term premium measure to the cost releases.

Fig. 5. **Changes in 10-year bond yields**



Notes: The light gray lines denote the cumulative changes in the 10-year nominal bond yield over our sample period. The red lines depict the cumulative changes on large negative proposal days that do not coincide with FOMC meeting days. The dark blue line in the right panel shows the changes on FOMC meeting days. The dark gray lines denote the cumulative changes around the remaining days.

Column 1 of Panel A reports the average daily change in the 10-year zero coupon Treasury yield on days with large negative proposals, excluding FOMC announcement days. The average daily change is 0.38 bps, with a t-statistic of 2.16. The cumulative change on days with large negative proposals is 4.33%, while on other days, the cumulative change is -5.70%. The negative trend on other days accelerated after the financial crisis in 2008, which is illustrated in the left panel of Figure 5. The large positive cumulative effect on days with large negative cost releases partially offsets the negative trend on other days, as evidenced by the small negative average daily change when considering all days.

The right panel of Figure 5 highlights an important source of the negative trend in long-term nominal yields. The blue line corresponds to the cumulative changes in the three days centered around FOMC meetings following Hillenbrand (2021), which documents that Fed policy contributed to the secular decline in interest rates over the past few decades. The negative trend around FOMC days is also exhibited in our sample (cumulative effect of -3.18%), and accounts for the accelerating decline in interest rates immediately after the Financial Crisis. The red line shows the opposite pattern on the days with cost releases of large negative proposals, offsetting the majority of the effects of monetary policy. Table B.6 in the Appendix tabulates the average daily and cumulative

Table 5. **Changes in long-term yields**

A. 10-year nominal yield	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	0.38	-0.13	-0.02
t-statistic	[2.16]	[-1.41]	[-0.30]
p-value	(0.93)	(0.20)	–
Cumulative change in %	4.33	-5.70	-1.37
p-value	(0.99)	(0.01)	–
Observations	1,128	4,518	5,646

B. 10-year expected average short rate	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	0.15	-0.03	0.00
t-statistic	[1.29]	[-0.58]	[0.07]
p-value	(0.79)	(0.33)	–
Cumulative change in %	1.64	-1.43	0.21
p-value	(0.99)	(0.12)	–
Observations	1,128	4,518	5,646

C. 10-year term premia	Large negative proposal days (1)	Other days (2)	All days (3)
Mean bps	0.24	-0.09	-0.03
t-statistic	[1.59]	[-1.14]	[-0.38]
p-value	(0.85)	(0.28)	–
Cumulative change in %	2.69	-4.27	-1.57
p-value	(0.99)	(0.02)	–
Observations	1,128	4,518	5,646

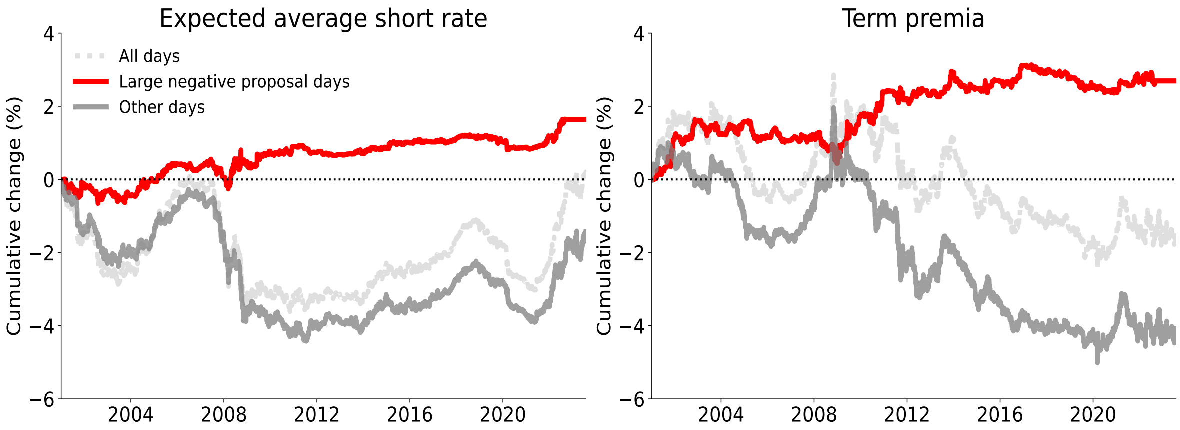
Notes: Panel A presents the average daily and cumulative changes in the 10-year nominal yield, categorized across three distinct sets of days. Column 1 reports changes on days with large negative proposals that do not coincide with FOMC meeting days. Column 2 reports changes on other trading days, and column 3 reports changes across all trading days. Panels B and C use the same day classifications, but compute changes in the 10-year expected average short rate and the 10-year term premia, respectively. t-statistics are presented within square brackets. We report the percentage of simulated changes that fall below the actual realizations in parentheses.

yield changes observed on FOMC meeting days.

The offsetting effects on FOMC days and large negative proposal days also provide a potential explanation for why papers such as Jiang et al. (2019, 2021) do not find systematic evidence that surplus news extracted from aggregate surplus data affects Treasury yields at lower frequencies (e.g., quarterly).

Table 5 decomposes the 10-year nominal yield into the average nominal short rate

Fig. 6. **Changes in expected short rates and term premia**



Notes: The figure shows cumulative changes in the 10-year expected average short rate (left panel) and 10-year term premia (right panel) over our sample period. The light gray lines denote the cumulative over the whole sample. The red lines depict the cumulative changes on large negative proposal days that do not coincide with FOMC meeting days, while the dark gray lines denote the cumulative changes on the remaining days.

expectations over the next 10 years and the 10-year nominal term premium. We find that the 0.38 bps rise in the nominal yield on large negative proposal days is attributed to a 0.15 bps increase in expected short rates and a 0.24 bps rise in nominal term premia. The slight discrepancy from the exact sum of 0.38 bps is due to the two-digit rounding.

Figure 6 plots the cumulative change in the average expected short rates and term premia on days with large negative proposals. The cumulative change is 1.64% for expected short rates and 2.69% for the nominal term premium, combining to produce the 4.33% cumulative change in the nominal yield. Most of the reaction in long-term yields to large negative proposals is therefore attributed to adjustments in the nominal term premia rather than in the average expected path of future short rates.

2.5 Additional results

This section presents additional robustness tests and analyses with the corresponding Tables provided in the Appendix.

Bond prices on the large negative proposal days could also be influenced by news other than the CBO cost estimate releases. Table B.1 shows that both the average daily and cumulative changes in Treasury values are more pronounced when we exclude days that coincide with FOMC meetings or when large macroeconomic news is released. We categorize macroeconomic news as large when the absolute value of the analysts' forecast error exceeds its rolling window median for each of the top 50 macroeconomic indicators.

Appendix B.2 shows that the effect of the cash flow projections on the government bond portfolio is primarily due to its impact on debt over five years, with only minimal effects observed for shorter maturities.

Table B.3 presents the average daily and cumulative changes in Treasury values before, on, and after the large negative proposal days. We find a negligible change in Treasury values (with t-statistics below 0.7) in the days leading up to the cost release. There is a statistically significant drop in Treasury values on the day of the cost releases, as previously shown in Section 2.2. Treasury values decline in the days following the cost release, although this decline is not statistically significant (t-statistics above -0.7).

Table B.4 shows the average daily and cumulative changes in Treasury values on specific dates associated with crucial junctures in the legislative process, focusing on the large negative proposals. The first of these dates represents the bill's introduction in either the House or the Senate. The second is the day the CBO cost estimate report is released (the focus of our main analysis). The third date corresponds to the bill's voting in either the House or the Senate, and the final date denotes its enactment into public law if passed. We find the largest average effect on the days of the CBO cost release. The effects are negative on the other three legislative dates, but only statistically significant on the voting days.

3 Interpreting the news content

The previous sections presented evidence that the cost releases contain news and that the relevant information to bond investors is concentrated in the cash flow estimates of large negative proposals. We now relate our findings to the news content associated with large negative proposals in the context of the present value relations outlined in Section 1.2.

The present value relation outlined in equation (8) implies that the systematic Treasury value response around large negative proposal days is attributed to cash flow news about proposal z of the current cost release, aggregate cash flow news excluding proposal z, or government discount rate news being revealed, rewritten as

$$\Delta b_{t,t+1} = \eta^{(z)}_{t+\Delta t} + \eta^{(cf)}_{t+\Delta t} - \eta^{(r)}_{t+\Delta t} \tag{17}$$

where $\eta^{(z)}_{t+\Delta t} \equiv (\texttt{cf}^{(z)}_{t+\Delta t} - \texttt{cf}^{(z)}_{t})$ is the cash flow news about proposal z, $\eta^{(cf)}_{t+\Delta t} \equiv \Delta\texttt{CF}_{t+\Delta t}(\texttt{current bills}\backslash z) + \Delta\texttt{CF}_{t+\Delta t}(\texttt{future bills})$ is the aggregate cash flow news related to current and future bills excluding z, and $\eta^{(r)}_{t+\Delta t} \equiv \Delta\texttt{DR}_{t+\Delta t}$ is growth and inflation-adjusted government discount rate news.

Our empirical evidence finds that conditioning on `large negative` proposals using the cash flow contribution measure $\texttt{cbo}^{(z)}_{t+\Delta t}$ generates negative systematic Treasury value changes. This evidence would suggest that bond investors are systematically underestimating the magnitude of negative cash flows in individual proposals, aggregate surpluses, or discount rates if the definitions of `large` and `negative` can be predicted using information before the cost release date and the cost release date of large negative proposals is not systematically related to news about aggregate bond price factors.

We predict the `large negative` set of proposals defined in Section 2.2 by analyzing the text contained in the proposal's summary when it is first introduced, usually around 150 days before the CBO cost release. We label the predicted set as $\widehat{\texttt{large}}_t\ \widehat{\texttt{negative}}_t$ to highlight that they are based on information available *before* the cost release date.

We first classify a proposal as $\widehat{\texttt{negative}}_t$ if the summary, when introduced, indicates that the proposal is expected to increase spending (i.e., searching for terms related to 'spending', 'cost'). We then construct the predicted $\widehat{\texttt{large}}_t\ \widehat{\texttt{negative}}_t$ set if the $\widehat{\texttt{negative}}_t$ proposals' summary also contains keywords related to the major categories of mandatory spending (i.e., searching for the keywords 'social security', 'medicare', 'medicaid', and 'health') or the major categories of discretionary spending (i.e., searching for the keywords 'military', 'defense', and 'infrastructure').

We find 61% of the $\widehat{\texttt{large}}_t\ \widehat{\texttt{negative}}_t$ proposals categorized using information before the cost release overlap with the `large negative` proposals classified using cash flow information in the cost release. The large overlap between these two sets implies that broad characteristics of the proposal's cash flows (i.e., if they are negative and above the median in magnitude) are predictable. We next verify that the Treasury valuations exhibit the same negative responses around the predicted $\widehat{\texttt{large}}_t$ $\widehat{\texttt{negative}}_t$ proposals.

Panel A of Table 6 shows that the average Treasury value change around the predicted $\widehat{\texttt{large}}_t$ $\widehat{\texttt{negative}}_t$ proposals is negative (-2.15 basis points and t-statistic = -1.90) which is similar in magnitude to when we computed the changes around `large negative` days, which is not surprising given that $\widehat{\texttt{large}}_t$ $\widehat{\texttt{negative}}_t$ is a strong predictor of `large negative`. The total cumulative change over the sample period is -13.18%, and only 4% of the 10,000 simulated samples, each comprising 612 randomly selected days, exhibit cumulative effects less than the -13.18% observed in the actual data.

We next show that the cost release dates of $\widehat{\texttt{large}}_t$ $\widehat{\texttt{negative}}_t$ proposals are not systematically related to potential innovations or levels of aggregate factors affecting bond valuations. Panel B controls for a wide array of macroeconomic news (see Table A.1 for a complete list of macro announcements) realized on the $\widehat{\texttt{large}}_t$ $\widehat{\texttt{negative}}_t$ proposal days. We find that the changes in Treasury values increase in magnitude when we exclude days that coincide with large macroeconomic news. Panel C examines the changes in Treasury values one business day before the $\widehat{\texttt{large}}_t$ $\widehat{\texttt{negative}}_t$ proposal days. We find that on the day before the cost release of $\widehat{\texttt{large}}_t$ $\widehat{\texttt{negative}}_t$ proposals, the average Treasury value changes are the opposite sign (although not statistically significant) as on the day of the cost release.

We should not find systematic Treasury value changes around `large negative` proposal days in a full information rational expectations (FIRE) framework given that we have just shown the definition for `large negative` can be predicted using information well before the actual cost release and that the actual cost release dates of these predicted large negative proposals do not systematically relate to the levels and innovations of macroeconomic factors. Therefore, the average Treasury value changes on these days should not be negative under FIRE, summarized as

$$E\left[\Delta b_{t,t+1}\mathbb{1}^{(\hat{z})}_{t+\Delta t}\right] = E\left[\left(\eta^{(\hat{z})}_{t+\Delta t}+\eta^{(cf)}_{t+\Delta t}-\eta^{(r)}_{t+\Delta t}\right)\mathbb{1}^{(\hat{z})}_{t+\Delta t}\right] = 0, \tag{18}$$

where $\mathbb{1}^{(\hat{z})}_{t+\Delta t}$ is an indicator function that takes on the value of 1 if in the event window $[t, t+1]$ there is cost release of a proposal with the predetermined characteristic $\widehat{\texttt{large}}_t$ $\widehat{\texttt{negative}}_t$ denoted as $\hat{z}$. This equation tells us that rational bond investors are unlikely

Table 6. **Selecting large negative proposal days using ex-ante information**

A. Predicted large negative proposal days	Predicted large negative proposal days	Other days	All days
Mean bps	-2.15	0.35	0.07
t-statistic	[-1.90]	[0.88]	[0.20]
p-value	(0.05)	(0.82)	–
Cumulative change in %	-13.18	17.23	4.06
p-value	(0.04)	(0.93)	–
Observations	612	4,885	5,497

B. Predicted large negative proposal days, excluding large macro news days	Predicted large negative proposal days	Other days	All days
Mean bps	-3.69	0.34	0.07
t-statistic	-2.39	0.88	0.20
p-value	(0.02)	(0.82)	–
Cumulative change in %	-13.40	17.45	4.06
p-value	(0.01)	(0.93)	–
Observations	363	5,134	5,497

C. One business day prior to the predicted large negative proposal days	Predicted large negative proposal days	Other days	All days
Mean bps	1.08	-0.05	0.08
t-statistic	[0.97]	[-0.12]	[0.20]
p-value	(0.78)	(0.35)	–
Cumulative change in %	6.61	-2.42	4.18
p-value	(0.88)	(0.32)	–
Observations	612	4,885	5,497

Notes: This table presents the average daily and cumulative changes in Treasury values, organized across three different sets of days. Column 1 in panel A presents changes in Treasury values on days identified as likely to have large negative proposals. We predict these bills by analyzing the summary of each proposal at its introduction, focusing on keywords related to spending (such as 'spending', 'cost') and major spending categories like 'social security', 'medicare', 'medicaid', 'military', 'defense', and 'infrastructure'. Column 1 in Panel B considers these same days but excluding those days that overlap with FOMC meeting days and large news from the top 50 macroeconomic indicators. We categorize macroeconomic news as large when the absolute value of the analysts' forecast error exceeds its rolling-window median for each of the top 50 macroeconomic indicators. Column 1 in Panel C considers one business day before the predicted large and negative proposal days. Column 2 in all panels reports changes on the remaining trading days, while column 3 encompasses changes across all trading days. t-statistics are presented within square brackets. We report the percentage of simulated changes in the Treasury values that fall below the actual realizations in parentheses.

to consistently underestimate the costs of new legislative proposals, aggregate deficits, or government discount rates on large negative cost release days over our 25-year sample if they have full information about the processes governing surpluses and discount rates. However, we document systematic negative Treasury value changes on these days, suggesting deviations from FIRE.

The positive responses of nominal discount rate components and inflation expectations around the `large negative` proposals provide further corroborating evidence that bond investors are not pricing treasuries in a FIRE setting over our sample. A potential deviation from full information is due to the reversal in policy at the start of our sample and the subsequent drift towards fiscal profligacy, characterized by increasing deficits and rising debt relative to GDP over the past 25 years (illustrated in Figure B.9). Bond investors at the start of our sample in 1997 probably did not know the true model governing surplus policy and would have needed to gradually learn about the increasing trend in deficits slowly unfolding over the sample.

The cost releases about individual proposals provide real-time budgetary information that bond investors could have used to update their beliefs about the overall stance of fiscal policy. We posit that the systematic Treasury pricing responses are attributed to investors using the cost releases as signals to update their beliefs about the duration and impact of the aggregate deficits rather than from cash flow surprises pertaining to individual proposals. For example, if investors observe an increasing frequency of large negative proposals, this could reveal policymakers' willingness to run persistent deficits. Absent long-run expectations of Ricardian policy to offset these persistent deficits in the future, bond investors would lower Treasury valuations.

We formalize this intuition about investor learning next in a model where rational Bayesian investors use incoming cost releases, and past realized surpluses to revise their beliefs about the persistent components of the aggregate surplus and government discount rate processes in a present value framework.

4 Investors learning about deepening deficits

We rationalize the main empirical findings documented in Section 2 in a model where rational Bayesian investors determine the value of aggregate Treasurys in a present value framework by learning about the fiscal stance. We model the fiscal stance as the unobservable persistent components of surplus policy, government discount rates, and the future path of debt. Bond investors learn about the stance of future policy using incoming data from CBO cost releases, realized surpluses, and bond price data.

We find that the cost releases enable investors to learn about the parameters governing the fiscal stance. Parameter learning is slow, given the significant persistence and magnitude of the departure in fiscal policy, which is akin to rational agents gradually learning about the unobservable persistent components of the nominal short rate highlighted in Farmer et al. (2021). Investors at the start of our CBO data sample in 1997 would have observed a significant budget consolidation throughout the 1990s, culminating in positive surpluses by the end of the decade.

Investors at the start of our sample were unlikely to know the full extent of the dramatic reversal and subsequent drift in policy that unfolded over the next few decades. We show that the large negative cost releases generate gradual parameter revisions, leading to sustained negative Treasury value responses throughout our sample, like in the data. The model can also reproduce insignificant Treasury value changes to large positive proposals.

4.1 The model and learning from CBO cost estimates

The model operates on a monthly frequency to align with aggregate realized surplus data sampled at the highest frequency available. We use the superscript 'o' notation to denote variables observed by the investor and T to denote the longest forecast horizon of the CBO's cost estimates (i.e., 10 years). We specify the processes governing the present value of surpluses up to horizon T separately from the remaining value to capture how the cost releases may contain distinct information about the fiscal stance at different horizons.

We assume that bond investors model the level of realized aggregate surplus to GDP $\hat{S}^{o}_{t+1}$ up to horizon T as the sum of a persistent conditional mean χ_t and an orthogonal shock ϵ_{st+1} given by

$$\begin{aligned}\hat{S}^o_{t+1} &= \chi_t + \epsilon_{st+1}, & (19)\\ \chi_{t+1} &= \mu_\chi + \rho_\chi(\chi_t - \mu_\chi) + \epsilon_{\chi t+1}, & (20)\end{aligned}$$

where the latent process χ_t is not observable by bond investors but $\hat{S}^o_{t+1}$ is observable. We also assume that bond investors do not observe the parameters μ_χ and ρ_χ.

We similarly specify the model of realized growth and the inflation-adjusted log government portfolio return $\hat{r}^o_{gt+1}$ up to horizon T as the sum of a persistent conditional mean h_t and an orthogonal shock $\epsilon_{r,t+1}$ as follows

$$\begin{aligned}\hat{r}^o_{gt+1} &= h_t + \epsilon_{rt+1}, & (21)\\ h_{t+1} &= \mu_h + \rho_h(h_t - \mu_h) + \epsilon_{ht+1}, & (22)\end{aligned}$$

where the latent process h_t is not observable by bond investors while $\hat{r}^o_{gt+1}$ is observable. We also assume bond investors do not observe the parameters μ_h and ρ_h.

The bond investor uses the model for surpluses and government returns with the dynamic government budget identity to link the observable aggregate market value of public debt to the latent states. We can separate the cash flow and discount rate terms up to horizon T in the present value relation presented in equation (5) according to

$$\hat{b}^o_t = \alpha^\star + \mathbb{E}_t \sum_{j=1}^{T} \nu^{j-1}\gamma \hat{S}^o_{t+j} - \mathbb{E}_t \sum_{j=1}^{T} \nu^{j-1} \hat{r}^o_{gt+j} + \mathbb{E}_t \nu^T \hat{b}_{t+T}, \tag{23}$$

where $\hat{b}^o_t$ is the observable log market value of government debt to GDP ratio and $\mathbb{E}_t\nu^T\hat{b}_{t+T} = \mathbb{E}_t \sum_{j=T+1}^{\infty} \nu^{j-1}(\gamma\hat{S}_{t+j} - \hat{r}_{gt+j})$ is the expected value of debt to GDP at $t+T$ which is equal to the present value of future surplus to GDP for $j > T$ if we impose the transversality condition.

We assume that bond investors model the expected value of debt to GDP ($\psi_t \equiv \mathbb{E}_t\nu^T\hat{b}_{t+T}$) as a latent process given by

$$\psi_{t+1} = \mu_\psi + \rho_\psi(\psi_t - \mu_\psi) + \epsilon_{\psi t+1}, \tag{24}$$

where the parameters μ_ψ and ρ_ψ are unobservable to investors. We model the continuation value at horizon T directly rather than separately modeling the cash flows and returns beyond T to capture the notion that the cost releases have more precise information about the fiscal condition over the bill's forecast horizon.

Using the present value restriction and the processes for the latent states presented in equations (20), (22) and (24), we can express b_t^o in terms of the latent states according to

$$b_t^o = b_0 + b_\chi \chi_t + b_h h_t + \psi_t, \tag{25}$$

where the coefficients b_0, b_χ, b_h, and b_ψ are detailed in Appendix E.

The three shocks to the latent variables $\epsilon_{\chi,t+1}$, $\epsilon_{h,t+1}$, and $\epsilon_{\psi,t+1}$ have mean zero, a variance-covariance matrix given by

$$\text{var}\left(\begin{bmatrix} \epsilon_{\chi,t+1} \\ \epsilon_{h,t+1} \\ \epsilon_{\psi,t+1} \end{bmatrix}\right) = \begin{bmatrix} \sigma_\chi^2 & \sigma_{\chi h} & \sigma_{\chi\psi} \\ \sigma_{\chi h} & \sigma_h^2 & \sigma_{h\psi} \\ \sigma_{\chi\psi} & \sigma_{h\psi} & \sigma_\psi^2 \end{bmatrix}, \tag{26}$$

and are independent and identically distributed over time. The orthogonal shocks to realized surplus ($\epsilon_{\chi,t+1}$) and returns ($\epsilon_{r,t+1}$) are assumed to be independent of the other shocks.

We next model how bond investors use the incoming cost releases to update their beliefs about surplus policy. The CBO cost estimate for an arbitrary proposal z in month t gives annual nominal cash flow estimates starting in the next fiscal year up to the fiscal year at horizon T. We normalize these cash flows by CBO's nominal GDP projection for the closest month of the same year. We then sum all these normalized cash flows within each proposal and across proposals of month t to get a monthly observable CBO cost intensity measure that we denote as $\overline{\mathcal{V}}_t^o$.

We assume that the monthly cost intensity measure $\overline{\mathcal{V}}_t^o$ is a noisy signal about the persistent component in surplus policy χ_t, modeled as

$$\overline{\mathcal{V}}_t^o = c_0 + c_1 \chi_t + \epsilon_{c,t}, \tag{27}$$

where the coefficients c_0 and c_1 are unobservable to investors and $\epsilon_{c,t} \sim N(0, \sigma_c^2)$ is independent to all other shocks.

To summarize the information structure, bond investors do not observe the vector of latent states

$$\mathcal{Z}_t \equiv [\chi_t, h_t, \psi_t]', \tag{28}$$

and they do not know the value of the parameters

$$\Theta \equiv \left[\mu_\chi, \rho_\chi, \sigma_s^2, \sigma_\chi^2, c_0, c_1, \sigma_c^2, \mu_h, \rho_h, \sigma_r^2, \sigma_h^2, \mu_\psi, \rho_\psi, \sigma_\psi^2, \sigma_{\chi h}, \sigma_{\chi\psi}, \sigma_{h\psi}\right]'. \tag{29}$$

They observe monthly surpluses, cost intensity measure, government returns adjusted for inflation and growth, and debt to GDP, summarized in the vector

$$\mathcal{Y}_t^o = [\hat{S}_t^o, \overline{\mathcal{V}}_t^o, \hat{r}_{gt}^o, b_t^o]. \tag{30}$$

Utilizing the incoming data $\mathcal{Y}_t^o$, investors update their initial beliefs about the parameters Θ and the latent states $\mathcal{Z}_t$. Next, we outline how investors update their beliefs based on the observed data.

4.2 Updating of states and parameters

We use Bayesian inference for the model parameters and the hidden states. We express the vector of observables $\mathcal{Y}_t^o$ as a function of the latent states. The link between these observables and states are given by

$$\mathcal{Y}_t^o \quad = \quad A_t \left(D + Z z_t + u_t,\right) \quad u_t \sim N(0, \Sigma_u), \tag{31}$$

where D and Z are a function of the parameter vector Θ, the state vector z_t mainly comprises the latent states χ_t, h_t, ψ_t, their lags and the orthogonal shocks $\epsilon_{\chi t+1}$, ϵ_{rt+1}, and ϵ_{ct+1}. The matrix A_t serves as a selection matrix that accounts for the differences in data availability due to the CBO cost estimates beginning in 1997, while other observable variables date back to 1980.

The state vector follows a vector autoregressive process expressed as

$$z_t \;=\; \Phi_0 + \Phi z_{t-1} + \omega_t, \quad \omega_t \sim N(0, \Sigma_\omega), \tag{32}$$

where Φ_0, Φ, and Σ_ω are a function of the parameter vector Θ. We use a Metropolis–Hastings algorithm for Bayesian inference. We describe this algorithm, the prior distribution, and the state-space system in Appendix E.

To isolate the impact of the CBO cost intensity measure on the latent states and parameters, we estimate the model with and without the monthly CBO measure as an observable variable. We attribute the differences in these two sets of estimates to the information contained in the cost releases.

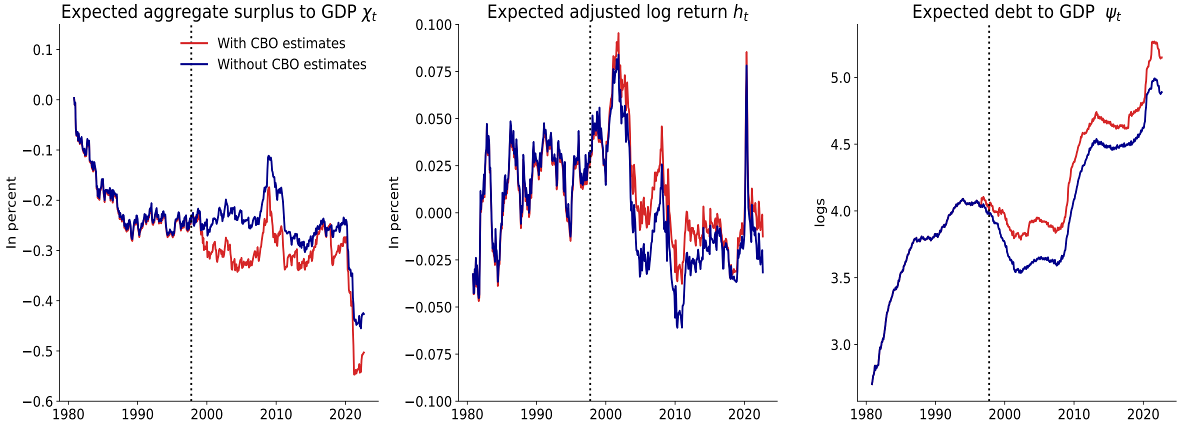
We begin our analysis by assessing the impact of CBO cost releases on the latent states by estimating the model with fixed parameters over the full sample 1980-2022. Given the parameter values, we recursively filter the sequence of latent states, reflecting new information in observable data. We later recursively estimate the parameters and latent states, allowing investors to update their beliefs about the parameters governing the latent states with the incoming data.

Figure 7 plots the mean estimates of the latent states conditional on data available up to time t but with the parameter estimates computed using the entire sample. The red line refers to the estimated states using CBO cost intensity data, the blue line corresponds to the estimates without using CBO data, and the vertical black line denotes the start of our CBO cost release data in 1997.

The left panel of Figure 7 displays the series for the latent component in surplus to GDP χ_t. Prior to the introduction of the CBO cost release data in 1997, both lines are closely aligned and show an initial downward trend embodying the large deficits unfolding during this period. The estimated χ_t that integrates CBO data exhibited a steeper decline after 1997, implying that the inclusion of the cost intensity measure lowers the conditional mean of surpluses throughout the 1997 to 2022 period. We later show the wedge between the two estimated paths of χ_t is driven by the arrival of large negative cost releases.

The center panel plots the latent component of the inflation and growth-adjusted

Fig. 7. **State estimates**



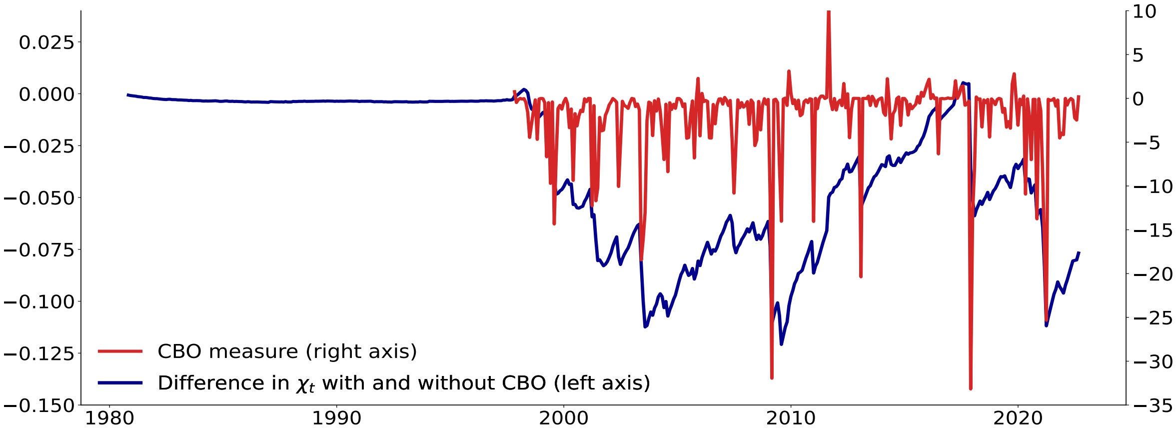
Notes: This figure depicts the evolution of the latent states χ_t, h_t, and ψ_t. We plot the mean of the posterior distribution of the states conditional on data available up to time t and calculated using the entire sample for parameter estimation. In each panel, the latent states conditioned on the CBO cost estimates are marked with red lines, whereas the dark blue lines indicate state estimates that do not incorporate the CBO information. The vertical black dotted line in each panel signifies the point at which the CBO cost estimates become available.

government discount rate h_t. The estimated path of h_t using cost release data is slightly higher, which is consistent with our evidence in Section 2.3 showing how the daily convenience yield and nominal term premia responses increase nominal government discount rates on large negative cost release days. The differences in the estimated h_t are muted when compared to the other latent states, which could be due to expected inflation rising on these days (documented in Section 2.3), which provides an offsetting force to the nominal discount rate.

The right panel shows the estimated path of the expected value of debt to GDP at horizon T. The estimated ψ_t illustrates the investor expecting a higher future debt burden when the CBO cost release data is used. The CBO cost releases reveal information about the drift toward larger future deficits through χ_t, which are expected to be financed through additional government borrowing.

Figure 8 examines how the differences in the estimated latent states relate to the CBO cost measure $\overline{\mathcal{V}}_t^o$. The left panel plots the difference in the estimates of χ_t with and without using the cost releases (blue line), and the CBO cost intensity measure $\overline{\mathcal{V}}_t^o$ (red line). This figure visualizes how the conditional mean of surpluses tends to decline when there are large negative values in the CBO measure (i.e., months with a high intensity

Fig. 8. **Impact of CBO cost estimates on expected aggregate surplus**



Notes: The blue line displays the difference in the χ_t estimate with and without the inclusion of CBO cost estimates. The CBO cost measure ($\overline{\mathcal{V}}_t^o$) is shown in red and plotted on the right y-axis.

of large negative proposals). Even though most of the proposals from the cost releases do not get enacted, they reveal the willingness of policymakers to sustain larger future deficits that eventually materialize.

Table 7 formalizes the statistical association between the differences in estimated latent states with and without CBO cost data and the cost intensity measure. The first column runs the regression

$$\Delta\chi_t = a + b\overline{\mathcal{V}}_t^o + e_t, \tag{33}$$

where $\Delta\chi_t$ is defined as the difference in the estimated χ_t expressed in basis points and $\overline{\mathcal{V}}_t^o$ is expressed in percent. The slope coefficient in this regression is 0.147 with a t-statistic of 3.9, interpreted as a decrease of 0.147 basis points in the conditional mean of surplus to GDP for each 1% increase in the CBO measure. The constant term is -5.343 with a t-statistic of -28, reflecting the large decline in $\Delta\chi_t$ induced by the CBO measure.

Column 2 of Table 7 regresses the difference in the persistent component of real discount rates with and without cost release data (denoted as Δh_t) on the cost intensity measure $\overline{\mathcal{V}}_t^o$. The slope coefficient estimate is positive (0.008) but not statistically significant (t-statistic of 0.792). The positive but muted response is consistent with Figure 8 showing a smaller wedge between the two estimated series for h_t. This could

Table 7. **Impact of CBO cost estimates on the state variables**

	Difference in state estimates with and without CBO		
	$\Delta\chi_t$ (1)	Δh_t (2)	$\Delta\psi_t$ (3)
Constant	-5.343	1.301	0.215
t-statistic	[-28.044]	[24.176]	[60.661]
$\overline{\mathcal{V}}_t^o$	0.147	0.008	-0.002
t-statistic	[3.915]	[0.792]	[-3.549]
R^2 in %	4.907	0.211	4.069
Observations	299	299	299

Notes: Column 1 presents regression results for the equation:

$$\Delta\chi_t = a + b\overline{\mathcal{V}}_t^o + \epsilon_t,$$

where $\Delta\chi_t$ denotes the difference in the χ_t estimate with and without the inclusion of CBO cost estimates. The variable $\overline{\mathcal{V}}_t^o$ denotes the CBO cost measure. In columns 2 and 3 we replace $\Delta\chi_t$ with Δh_t and $\Delta\psi_t$, respectively. $\Delta\chi_t$ and Δh_t are in basis points, $\Delta\psi_t$ is in logs, and $\overline{\mathcal{V}}_t^o$ is in percent. t-statistics are in squared brackets.

reflect how the opposing effects of nominal discount rates and expected inflation on large negative proposal days mute the response of real discount rates.

Column 3 of Table 7 considers the difference in the expected debt-to-GDP with and without cost release data, denoted as $\Delta\psi_t$. We regress $\Delta\psi_t$ on the cost intensity measure, yielding a slope coefficient estimate that is negative (-0.002) and statistically significant (t-statistic of -3.5). This regression result highlights how a high intensity of large negative proposals generates expectations of higher debt a decade from now (T). When viewed in conjunction with the regression evidence for $\Delta\chi_t$ and the present value restrictions, higher debt expectations are needed to fund the larger anticipated future deficits revealed in the cost releases.

The sustained impact of the cost releases on the latent states suggests that investors are revising their beliefs about the stance of policy characterized by the structural parameters governing these processes. For instance, observing a high concentration of large negative cost releases that predict sustained deficits leads investors to infer that the unconditional mean μ_χ is lower and the persistence parameter ρ_χ is higher for the expected surplus process. We allow investors to recursively update the parameters governing the latent states in our next procedure.

We start the parameter learning in 1997, coinciding with the availability of CBO

Table 8. **Impact of CBO cost estimates on key model parameters**

	Difference in parameter estimates with and without CBO					
	$\Delta\mu_\chi$ (1)	$\Delta\rho_\chi$ (2)	$\Delta\mu_h$ (3)	$\Delta\rho_h$ (4)	$\Delta\mu_\psi$ (5)	$\Delta\rho_\psi$ (6)
Constant	-3.0993	0.0112	1.5113	0.0028	0.0023	-0.0012
t-statistic	[-26.1538]	[39.1102]	[15.5908]	[8.3550]	[16.0954]	[-11.0344]
$\overline{\mathcal{V}}^o_t$	0.0599	0.0000	-0.0191	-0.0000	-0.0001	-0.0001
t-statistic	[2.6002]	[0.6431]	[-1.0119]	[-0.3765]	[-2.7218]	[-2.6945]
R^2 in %	2.4430	0.1529	0.3778	0.0525	2.6704	2.6186
Observations	299	299	299	299	299	299

Notes: Column 1 presents regression results for the equation:

$$\Delta\mu_\chi = a + b\overline{\mathcal{V}}^o_t + \epsilon_t,$$

where $\Delta\mu_\chi$ denotes the difference in the μ_χ estimate with and without the inclusion of CBO cost estimates. The variable $\overline{\mathcal{V}}^o_t$ denotes the CBO cost measure. In columns 2 to 6 we replace $\Delta\mu_\chi$ with $\Delta\rho_\chi$, $\Delta\mu_h$, $\Delta\rho_h$, $\Delta\mu_\psi$, and $\Delta\rho_\psi$, respectively. The variables $\Delta\mu_\chi$ and $\Delta\mu_h$ are in basis points and $\overline{\mathcal{V}}^o_t$ is in percent. t-statistics are in squared brackets.

cost estimates. Bond investors are initially endowed with informative beliefs about the parameter values based on parameter estimates using maximum likelihood on data from October 1980 to January 1997. They center their initial beliefs around these parameter estimates. From January 1997 onward, bond investors observe new data each month and apply Bayes' Law to iteratively update their initial beliefs about the states and parameters. This recursive updating process results in a time series of evolving parameter estimates and latent states extending to December 2022.

To evaluate the impact of the CBO measure on the recursive parameter estimates, we estimate the model including and excluding the CBO measure from the observable vector. Revisions in the latent states in the current procedure can be due to parameter learning. We then regress the differences in parameter estimates on the CBO cost intensity measure according to

$$\Delta\Theta^i_t = a + b\overline{\mathcal{V}}^o_t + e_t, \tag{34}$$

where $\Delta\Theta^i_t$ denotes the difference in posterior means for parameter i at time t between model estimations with and without the CBO measure. Table 8 presents the results, and Figure B.8 in the Appendix illustrates the evolution of the mean of the posterior distribution of the parameters.

Columns 1 and 2 of Table 8 demonstrate that negative CBO cost releases lead to a sustained reduction in the unconditional mean estimate μ_χ and a rise in the persistence parameter ρ_χ of the latent surplus process χ_t, although the impact on persistence parameter is not statistically significant. The continual trend of revising the persistence upwards and the mean downwards reflects investors' learning about policymakers' predilection toward running large deficits over the last two decades. The parameter learning is gradual because the policy drift is persistent and constitutes a substantial departure from fiscal policy in the previous decades, including a reversal of the budget consolidations of the 1990s.

Columns 3 and 4 indicate that including the CBO cost intensity measure in the estimation results in growth and inflation-adjusted government discount rates with a higher unconditional mean μ_h and persistence ρ_h. However, the parameter revisions related to the discount rate do not significantly correlate with the CBO measure, indicated by the insignificant coefficient on $\overline{\mathcal{V}}_t^o$. The insignificant relations are consistent with our previous analysis documenting the muted responses of the estimated h_t to the cost releases.

Columns 5 and 6 demonstrate that incorporating the CBO cost releases in the estimation corresponds to a statistically significant increase in both the unconditional mean μ_ψ and the persistence ρ_ψ of the latent process governing the expected future debt-to-GDP ratio ψ_t. Overall, Table 8 highlights that the cost releases allow investors to learn about the unobservable parameters governing future surplus and debt policy jointly with the latent states. We next examine the implications of parameter learning on Treasury values.

We compute the aggregate Treasury value in the model using equation (25) for two sets of parameters and latent states. The first set comes from the recursive model estimation that does not incorporate the CBO cost estimates. The second set of parameters and latent states adjusts the first set with the predicted changes in parameters and states, calculated using the regressions from equations (33) and (34). We attribute the differences in Treasury values implied by the two estimated sets to the information contained in the cost releases. The recursive parameter estimates are critical for generating consistent

Table 9. **Model-implied changes in debt values**

A. Large negative proposal periods

	Posterior		
	5%	50%	95%
Mean bps	-2.04	-1.56	-1.25
Cumulative change in %	-25.72	-23.31	-15.10

B. Large positive proposal periods

	Posterior		
	5%	50%	95%
Mean bps	0.09	0.11	0.12
Cumulative change in %	1.23	1.15	1.68

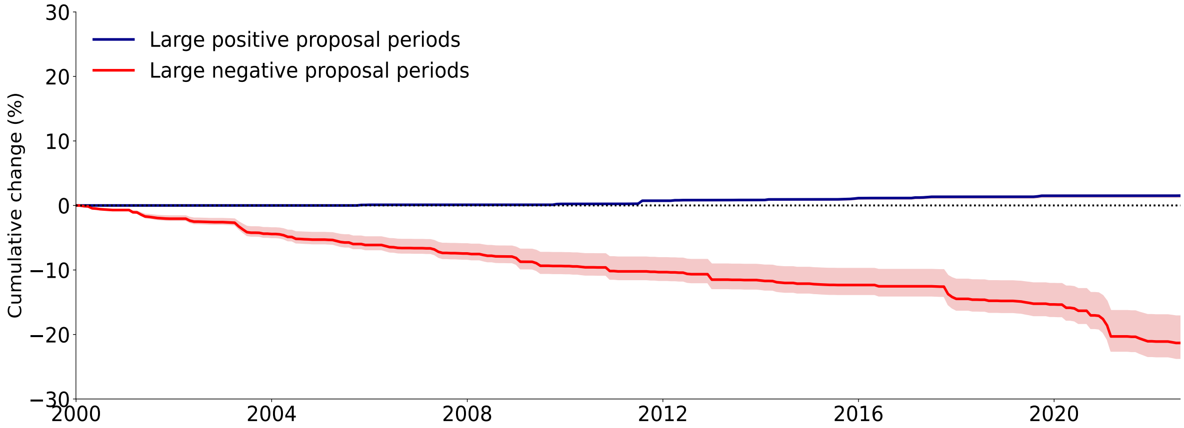
Notes: This table displays the 5%, 50%, and 95% percentiles for the model-implied average and cumulative changes in Treasury values. In Panel A, the estimates are presented for periods when the CBO measure is negative and falls below its median value. Conversely, Panel B provides estimates for periods where the CBO measure is positive and exceeds its median value.

downward revisions in Treasury values to large negative cost releases.

Table 9 presents the implied changes in Treasury values from the model, attributing to periods with large negative cost releases and large positive cost releases. We define 'large' analogously to Section 2.2 by selecting the cost releases that are above the median in magnitude for the positive and negative categories separately. The table reports the posterior distribution of the mean Treasury value response at the 5th, 50th, and 95th percentiles. To align our estimates with the daily frequency event study evidence presented in Table 2, we adjust the average monthly change by dividing it by five to reflect the fact that, on average, there are five large negative proposals occurring each month.

Panel A shows that the average model-implied change in Treasury values is negative in periods of large negative cost releases. The posterior median is -1.56 bps, similar to the -1.84 bps average daily change in actual data that falls within the 90% credible intervals of the model's posterior distribution. The cumulative change in periods with large negative proposals implied by the model is -23.31%, in line with the -21% cumulative change observed in the actual data. The red line in Figure 9 illustrates how the cumulative changes in large negative periods from the model exhibit a smooth downward trend like in the actual data.

Fig. 9. **Model-implied cumulative change in debt values**



Notes: This figure displays the model-implied cumulative change in Treasury values for the large negative proposal periods (red line) and the large positive proposal periods (blue line). The light-shaded areas correspond to 90% credible intervals.

Panel B of Table 9 presents the model-implied change in Treasury values in periods with large positive cost releases. The posterior median of the average change in these periods is positive but relatively small and insignificant like in the actual data. The cumulative change is also small over the sample period due to a combination of the small effects and fewer positive proposals.

4.3 Quantifying the effects of surplus news on Treasury values

This section decomposes the Treasury value response into surplus news, discount rate news, and news about future debt expectations at a 10-year horizon according to the intertemporal budget identity presented in equation (23). We use this decomposition to isolate the contribution of surplus news on the realized Treasury value to GDP using our recursive model estimates. We focus our analysis on the periods with large negative proposals since the pricing effects are concentrated there.

We impute the impact of the large negative cost releases on surplus news by first calculating the surplus contribution ($\mathbb{E}_t \sum_{j=1}^{T} \nu^{j-1}\gamma \hat{S}^o_{t+j}$) under the two sets of recursive parameter and state estimates like in Table 9, with one set incorporating the cost releases and the other excluding them, and then taking the difference in the imputed surplus contributions on the large negative proposal periods. We back out the remaining

Table 10. **Decomposition in the model-implied changes in debt values**

A. Effect of cash flow news

	Posterior		
	5%	50%	95%
Mean bps	-2.83	-2.74	-2.62
Cumulative change in %	-38.49	-37.29	-35.61

B. Effect of expected value of debt to GDP news

	Posterior		
	5%	50%	95%
Mean bps	1.07	1.19	1.36
Cumulative change in %	14.48	16.18	18.56

Notes: This table decomposes the model-implied Treasury value response into surplus news and news coming from the future value of debt.

contributions to the present value from discount rates and future expected debt as a residual between the Treasury value and surplus contributions. We also take the difference in this residual term under the two sets of parameters and states.

Table 10 presents the results for how the cost releases affect surplus news and the residual term implied by the model. Panel A documents that the posterior median of the average surplus news of large negative cost releases is -2.74 bps. Panel B reports that the posterior median of the average change in the residual term is 1.19 bps, which is mostly driven by expectations of a higher future debt burden, given that the real discount rate effects are negligible. The future debt expectation response partially counteracts the negative impact of surplus news on Treasury values. The combined effect delivers the -1.56 bps model-implied average Treasury change reported in Table 9. These calculations highlight how the majority (57%) of the surplus news from large negative cost releases is passed through to Treasury values.

The model estimation implies that the negative Treasury value responses to large negative cost releases primarily reflect investors updating their beliefs about the aggregate surplus process rather than cash flow news about individual bills. When investors observe periods with a high concentration of proposals related to spending increases or tax cuts, we show that the cost releases provide valuable signals about a drift toward a more profligate stance in fiscal policy.

We can use our model estimates of future Treasury supply to contextualize our empirical estimates from Section 2. The estimated revision in the expected future Treasury supply scaled by GDP in 10 years is 1.19 bps on large negative proposal days. We previously documented a 0.38 bps change in long-term yields and a -0.09 bps response in the convenience yield on these days. These estimates imply that a percentage point increase in the expected Treasury supply to GDP corresponds to a 31.93 bps (= 0.38/1.19 × 100 bps) change in the 10-year nominal yield and a -7.56 bps (= -0.09/1.19 × 100 bps) response in the convenience yield on large negative proposal days. For comparison, Krishnamurthy and Vissing-Jorgensen (2012), finds these estimates to be 1.5 bps and -4.25 bps, respectively, using annual regressions.

5 Conclusion

We document that daily CBO cost projections about legislative proposals reveal news about the future path of primary surpluses priced in by bond investors. We find the most important news is concentrated on days with cost releases of large negative proposals over our sample, corresponding to significant negative daily Treasury value responses. The cumulative daily Treasury value change on these large negative proposal days is -20%, while they are negligible on large positive cost release days.

The Treasury valuation effects on days with large negative cost releases are inconsistent with a standard FIRE framework. Given that we can predict large negative proposals well before the cost release and show that large negative proposal days are not systematically related to aggregate factors affecting bond prices, these treasury value responses suggest that bond investors appear to be consistently underestimating the cash flow of the proposals, aggregate surpluses, or discount rates before the cost releases. The significant responses in convenience yields, expected inflation, nominal term premia, and long-term nominal yields on these days further reinforce the deviations of FIRE.

We argue that investors are using the cost releases as signals to learn about the policy stance. Bond investors at the start of our sample in 1997 probably did not know the true model governing surplus policy and would have needed to gradually learn about the trend in deficits unfolding over the sample. We formalize this intuition about investor learning in a present value model where Bayesian investors use incoming cost releases to learn about the parameters and states governing surpluses, discount rates, and expected future Treasury supply.

Our model can account for the drops in the valuation of Treasurys on large negative proposal days and the insignificant responses on large positive proposal days. Cost releases about negative proposals enable investors to update their beliefs about the parameters governing policymakers' willingness to run persistent deficits and borrow more. The Treausry valuation drops imply investors do not expect Ricardian policy in the future to offset the increasing deficits. Our model finds that the majority of the Treasury value response on large negative proposal days is attributed to revisions in aggregate surplus news.

Overall, our paper highlights that the CBO cost projections about individual proposals contain valuable budgetary news, allowing bond investors to learn about the trajectory of future surpluses.

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Appendix

Can U.S. Treasury Markets Add and Subtract?

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December 2023

Appendix Table of Contents

Appendix A - Data

A.1 Variables definitions and data sources

This section describes the data sources and construction of the variables used in our main empirical tests.

A.1.1 Measuring aggregate Treasury values

We compute a daily series of marketable debt held by the public as in Hall and Sargent (2011). Let B_t denote the market value of government debt at time t. We calculate B_t by separating all coupon and principal payments from outstanding treasuries held by the public, pricing each maturity as zeros, and then aggregating ($B_t = \sum_{j=1}^{n} q_{t+j}^{t} f_{t+j}^{t}$, where f_{t+j}^{t} represents the total nominal debt payment committed for j years from time t). This calculation includes all principal and coupon payments guaranteed by the government to be paid at time $t + j$. The price of a one-dollar zero-coupon bond maturing at time $t + j$ is denoted by q_{t+j}^{t}.

We use the daily prices and quantities of US Treasuries obtained from the Center for Research in Security Prices (CRSP) to help construct the series for B_t. To compute the nominal payments f_{t+j}^{t} for each Treasury note and bond, we use the outstanding face value (tdpubout) with pertinent bond characteristics such as coupon rates and maturity dates.

While CRSP does not provide this variable for Treasury bills (tdpubout is missing for bills), we follow Hall and Sargent (2011) and derive tdpubout for bills as a residual. We acquire a monthly series of face values of public debt that mature within one year from Table FD-5 of the Treasury Bulletin. We then subtract the tdpubout value for bonds and notes maturing within one year and assume that tdpubout for Treasury bills remains constant within each month and allocate it to each specific bill proportionally, based on the daily series of the total amount outstanding (tdtotout) for which we have CRSP observations. Finally, we obtain the day of coupon and principal payment from treasurydirect.gov.

We fit a zero-coupon forward curve using coupon bond prices to compute q_{t+j}^{t}, following the approach of Gürkaynak et al. (2007). We extend the yield curve to maturities of less than one year by incorporating market yields on US Treasury securities at constant maturities of one month, three months, and six months and linear interpolating for the remaining maturities.

A.1.2 Controlling for macroeconomic announcements

We use real-time data from the Bloomberg Professional Service to account for macroeconomic news. Specifically, we control for macroeconomic news releases by computing the difference between the realized value and the expected value of macroeconomic indicator k at time t, denoted A_{kt} and E_{kt} respectively. We standardize this difference by dividing it by the sample standard deviation of $A_{kt} - E_{kt}$, denoted $\hat{\sigma}_k$, following the approach in Balduzzi, Elton, and Green (2001), Andersen, Bollerslev, Diebold, and Vega (2003) and

Bianchi, Gómez-Cram, Kind, and Kung (2023):

$$S_{kt}^{macro} = \frac{A_{kt} - E_{kt}}{\hat{\sigma}_k}.$$

This standardization allows us to compare indicators with different units of measurement but it does not affect the statistical significance of our estimates, as $\hat{\sigma}_k$ is constant for any given indicator.

To obtain the expected value E_{kt} for each indicator, we use the median forecast from the most recent weekly survey of economists conducted by Bloomberg prior to the announcement. Bloomberg collects forecasts from major consulting firms and investment banks and reports the median forecast shortly before each release. We provide a list of the 50 macroeconomic indicators used as controls in Table A.1.

Table A.1. **Macroeconomic announcements**

Event	Ticker	Relevance	Count	Time
Change in Nonfarm Payrolls	NFP TCH Index	99.213	95	08:30:00
Initial Jobless Claims	INJCJC Index	98.425	413	08:30:00
FOMC Rate Decision (Upper Bound)	FDTR Index	97.638	126	14:00:00
GDP Annualized QoQ	GDP CQOQ Index	96.850	94	08:30:00
CPI MoM	CPI CHNG Index	96.063	95	08:30:00
ISM Manufacturing	NAPMPMI Index	95.276	190	10:00:00
U. of Mich. Sentiment	CONSSENT Index	94.488	190	10:00:00
Conf. Board Consumer Confidence	CONCCONF Index	93.701	95	10:00:00
Durable Goods Orders	DGNOCHNG Index	92.913	139	08:30:00
Retail Sales Advance MoM	RSTAMOM Index	92.126	95	08:30:00
New Home Sales	NHSLTOT Index	91.339	95	10:00:00
Industrial Production MoM	IP CHNG Index	90.551	95	09:15:00
Markit US Manufacturing PMI	MPMIUSMA Index	90.000	111	09:45:00
Unemployment Rate	USURTOT Index	89.291	95	08:30:00
Housing Starts	NHSPSTOT Index	88.976	95	08:30:00
Existing Home Sales	ETSLTOTL Index	88.189	95	10:00:00
ADP Employment Change	ADP CHNG Index	87.402	95	08:15:00
PPI Final Demand MoM	FDIDFDMO Index	86.614	82	08:30:00
Personal Spending	PCE CRCH Index	85.827	95	08:30:00
Personal Income	PITLCHNG Index	85.827	95	08:30:00
Factory Orders	TMNOCHNG Index	85.039	95	10:00:00
Trade Balance	USTBTOT Index	84.252	95	08:30:00
Leading Index	LEI CHNG Index	83.465	95	10:00:00
Empire Manufacturing	EMPRGBCI Index	82.677	95	08:30:00
MNI Chicago PMI	CHPMINDX Index	81.890	188	09:45:00
Wholesale Inventories MoM	MWINCHNG Index	81.102	144	10:00:00
ISM Services Index	NAPMNMI Index	79.528	190	10:00:00
Philadelphia Fed Business Outlook	OUTFGAF Index	78.740	95	08:30:00
GDP Price Index	GDP PIQQ Index	77.480	94	08:30:00
Import Price Index MoM	IMP1CHNG Index	77.165	95	08:30:00
CPI Ex Food and Energy MoM	CPUPXCHG Index	76.850	95	08:30:00
Pending Home Sales MoM	USPHTMOM Index	76.378	94	10:00:00
Monthly Budget Statement	FDDSSD Index	75.591	95	14:00:00
ISM Prices Paid	NAPMPRIC Index	74.016	285	10:00:00
Current Account Balance	USCABAL Index	71.653	31	08:30:00
Richmond Fed Manufact. Index	RCHSINDX Index	70.866	95	10:00:00
CPI YoY	CPI YOY Index	70.079	95	08:30:00
Markit US Services PMI	MPMIUSSA Index	70.000	74	09:45:00
Change in Manufact. Payrolls	USMMMNCH Index	69.449	95	08:30:00
Continuing Claims	INJCSP Index	68.898	413	08:30:00
FHFA House Price Index MoM	HPIMMOM Index	68.504	95	09:00:00
Personal Consumption	GDPCTOT Index	67.795	94	08:30:00
PPI Final Demand YoY	FDIUFDYO Index	67.716	82	08:30:00
PPI Ex Food and Energy MoM	FDIDSGMO Index	66.142	82	08:30:00
PPI Ex Food and Energy YoY	FDIUSGYO Index	65.354	82	08:30:00
Retail Sales Ex Auto MoM	RSTAXMOM Index	64.488	95	08:30:00
Dallas Fed Manf. Activity	DFEDGBA Index	63.779	94	10:30:00
Capacity Utilization	CPTICHNG Index	63.386	95	09:15:00
Building Permits	NHSPATOT Index	62.283	95	08:30:00
NFIB Small Business Optimism	SBOITOTL Index	61.417	94	06:00:00

The table lists the macroeconomic announcements we use as controls in our analysis. We identified the top 50 macroeconomic announcements based on their relevance score, which is a metric calculated by Bloomberg. The relevance score is determined by the number of "alerts" set by all users for a particular event relative to all alerts set for other U.S. economic events. We also include the count and time of each announcement. Count represents the number of announcements within our sample period. Time denotes the Eastern Time (ET) at which the announcement was most commonly released during our sample period, but we always use the actual release time in our analysis.

A.2 Selected CBO cost estimates

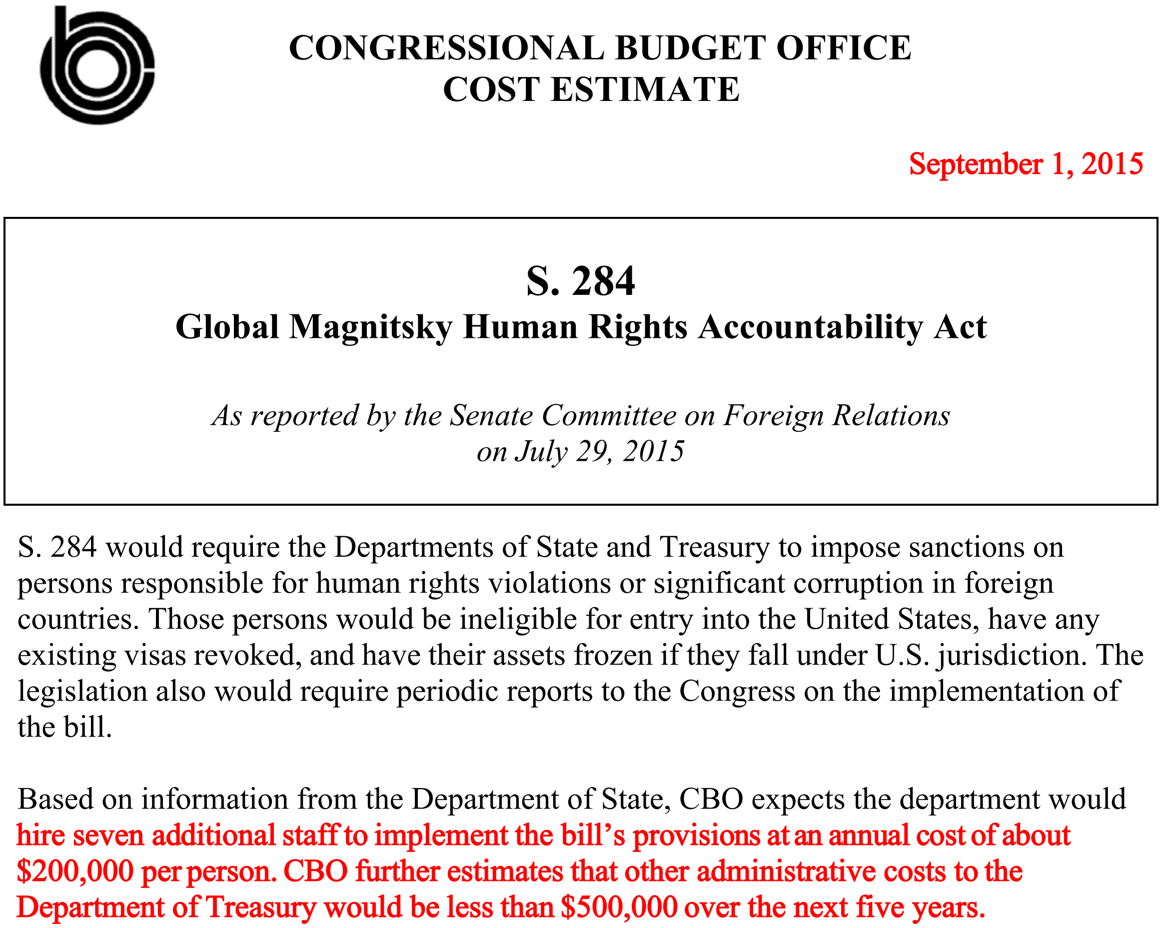
We use two examples to illustrate the informational content and highlight the different formats in cost releases.

Panel A of Figure A.1 presents an example of a bill with a small budgetary impact, S. 284, related to human rights. The first item that we collect is the date of the cost release in the top right corner. The cost estimates for small bills are typically presented in text format. We highlighted the text containing the cost estimates in red, which says *"seven additional staff to implement the bill's provisions at an annual cost of about $200,000 per person"* plus an additional 500K in administrative costs over 5 years.

Larger bills (e.g., those above the median in size) usually contain a detailed table at the end of the cost release, outlining the projected cash flows linked to the proposal. Panel B of Figure A.1 displays the CBO cost estimate for the Tax Cuts and Jobs Act. The text provides an overview of the proposal, while the accompanying table (highlighted in red) specifies the net increase in deficits from the proposal for the upcoming year and the subsequent decade if enacted.

Fig. A.1. **Examples of CBO cost estimates**

Panel A: **CBO Cost estimate for S.284**



CONGRESSIONAL BUDGET OFFICE
COST ESTIMATE

September 1, 2015

S. 284
Global Magnitsky Human Rights Accountability Act

As reported by the Senate Committee on Foreign Relations
on July 29, 2015

S. 284 would require the Departments of State and Treasury to impose sanctions on persons responsible for human rights violations or significant corruption in foreign countries. Those persons would be ineligible for entry into the United States, have any existing visas revoked, and have their assets frozen if they fall under U.S. jurisdiction. The legislation also would require periodic reports to the Congress on the implementation of the bill.

Based on information from the Department of State, CBO expects the department would **hire seven additional staff to implement the bill's provisions at an annual cost of about $200,000 per person. CBO further estimates that other administrative costs to the Department of Treasury would be less than $500,000 over the next five years.**

Panel B: **CBO Cost estimate for H.R.1**

CONGRESSIONAL BUDGET OFFICE
COST ESTIMATE

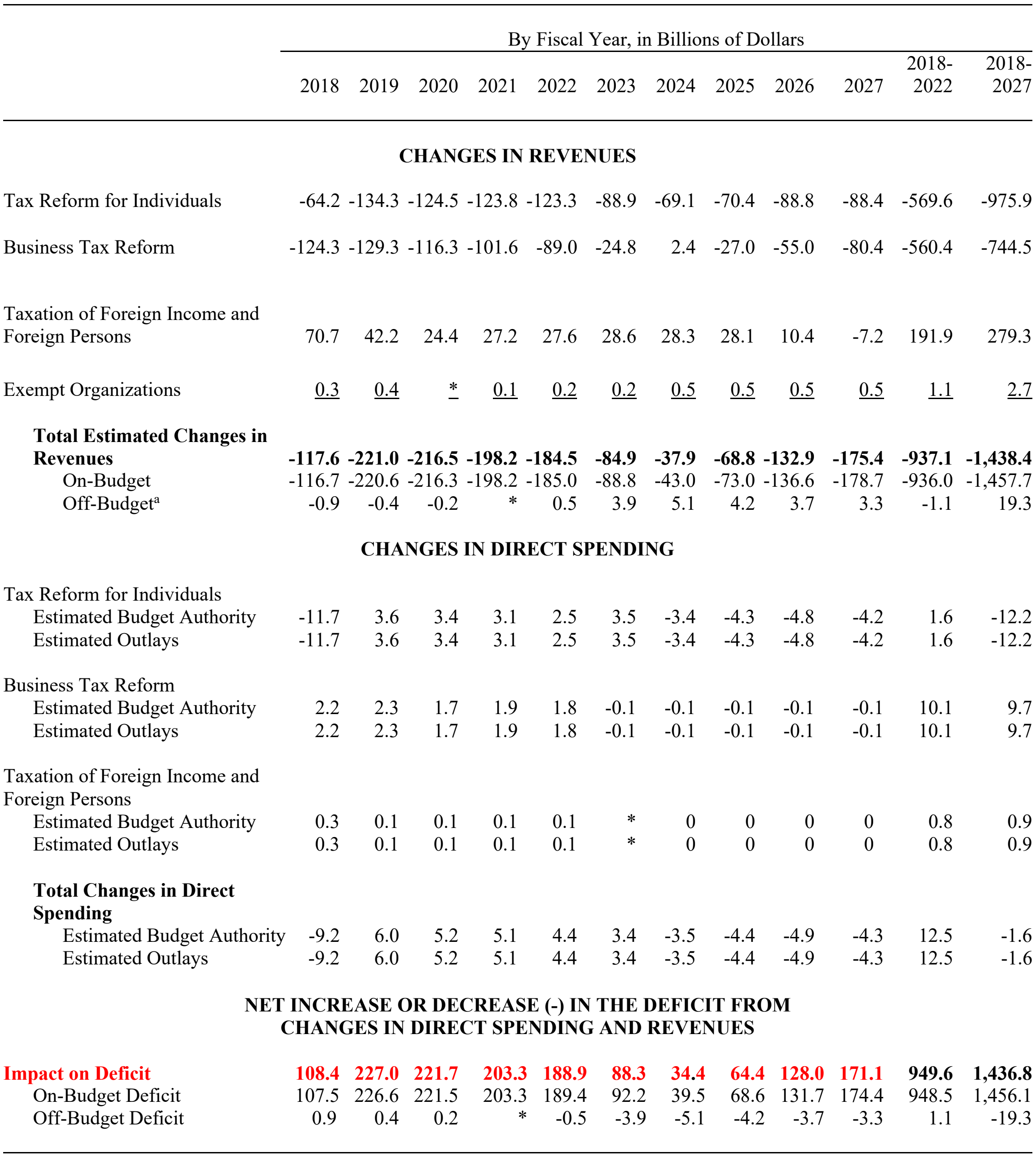
November 13, 2017

H.R. 1
A bill to provide for reconciliation pursuant to titles II and V of the Concurrent Resolution on the Budget for Fiscal Year 2018

As ordered reported by the House Committee on Ways and Means on November 9, 2017

SUMMARY

H.R. 1, the Tax Cuts and Jobs Act, would amend numerous provisions of U.S. tax law. The bill would modify the individual income tax brackets and tax rates in effect under current law. The bill also would increase the standard deduction and the child tax credit. Deductions for personal exemptions and certain itemized deductions would be repealed, along with the individual and corporate alternative minimum tax (AMT) and, starting in 2025, the estate tax. H.R. 1 would replace the structure of corporate income tax rates, which has a top rate of 35 percent under current law, with a single 20 percent rate, and would establish a maximum tax rate of 25 percent for qualified business income of an individual from certain pass-through entities. Among other changes, the bill would also substantially alter the current system under which U.S. corporations are subject to taxation on their worldwide income.



	By Fiscal Year, in Billions of Dollars											
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2018-2022	2018-2027
CHANGES IN REVENUES												
Tax Reform for Individuals	-64.2	-134.3	-124.5	-123.8	-123.3	-88.9	-69.1	-70.4	-88.8	-88.4	-569.6	-975.9
Business Tax Reform	-124.3	-129.3	-116.3	-101.6	-89.0	-24.8	2.4	-27.0	-55.0	-80.4	-560.4	-744.5
Taxation of Foreign Income and Foreign Persons	70.7	42.2	24.4	27.2	27.6	28.6	28.3	28.1	10.4	-7.2	191.9	279.3
Exempt Organizations	0.3	0.4	*	0.1	0.2	0.2	0.5	0.5	0.5	0.5	1.1	2.7
Total Estimated Changes in Revenues	**-117.6**	**-221.0**	**-216.5**	**-198.2**	**-184.5**	**-84.9**	**-37.9**	**-68.8**	**-132.9**	**-175.4**	**-937.1**	**-1,438.4**
On-Budget	-116.7	-220.6	-216.3	-198.2	-185.0	-88.8	-43.0	-73.0	-136.6	-178.7	-936.0	-1,457.7
Off-Budget[a]	-0.9	-0.4	-0.2	*	0.5	3.9	5.1	4.2	3.7	3.3	-1.1	19.3
CHANGES IN DIRECT SPENDING												
Tax Reform for Individuals												
Estimated Budget Authority	-11.7	3.6	3.4	3.1	2.5	3.5	-3.4	-4.3	-4.8	-4.2	1.6	-12.2
Estimated Outlays	-11.7	3.6	3.4	3.1	2.5	3.5	-3.4	-4.3	-4.8	-4.2	1.6	-12.2
Business Tax Reform												
Estimated Budget Authority	2.2	2.3	1.7	1.9	1.8	-0.1	-0.1	-0.1	-0.1	-0.1	10.1	9.7
Estimated Outlays	2.2	2.3	1.7	1.9	1.8	-0.1	-0.1	-0.1	-0.1	-0.1	10.1	9.7
Taxation of Foreign Income and Foreign Persons												
Estimated Budget Authority	0.3	0.1	0.1	0.1	0.1	*	0	0	0	0	0.8	0.9
Estimated Outlays	0.3	0.1	0.1	0.1	0.1	*	0	0	0	0	0.8	0.9
Total Changes in Direct Spending												
Estimated Budget Authority	-9.2	6.0	5.2	5.1	4.4	3.4	-3.5	-4.4	-4.9	-4.3	12.5	-1.6
Estimated Outlays	-9.2	6.0	5.2	5.1	4.4	3.4	-3.5	-4.4	-4.9	-4.3	12.5	-1.6
NET INCREASE OR DECREASE (-) IN THE DEFICIT FROM CHANGES IN DIRECT SPENDING AND REVENUES												
Impact on Deficit	**108.4**	**227.0**	**221.7**	**203.3**	**188.9**	**88.3**	**34.4**	**64.4**	**128.0**	**171.1**	**949.6**	**1,436.8**
On-Budget Deficit	107.5	226.6	221.5	203.3	189.4	92.2	39.5	68.6	131.7	174.4	948.5	1,456.1
Off-Budget Deficit	0.9	0.4	0.2	*	-0.5	-3.9	-5.1	-4.2	-3.7	-3.3	1.1	-19.3

Notes: These figures show examples of the CBO cost releases. Panel A displays the cost estimates for a smaller bill, S. 287, while Panel B features the cost estimates for a larger bill, H.R. 1.

A.3 Relation between the CBO's aggregate surplus projections and bill-level estimates

This section relates the bill-level cost estimates with the CBO's aggregate surplus projections.

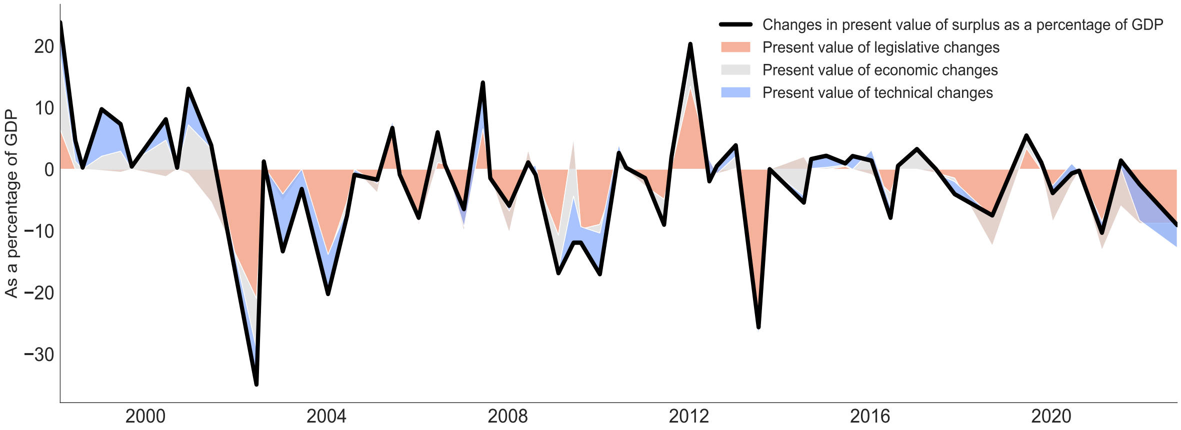
One of CBO's mandated obligations is to produce the annual Budget and Economic Outlook, presenting baseline projections of the surplus or deficit for the upcoming decade. This report is typically published at the beginning of the year and undergoes revisions in March and July. The baseline projections are not intended as forecasts of budgetary or economic outcomes; rather, they represent the CBO's assessment of how the budget and the economy would evolve under existing laws. Hence, the baseline serves as a reference point for evaluating the potential effects of proposed legislation.

Figure A.2 shows the changes in the present value of the CBO's surplus projection between two consecutive reports, where negative values indicate an increase in deficits. The changes in the present value of the surplus have been scaled by Gross Domestic Product (GDP). The black line in the figure reveals significant revisions in the CBO's 10-year cumulative projections between consecutive reports, with a standard deviation of 9.3%, despite an average time gap of 140 days between reports.

Figure A.2 further breaks down the revisions in the expected future surpluses into three distinct components. The red-shaded area represents revisions attributed to legislative changes resulting from laws enacted since the agency published its prior baseline projections. This category accounts for the majority of changes in the CBO baseline projections, contributing to 56% of the variance in surplus changes.

The remaining 44% of the variance in surplus changes is equally accounted for by the second and third categories, namely economic changes and technical changes. Economic changes arise from revisions made to the agency's economic forecast, which includes adjustments to incorporate the macroeconomic effects of recently enacted legislation. Technical changes serve as a residual category, capturing revisions to projections that are neither legislative nor economic in nature.

Fig. A.2. **Changes in expected surplus or deficits [-] as a percentage of GDP**



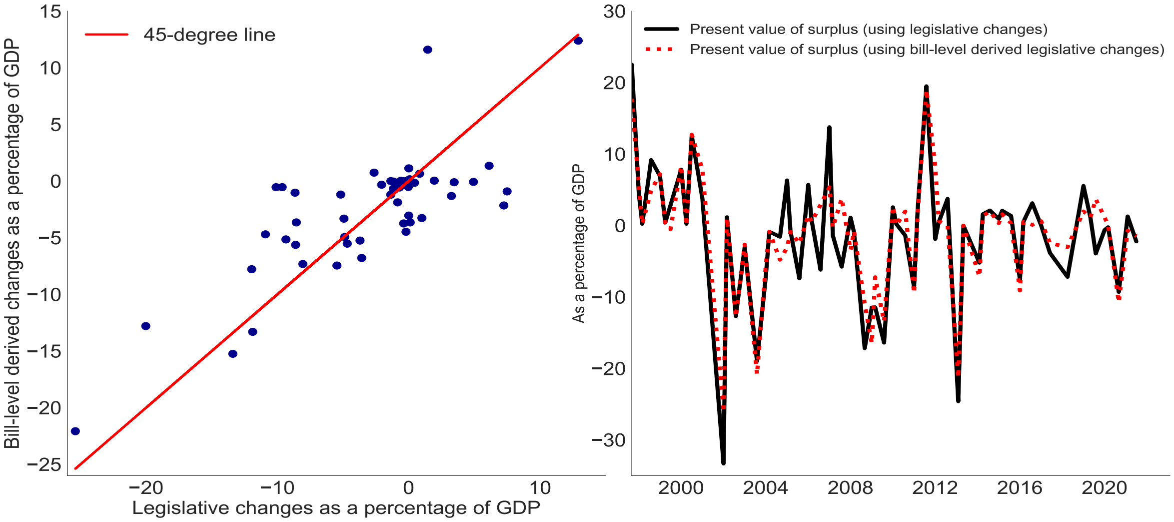
Notes: The figure shows changes in the present value of the CBO's surplus projection between two consecutive Budget and Economic Outlook reports, where negative values indicate an increase in deficits. The changes in the present value of the surplus have been scaled by GDP. The figure further breaks down the revisions in the expected future surpluses into three distinct components. The red-shaded area represents revisions attributed to legislative changes. The gray-shaded area denotes economic changes, while the blue-shaded area denotes technical changes.

Next, we use the cost estimates for proposed legislation to reconstruct the aggregate legislative changes and capture the timing of public cost estimate disclosures.

We can evaluate the significance of cost estimates at the bill level by combining the estimates for all bills enacted between two successive Budget and Economic Outlook reports. This aggregated series of cost estimates should closely align with the legislative changes depicted in Figure A.2, as both series track the modifications to the deficit arising from recently enacted laws. Creating these cost estimates from scratch has the advantage of pinpointing the exact moment of their public release.

To illustrate this relationship, the left panel of Figure A.3 presents a binned scatter plot between the present value of legislative changes and the present value of bill-derived changes, both scaled by GDP. The figure depicts the two series closely tracking each other, aligning near the 45-degree line represented by the red line. Furthermore, as seen in the right panel of Figure A.3, both legislative changes (represented by the black straight line) and bill-derived cost estimates (represented by the red dotted line) produce a series of changes in the present value of the CBO surplus projection that closely follow each other with a correlation above 90%.

Fig. A.3. **Bill-level expected changes in surplus or deficit [-] versus legislative changes**

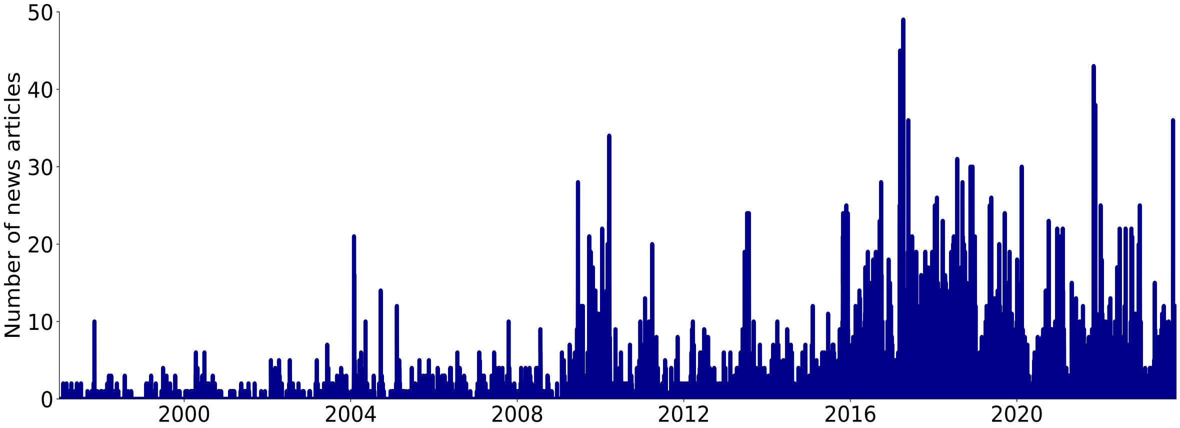


Notes: The left panel shows a binned scatter plot between the present value of legislative changes and the present value of bill-derived changes, both scaled by GDP. The bill-derived changes are computed by combining the estimates for all bills enacted between two successive Budget and Economic Outlook reports. The right panel shows the present value of the CBO surplus projection using the legislative changes series (illustrated by the black line) and the bill-derived changes (represented by the red dotted line).

Appendix B - Additional analysis

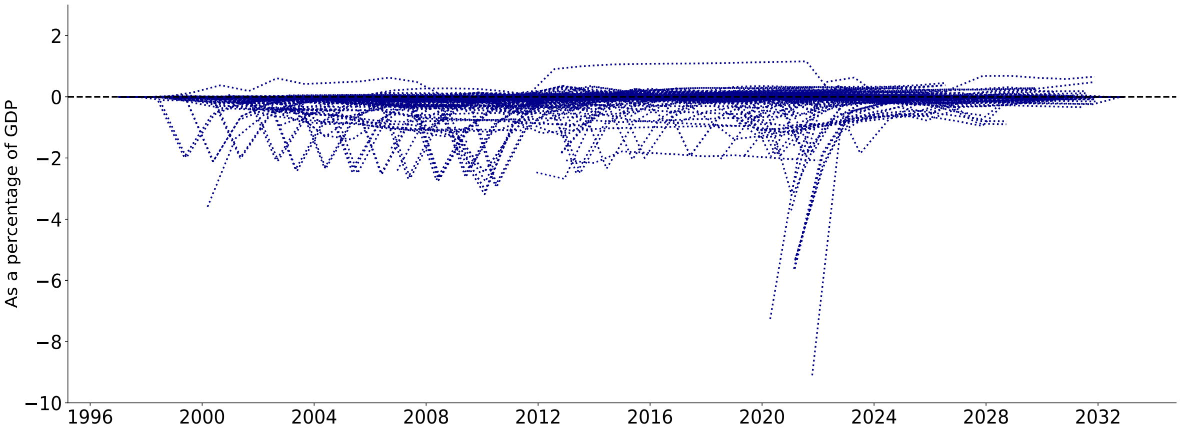
B.1 Additional Tables and Figures

Fig. B.1. **News media coverage of CBO cost esimtates**



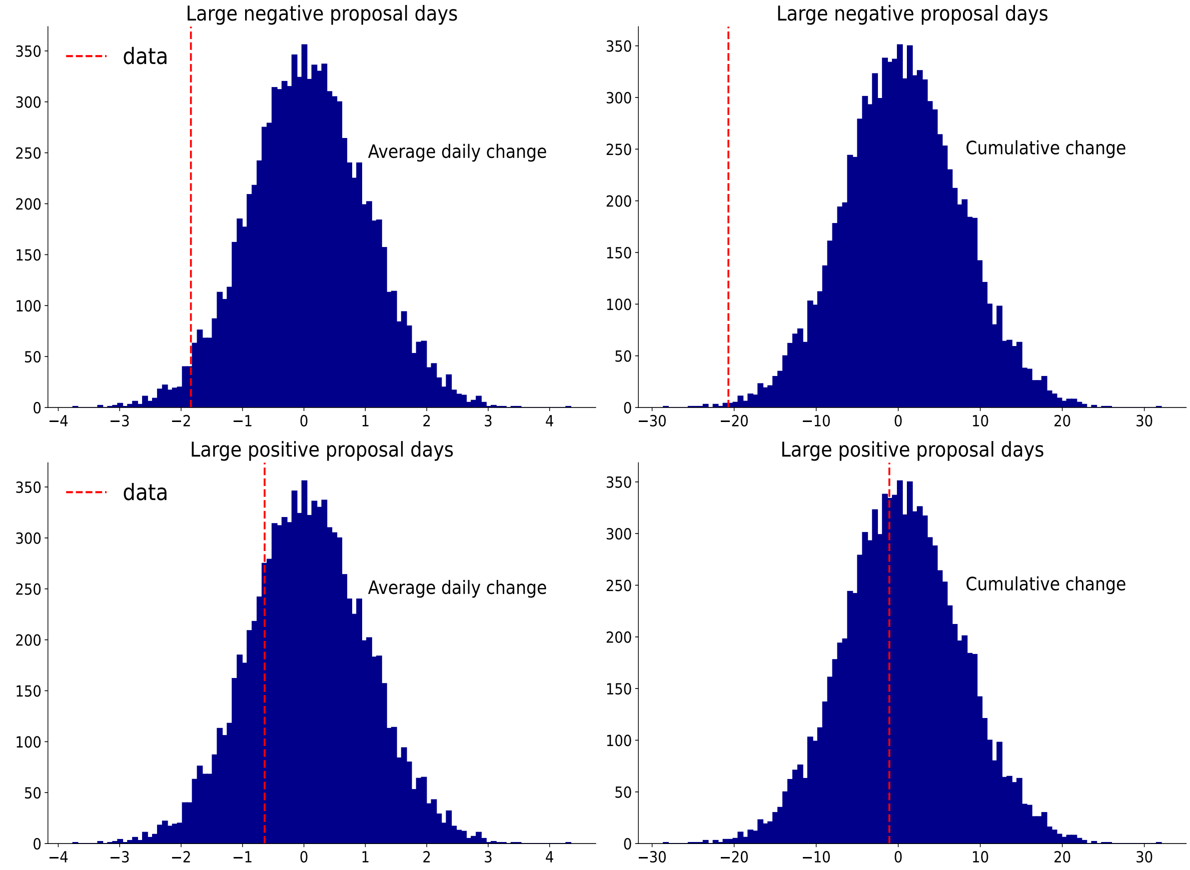
Notes: This figure shows the count of news media articles in the LexisNexis database that mention both "Congressional Budget Office" and "cost estimate". The data covers the period from 1997 to 2022.

Fig. B.2. **Bill-level expected net effect of surplus or deficit [-] as percentage of GDP**



Notes: The figure shows the expected net increase or decrease (indicated by [-]) in the deficit scaled by projected GDP. Each dotted line corresponds to a cost estimate for a specific bill, covering the current year and the subsequent decade. In total, we show 15,533 unique cost estimates spanning the 105th Congress (1997-1998) to the 117th Congress (2021-2022).

Fig. B.3. **Changes in Treasury values on random days**



Notes: We generate 10,000 samples. Each sample randomly selects without replacement 1,125 days and 170 days, corresponding to the number of observations in our actual sample for large negative and positive proposals, respectively. Subsequently, we compute the average daily and cumulative changes in Treasury values for each sample. The actual realizations are denoted by the red vertical lines. The top panel shows the actual realizations and simulated statistics for large negative proposal days, while the bottom panel presents them for days with large positive proposals.

Table B.1. **Large negative proposal days, excluding large macro news days**

	Large negative proposal days	Other days	All days
Mean bps	-3.08	0.54	0.07
t-statistic	[-2.81]	[1.36]	[0.20]
p-value	(0.01)	(0.93)	–
Cumulative change in %	-21.97	26.02	4.06
p-value	(0.00)	(0.99)	–
Observations	713	4,784	5,497

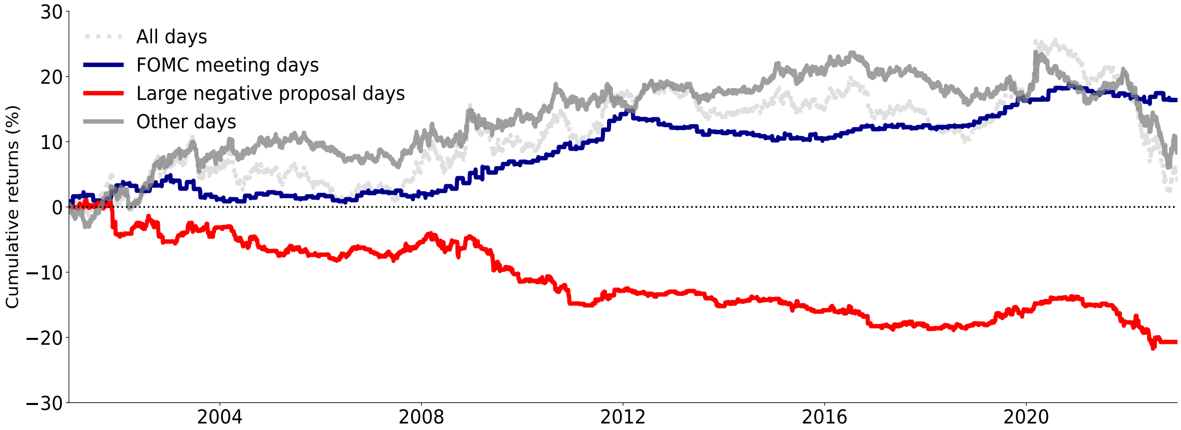
Notes: This table presents the average daily and cumulative changes in Treasury values, organized across three different sets of days. Column 1 reports changes on days with large negative proposals, specifically excluding those that overlap with FOMC meeting days and large news from the top 50 macroeconomic indicators. For each indicator, we determine the news component by calculating the deviation of actual values from median forecasts and standardizing this difference using its standard deviation. The large macro-news is then classified as the days where the absolute value of the news component exceeds its median absolute value, as calculated over a rolling 3-month window. Column 2 reports changes on other trading days and column 3 reports changes on all trading days. t-statistics are in squared brackets. We report the percentage of simulated changes in Treasury values that fall below the actual realizations in parentheses.

Table B.2. **Treasury value changes on large proposal days and FOMC meeting days**

	Deficit proposal days (1)	FOMC meeting days (2)	Other days (3)	All days (4)
Mean bps	-1.84	3.09	0.22	0.07
t-statistic	[-2.20]	[2.36]	[0.49]	[0.20]
p-value	(0.02)	(0.98)	(0.64)	(0.50)
Cumulative change in %	-20.70	16.39	8.36	4.06
p-value	(0.00)	(1.00)	(0.74)	(0.55)
Observations	1,125	530	3,842	5,497

Notes: This table presents the average daily and cumulative changes in Treasury values, organized across four different sets of days. Column 1 reports changes on days with large negative proposals, specifically excluding those that overlap with FOMC meeting days. Column 2 reports changes in a 3-day window centered on FOMC meeting days. Column 3 reports changes on other trading days and column 4 reports changes on all trading days. t-statistics are in squared brackets. We report the percentage of simulated changes in Treasury values that fall below the actual realizations in parentheses.

Fig. B.4. **Bond Returns around Deficit Projections and FOMC meeting days**



Notes: This figure shows the cumulative change in Treasury values on four different sets of days. The light gray line displays the cumulative change using all trading days. The red line shows the cumulative change using the large negative proposal days that do not coincide with FOMC meeting days. The dark blue line shows cumulative change in a 3-day window centered on FOMC meeting days. The dark gray lines show the cumulative change using all remaining trading days. The sample period runs from January 2000 to December 2022.

Table B.3. **Changes in Treasury values around large proposal days**

	Days around large negative proposal days				
	-2	-1	0	1	2
Mean bps	0.56	0.22	-1.84	-0.58	-0.56
t-statistic	[0.67]	[0.26]	[-2.20]	[-0.71]	[-0.63]
p-value	(0.70)	(0.56)	(0.02)	(0.24)	(0.25)
Cumulative change in %	6.19	2.44	-20.70	-6.53	-6.13
p-value	(0.79)	(0.60)	(0.00)	(0.16)	(0.17)
Observations	1,104	1,120	1,125	1,116	1,093

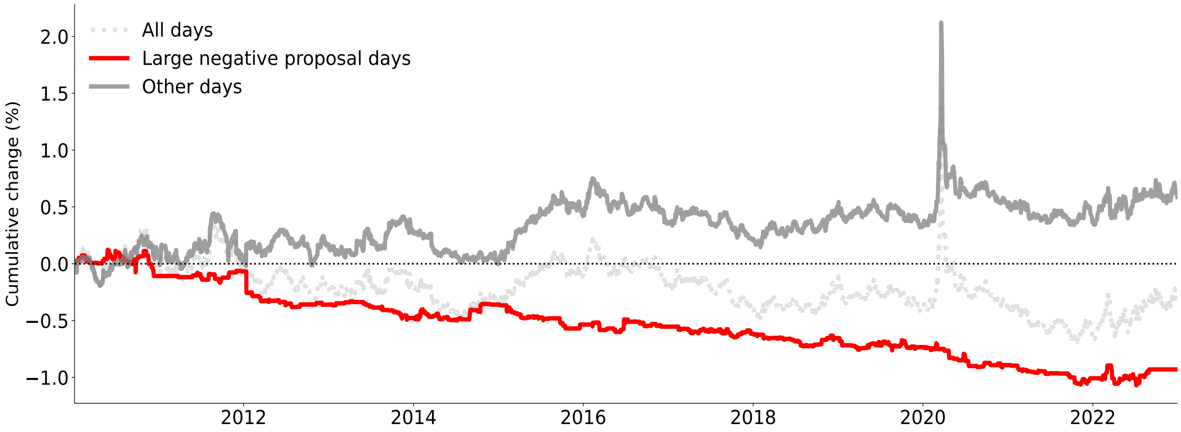
Notes: This table presents the average daily and cumulative changes in Treasury values around the large negative proposal dates. The numbers at the top of each column represent the business days before, on, or after the release date of the CBO cost estimates. t-statistics are in squared brackets. We report the percentage of simulated changes in Treasury values that fall below the actual realizations in parentheses.

Table B.4. **Changes in Treasury values around different stages of the bill**

	Different stages of the bill			
	CBO Report	Introduced	Vote	Became Public Law
Mean bps	-1.84	-0.14	-1.01	-0.09
t-statistic	[-2.20]	[-0.21]	[-1.31]	[-0.05]
p-value	(0.02)	(0.41)	(0.12)	(0.43)
Cumulative change in %	-20.70	-1.98	-12.87	-0.29
p-value	(0.00)	(0.36)	(0.03)	(0.45)
Observations	1,125	1,430	1,275	320

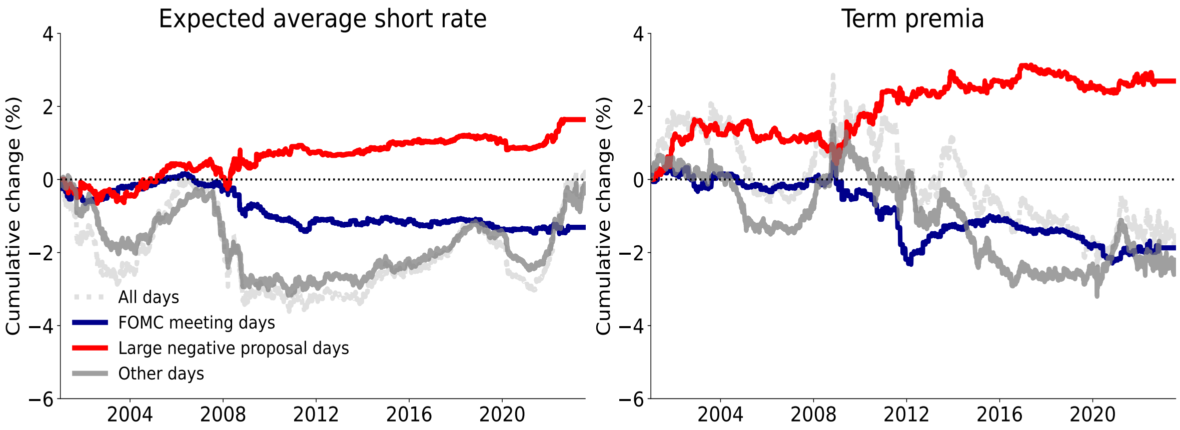
Notes: This table presents the average daily and cumulative changes in Treasury values on four specific days corresponding to key stages of bills with large negative proposals. The initial date marks the bill's introduction in either the House or the Senate. The second date aligns with the release of the cost estimate report by the CBO. The third date corresponds to the voting on the bill in either the House or the Senate. The final date signifies when the bill is enacted as public law. *t*-statistics are in squared brackets. We report the percentage of simulated changes in Treasury values that fall below the actual realizations in parentheses.

Fig. B.5. **Changes in the convenience yields on large negative proposal days after 2009**



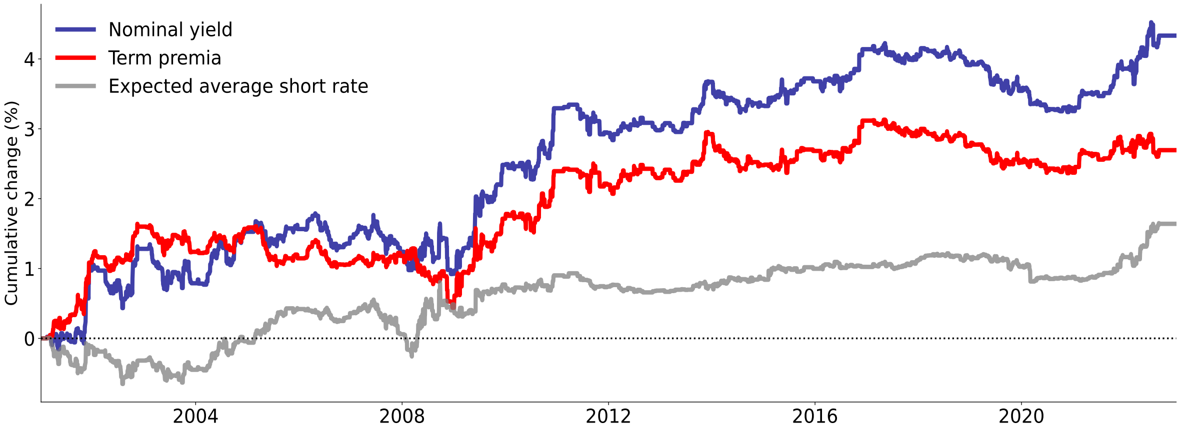
Notes: The light gray lines show the cumulative change in the convenience yields over the sample period after 2009. The red line shows the cumulative change on large negative proposal days that do not coincide with FOMC meeting days. The dark gray line denotes the cumulative changes around the remaining days.

Fig. B.6. **Changes in expected short rates and term premia on large negative proposal days**



Notes: The figure shows cumulative changes in the 10-year expected average short rate (left panel) and 10-year term premia (right panel) over our sample period. The light gray lines denote the cumulative over the whole sample. The red lines depict the cumulative changes on large negative proposal days that do not coincide with FOMC meeting days, while the dark blue lines depict changes on FOMC meeting days. The dark gray lines denote the cumulative changes on the remaining days.

Fig. B.7. **Decomposition of the 10-year nominal yield on large negative proposal days**



Notes: The dark blue line depicts the cumulative changes in the 10-year nominal yield on large negative proposal days that do not coincide with FOMC meeting days. The red and dark gray lines denote cumulative changes in the 10-year expected average short rate and 10-year term premia on these same days, respectively.

Table B.5. **Changes in inflation expectations on large negative proposal days**

	A. Inflation swap tenors			
	1 year	3 years	5 years	10 years
Mean bps	0.42	0.22	0.21	0.21
t-statistic	[1.13]	[1.07]	[1.19]	[1.52]
p-value	(0.88)	(0.88)	(0.90)	(0.95)
Cumulative change in %	3.38	1.77	1.64	1.65
p-value	(0.88)	(0.88)	(0.90)	(0.95)
Observations	800	800	800	800

Notes: This table presents the average daily and cumulative changes in inflation swaps with different tenures on days with large negative proposals that do not coincide with FOMC meeting days. Each column shows results using four different tenors: 1, 3, 5, and 10 years. t-statistics are presented within square brackets. We report the percentage of simulated changes that fall below the actual realizations in parentheses.

Table B.6. **Changes in long term yields on large negative proposal days and FOMC meeting days**

A. 10-year nominal yield	Large negative proposal days (1)	FOMC meeting days (2)	Other days (3)	All days (4)
Mean bps	0.38	-0.60	-0.06	-0.02
t-statistic	[2.16]	[-1.99]	[-0.68]	[-0.30]
p-value	(0.93)	(0.09)	(0.39)	(0.50)
Cumulative change in %	4.33	-3.18	-2.52	-1.37
p-value	(0.99)	(0.00)	(0.13)	(0.35)
Observations	1,128	532	3,986	5,646

B. 10-year expected average short rate	Large negative proposal days (1)	FOMC meeting days (2)	Other days (3)	All days (4)
Mean bps	0.15	-0.25	-0.00	0.00
t-statistic	[1.29]	[-1.28]	[-0.05]	[0.07]
p-value	(0.79)	(0.17)	(0.46)	(0.50)
Cumulative change in %	1.64	-1.31	-0.12	0.21
p-value	(0.99)	(0.01)	(0.44)	(0.54)
Observations	1,128	532	3,986	5,646

C. 10-year term premia	Large negative proposal days (1)	FOMC meeting days (2)	Other days (3)	All days (4)
Mean bps	0.24	-0.35	-0.06	-0.03
t-statistic	[1.59]	[-1.22]	[-0.70]	[-0.38]
p-value	(0.85)	(0.20)	(0.40)	(0.50)
Cumulative change in %	2.69	-1.87	-2.40	-1.57
p-value	(0.99)	(0.01)	(0.13)	(0.31)
Observations	1,128	532	3,986	5,646

Notes: Panel A presents the average daily and cumulative changes in the 10-year nominal yield, categorized across four distinct sets of days. Column 1 reports changes on days with large negative proposals that do not coincide with FOMC meeting days, while column 2 reports changes on FOMC meeting days. Column 3 reports changes on other trading days and column 4 reports changes on all trading days. Panels B, and C use the same-day classifications, but compute changes in the 10-year expected average short rate and the 10-year term premia, respectively. t-statistics are presented within square brackets. We report the percentage of simulated changes that fall below the actual realizations in parentheses.

Table B.7. **Changes in nominal yields for different maturities on large negative proposal days**

A. Nominal yields

	Maturity			
	1 year	3 years	5 years	10 years
Mean bps	0.15	0.32	0.38	0.38
t-statistic	[1.09]	[1.76]	[2.09]	[2.16]
p-value	(0.78)	(0.88)	(0.92)	(0.93)
Cumulative change in %	1.66	3.57	4.30	4.33
p-value	(0.98)	(0.99)	(0.99)	(0.99)
Observations	1,128	1,128	1,128	1,128

B. 10-year expected average short rate

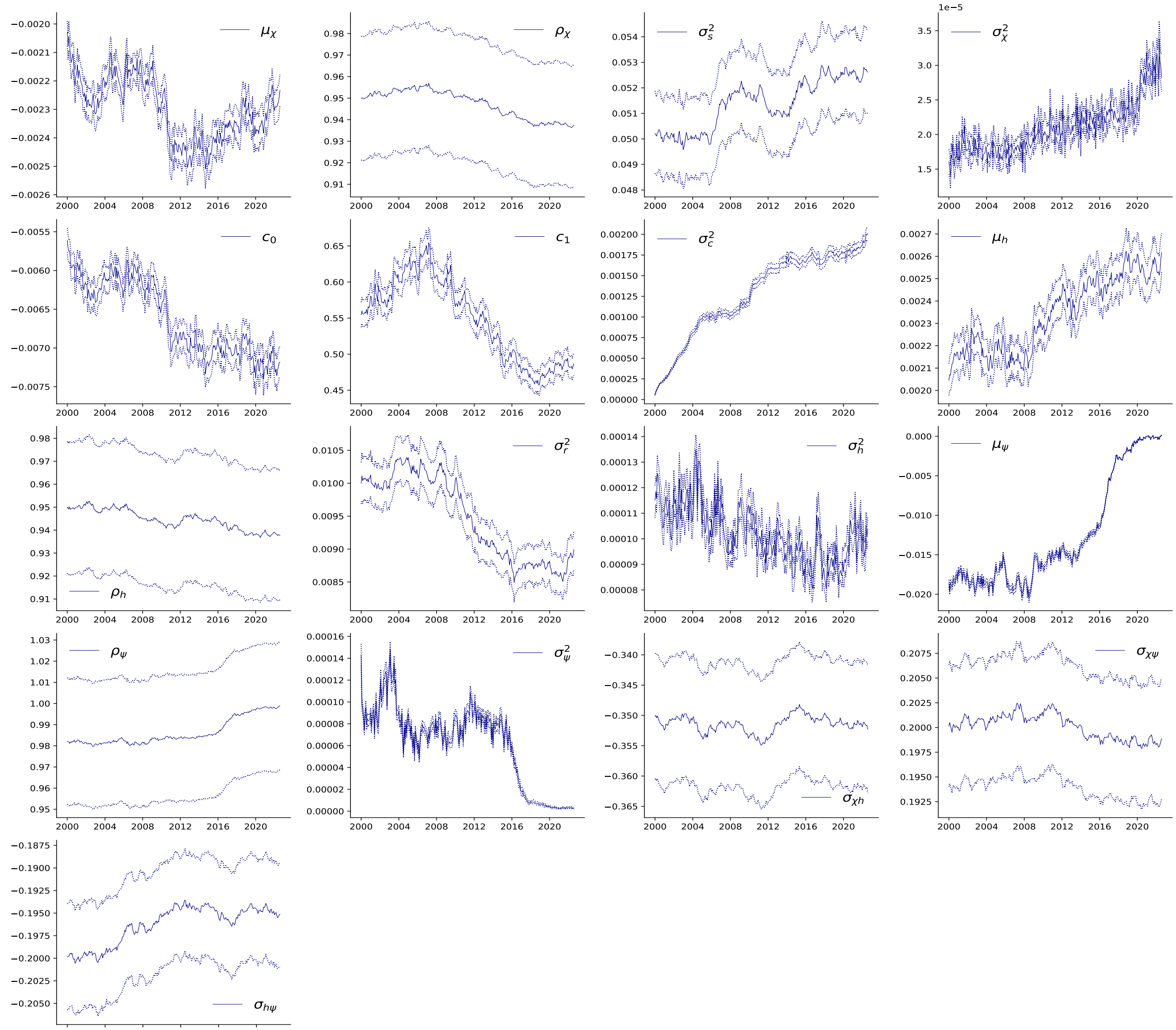
	Maturity			
	1 year	3 years	5 years	10 years
Mean bps	0.11	0.16	0.17	0.15
t-statistic	[0.88]	[1.12]	[1.20]	[1.29]
p-value	(0.71)	(0.75)	(0.77)	–
Cumulative change in %	1.24	1.81	1.88	1.64
p-value	(0.94)	(0.97)	(0.98)	–
Observations	1,128	1,128	1,128	1,128

C. Nominal term premia

	Maturity			
	1 year	3 years	5 years	10 years
Mean bps	0.04	0.16	0.22	0.24
t-statistic	[0.58]	[1.64]	[1.86]	[1.59]
p-value	(0.63)	(0.84)	(0.89)	–
Cumulative change in %	0.42	1.76	2.43	2.69
p-value	(0.81)	(1.00)	(1.00)	–
Observations	1,128	1,128	1,128	1,128

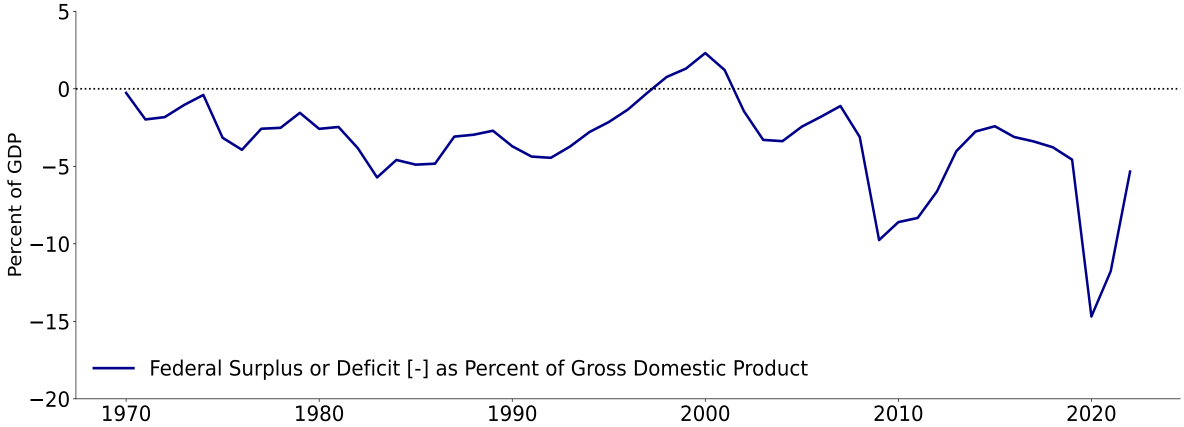
Notes: Panel A table presents the average daily and cumulative changes in nominal yields with different maturities on days with large negative proposals that do not coincide with FOMC meeting days. Each column shows results using four different maturities: 1, 3, 5, and 10 years. Panels B and C present the same results for the expected average short rate and the nominal term premia, respectively. t-statistics are presented within square brackets. We report the percentage of simulated changes that fall below the actual realizations in parentheses.

Fig. B.8. **Evolution of the parameter estimates**



Notes: Each panel plots the evolution of beliefs about the model parameters. The blue solid lines are the posterior median estimates, and the dotted blue lines are the 5th and 95th percentiles of the posterior distribution.

Fig. B.9. **Federal Surplus or Deficit [-] as Percent of Gross Domestic Product**



Notes: The dark blue line depicts the federal surplus or deficit [-] as percent of gross domestic product.

B.2 Decomposition of the effects by maturity

In this section, we show that the effect of the cashflow contributions on the value of the government bond portfolio is primarily due to its impact on debt over 5 years, with only minimal effects observed for shorter maturities.

Given the values of f^t_{t+j} and q^t_{t+j} for each maturity at time $t+j$ described in Section 1.3 in the main text, we can compute the value-weighted average return on the nominal portion of debt as:

$$r_t = \sum_{j}^{n} r^j_{t-1,t}\omega^j_{t-1} \tag{B.1}$$

where $r^j_{t-1,t} = q^t_{t+j-1}/q^{t-1}_{t+j-1}$ and the weight, ω^j_{t-1}, depends on the market value of government debt outstanding for that specific maturity j on the previous day $t-1$ and it is given by:

$$\omega^j_{t-1} = \frac{q^{t-1}_{t+j-1} f^{t-1}_{t+j-1}}{\sum_{j=1}^{n} q^{t-1}_{t+j-1} f^{t-1}_{t+j-1}}. \tag{B.2}$$

An advantage of expressing the returns as in equation B.1 is that it allows for a decomposition of returns by maturity. Specifically, we decompose the bond return into four distinct maturity groups. These segments comprise treasuries maturing within a year, represented by $\sum_{j=0}^{1y} r^j_t\omega^j_{t-1}$, those with maturities spanning from 1 to 4 years, $\sum_{j=1y}^{4y} r^j_t\omega^j_{t-1}$, bonds and notes maturing between 4 and 10 years, $\sum_{j=4y}^{10y} r^j_t\omega^j_{t-1}$, and finally, bonds with maturities extending beyond 10 years, articulated by $\sum_{j=10y}^{30y} r^j_t\omega^j_{t-1}$. Cumulatively, these segments represent the aggregate return r_t.

Table B.8 presents the results. Each entry in the table is derived from a distinct OLS regression, as delineated in equation (13) in the main text. Column 2 shows the effect of $\texttt{cbo}^{(z)}_t$ on treasuries maturing within a year. The estimated effect is small and statistically insignificant (b= 0.03; t-statistic = 1.25). As we progress through Columns 3 to 5, the estimated effects monotonically increase with the increasing maturity of the treasuries: 1-4 years (b= 0.19; t-statistic = 1.65), 5-10 years (b= 0.62; t-statistic = 1.97), and those maturing after 10 years (b= 0.83; t-statistic = 2.022). The combined effect across these maturities is 1.67, shown in Column 1, with roughly 0.87% of this magnitude arising from treasuries maturing beyond 5 years.

Table B.9 presents the average daily and cumulative returns on the government debt portfolio on large negative proposal days. We find the effect of the cash flow projections on the government bond portfolio is primarily due to its impact on debt over 5 years, with only minimal effects observed for shorter maturities.

Table B.8. **Decomposition of the effects by maturity**

		Decomposition of the nominal returns, $r_{t,t+1}$, by maturity of obligation			
Coefficient	$r_{t,t+1}$ (1)	Below 1 y (2)	1 y to 4 y (3)	5 y to 10 y (4)	Above 10 y (5)
$\texttt{cbo}_t^{(z)}$	1.67	0.03	0.19	0.62	0.83
t-statistic	[2.17]	[1.25]	[1.65]	[1.97]	[2.00]
R^2 in %	4.94	9.00	5.14	4.39	4.31
Observations	2,989	2,989	2,989	2,989	2,989
Controls	Yes	Yes	Yes	Yes	Yes

Notes: This table presents regression results for the equation:

$$\sum_{j\in MaturityBracket} r_t^j \omega_{t-1}^j = b \cdot \texttt{cbo}_t^{(z)} + controls_t + c_t + \epsilon_t,$$

where $\sum_{j\in MaturityBracket} r_t^j \omega_{t-1}^j$ decomposes the daily nominal return on the government debt portfolio by maturity brackets. The column labeled with "Below 1 y" is $\sum_{j=0}^{1y} r_t^j \omega_{t-1}^j$; column labeled "1 y to 4 y" is $\sum_{j=1y}^{4y} r_t^j \omega_{t-1}^j$; column labeled "5 y to 10 y" is $\sum_{j=4y}^{10y} r_t^j \omega_{t-1}^j$; column labeled "Above 10 y" is $\sum_{j=10y}^{30y} r_t^j \omega_{t-1}^j$. $\texttt{cbo}_t^{(z)}$ denotes the aggregate surplus of each proposal, where we sum the cash flow contributions of cost releases reported on the same day. In all regressions, we use various controls. We use news announcements of the top 50 macroeconomic indicators as contemporaneous controls. We also control for lagged daily returns from $t-6$ to $t-1$, and the following lagged macro variables available at the daily frequency: CBOE Volatility Index, 10-Year Treasury Constant Maturity Minus 2-Year Treasury Constant Maturity, Federal Funds Effective Rate, 10-Year Breakeven Inflation Rate, Term premia on a 10 Year Zero Coupon Bond. The daily returns are in basis points, while $\texttt{cbo}_t$ is in percent (as a percentage of GDP). t-statistics are in squared brackets.

Table B.9. **Decomposition of the effects by maturity**

		Decomposition of the nominal returns, $r_{t,t+1}$, by maturity of obligation			
Coefficient	$r_{t,t+1}$ (1)	Below 1 y (2)	1 y to 4 y (3)	5 y to 10 y (4)	Above 10 y (5)
Mean bps	-1.84	-0.01	-0.25	-0.73	-0.83
t-statistic	[-2.20]	[-0.57]	[-1.53]	[-2.19]	[-2.16]
p-value	(0.02)	(0.18)	(0.06)	(0.02)	(0.03)
Cumulative return in %	-20.70	-0.15	-2.80	-8.16	-9.31
p-value	(0.00)	(0.11)	(0.01)	(0.00)	(0.00)
Observations	1,125	1,125	1,125	1,125	1,125

Notes: This table presents the average daily and cumulative returns on the government debt portfolio by maturity brackets. The column labeled with "Below 1 y" is $\sum_{j=0}^{1y} r_t^j \omega_{t-1}^j$; column labeled "1 y to 4 y" is $\sum_{j=1y}^{4y} r_t^j \omega_{t-1}^j$; column labeled "5 y to 10 y" is $\sum_{j=4y}^{10y} r_t^j \omega_{t-1}^j$; column labeled "Above 10 y" is $\sum_{j=10y}^{30y} r_t^j \omega_{t-1}^j$. t-statistics are in squared brackets. We report the percentage of simulated changes in Treasury values that fall below the actual realizations in parentheses.

Appendix C - Linearized Budget Identity

We describe the linearization of the budget identity introduced in the main text in Section 1.2. We start with the one-period government budget identity in terms of normalized variables:

$$\hat{B}_t + \hat{S}_t = \frac{1+\tilde{r}_{gt}}{\Pi_t \Delta Y_t} \hat{B}_{t-1}, \tag{C.1}$$

where $\hat{B}_t \equiv B_t/Y_t$ is debt to GDP, $\hat{S}_t \equiv S_t/Y_t$, $\Pi_t \equiv P_t/P_{t-1}$ is inflation, and $\Delta\hat{Y}_t \equiv \hat{Y}_t/\hat{Y}_{t-1}$ is real GDP growth. Taking logs of the equation above at $t+1$, we have:

$$\log\left(e^{b_{t+1}} + \hat{S}_{t+1}\right) = \tilde{r}_{gt+1} - \pi_{t+1} - \Delta y_{t+1} + b_t, \tag{C.2}$$

where $\pi_t \equiv \log(\Pi_t)$, $\Delta y_t \equiv \log(\Delta Y_t)$, and $b_t \equiv \log(\hat{B}_t)$. Define the growth and inflation-adjusted bond return as above $\hat{r}_{gt+1} \equiv \tilde{r}_{gt+1} - \pi_{t+1} - \Delta y_{t+1}$, and rewrite:

$$\log\left(e^{b_{t+1}} + \hat{S}_{t+1}\right) = \hat{r}_{gt+1} + b_t, \tag{C.3}$$

Take a first-order Taylor expansion of the term on the left around the steady state, linearizing log debt to GDP and the level of surplus to GDP:

$$\log\left(e^{b_{t+1}} + \hat{S}_{t+1}\right) = \log\left(e^{b} + \hat{S}\right) + \left(\frac{e^b}{e^b+\hat{S}}\right)(b_{t+1}-b) + \left(\frac{1}{e^b+\hat{S}}\right)(\hat{S}_{t+1}-\hat{S}) \tag{C.4}$$

Our process specified for $\hat{S}_t$ implies the steady state value $\hat{S} = \mu$. Collecting the constant terms:

$$\log\left(e^{b_{t+1}} + \hat{S}_{t+1}\right) = \alpha + \nu b_{t+1} + \gamma \hat{S}_{t+1} \tag{C.5}$$

where the coefficients depend on the parameters of the log steady state debt to GDP ratio (b) and the steady state level of the surplus to GDP ratio μ:

$$\alpha \equiv \log\left(e^b + \mu\right) - \left(\frac{e^b}{e^b+\mu}\right) b - \left(\frac{1}{e^b+\mu}\right)\mu \tag{C.6}$$

$$\nu \equiv \left(\frac{e^b}{e^b+\mu}\right) \tag{C.7}$$

$$\gamma \equiv \left(\frac{1}{e^b+\mu}\right) \tag{C.8}$$

Note that $\nu = e^{-\hat{r}_g}$. Using this approximation, we can then write the linearized budget equation as:

$$\alpha + \nu b_{t+1} + \gamma \hat{S}_{t+1} = \hat{r}_{gt+1} + b_t. \tag{C.9}$$

Assume that $\nu < 1$. We can iterate the linearized identity forward and impose the transversality condition to obtain:

$$b_t = \alpha \sum_{j=1}^{\infty} \nu^{j-1} + \sum_{j=1}^{\infty} \nu^{j-1} \gamma \hat{S}_{t+j} - \sum_{j=1}^{\infty} \nu^{j-1} \hat{r}_{gt+j}, \tag{C.10}$$

where the constant term can be simplified using the sum of a geometric series to express the equation above as:

$$b_t = \alpha^{\star} + \sum_{j=1}^{\infty} \nu^{j-1} \gamma \hat{S}_{t+j} - \sum_{j=1}^{\infty} \nu^{j-1} \hat{r}_{gt+j}, \tag{C.11}$$

where $\alpha^{\star} \equiv \alpha/(1-\nu)$.

Appendix D - Expected nominal return decomposition

We provide the derivations for the approximate expected nominal return decomposition introduced in Section 2.3. We assume that the representative bond investor has preferences defined over the real balances of government bonds:

$$U_t = E_t \sum_{t=0}^{\infty} \beta^t u(C_t^\star) \tag{D.1}$$

$$C_t^\star = C_t + \theta_t \frac{B_t}{P_t} \tag{D.2}$$

where β is the time discount factor, c_t is real consumption, B_t is the total nominal market value of the government bonds, P_t is the price level, and θ_t is a parameter capturing the preference for government bonds that can depend on budget news.

The representative investor holds the entire government bond portfolio, modeled as perpetual nominal debt with a geometrically decaying coupon rate ϕ. The nominal coupons at time $t+j$ would be $(1-\phi)^{j-1}\upsilon F_t$, where υ is the current coupon at time t. We can choose ϕ to match the average maturity of the government bond portfolio. Define $B_t = Q_t F_t$, where Q_t is the nominal bond price, and F_t is the face value of debt. The budget equation of the household is given by $P_t C_t + Q_t F_t = D_t + (\upsilon + (1-\phi)Q_t)F_{t-1}(1-\delta_t)$, where δ_t is the default rate on outstanding debt, and D_t is the income earned by the household. We can write the budget constraint of the household in terms of the market value of debt and the bond portfolio return:

$$P_t C_t + B_t = D_t + (1 + r_{gt}) B_{t-1}(1-\delta_t), \tag{D.3}$$

where $(1 + r_{gt}) \equiv (\upsilon + (1-\phi)Q_t)/Q_{t-1}$ is the holding period return. The investor maximizes lifetime utility by choosing a sequence of consumption and bond holdings. We assume complete markets so that the household can trade a full set of Arrow securities, implying that the intertemporal marginal rate of substitution is equal to the state prices.

The Lagrangian is given by:

$$\mathcal{L}_t = E_t \left[\sum_{t=0}^{\infty} \beta^t \Big(u(C_t^\star) + \lambda_t (D_t + (1 + r_{gt}) B_{t-1}(1-\delta_t) - P_t C_t - B_t) \Big) \right]. \tag{D.4}$$

The corresponding first-order conditions are with respect to C_t and B_t:

$$u'(C_t^\star) - \lambda_t P_t = 0 \tag{D.5}$$

$$\frac{u'(C_t^\star)}{P_t}\theta_t - \lambda_t + E_t \Big[\beta \lambda_{t+1} (1 + r_{gt+1})(1 - \delta_{t+1}) \Big] = 0 \tag{D.6}$$

Combining these equations gives us the following Euler equation:

$$1 - \theta_t = E_t \Big[M_{t+1}^{\$} (1 + r_{gt+1})(1 - \delta_{t+1}) \Big] \tag{D.7}$$

where $M_{t+1}^{\$} \equiv M_{t+1}/\Pi_{t+1}$ is the one-period nominal stochastic discount factor and $M_{t+1} \equiv \beta u'(C_{t+1})/u'(C_t)$ is the real stochastic discount factor and $\Pi_{t+1} \equiv P_{t+1}/P_t$ is gross inflation. The Euler equation can also be expressed equivalently in terms of the bond price:

$$Q_t = \frac{E_t\left[M_{t+1}^{\$}(\upsilon + (1-\phi)Q_{t+1})(1-\delta_{t+1})\right]}{1-\theta_t} \tag{D.8}$$

Using the assumption $1-\theta_t^{(2)} \approx e^{\theta_t^{(2)}}$ and letting $\mathbb{1}_{\{\chi_{t+1}=1\}}$ denote the default indicator function, we can write

$$\begin{aligned} Q_t &= \left(E_t\left[M_{t+1}^{\$}(\upsilon + (1-\phi)Q_{t+1})(1-\mathbb{1}_{\{\chi_{t+1}=1\}})\right]\right)e^{\theta_t} && \text{(D.9)} \\ &+ \left(E_t\left[M_{t+1}^{\$}(\upsilon + (1-\phi)Q_{t+1})(1-\delta_{t+1})\mathbb{1}_{\{\chi_{t+1}=1\}}\right]\right)e^{\theta_t} && \text{(D.10)} \end{aligned}$$

where χ_t is equal 1 if there is default and 0 if there is no default. Assume that the realized default event is uncorrelated with the stochastic discount factor, let $\gamma_t \equiv E_t[\mathbb{1}_{\chi_{t+1}=1}]$ denote the conditional probability of default next period, and assume that the loss rate is predetermined so that we can write:

$$\begin{aligned} Q_t &= \left\{(1-\gamma_t)E_t\left[M_{t+1}^{\$}(\upsilon + (1-\phi)Q_{t+1})\right] + \gamma_t E_t\left[M_{t+1}^{\$}(\upsilon + (1-\phi)Q_{t+1})\right](1-\delta_{t+1})\right\}e^{\theta_t} \\ &\approx e^{-\gamma_t\delta_{t+1}+\theta_t}E_t\left[M_{t+1}^{\$}(\upsilon + (1-\phi)Q_{t+1})\right]. && \text{(D.11)} \end{aligned}$$

Note that Q_{t+1} depends on γ_{t+1} and δ_{t+2}.

Rearrange the equation above:

$$1 = E_t\left[M_{t+1}^{\$}(1+r_{gt+1})\right]e^{-\gamma_t\delta_{t+1}+\theta_t}, \tag{D.12}$$

or,

$$1 = E_t\left[e^{m_{t+1}^{\$}+r_{gt+1}}\right]e^{-\gamma_t\delta_{t+1}+\theta_t}. \tag{D.13}$$

Assuming the $m_{t+1}^{\$}$ and r_{gt+1} are jointly lognormal, we can express the Euler equation as:

$$1 = e^{E_t\left[m_{t+1}^{\$}\right]+E_t[r_{gt+1}]+1/2\mathrm{Var}_t(m_{t+1}^{\$}+r_{gt+1})-\gamma_t\delta_{t+1}+\theta_t}. \tag{D.14}$$

Take logs of both sides of the equation above and expand the conditional variance of the sum to get:

$$0 = E_t\left[m^{\$}_{t+1}\right] + E_t\left[r_{gt+1}\right] + \frac{1}{2}\mathrm{Var}_t(m^{\$}_{t+1}) + \frac{1}{2}\mathrm{Var}_t(r_{gt+1}) \\ +\mathrm{Cov}_t(m^{\$}_{t+1}, r_{gt+1}) - \gamma_t\delta_{t+1} + \theta_t \tag{D.15}$$

Substitute in the log nominal short rate, $i_t \equiv -E_t[m^{\$}_{t+1}] - 1/2\mathrm{Var}_t[m^{\$}_{t+1}]$:

$$0 = -i_t + E_t\left[r_{gt+1}\right] + \frac{1}{2}\mathrm{Var}_t(r_{gt+1}) + \mathrm{Cov}_t(m^{\$}_{t+1}, r_{gt+1}) - \gamma_t\delta_{t+1} + \theta_t. \tag{D.16}$$

Rearranging, and substituting, we get:

$$E_t[r_{gt+1}] = \underbrace{i_t}_{\substack{\text{nominal}\\ \text{short rate}}} - \underbrace{\theta_t}_{\substack{\text{convenience}\\ \text{yield}}} + \underbrace{\gamma_t\delta_{t+1}}_{\substack{\text{expected}\\ \text{default loss}}} \underbrace{- \frac{1}{2}\mathrm{Var}_t(r_{gt+1}) - \mathrm{Cov}_t(m^{\$}_{t+1}, r_{gt+1})}_{\text{bond risk premium}} \tag{D.17}$$

The risk premium term also embeds credit risk premia (covariance risk with future default events).

Appendix E - Learning about Future Surpluses

Section E.1 describes the state-space representation for the learning model. Section E.2 presents the assumed distribution of initial beliefs and describes the algorithm used for posterior inference.

E.1 State-space representation of the learning model

Below we describe the state-space representation for the learning model. To do so, we first need to express the vector of observables, $\mathcal{Y}^o_t$, as a function of the latent states. The link between these observables and states can be expressed as follows:

$$\mathcal{Y}^o_t \quad = \quad A_t \left(D + Z z_t + u_t, \right) \quad u_t \sim N(0, \Sigma_u), \tag{E.1}$$

where D and Z is a function of the parameter vector Θ. The matrix A_t acts as a selection matrix, accounting for deterministic changes in data availability. The state vector z_t comprises the latent states, their lags, and the orthogonal shocks.

The state vector follows a vector autoregressive process of the form:

$$z_t \quad = \quad \Phi_0 + \Phi z_{t-1} + \omega_t, \quad \omega_t \sim N(0, \Sigma_\omega), \tag{E.2}$$

where Φ_0, Φ, and Σ_ω is a function of the parameter vector Θ.

Section E.1.1 below provides the details for the measurement equation, while Section E.1.2 provides the details for the state-transition equation.

E.1.1 Measurement equation

The vector of observables is given by:

$$y^o_t = [\hat{S}^o_t,\ \overline{\mathcal{V}}^o_t,\ b^o_t,\ \hat{r}^o_{gt}],$$

where $\hat{S}^o_{t+j}$ denotes the realized surplus to GDP ratio, $\overline{\mathcal{V}}^o_t$ denotes the CBO bill-level cost estimates released during month t providing annual cost projections for the next year and the following decade, $\hat{r}_{gt}$ is the return on the government bond portfolio adjusted for both growth and inflation, and b^o_t is the realized debt-to-GDP ratio.

Next, we describe the link between the observables and the latent states.

- *Realized surplus.* We assume agents employ the following model to learn about surplus to GDP:

  $$\hat{S}^o_{t+1} \quad = \quad \chi_t + \sigma_s \epsilon_{s,t+1}, \qquad \epsilon_{s,t+1} \sim N(0,1), \tag{E.3}$$

  where $\hat{S}^o_{t+1}$ represents the observed monthly surplus normalized by the GDP of the preceding year. The conditional mean for $\hat{S}^o_{t+1}$ is given by χ_t, which is not observed by the agents. We define the law of motion for χ_t in Section E.1.2.

- *Bill-level cost estimates.* The CBO cost estimate for an arbitrary proposal z in month t gives annual nominal cash flow estimates starting in the next fiscal year up to the fiscal year T. We normalize these cash flows by CBO's nominal GDP projection with the closest month of the same year. We then sum all these normalized cash flows within each proposal and across proposals of month t to get a monthly observable CBO cost intensity measure that we denote as $\overline{\mathcal{V}}^o_t$.

We assume that the monthly cost intensity measure $\overline{\mathcal{V}}^o_t$ is a noisy signal about the persistent component in surplus policy χ_t, modeled as

$$\overline{\mathcal{V}}^o_t = c_0 + c_1\chi_t + \epsilon_{c,t} \tag{E.4}$$

where the coefficients c_0 and c_1 are unobservable to investors and $\epsilon_{c,t} \sim N(0, \sigma_c^2)$ is independent to all other shocks.

- *Realized return on the government bond portfolio.* From equation (21) in the main text it directly follows that:

$$\hat{r}^o_{gt+1} \quad = \quad h_t + \epsilon_{r,t+1}. \tag{E.5}$$

- *Contemporaneous debt-to-GDP ratio.* From equation (23) in the main text we have:

$$\hat{b}^o_t = \alpha^\star + \mathbb{E}_t \sum_{j=1}^{T} \nu^{j-1}\gamma \hat{S}^o_{t+j} - \mathbb{E}_t \sum_{j=1}^{T} \nu^{j-1}\hat{r}^o_{gt+j} + \mathbb{E}_t \nu^T \hat{b}_{t+T}$$

Using equations (20) and (19) in the main text we can express

$$\mathbb{E}_t \sum_{j=1}^{T} \nu^{j-1}\gamma \hat{S}^o_{t+j} = b_{0,\chi} + b_\chi \chi_t$$

where $b_{0,\chi} = \gamma\left(\frac{1-\nu^T}{1-\nu} - \frac{1-(\nu\rho_\chi)^T}{1-\nu\rho_\chi}\right)\mu_\chi$ and $b_\chi = \gamma\frac{1-(\nu\rho_\chi)^T}{1-\nu\rho_\chi}$.

Using equations (22) and (21) in the main text we can express

$$-\mathbb{E}_t \sum_{j=1}^{T} \nu^{j-1}\hat{r}^o_{gt+j} = b_{0,h} + b_h h_t$$

where $b_{0,h} = -\left(\frac{1-\nu^T}{1-\nu} - \frac{1-(\nu\rho_h)^T}{1-\nu\rho_h}\right)\mu_h$ and $b_h = -\frac{1-(\nu\rho_h)^T}{1-\nu\rho_h}$.

We also assume that $\mathbb{E}_t \nu^T \hat{b}_{t+T} = \psi_t$ is a latent state that follows an AR(1) process given by:

$$\psi_{t+1} = \mu_\psi + \rho_\psi(\psi_t - \mu_\psi) + \epsilon_{\psi t+1}. \tag{E.6}$$

Hence, the expression for b_t^o is given by

$$b_t^o = b_0 + b_\chi \chi_t + b_h h_t + \psi_t. \tag{E.7}$$

with $b_0 = \alpha^\star + b_{0,\chi} + b_{0,h}$.

Finally, we can write equations (E.3), (E.4), (E.5) , and (E.7) as follows

$$y_t^o \quad = \quad A_t\left(D + Zz_t + \Sigma_u u_t,\right) \quad u_t \sim N(0, I), \tag{E.8}$$

- Prior to January 1997:

$$y_t^o = \begin{bmatrix} \hat{S}_{t+1}^o \\ \hat{r}_{gt+1}^o \\ b_t^o \end{bmatrix}, \quad A_{t+1} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}. \tag{E.9}$$

- From January 1997 to Decemeber 2022:

$$y_t^o = \begin{bmatrix} \hat{S}_t^o \\ \overline{\mathcal{V}}_t^o \\ \hat{r}_{gt}^o \\ b_t^o \end{bmatrix}, \quad A_{t+1} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}. \tag{E.10}$$

If we define the vector of states as

$$z_t = \begin{bmatrix} \chi_{t+1} & \chi_t & \epsilon_{s,t+1} & \tilde{\epsilon}_{c,t+1} & h_{t+1} & h_t & \epsilon_{r,t+1} & \psi_{t+1} & \psi_t \end{bmatrix}'_{9\times 1} \tag{E.11}$$

Then, the coefficient matrices D, Z, and Σ_u are given by:

$$D = \begin{bmatrix} 0 \\ c_0 \\ 0 \\ b_0 \end{bmatrix}_{4\times 1}, \qquad \Sigma^u = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}_{4\times 4}.$$

$$Z = \begin{bmatrix} 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ c_\chi & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ b_\chi & 0 & 0 & 0 & b_h & 0 & 0 & 1 & 0 \end{bmatrix}_{4\times 9}.$$

E.1.2 State-transition equation

Given the state vector z_t in equation (E.11) and the law of motion for the state variables, we write the state-transition equation as

$$z_t \quad = \quad \Phi_0 + \Phi z_{t-1} + \omega_t, \quad \omega_t \sim N(0, \Sigma^\omega). \tag{E.12}$$

and the matrices Φ are given by Σ^{ω} :

$$\Phi_0 = \begin{bmatrix} \mu_\chi(1-\rho_\chi) \\ 0 \\ 0 \\ 0 \\ \mu_h(1-\rho_h) \\ 0 \\ 0 \\ \mu_\psi(1-\rho_\psi) \\ 0 \end{bmatrix}_{4\times 1}, \Phi = \begin{bmatrix} \rho_\chi & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \rho_h & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \rho_\psi & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}_{9\times 9}, \Sigma_\omega = \begin{bmatrix} \sigma_\chi^2 & 0 & 0 & 0 & \sigma_{\chi,h} & 0 & 0 & \sigma_{\chi,\psi} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \sigma_s^2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma_c^2 & 0 & 0 & 0 & 0 & 0 \\ \sigma_{\chi,h} & 0 & 0 & 0 & \sigma_h^2 & 0 & 0 & \sigma_{h,\psi} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \sigma_r^2 & 0 & 0 \\ \sigma_{\chi,\psi} & 0 & 0 & 0 & \sigma_{h,\psi} & 0 & 0 & \sigma_\psi^2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}_{9\times 9}.$$

E.2 Prior Distribution and posterior inference

Define the parameter vector, Θ, as:

$$\Theta = \left[\mu_\chi, \rho_\chi, \sigma_s^2, \sigma_\chi^2, c_0, c_1, \sigma_c^2, \mu_h, \rho_h, \sigma_r^2, \sigma_h^2, \mu_\psi, \rho_\psi, \sigma_\psi^2, \sigma_{\chi h}, \sigma_{\chi\psi}, \sigma_{h\psi}\right]'.$$

Let $p(\Theta)$ denote the joint prior distribution on the parameter vector Θ, and let $p(y|\Theta)$ denote the likelihood function of the data given the parameter vectors. Our goal is to sample from the posterior distribution of the parameters given the data y^o, where Bayes' theorem provides the link:

$$p(\Theta|y^o) = \frac{p(y^o|\Theta)p(\Theta)}{p(y^o)}.$$

E.2.1 Prior Distribution

We assume the following distribution for the priors:

$$\begin{aligned} \Theta_i &\sim \mathcal{N}(\mu_{\Theta_i}, \sigma^2_{\Theta_i}) && \text{for} && \Theta_i \in \{\mu_\chi, \mu_h, \mu_\psi, \sigma_{\chi h}, \sigma_{\chi\psi}, \sigma_{h\psi}, c_0, c_1\}, \\ \Theta_i &\sim \mathcal{N}^{\mathcal{T}}(\mu_{\Theta_i}, \sigma^2_{\Theta_i}) && \text{for} && \Theta_i \in \{\rho_\chi, \rho_h, \rho_\psi\}, \\ \Theta_i &\sim \mathcal{IG}(\alpha_{\Theta_i}, \beta_{\Theta_i}) && \text{for} && \Theta_i \in \{\sigma_\chi^2, \sigma_s^2, \tilde{\sigma}_c^2, \sigma_r^2, \sigma_h^2, \sigma_\psi^2\}, \end{aligned}$$

where $\mathcal{N}$ denotes the normal distribution, $\mathcal{N}^{\mathcal{T}}$ is the truncated (outside of the interval $(-1, 1)$) normal distribution, and $\mathcal{IG}$ is the inverse gamma distribution. We start the initial beliefs at the maximum likelihood estimates using data from 1980 to December 1997.

E.2.2 Posterior inference

We now describe the Metropolis–Hastings algorithm that we use for Bayesian inference. We start with an initial guess of the parameters $\Theta^{(0)}$, and states $\psi_{1:T}^{(0)}$, $\chi_{1:T}^{(0)}$, and $h_{1:T}^{(0)}$, where the subscript $\{1:T\}$ denotes the sequence of latent states from time 1 to time T.

Given a draw $\Theta^{(k)}$, $\psi_{1:T}^{(k)}$, $\chi_{1:T}^{(k)}$, and $h_{1:T}^{(k)}$, we generate the next draw $k+1$ as follows:

1. Draw $\Theta^{(k+1)} \mid \psi_{1:T}^{(k)}, \chi_{1:T}^{(k)}, h_{1:T}^{(k)}, y_{1:T}^{o}$. Since there is no close-form expression for the posterior of $\Theta^{(k+1)}$, we use a standard random-walk Metropolis–Hastings algorithm, where we target a 30% acceptance rate over the burn-in period.

2. Given $\Theta^{(k+1)}, y^o_{1:T}$ obtain $\psi^{(k)}_{1:T}, \chi^{(k)}_{1:T}, h^{(k)}_{1:T}$ via the Kalman filter using the state-space representation described in Section E.1.

We iterate over these steps to generate 25,000 draws from the posterior distribution of the parameters and states for each time period T.