The Expected Fiscal Reaction to Monetary Policy

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September 2026

We develop a novel high-frequency measure of the expected fiscal reaction to monetary policy and show that it implies diminished monetary policy effectiveness. Using changes around FOMC announcements in the breakeven tax rate implied by taxable Treasuries and tax-exempt municipal bond ETFs, we find that monetary tightening raises expected future taxes. This reaction has roughly halved since COVID and no longer varies with government indebtedness. We calibrate a HANK model to interpret these findings. Because households are non-Ricardian, both the timing of fiscal adjustment and the stock of debt shape the response of inflation to monetary policy. The weaker post-COVID fiscal reaction makes monetary tightening about half as disinflationary as it was pre-COVID, and projected higher debt levels will further erode tightening's impact.

Keywords: Monetary-Fiscal Interactions, Tax Expectations, Municipal Bonds, High-Frequency Identification, HANK

JEL Classification: E21, E31, E43, E52, E62, E63

*The authors declare that they have no relevant or material financial interests that relate to the research described in this paper. The views expressed in this paper are those of the authors and not necessarily those of the Federal Reserve Board or the Federal Reserve System.

1 Introduction

Whether higher interest rates are effective at lowering inflation depends on the fiscal reaction to monetary policy. Higher rates slow demand by making borrowing more expensive, but higher rates also increase interest payments to bondholders [leading to a possible income effect]. How the accompanying larger deficit and higher debt is expected to be repaid helps determine the magnitude of the inflation response (Cochrane, 2001; Sims, 2011). The importance of this expectation has grown as debt has grown (BIS, 2026). As Cochrane's (2025) observes "[all conventional models] are 'monetary-fiscal' theories of disinflation". Some models distinguish two regimes according to whether fiscal or monetary policy adjusts to provide repayment (Leeper, 1991), while recent work (Angeletos et al., 2024), (Rachel and Ravn, 2025) emphasizes a continuum of possible monetary and fiscal responses. Yet in these models, the fiscal reaction is assumed rather than based on evidence.

This paper empirically grounds the expected fiscal reaction and analyzes its wider implications. We develop a novel measure of the expected fiscal reaction to monetary policy and combine it with a heterogeneous-agent New Keynesian (HANK) model disciplined by microeconomic evidence on marginal propensities to consume. Together they locate the U.S. economy on the monetary-fiscal continuum, show how far it has moved in recent years, and quantify what the move implies for the inflation response to monetary tightening both now and in projections of the future. Using a HANK model is crucial to revealing the impact of fiscal expectations, and the insufficiency of the Taylor Rule to guarantee monetary tightening is disinflationary.

Empirically, we recover changes in expected future taxes from movements in the spread between federally taxable Treasuries and tax-exempt municipal bond ETFs around FOMC announcements. We find that contractionary monetary shocks raise expected taxes—direct evidence of monetary-fiscal interactions—and that this reaction has roughly halved since COVID and no longer varies with government indebtedness. Our HANK model implies that the post-COVID decline in expected fiscal backing makes monetary tightening substantially less disinflationary—by about a quarter on impact

and 80 percent over the first two years. The weaker effect of tightening is amplified by larger debt levels: about 10 percent from the already weakened level if debt-to-GDP is 20 percentage points higher, as Congressional Budget Office (2026) projects for 2036.

Our empirical measure comes from a no-arbitrage condition. The spread between federally taxable Treasuries and tax-exempt municipal bonds defines a breakeven expected tax rate (BETR): the marginal tax rate that equates the after-tax returns of the two instruments (Poterba, 1989). At low frequency, the average BETR is an accurate forecast of the future marginal tax rate faced by top earners, who hold most municipal bonds (Kueng, 2014). We interpret the BETR as a proxy for expectations of fiscal consolidation broadly, not solely of the top tax rate. If expectations are that the government will stabilize debt, the expected tax rate on top earners will increase. As entitlement spending rises, discretionary spending shrinks, and income concentrates at the top of the income distribution (the top 1 percent of earners currently pay roughly 40 percent of federal income taxes), raising taxes on top earners is a likely, and growing, margin of any fiscal adjustment (Congressional Budget Office, 2026; Bricker et al., 2020). To further support our interpretation of the BETR, we show that the BETR rose after Democrats won control of the Senate in 2021, and with it the ability to enact their desired spending and tax plans.

Reading the BETR from market data is not straightforward. The level of the spread between the after-tax return on Treasury and municipal bonds is confounded by credit and liquidity premia. We address these concerns in three ways. First, we leverage liquid, exchange-traded municipal bond ETFs, which reprice rapidly, rather than the underlying municipal bonds, which trade infrequently. Using ETFs with different durations also allows us to calculate a BETR curve at different horizons. Second, we study high-frequency changes in the BETR around FOMC announcements rather than its level, differencing out slow-moving premia to isolate the expected tax component. Third, we use high-frequency controls for time-varying liquidity and credit risk. This general method of high-frequency identification can be used to measure fiscal reactions to other shocks as well.

A contractionary monetary shock that raises the 10-year Treasury yield by one basis point raises expected taxes by about 0.4 basis point at the 2-to-8-year horizon before COVID. A structural-break test (Bai and Perron, 2003) splits the sample at the pandemic, and the post-COVID response falls to roughly 0.2 basis point. When we decompose the nominal monetary shock into real and expected inflation components, we find that the real component drives the result, consistent with an interest-on-debt channel. We then interact the shock with measures of indebtedness: before COVID, higher government indebtedness produced larger tax revisions, exactly as debt-stabilization motives predict. After COVID, this relationship vanishes, even though debt is higher. The results are robust to using a state-specific municipal bond ETF and controlling with a taxable municipal bond ETF. They are also similar with the one-year monetary policy surprise of Bauer and Swanson (2023) in place of the 10-year shock.

We take our empirical findings to a model to estimate what effect changing fiscal responses have on the effectiveness of monetary policy. The model is a parsimonious HANK economy—a three-equation New Keynesian model augmented with a fiscal block—in which the government's budget constraint links monetary policy to expected taxes. Two parameters describe the policy regime: how aggressively monetary policy responds to inflation and how quickly fiscal policy raises taxes to stabilize debt. We characterize which combinations of the two yield a unique bounded equilibrium, and show that the inflation response to a monetary tightening varies smoothly between so-called "monetary dominance" and "fiscal dominance" regimes. Because households are non-Ricardian, the speed of the fiscal reaction, not just the eventual level of taxes, matters for inflation: a slower fiscal reaction defers tax increases onto more distant income, which high-MPC households largely ignore, so it does less to cool demand today. We map our pre- and post-COVID estimates of the fiscal reaction into a single fiscal-response parameter, holding the rest of the calibration fixed, so that the two regimes differ only in how promptly fiscal policy backs monetary tightening.

Both of our estimated regimes lie in the conventional region where tightening lowers inflation, but the post-COVID decline in the fiscal response

makes monetary tightening substantially less disinflationary: the inflation response is about a quarter smaller on impact, roughly 80 percent smaller over the first two years, and turns mildly positive by five years. The two regimes raise a similar cumulative tax but differ in its timing; because households have high marginal propensities to consume, the deferred post-COVID hikes fall on distant income they smooth through, so the attenuation builds with the horizon. The post-COVID regime sits close to the region of the parameter space where tightening raises inflation. These conclusions are robust to allowing for long-term debt and an empirically realistic earnings heterogeneity channel of monetary policy, but rely crucially on the profile of intertemporal MPCs.

Using a canonical RANK or TANK model instead of a HANK model would understate the importance of the fiscal reaction by an order of magnitude. With a representative agent (RANK), Ricardian equivalence holds exactly and the speed of the fiscal reaction has no effect on inflation at all; it decides only whether a bounded equilibrium exists. A spender-saver economy (TANK) is non-Ricardian, but can only match the average MPC on impact, without matching its profile over time (Auclert et al., 2024). As a result, the fiscal reaction moves inflation 9 times less than in our HANK model at our calibrated monetary stance, and up to 38 times less near the frontier of the determinate region. TANK also implies that monetary tightening can never be inflationary while the central bank obeys the Taylor principle. In contrast, our HANK model provides no such reassurance to central banks.

Literature review. Our measurement of the BETR fits with a longer history of calculating the BETR from the spread between Treasuries and municipal bonds surveyed by Spreen and Gerrish (2022). A complementary literature such as Schwert (2017), Longstaff (2011), Fleckenstein and Longstaff (2025), and Ang et al. (2010) has demonstrated that this spread is confounded by credit risk and liquidity premia. This paper incorporates those findings by focusing on changes in the BETR rather than levels, using high-frequency changes in municipal bond ETFs, and controlling for time-

varying liquidity and credit risk proxies in order to isolate the changes in the tax component of the spread.

Constructing a monthly term structure of municipal yields, Kueng (2014) demonstrates that the BETR is an accurate and unbiased predictor of future marginal tax rates faced by high-income earners—who are the primary holders of the asset. Crucially, he finds that household consumption responds significantly to changes in the BETR, validating it as a measure of "fiscal news." This paper looks solely at changes in the BETR, and relies on this as a measure of (the change in) fiscal news.

This approach to fiscal news aligns with the "fiscal foresight" literature. Leeper et al. (2013) and Leeper et al. (2012) utilize a lower-frequency 5-year BETR to identify tax news shocks within a DSGE framework. They argue that because tax changes are rarely confined to a single bracket, the BETR serves as a sufficient statistic for the broader path of fiscal policy, an argument we also adopt. Mertens and Ravn (2013) use narrative shocks to identify tax changes, finding results consistent with the market-based signals in the municipal spread. This paper's analysis extends this by employing high-frequency identification around monetary policy windows, capturing the high-frequency revision in expectations across the entire term structure.

Empirically, the literature has struggled to measure fiscal responses in real-time. Sims (2011) estimates a model in which uncertainty about future fiscal policy made the tightenings of the 1970s perverse, but infers fiscal expectations from the model rather than observing them. Similarly, Caramp and Feilich (2024) shows that higher debt may interfere with monetary policy effectiveness, a finding we investigate empirically pre- and post-Covid. Auerbach and Yagan (2025) show that at a yearly frequency, pre-2004, forecasts of increased deficits led to later deficit reduction, but this relationship disappeared post-2004. Bianchi and Melosi (2019) and Bianchi et al. (2023) document the inflationary power of unbacked fiscal spending, but the reverse channel—how fiscal agents respond to monetary tightening—remains generally unidentified. Bouscasse and Hong (2026) attempt to measure this channel using Tealbook forecasts to construct a Romer and Romer (2004) style shock series. This paper complements these approaches with a direct,

high-frequency market-based measure.

On the theory side, a long literature establishes that the inflation consequences of monetary policy depend on the fiscal response. Leeper (1991) classifies policy into active and passive regimes, and Cochrane (2001) shows that the maturity structure of the debt determines whether a fiscal shock produces inflation now or later. Cochrane (2024) argues that higher rates raise inflation in the long run unless a fiscal contraction accompanies them. Caramp and Silva (2023) show that the fiscal response shapes transmission in any monetary-fiscal regime, through a wealth effect that depends on the present value of taxes, and that transmission is weaker when government debt is high. Because Ricardian equivalence holds in these models, only that present value matters. We measure the whole path of the expected response—its speed, not only its eventual size—and find that the dependence on debt that Caramp and Silva document held before COVID and has since disappeared.

Our model belongs to a literature that studies these interactions with non-Ricardian households. Kaplan et al. (2023) characterize price-level determination under incomplete markets, and Angeletos et al. (2024) show that HANK reproduces the core predictions of the fiscal theory through wealth effects on demand, without requiring monetary policy to be passive; Kaplan (2025) surveys what this class of models implies for policy. The closest paper to ours is Rachel and Ravn (2025), characterize determinacy across a continuum of policy regimes in an overlapping-generations setting. That the speed of adjustment matters, and not only its eventual size, follows from the intertemporal Keynesian cross of Auclert et al. (2024). Angeletos et al. (2025) draw the normative counterpart: because delaying tax hikes stimulates demand and eases tax distortions, a central bank may prefer slow fiscal adjustment to fast. Our question is positive: we estimate the speed of adjustment the public expects, and quantify what its post-COVID change implies for the power of monetary policy.

Outline. The remainder of the paper proceeds as follows. Section 2 presents the empirical analysis: we derive the change in the BETR from a no-

arbitrage condition, estimate its response to monetary policy shocks using high-frequency municipal bond ETF data, and establish our three main findings—that the BETR rises following a contractionary monetary policy shock, that this response has roughly halved post-COVID, and that its dependence on government indebtedness has disappeared. Section 3 develops and calibrates the HANK model and uses it to quantify how the weaker post-COVID fiscal reaction attenuates the effect of monetary policy on inflation. Section 4 presents model extensions to long bonds and cyclical income risk. Section 5 concludes.

2 Empirical Results

In this section, we measure the change in the BETR caused by monetary policy shocks. We establish that the BETR rises following a monetary tightening, and that this reaction has shrunk substantially post-COVID. Additionally, the BETR was responsive to debt pre-COVID, but is not post-COVID, despite a substantially higher debt load.

We start in Section 2.1 by using a no-arbitrage condition between the after-tax return of Treasuries and municipal bonds to derive the equation that defines the BETR. Then, in Section 2.2 we run regressions to estimate the high-frequency change in BETR caused by monetary policy shocks, using a multitude of liquidity and risk controls. For more detail on the construction of the data behind the regressions, see Appendix B. We show in Section 2.2.1 that the results are robust to considering a municipal bond ETF that holds municipal bonds from a single state, and to using a taxable municipal bond ETF as a control versus our usual controls.

After that, in Section 2.3 we show there is a natural breakpoint around the COVID pandemic that splits the sample into pre- and post-COVID periods. The BETR response post-COVID is roughly half the magnitude of the response pre-COVID. We use these responses to inform our model in Section 3. We go further, separating the nominal monetary policy shock into an expected real shock and an expected inflation shock in Section 2.3.1.Interacting the expected real shock with different measures of government

indebtedness, we find that the level of indebtedness affected the BETR's response to monetary policy shocks pre-COVID, but does not post-COVID.

2.1 Derivation of Change in Breakeven Expected Tax Rate

No arbitrage implies that the yield on the taxable Treasury Y_d^T at duration d after taxes τ_d, should be the same as the yield on the equivalent tax-exempt municipal bond Y_d^M.

$$(1) \qquad (1-\tau_d)Y_d^T = Y_d^M,$$

while noting that differences in liquidity and risk make determination of the equivalent municipal bond difficult. Given differences in coupons between Treasuries and municipal bonds, comparing the two types of securities requires translating from maturity to duration. Comparing different durations of Treasuries and municipal bonds defines the breakeven expected tax rate τ_d at different durations, allowing the calculation of an entire breakeven expected tax rate curve.

In this paper, we analyze changes in the BETR (at different durations) instead of the level of the BETR. Translating the BETR level condition Equation 1 to an equation in changes through the total differential,

$$\Delta\tau_d \approx \left(-\frac{1}{Y_d^T}\right)\Delta Y_d^M + \left(\frac{Y_d^M}{Y_d^{T,2}}\right)\Delta Y_d^T$$

where Δ represents the change in a given variable.

We will approximate the change in the yield of the municipal bond ΔY_d^M using the log change in the price of municipal bond ETF ΔP_{ETF} and the duration of the ETF d_{ETF}

$$(2) \qquad \Delta Y_d^M \approx -\frac{\Delta \log\, P_{ETF}}{d_{ETF}}.$$

Simplifying,

$$\Delta\tau_d \approx \left(\frac{1}{Y_d^T}\right)\frac{\Delta\log P_{ETF}}{d_{ETF}} + \left(\frac{Y_d^M}{Y_d^{T,2}}\right)\Delta Y_d^T. \tag{3}$$

Analyzing different ETFs with different durations will provide estimates of $\Delta\tau_d$ across the BETR curve.

2.2 Regressions

To identify the response of fiscal expectations to monetary policy shocks, we estimate the following specification for each municipal bond ETF:

$$\begin{aligned}\Delta\tau_{ETF,t} = {} & \alpha_{ETF} + \beta_1 \text{Monetary Policy Shock}_t + \beta_2 Y_{ETF,t}^T \\ & + \beta_3(\text{Monetary Policy Shock}_t \times Y_{ETF,t}^T) \\ & + \gamma \text{Controls}_{ETF,t} + \epsilon_{ETF,t}\end{aligned} \tag{4}$$

where $\Delta\tau_{ETF,t}$ is the change in the implied breakeven expected tax rate during the high-frequency window t surrounding an FOMC announcement (either the statement release or the press conference). The term Monetary Policy Shock$_t$ represents the change in the relevant interest rate shock over the same tight window. Controls$_{ETF,t}$ is a vector of high-frequency liquidity and risk proxies. Because the durations of the underlying ETFs drift over time, these controls and the duration-matched Treasury variables are subscripted by ETF and evaluated at each event window.

This specification includes the pre-shock level of the mean 0 centered duration-matched Treasury yield, $Y_{ETF,t}^T$, and its interaction with the monetary policy shock. Because the implied tax rate in Equations 1 and 3 is a non-linear function with the Treasury yield in the denominator, a standard regression of $\Delta\tau$ on the shock may be biased; a shock at a 2% Treasury yield alters the ratio differently than an identical shock at a 4% Treasury yield. By including the yield level (β_2) and the interaction term (β_3), we explicitly absorb this effect. This structure ensures that the base sensitivity (β_1) and the convexity parameter (β_3) isolate genuine repricing of the tax exemption

from the non-linear effects of the yield curve's level.

Table 1 lists the municipal bond ETFs we include in our analysis. The average duration column calculates the average duration of the ETFs on days with FOMC meetings, with the standard deviation of the duration in parentheses below. These ETFs were chosen due to their liquidity, their average duration covering a substantial part of the yield curve, and taking into account data limitations.

Table 1: Municipal Bond ETFs

Name	**Ticker**	**Average Duration (years) (Std. Dev.)**
iShares Short-term National Municipal Bond ETF	SUB	1.9 (0.1)
State Street SPDR Nuveen ICE Short Term Municipal Bond ETF	SHM	2.7 (0.1)
iShares National Muni Bond ETF	MUB	5.1 (0.4)
Invesco National AMT-Free Municipal Bond ETF	PZA	6.7 (1.3)
State Street SPDR Nuveen ICE High Yield Municipal Bond ETF	HYMB	7.2 (1.5)

Source: Authors' calculations, Bloomberg

While on average the BETR is an accurate forecast of tax rates, there are two main concerns about the differences between municipal bonds and Treasury bonds: differences in credit risk between municipal bond issuing entities and the federal government, and differences in liquidity between municipal bonds and Treasuries. Looking at changes in the BETR rather than the level of the BETR limits these concerns to changes in credit risk and changes in liquidity following a monetary policy shock. For more detail

on construction of the controls, see Appendix B.

For credit risk controls, we include the change in

- CDX index[1]: The CDX.NA.IG.5Y index is designed to measure the price of a 5-year Credit Default Swap (CDS) on investment grade corporate bonds. The municipal bond ETFs in Table 1, with the exception of the high-yield ETF HYMB, are rated as investment grade, making this index relevant to the credit risk of the municipal bonds. The 5-year horizon differs from the average durations in Table 1, but the 5-year index is the most liquid maturity of investment grade CDS indexes.

- VIX index: The VIX index is designed to measure equity volatility. As a measure of tail risk, the VIX implicitly measures credit risk, and risk on/off sentiment. While the MOVE index, designed to measure volatility of Treasuries, is relevant, it is not available at a high enough frequency until after 2019.

and for liquidity controls, we include the change in

- Bid-Ask Spread of the ETF: The bid-ask spread of the ETF is a standard measure of equity liquidity.

- Discount to NAV of ETF: The discount to net asset value (NAV) of the ETF measures the dislocation between the price at which the ETF is trading and the value of the ETF's constituent municipal bonds. As the ETFs are designed to enable easy swapping between bonds and shares, changes in discount to NAV reflect changes in bond market liquidity.

- Convenience yield of Treasury at ETF duration: The convenience yield is the difference between a duration matched Treasury and OIS. This

[1]There is a MCDX index designed by S&P Global to measure the price of municipal debt, but is only available at an hourly frequency. It is based on a small number of idiosyncratic municipal bonds that trade infrequently. Including the change in the MCDX index at the times closest to the FOMC release or press conference as a control led to no notable changes..

measure of Treasury liquidity reflects the willingness of investors to pay extra to hold liquid Treasury instruments.

Controlling for changes in credit risk and liquidity in response to monetary policy shocks risks limiting some of the impact of monetary policy shocks. Research such as Kekre and Lenel (2022) shows that monetary policy works through risk channels that these controls may eliminate. Unfortunately, there is little way to control for the credit risk difference between Treasuries and municipal bonds while preserving those channels. For example, an interest rate hike may push some municipal issuers closer to default (compared to the Federal government), raising their credit risk and decreasing the price (and increasing the yield) of their debt. While the regression controls are designed to prevent this increase in risk from affecting the estimate of the BETR, the increase would affect the transmission of monetary policy through the macroeconomy. Relatedly, while the main set of controls do not include changes in inflation expectations, another channel for the transmission of monetary policy, that possibility will be explored in Section 2.3.1. see Appendix B.

For the following tables, and most tables in the paper, we concentrate on the ETF iShares National Muni Bond ETF, ticker MUB. This ETF has the second most assets under management ($42 billion as of the end of 2025) of any municipal bond ETF, and the most assets of all ETFs in Table 1. (The municipal bond with the most assets under management, $43 billion, is the Vanguard Tax-Exempt Bond ETF, ticker VTEB, for which we lack duration data for a large number of meetings.) MUB is also a good benchmark as its duration, reported in Table 1, is just over 5 years, in the middle of the maturities examined.

As we centered the ETF-maturity matched Treasury yields at mean 0, the coefficients reported in this and subsequent tables are the effect at the average yield in the sample (2.48% for MUB in the entire 2016-2025 sample). The first set of 3 models in Table 2 use shocks to the 10-year Treasury as the monetary policy shock. The second set uses the MPS shock of Bauer and Swanson (2023), roughly the first principal component of movements

Table 2: Analyzing MUB, Average Treatment Effect of 1 basis point Monetary Policy Shocks on BETR

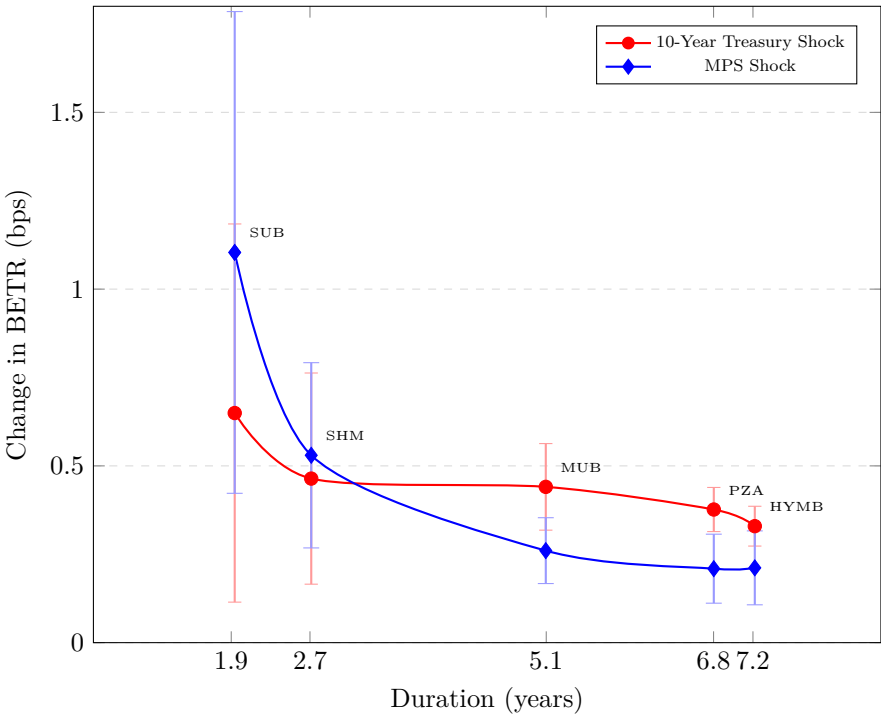
	(1)	(2)	(3)	(4)	(5)	(6)
10-Year Treasury Shock	0.167***	0.252***	0.441***			
	(0.032)	(0.041)	(0.062)			
MPS Shock				0.136***	0.238***	0.260***
				(0.028)	(0.035)	(0.047)
MUB-Duration Treasury Yield (Y^T_{MUB})		0.002**	0.001*		0.002*	0.002*
		(0.001)	(0.001)		(0.001)	(0.001)
10-Year Treasury Shock x Y^T_{MUB}		−0.126***	−0.093***			
		(0.032)	(0.031)			
MPS Shock x Y^T_{MUB}					−0.126***	−0.102***
					(0.028)	(0.024)
Controls	No	No	Yes	No	No	Yes
Num.Obs.	130	130	130	130	130	130
R2 Adj.	0.208	0.385	0.540	0.115	0.208	0.300

Note: * p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.
Source: Authors' calculations, Bloomberg

in interest rate-linked assets between 3 months and 1 year maturity. The β_1 coefficient on the monetary policy shock in models 3 and 6 is 0.45 for the 10-year Treasury shock, while it's 0.25 for the MPS shock. The larger coefficient on the 10-year Treasury shock should be expected at this 5 year duration: a 1 year MPS shock may not have sufficient persistence to exist by the 5 year horizon. The set of risk and liquidity controls adds substantially to the fit of both regressions, comparing models 1 and 3, and models 4 and 6.

We extend the regressions from MUB to the entire list of ETFs in Table 1 in Figure 1. We plot the coefficient on the 10-Year Treasury shock for each ETF. The x-axis is the average duration of the ETF in the sample as shown in Table 1. As ETF maturities are different across ETFs, and across time for a single ETF, taking the average is a necessary simplification. We include a smoothed curve to enhance readability.

Figure 1: Marginal Effect of Monetary Policy Shocks on the BETR



This figure plots the estimated marginal effect of a 1 basis point contractionary monetary policy shock on the Breakeven Expected Tax Rate (BETR) across municipal ETFs using the 10-Year Treasury and the MPS Shock. The marginal effects are evaluated at the average ETF-matched maturity Treasury yield for each ETF. Error bars represent 95% confidence intervals estimated using robust standard errors. Smoothed lines added for readability.
Source: Authors' calculations, Bloomberg

Comparing the impact of 10-Year Treasury shocks and MPS shocks with controls across the ETFs in Figure 1, the MPS shock leads to a larger change in the BETR around the short 2-year horizon, while it has roughly half the magnitude at longer durations, as can be seen by comparing Models 3 and 6 in Table 2. The sharp increase at the 2-year horizon mirrors the shorter 1-year horizon nature of the MPS shock compared to the longer 10-year horizon of the 10-Year Treasury shock.

2.2.1 Robustness Checks

We conduct two robustness checks on the ETF-derived change in BETR. First, we investigate whether the results change if we consider a state-specific municipal bond ETF rather than a national municipal bond ETF with municipal bonds from across the country. We find that the state-specific municipal bond ETF's behavior is almost identical to its counterpart national ETF. Second, we consider whether a *taxable* municipal bond ETF provides additional information to the current set of controls. We find the taxable municipal bond ETF provides less information than the set of controls, and potentially biases the results.

Many states exempt only their own municipal bonds from state-level taxation. The municipal bond ETFs we consider in Table 1 hold municipal bonds from across the country, making the funds potentially taxable for some holders. If the funds are taxable for some holders, that would bias the results of the change in BETR calculations. Arguing against this possibility, both Kueng (2014) and Fleckenstein and Longstaff (2025) find a small impact of state taxes on the desirability of municipal bonds. About 20% of the country lives in a state with no state income tax. The federal tax deductibility of state and local taxes–the SALT deduction–may also play a role. Rational market participants living in states where the national municipal bond ETFs are taxable would not bid as much for the ETFs as participants living in states where the ETFs are tax-exempt. Thus the marginal price-setter is likely in a tax-exempt state.

More directly, we can test whether a state-specific municipal bond ETF behaves similarly to its counterpart national municipal bond ETF. Table 3 introduces a California-specific municipal bond ETF ticker PWZ, and its national counterpart from Table 1 ticker PZA. Both are issued by Invesco and have a very similar maturity.

Table 3: National and State-specific Municipal Bond ETF Counterparts

Name	**Ticker**	**Average Duration (years) (Std. Dev.)**
Invesco National AMT-Free Municipal Bond ETF	PZA	6.80 (1.5)
Invesco California AMT-Free Municipal Bond ETF	PWZ	6.79 (1.2)

Source: Authors' calculations, Bloomberg

PWZ holds municipal bonds issued by Californian entities. California makes these bonds tax-exempt at the state and local level, while taxing out-of-state municipal bonds. Concerns regarding the taxability of the national municipal bond ETFs should not apply to PWZ. Table 4 shows the results of applying the baseline change in BETR analysis of Equation 4 to PZA and PWZ. The coefficient on the 10-Year Treasury shock is almost identical across the two ETFs, while the R^2 is substantially lower in the PWZ analysis. We take this as confirmation that our results are robust to concerns about state-specific municipal bonds.

The calculation of the change in the BETR relies on comparing taxable Treasuries with tax-exempt municipal bond ETFs, while using controls to equate the risk and liquidity between the two bonds. But it's possible the set of controls is not adequate. There is another instrument that splits the difference between the two types of bonds: taxable municipal debt. Differences in reactions between taxable and tax exempt municipal bonds should isolate the reaction of expected taxes.

This form of municipal debt exists as state or local entities issue bonds that primarily benefit a private entity, e.g. a stadium. There is a taxable municipal debt ETF, ticker BAB, that we can use for our analysis. Unfortunately, as seen in Table 5, BAB's average duration is substantially higher than HYMB, the tax-exempt ETF with the longest duration in Table 1. (Taxable municipal debt was promoted and subsidized by the 2009 Ameri-

Table 4: Average Effect of Monetary Policy Shocks on BETR Using PZA, PWZ

	(1)	(2)
10-Year Treasury Shock	0.377***	0.380***
	(0.032)	(0.081)
10-Year Treasury Shock x Y^T_{PZA}	−0.102***	
	(0.020)	
10-Year Treasury Shock x Y^T_{PWZ}		−0.134***
		(0.048)
Controls	Yes	Yes
Num.Obs.	130	122
R2 Adj.	0.569	0.325

Note: * p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.
Source: Authors' calculations, Bloomberg

can Recovery and Reinvestment Act Federal Highway Administration, Office of Innovative Program Delivery (2017) as "Build America Bonds", hence the ticker BAB).

We compare the impact of three BAB-derived controls with the set of controls detailed previously. The first two derived controls mirror controls already used: the change in the bid-ask spread of BAB, and the change in the discount to NAV of BAB. The third control is the BAB-implied change in yield calculated with Equation 2 orthogonalized to the change in yield of a BAB duration-matched Treasury. This control attempts to measure the idiosyncratic movement in yield at BAB's duration. Including the simple difference in yields would, at an average duration of 8.7 years, nearly match the 10-Year Treasury shock used to measure monetary policy.

Table 6 uses HYMB to derive the change in BETR in response to a 10-Year Treasury shock with three sets of controls. In Model 1, we use the standard set of controls; in Model 2, we use the three BAB-derived controls; in Model 3 we combine the standard controls with the three BAB-derived

Table 5: Tax-Exempt and Taxable Municipal Bond ETF Counterparts

Name	**Ticker**	**Average Duration (years) (Std. Dev.)**
State Street SPDR Nuveen ICE High Yield Municipal Bond ETF	HYMB	7.2 (1.5)
Invesco Taxable Municipal Bond ETF	BAB	8.7 (0.7)

Source: Authors' calculations, Bloomberg

Table 6: Change in BETR via HYMB with standard controls and BAB-derived controls

	(1)	(2)	(3)
10-Year Treasury Shock	0.329***	0.306***	0.333***
	(0.028)	(0.045)	(0.028)
BAB Bid-Ask Spread		0.001	0.006*
		(0.004)	(0.003)
BAB Discount to NAV		−0.626	−1.458**
		(0.829)	(0.676)
Orthogonalized BAB Yield		−0.225**	−0.066
		(0.091)	(0.066)
Y^T_{HYMB}	0.002*	0.001	0.001
	(0.001)	(0.001)	(0.001)
10-Year Treasury Shock x Y^T_{HYMB}	−0.106***	−0.155***	−0.106***
	(0.021)	(0.030)	(0.020)
Controls	Yes	No	Yes
Num.Obs.	130	130	130
R2 Adj.	0.624	0.387	0.629

Note: * p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.
Source: Authors' calculations, Bloomberg

controls. Across all the models, the coefficient on the 10-Year Treasury shock is highly significant, and nearly identical. From Model 1 to 2, the R^2 decreases by a half, indicating that the BAB-derived controls fit less well than the more global risk and liquidity controls included in the standard controls. In Model 3, the addition of the BAB-derived controls to the standard controls leads to little change in both the coefficient on the 10-Year Treasury shock and the R^2 compared to Model 1, indicating that the BAB-derived controls are effectively spanned by our standard set of controls and giving confidence that our standard set of controls is comprehensive.

2.3 Pre- and Post-COVID Change in BETR

Given the unprecedented monetary and fiscal actions during the COVID-19 pandemic, it's natural to wonder if the relationship between monetary policy shocks and changes in the BETR has changed. The answer is yes: in the post-COVID period, monetary policy shocks lead to smaller changes, roughly half the size, in BETR than in the pre-COVID period. We will use the results to inform our model in Section 3, specifically to parameterize the tax function.

We use a Bai-Perron test to identify breakpoints in the change in BETR in response to monetary policy shocks for each of the ETFs. Using regressions that include the standard set of controls, the test identifies breaks mid-2020 and in 2021 that include most of the COVID pandemic. Table 7 shows the breakpoints chosen by BIC for all of the ETFs as well as the breakpoint chosen if forced to identify a single breakpoint.

For more clarity, Figure 2 plots the residuals of our baseline change in BETR with MUB regression. The middle interval identified by Table 7 is highlighted in gray, and shows noticeably larger variance.

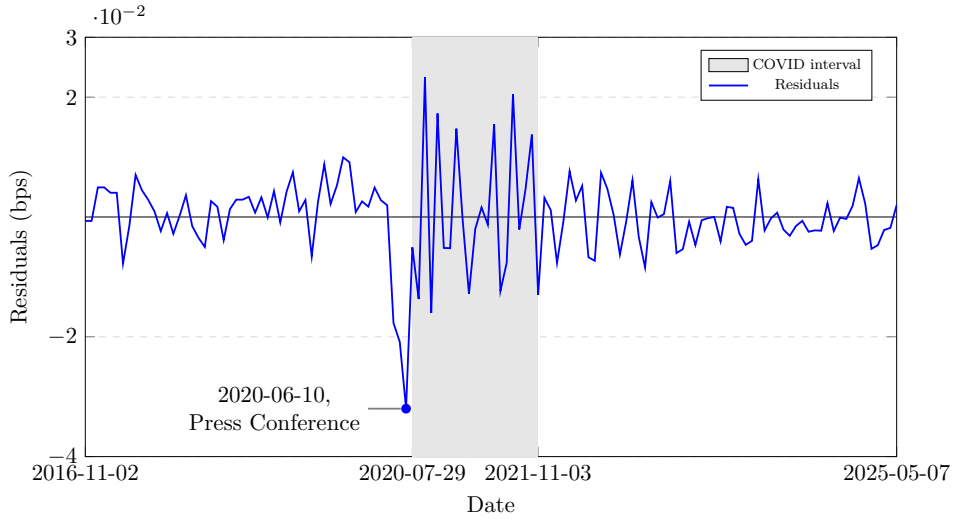
Table 8 reports change in BETR regressions using the near 5-year duration ETF MUB and both 10-Year Treasury and MPS shocks in the different intervals identified by the breakpoints. (For simplicity, the MPS shocks share the same breakpoints as the 10-Year Treasury Shocks.) We recenter the yields for each interval. Pre-COVID corresponds to the first interval,

Table 7: Breakpoints by Ticker

Ticker	First Break	Second Break	Single Break
SUB	2020-04-29	2021-06-16	2021-06-16
SHM	2020-01-29	2021-06-16	2021-04-28
MUB	2020-07-29	2021-11-03	2020-09-16
PZA	2020-09-16	2021-11-03	2020-12-16
HYMB	2020-07-29	2021-09-22	2020-12-16

Source: Authors' calculations, Bloomberg

Figure 2: Residuals of Regression of BETR Changes using MUB on 10-Year Treasury



The blue line is the residuals of a regression of BETR changes using MUB on 10-Year Treasury shocks and controls over the full 2016-2025 sample. The light gray period, corresponding to most of the COVID pandemic, is the middle interval identified by Bai-Perron breakpoints for this regression reported in Table 7.
Source: Authors' calculations, Bloomberg

Table 8: MUB: Average Effect of Monetary Policy Shocks on BETR

	Pre-COVID	Post-COVID	Pre-COVID	Post-COVID
10-Year Treasury Shock	0.514***	0.238***		
	(0.072)	(0.026)		
MPS Shock			0.449***	0.140***
			(0.075)	(0.039)
Y^T_{MUB}	0.005***	0.000	0.008**	−0.001
	(0.001)	(0.001)	(0.003)	(0.001)
Shock x Y^T_{MUB}	−0.480***	−0.036	0.002	0.000
	(0.102)	(0.024)	(0.316)	(0.026)
Controls	Yes	Yes	Yes	Yes
Num.Obs.	54	57	54	57
R2 Adj.	0.833	0.776	0.548	0.544

Note: * p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.
Source: Authors' calculations, Bloomberg

and post-COVID to the third interval in Table 7. The middle 2020-2021 interval, highlighted in gray in Figure 2, is not reported.

In Table 8, the coefficients on the 10-Year Treasury and MPS shocks pre-COVID are halved in the post-2021 period while R^2 remains high. For the 10-Year Treasury shock, the coefficient on the interaction term is no longer statistically significant. If we identify a single breakpoint, as shown in the third column of Table 7, the 2020-21 period is combined with the 2021-2025 period. Running the same set of regressions on these two periods leads to similar results.

We can examine the equivalent of Table 8 for all ETFs. For each ETF, we use the two breakpoints in the first two columns of Table 7 to separate the sample into pre- and post-COVID intervals. As the breakpoints differ across ETFs, each regression will use slightly different samples. Forcing all the ETFs to use MUB's breakpoints results in almost no changes. Figure 3 shows the coefficient on the 10-Year Treasury shock for all ETFs in pre- and post-COVID intervals. Because the duration of every ETF changes over time, the average duration of the ETFs shown in the figure differs between

pre- and post-COVID intervals.

Figure 3 shows that the change in BETR following a monetary policy shock post-COVID induced by a change in the 10-Year Treasury is roughly half the magnitude of the change in BETR pre-COVID.

2.3.1 Real and Inflation Shocks, and Debt

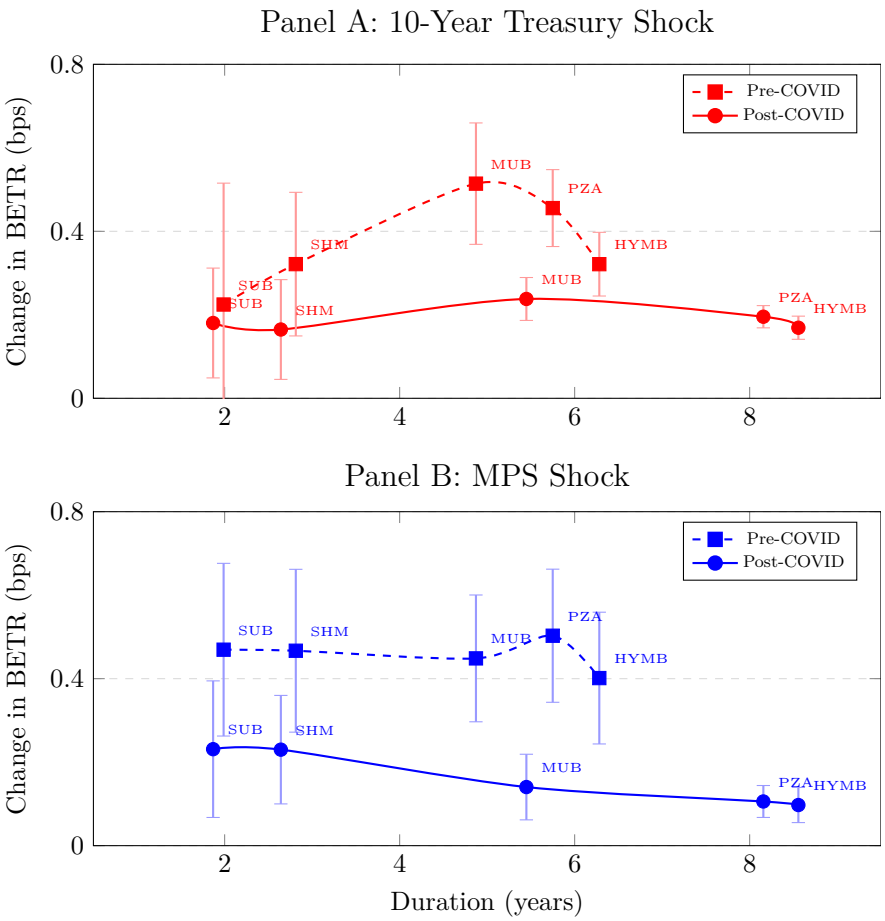
Our measures of monetary policy shocks have been strictly nominal shocks. The Federal Reserve controls a nominal interest rate, and it's natural to use other nominal rates as measures of shocks. However, nominal rates contain an expected inflation component that wouldn't necessarily change interest payments on debt as both rates and tax revenue would rise commensurately. Using high-frequency inflation swaps measures, we can decompose nominal monetary policy shocks into their expected real and breakeven inflation components. For simplicity, we refer to these as real and inflation shocks. We interact these shocks with measures of indebtedness. Pre-Covid, the real shocks interacted with the level of debt is significant; a higher debt-to-GDP ratio leads to a larger change in the BETR following a real shock. Post-COVID, the level of debt is insignificant.

We decompose the nominal 10-Year Treasury shock already used, and the 2-Year Treasury shock. The MPS shock is close to a 1-year maturity, but there are no high frequency measures of 1-year maturity inflation expectations. Both the 10- and 2-Year Treasury shocks can be directly decomposed into real and inflation components using inflation swaps: Change in Nominal X-Year Yield = Change in Real X-Year Yield + Change in X-Year inflation swap.[2] The impact of real shocks on the BETR shows the same magnitude of diminishment post-COVID as seen for nominal shocks in Section 2.3. For a full analysis of the effect of real and inflation components on the BETR without including debt, see Appendix C.

We investigate whether the magnitude of the real and expected inflation shocks on tax expectations is affected by the government's debt burden.

[2]Using the residuals of a regression of the MPS Shock on the change in the 2-Year Inflation Swap as the real component of the MPS Shock results in broadly similar results to decomposing the 2-Year Treasury yield.

Figure 3: Marginal Effect of Monetary Policy Shocks at Average Yield on the BETR: Pre- vs. Post-COVID



This figure plots the estimated marginal effect of a 1 basis point contractionary monetary policy shock on the Breakeven Expected Tax Rate (BETR) across municipal ETFs. The marginal effects are evaluated at the average ETF-maturity matched Treasury yield specific to each subsample (pre-COVID and post-COVID). Error bars represent 95% confidence intervals estimated using robust standard errors. Smoothed lines added for readability.
Source: Authors' calculations, Bloomberg

Theoretically, a contractionary real monetary shock tightens the government's intertemporal budget constraint. Under standard assumptions, an increase in real debt-servicing costs necessitates an offsetting increase in the present value of future primary surpluses, driving up expectations of future marginal tax rates. This sensitivity should be directly related to the outstanding stock of debt, which averaged roughly 70% of GDP in our pre-COVID sample and over 90% post-COVID.

$$
\begin{aligned}
\Delta\tau_{ETF,t} = \alpha_{ETF} &+ \beta_1 Y^T_{ETF,t} \\
&+ \beta_2 \text{Real Shock}_t + \beta_3(\text{Real Shock}_t \times Y^T_{ETF,t}) \\
&+ \beta_4 \text{Inflation Shock}_t + \beta_5(\text{Inflation Shock}_t \times Y^T_{ETF,t}) \\
&+ \beta_6(\text{Real Shock}_t \times \text{Debt Measure}_t) \\
&+ \beta_7(\text{Inflation Shock}_t \times \text{Debt Measure}_t) \\
&+ \beta_8 \text{Debt Measure}_t + \gamma \text{Controls}_{ETF,t} + \epsilon_{ETF,t}
\end{aligned} \tag{5}
$$

Equation 5 augments the baseline model with interaction terms between the real and inflation expectation components of the monetary policy shock and various measures of U.S. indebtedness. The first measure used is the ratio of government debt held by the public to GDP. The second measure, highlighted in Barro and Bianchi (2023), multiplies the debt-to-GDP ratio by the weighted average maturity of the outstanding debt. This measure adjusts for the reality that longer-term debt is less elastic to expected inflation, though it also isolates the Treasury from rollover risk. The third measure is the net interest payment-to-GDP ratio, as utilized by Furman and Summers (2020), which captures the flow of interest expenses relative to the flow of output. For the debt-to-GDP measures, we use the monthly par value of privately-held debt measures from the Federal Reserve Bank of Dallas (2026). All results are robust to using quarterly debt data, and deflating by potential GDP rather than GDP, see Appendix D.

Table 9 reports the estimated coefficient on the 10-Year Treasury Shock interaction with the three debt measures, β_6 from Equation 5, in pre- and post-COVID periods. Almost all the estimated coefficients in the pre-

Table 9: Coefficients on Real 10-Year Treasury Shock x Debt Measures Pre- and Post-COVID

	SUB	SHM	MUB	PZA	HYMB
Pre-COVID					
Debt-to-GDP	0.138***	0.098***	0.042***	−0.007	0.012
	(0.044)	(0.030)	(0.011)	(0.015)	(0.010)
WAM Debt-to-GDP	0.030***	0.017***	0.009**	0.001	0.002
	(0.007)	(0.005)	(0.004)	(0.005)	(0.002)
Net Int-to-GDP	1.055***	0.811***	−0.067	−0.083	0.139
	(0.339)	(0.240)	(0.177)	(0.133)	(0.120)
Post-COVID					
Debt-to-GDP	0.001	−0.005	0.005*	0.004	0.001
	(0.006)	(0.006)	(0.003)	(0.005)	(0.004)
WAM Debt-to-GDP	0.000	−0.002	0.001*	0.003***	0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Net Int-to-GDP	0.060	0.032	0.074**	0.014	−0.005
	(0.058)	(0.064)	(0.027)	(0.032)	(0.038)

Note: * p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.
Source: Authors' calculations, BEA, Dallas Federal Reserve, Treasury Department

COVID period are positive, and the majority both positive and statistically significant, especially in the nearer-durations where tax expectations are more accurate. This result matches the standard theoretical mechanism: higher debt burdens amplified the expected fiscal response to monetary tightening. In contrast, the estimated coefficients in the post-COVID period collapse to near zero and lose statistical significance.

The decoupling of changes in the BETR from the government's debt burden suggests investors do not expect the government will quickly use taxes to eliminate its debt, instead either delaying repayment or resorting to other means. We take pre- and post-COVID BETRs estimated in Section 2.3 to a model in Section 3. Fitting intuition, the change in fiscal expectations greatly weakens the efficiacy of monetary policy, especially as debt grows larger.

3 Model

We establish a model to quantify how the estimated decline in the expected fiscal reaction shown in Figures 3 and C.1 affects monetary policy's impact. We use a parsimonious HANK model—it is effectively a 3-equation New Keynesian model augmented with a fiscal block—that is quantitative in the sense that its demand block closely matches the microeconomic evidence on consumption that shapes monetary-fiscal interactions. Matching the roughly 50% fall in the expected fiscal reaction, the model implies that monetary tightening has become substantially less effective at lowering inflation—by about a quarter on impact and roughly 80% at a two-year horizon.

3.1 Setup

Time is discrete and each period corresponds to a quarter. The economy is inhabited by a unit mass of households, a representative final goods firm, and monetary and fiscal authorities.

Aggregate demand. Aggregate demand is the sum of household consumption and government spending. Positive government spending allows

the model to have realistic levels of public debt and taxes, but it is exogenous and kept constant throughout our experiments; fluctuations in aggregate demand are driven solely by consumption.

Households are heterogeneous with respect to income zY_t and assets a. The idiosyncratic component of income, z, follows an exogenous Markov process, and households smooth consumption by trading in one-period nominal bonds whose nominal return R^n_{t-1} is predetermined by the central bank. The decision problem of the households can be written in real terms as

$$V_t(z, a_{-1}) = \max_{c,a} u(c) + \beta \mathbb{E}_t \left[V_{t+1}(z_{+1}, a) \right] \tag{6}$$

$$\text{s.t. } c + a = \frac{R^n_{t-1}}{\pi_t} a_{-1} + zY_t - \mathcal{T}\Big(zY_t, \tau_t\Big) \tag{7}$$

$$z_{+1} \sim \Pi(z_{+1} \mid z), \qquad a \geq \underline{a}, \tag{8}$$

where π_t is gross inflation, $\mathcal{T}(\bullet, \tau_t)$ is an increasing and convex income tax function, and τ_t is a tax shifter which is adjusted by the government to implement its fiscal rule. Because taxes are levied on labor income that households take as given, they do not distort consumption-saving decisions.

The Bellman equation yields policy functions $c_t(z, a_{-1})$ and $a_t(z, a_{-1})$. Combining the asset policy with the Markov matrix for z, we can obtain the time-t distribution $D_t(z, a_{-1})$ by iterating forward from any initial distribution $D_{-1}(z, a_{-1})$. Finally, we obtain aggregate consumption, savings, and taxes net of transfers by aggregating the time-t policy functions with the time-t distribution:

$$C_t = \int c_t(z, a_{-1})\, dD_t(z, a_{-1}), \qquad A_t = \int a_t(z, a_{-1})\, dD_t(z, a_{-1}), \tag{9}$$

$$T_t = \int \mathcal{T}\Big(y_t(z), \tau_t\Big)\, dD_t(z, a_{-1}). \tag{10}$$

Aggregate supply. The supply block of the model reduces to the textbook loglinear Phillips curve

$$\log\left(\frac{\pi_t}{\pi^*}\right) = \kappa \left(\frac{v'(Y_t)}{u'(C_t)} - 1 \right) + \beta \mathbb{E}_t \left[\log\left(\frac{\pi_{t+1}}{\pi^*}\right) \right] \tag{11}$$

This equation implies that fluctuations in inflation around its steady-state π^* are driven by fluctuations in the marginal rate of substitution between consumption C_t and the labor required to produce output Y_t according to a slope parameter $\kappa > 0$ that captures the degree of nominal and real rigidities.

This Phillips curve is consistent with either price stickiness or wage stickiness, though not both. We make two assumptions of convenience that streamline our analysis. First, in line with much of the literature on monetary-fiscal interactions, we assume that fiscal adjustments do not distort labor supply. Taxes are allowed to depend on individual income, but are lump sum in this sense. Second, labor supply is mediated by unions that evaluate marginal utilities at the average level of consumption and labor. Keeping track of the (time-varying) average of individual marginal utilities is theoretically compelling and computationally trivial, but, to first-order, amounts to rescaling κ and may be ignored without loss of generality for our purposes.[3]

Monetary policy. The central bank sets the short-term nominal interest rate according to the policy rule

$$R_t^n = R^* + \phi_\pi \log\left(\frac{\pi_t}{\pi^*}\right) + \epsilon_t^{mp} \tag{12}$$

where R^* is the target for the gross nominal rate, π^* is the inflation target, and ϵ_t^{mp} is a monetary policy shock. The parameter $\phi_\pi \geq 0$ governs the responsiveness of monetary policy to inflation.

Fiscal policy. The government spends G^*, financed from tax revenues and issuing one-period nominal bonds. Letting B_t denote the real value of public debt, the government budget constraint is

$$B_t + T_t = \frac{R_{t-1}^n}{\pi_t} B_{t-1} + G^*. \tag{13}$$

[3]The scaling factor may be large in models with unequal exposure to labor demand fluctuations, but is generally soaked up by the adjustment costs determining κ during estimation because marginal utilities are unobservable (Bardóczy et al., 2024). We consider the effects on unequal exposure on aggregate demand as one of our extensions in Section 4.

The tax shifter is set according to the fiscal rule

$$T_t - T^* = \phi_B \frac{R^*}{\pi^*}(B_{t-1} - B^*) \tag{14}$$

where T^* and B^* are steady-state levels of tax revenues and public debt. The parameter $\phi_B \in [0, 1]$ governs the fiscal reaction to fluctuations in real debt. In the two extremes, $\phi_B = 0$ implies keeping tax revenues constant irrespective of the path of debt, and $\phi_B = 1$ implies keeping public debt constant by balancing the budget period by period. We will discuss the shape of the tax function that raises tax revenue T_t in the next section.

Equilibrium. Given a sequence of monetary policy shocks $\{\epsilon_t^{mp}\}_{t\geq 0}$, and initial conditions $\{D_{-1}, B_{-1}\}$, an equilibrium is a sequence of allocations $\{Y_t, C_t, A_t\}_{t\geq 0}$ and prices $\{R_t^n, \tau_t, \pi_t\}_{t\geq 0}$ such that: (a) households optimize; (b) the Phillips curve holds; (c) the government and central bank follow their policy rules; and (d) goods and asset markets clear

$$Y_t = C_t + G^*, \qquad A_t = B_t. \tag{15}$$

3.2 Calibration

Next, we discuss the calibration of the steady state of our model, and validate it on (intertemporal) marginal propensities to consume (MPC). The policy parameters ϕ_π and ϕ_B do not affect the deterministic steady state, and we defer their discussion to the next subsection.

Fixed parameters. We assume standard CRRA preferences

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}, \qquad v(l) = \varphi \frac{l^{1+\nu}}{1+\nu}, \tag{16}$$

and set the elasticity of intertemporal substitution to $\sigma^{-1} = 0.5$ and the Frisch elasticity to $\nu^{-1} = 0.5$. The scalar $\varphi > 0$ is introduced to reconcile the targeted levels of $Y = C = 1$ with optimal labor supply. We set the central bank's targets to $R^* = 1.01$ and $\pi^* = 1.005$, implying that both

inflation and real rate on government bonds are approximately 2% annually. We set government debt to $B^* = 2.8$, which corresponds to a debt-to-GDP ratio of 70%, close to pre-COVID levels in the U.S. We fix the slope of the Phillips curve at $\kappa = 0.01$, a low value typical of New Keynesian models estimated on pre-COVID data (see, e.g. Auclert et al., 2020).

The income process and the borrowing constraint are key determinants of MPCs in this class of models. We use the quarterly, discrete-time version of the leptokurtic income process estimated by Kaplan et al. (2018), which has become standard in quantitative HANK models with infinitely-lived households. The borrowing constraint we set to $\underline{a} = 0$, which is a reasonable value if we interpret assets in the model as financial assets net of revolving consumer debt (Bardóczy et al., 2024).

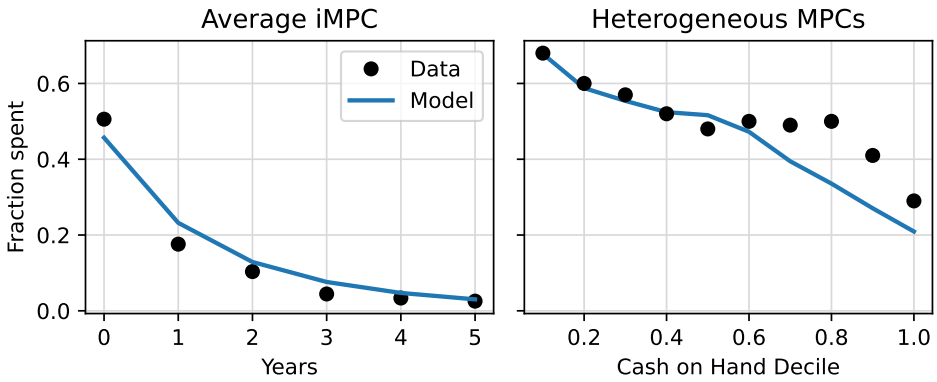
Tax function. Our empirical evidence from Section 2 on the fiscal reaction function is based on the top marginal federal income tax rate, making the choice and calibration of the tax function particularly important.

We adopt the tax function from Heathcote et al. (2017)

$$\mathcal{T}(y, \tau) = y - (1 - \tau)y^{1-\lambda}. \tag{17}$$

This is a parsimonious tax function with $\tau \in (0, 1)$ governing the level and $\lambda \in [0, 1]$ the progressivity of taxes. In the cross-section, it implies a log-linear relationship between pre-tax income and after-tax income that fits the U.S. tax system very well. We calibrate (τ, λ) jointly to match marginal income taxes for two income groups: a 40% marginal tax on the top 1% (which we interpret as the "top" marginal tax rate) and a 10% marginal tax on the bottom 50% of households. This procedure yields $\lambda = 0.102$ and $\tau = 0.088$. The progressivity parameter is well-within the range of values estimated by Fleck et al. (2025). The level parameter is not comparable to empirical estimates because it reflects the normalization of average pre-tax income, $\mathbb{E}[z]Y$. To judge the level of the taxes, we can instead consider that the bottom 50% pay close to zero taxes on average, and that government spending $G^* = 0.124$, which is determined residually from the government

Figure 4: Model Fit of Untargeted MPC Moments



Notes: The figure shows the average annual iMPCs from a lump-sum transfer on the left panel and the corresponding annual impact MPCs along the liquid asset distribution on the right panel. "Data" represents estimates of Fagereng et al. (2021) in the left panel and estimates of Holm et al. (2021) in the right panel.

budget, is of the right magnitude for U.S. government consumption of goods and services.

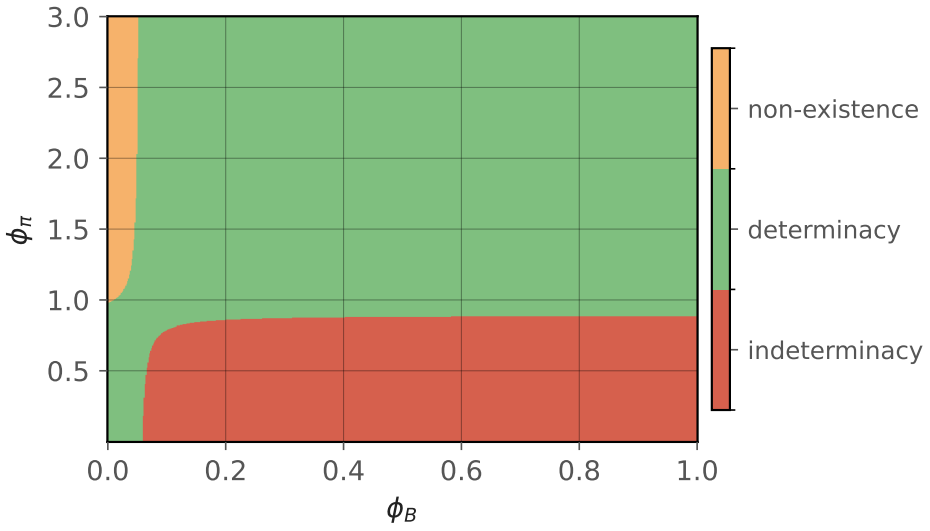
Validation. Figure 4 offers further validation of the model. The left panel compares the average annual iMPCs implied by the model with the estimates of Fagereng et al. (2021). The right panel compares annual impact MPCs across the liquid asset distribution with the estimates of Holm et al. (2021). The model matches well both the time-profile of aggregate spending and the cross-sectional heterogeneity of spending out of a lump-sum transfer. This is important, because the progressive tax system introduces a heterogeneous earnings channel of monetary policy, and the fiscal reaction operates through lump-sum—and potentially unequally distributed—taxes in our model.[4]

3.3 The bounds of fiscal-monetary policies

Next, we characterize how the fiscal and monetary policy parameters shape the set of unique, bounded equilibria around the deterministic steady state,

[4]See Auclert (2019); Kaplan et al. (2018), and Auclert et al. (2024) for typical monetary and government spending shocks, and Bardóczy et al. (2025) for targeted transfer shocks.

Figure 5: Determinacy Regions in our HANK Model



Notes: The figure shows local determinacy based on the winding number criterion. The horizontal axis plots values for the parameter ϕ_B which governs the responsiveness of fiscal policy to debt. The vertical axis plots values of the parameter ϕ_π which governs the responsiveness of monetary policy to inflation.

and show that the inflation response to a monetary policy shock varies smoothly between the textbook "monetary dominance" and "fiscal dominance" regimes. This result, which echoes the recent findings of Angeletos et al. (2024) in the context of an analytical OLG-NK model, underlines the importance of identifying the fiscal reaction function.

Throughout this section, we assume that the fiscal authority responds to monetary policy shocks by adjusting the level shifter τ_t, keeping the progressivity parameter λ constant at its calibrated value. Although progressivity may change over time, we view this as a useful benchmark, because it implies that the fiscal reaction itself does not affect inequality in after-tax incomes.[5]

[5] Werning (2015) shows that procyclical inequality dampens, and countercyclical inequality amplifies, aggregate consumption responses in incomplete markets models. We return to the question of cycical inequality in Section 4.

Figure 5 shows the regions of determinacy in our HANK model for a wide range of monetary and fiscal responsiveness parameters, ϕ_π and ϕ_B, respectively.[6] Three connected regions emerge. In the yellow region, the central bank is committed to fighting inflation according to the Taylor principle, while the government is unwilling to raise enough revenues to stabilize debt. As a result, there exists no bounded equilibrium.[7] In the red region, monetary policy accommodates inflation and the government is committed to stabilizing debt via taxation. The result is multiplicity, with different bounded paths of inflation and debt satisfying the equilibrium conditions. The remaining green region shows the combinations of policies that yield unique bounded equilibria. We restrict attention to these equilibria going forward.

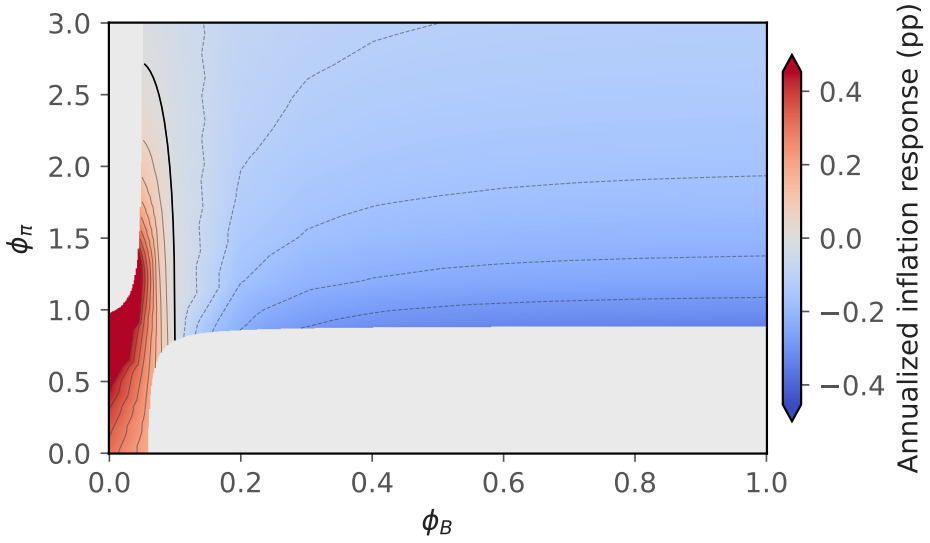
The determinate region contains the textbook parameterization of the New Keynesian model, with $\phi_\pi > 1$ and $\phi_B = 1$, in which monetary policy stabilizes inflation and fiscal policy stabilizes debt. In our HANK model with progressive income taxation, the threshold for ϕ_π lies around 0.88, reflecting that procyclical inequality dampens fluctuations in aggregate demand (Acharya and Dogra, 2020; Bilbiie, 2025). Moving towards lower levels of ϕ_B, the determinacy threshold changes little, until it suddenly falls off a cliff around $\phi_B = 0.2$. For $\phi_B \leq 0.06$, determinacy requires accommodative monetary policy and is even consistent with completely unresponsive monetary policy, $\phi_\pi = 0$.

How does the configuration of policy parameters affect the power of the monetary authority to change inflation? Figure 6 sheds light on this question by showing the average inflation response to a monetary policy shock. This metric clearly depends on how we summarize the inflation response and the

[6] Computing the determinacy regions at a high resolution requires solving the model for thousands of parameter combinations. We rely on the sequence-space Jacobian (SSJ) method of Auclert et al. (2021), combined with the winding number criterion, a sequence-space analog of the standard root-counting test of Blanchard and Kahn (1980). The winding number criterion was originally proposed by Onatski (2006) and generalized to HA models recently by Auclert et al. (2025).

[7] The yellow region may feature equilibria with explosive inflation and debt dynamics, as discussed in Woodford (2001). Loyo (1999) argues that such a fiscal-monetary policy mix contributed to the Brazilian hyperinflation in the early 1980s.

Figure 6: Average Inflation Response to a Monetary Policy Shock



Notes: The horizontal axis plots values for the parameter ϕ_B which governs the responsiveness of fiscal policy to debt. The vertical axis plots values of the parameter ϕ_π which governs the responsiveness of monetary policy to inflation. The color of the heatmap represents the average inflation response in the first 8 quarters following a monetary policy shock. The thick black contour line marks zero inflation response.

monetary policy shock that we use.[8] For concreteness, we report the average inflation response in the first 8 quarters, $\frac{1}{8}\sum_{h=0}^{8} d\pi_h$, following a 25-basis-point contractionary monetary policy shock with a quarterly autocorrelation of 0.8, $\{\epsilon_t^{mp}\}_{t\geq 0} = \{-25 \times 10^{-4} \times 0.8^t\}_{t\geq 0}$. The point we make, however, holds for a wide range of inflation response horizons and shock persistence.

Starting at the right lower corner of the heatmap once again, with $\phi_B \approx 1$ and $\phi_\pi \approx 1$, the inflation response is negative just like in the textbook NK model. Moving towards more aggressive inflation targeting (higher ϕ_π) dampens the inflation response, as the monetary authority leans against the shortfall in demand induced by the contractionary shock. Moving towards

[8] Using SSJ notation, the impulse responses to a particular exogenous variable Z depend on $\mathbf{H_U^{-1}H_Z}$. In contrast, determinacy depends only on $\mathbf{H_U}$, and hence is independent of the aggregate shocks being considered.

weaker fiscal reaction (lower ϕ_B) also dampens the inflation response, reflecting that the contraction is exacerbated by the government raising taxes to finance its debt in the face of higher interest rates and lower output. However, the changes in the inflation response are relatively small until we get to around $\phi_B = 0.1$. In this part of the parameter space, further reductions in fiscal reaction can turn the inflation response positive, with the steepest gradient at around $\phi_\pi = (0.8, 1.2)$. Peak inflation response is obtained at $\phi_B = 0$ and ϕ_π just below 1.0. At this point, inflating debt away is just barely possible but requires a large inflation response.

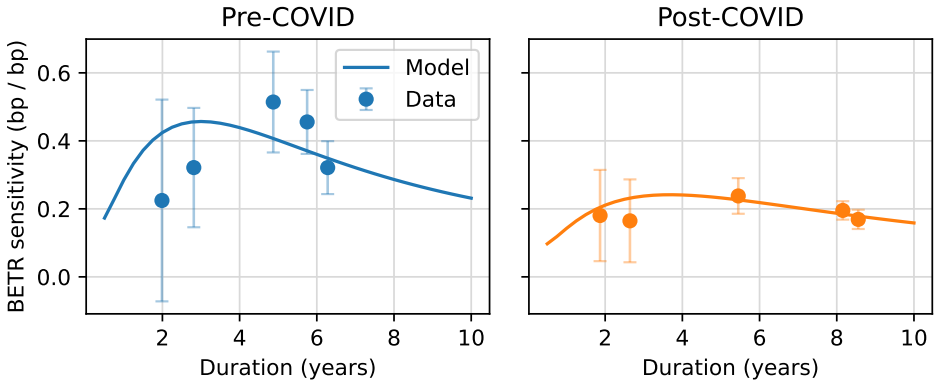
3.4 The decline in fiscal responsiveness

Confronted with the estimated responses of the top marginal tax rate, our model implies that the pre-COVID monetary-fiscal policy mix was well within conventional territory—where monetary tightening reduces inflation—but it has since shifted close to the threshold where monetary tightening becomes inflationary.

Calibrating the fiscal reaction function. Placing the pre-COVID and post-COVID policy regimes on the heatmap in Figure 6 requires calibrating ϕ_B, ϕ_π, and potentially other parameters to the empirical evidence. For now, our strategy is to calibrate only the fiscal absorption rate ϕ_B by matching the empirical term structure of the fiscal reaction, estimated in Section 2, to its model counterpart. We hold the deterministic steady state and all other parameters fixed, including the monetary stance $\phi_\pi = 2$, the Phillips curve slope $\kappa = 0.01$, and the persistence of the monetary policy shock $\rho_{mp} = 0.8$. We calibrate ϕ_B separately for the pre- and post-COVID regimes, so that the two regimes differ only in the fiscal reaction.

We follow a moment-matching approach, with five targeted moments for one parameter in each policy regime. Each municipal ETF, indexed by i, supplies one targeted moment, $\hat{m}_i$: the change in the BETR in response to a 10-year Treasury shock at the duration of the ETF, d_i. These coefficients are shown on Panel A of Figure 3. We make one adjustment to map these

Figure 7: Model Fit of Fiscal Reaction Pre- and Post-COVID



Notes: The figure shows the response of the breakeven expected tax rate (BETR) to a one-basis-point 10-year Treasury shock against the effective duration of the underlying municipal bond ETF, for the pre-COVID (left) and post-COVID (right) regimes. The markers are the estimated coefficients for the five ETFs, reproduced from Panel A of Figure 3, with error bars showing 95% confidence intervals. The solid line is the model-implied BETR term structure for the calibrated fiscal reaction.

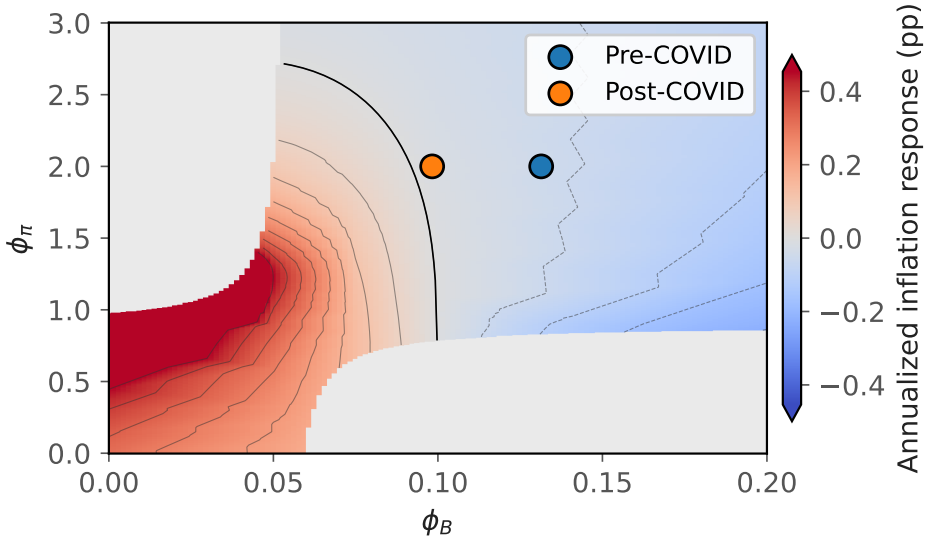
estimates into our model. Because the BETR prices only the marginal personal income tax—roughly one-third of total government revenue—whereas the model's single shifter τ absorbs all fiscal adjustment, we scale the targets by a factor of three.

To compute the model analogs, we solve for the linearized impulse responses to a unit monetary policy shock $\epsilon_t^{mp} = 0.8^t$, and compute

$$m_i(\phi_B) \;=\; \frac{\dfrac{1}{4d_i}\displaystyle\sum_{q=0}^{4d_i-1} d\mathrm{MTR}_q^{\mathrm{top}}}{4 \cdot dR_0^{n,10}}, \tag{18}$$

the impact revision in the d_i-year-averaged top marginal tax rate, divided by the annualized impact revision in the model's 10-year nominal yield $R^{n,10}$. The denominator is the 10-year rate for every ETF, matching the empirical design; only the numerator's averaging window $[0, 4d_i)$ varies with the duration d_i. The construction of these variables is explained in Appendix F.1.

Figure 8: Estimated Monetary-Fiscal Policy Regimes



Notes: The horizontal axis plots values for the parameter ϕ_B which governs the responsiveness of fiscal policy to debt. The vertical axis plots values of the parameter ϕ_π which governs the responsiveness of monetary policy to inflation. The color of the heatmap represents the average inflation response in the first 8 quarters following a monetary policy shock. The thick black contour line marks zero inflation response. The blue and orange circles represent the calibrated ϕ_B given $\phi_\pi = 2$.

With one parameter and five moments per regime, the system is overidentified. We calibrate ϕ_B by weighted least squares, weighting the distance from each empirical moment by the inverse of its standard deviation, $\hat{s}_i$:

$$\phi_B^\star = \arg \min_{\phi_B \in [0.02,\, 0.95]} \sum_{i=1}^{5} \left(\frac{m_i(\phi_B) - 3\hat{m}_i}{\hat{s}_i} \right)^2. \tag{19}$$

The procedure yields $\phi_B^\star = 0.13$ pre-COVID and $\phi_B^\star = 0.10$ post-COVID. As Figure 7 shows, the calibrated model reproduces the estimated term structure of the fiscal reaction remarkably well, lying within the 95% confidence intervals at every duration in both regimes.

Consequences for monetary policy. Figure 8 places the two calibrated regimes on the policy plane, zooming in on the relevant region with $\phi_B \in [0, 0.2]$. Both regimes lie inside the part of the determinate region where monetary tightening lowers inflation. The two stances, however, occupy very different parts of the inflation-response surface. The pre-COVID rule ($\phi_B = 0.13$) sits in the interior of the conventional region. The post-COVID rule ($\phi_B = 0.10$) has drifted toward the zero-response frontier, where the fiscal channel nearly offsets the conventional disinflationary force of higher interest rates.

The estimated decline in fiscal responsiveness translates into a sizable weakening of monetary transmission that grows with the horizon. Under the post-COVID stance, the eight-quarter average inflation response to the monetary tightening—the object mapped in Figures 6 and 8—is nearly 80% smaller than under the pre-COVID stance, and the impact response is about 28% smaller. By a twenty-quarter horizon the cumulated response has changed sign altogether: under the post-COVID stance the tightening is mildly *inflationary*.

This horizon profile follows from the intertemporal MPCs validated in Figure 4. Both regimes stabilize the debt with a similar cumulative tax—fiscal policy is Ricardian—but they differ in its timing: the lower post-COVID absorption rate lets the debt and its interest burden decay more slowly, so the tax increases are deferred. If households were also Ricardian, only the present value would matter and the two regimes would have the same implications for aggregate demand and inflation. Because the aggregate iMPC is instead strongly front-loaded, the timing of the adjustment shapes its drag on demand: the front-loaded pre-COVID hikes depress consumption early and, through the persistence of the iMPC, cumulatively, whereas the back-loaded post-COVID hikes fall on more distant income that households smooth through. The two inflation responses therefore nearly coincide on impact and diverge as the consumption shortfall accumulates, so that the gap widens from about a quarter on impact to a full sign reversal by twenty quarters.

4 Extensions

We consider two extensions of the model that may affect our conclusions: long-term debt and the earnings heterogeneity channel of monetary policy. The main text contains a brief summary of these extensions, with Table 10 showing how they affect the inflation response to monetary tightening. Appendices F.2 and F.3 provide additional details and results to support the claims we make in this section.

4.1 Long bonds

Our baseline model assumes that the government issues one-period nominal bonds, with a unit issued in period t paying 1 dollar in period $t+1$. In this extension, we generalize the setup to long-term bonds that pay δ^s in period $t+1+s$ for all $s \geq 0$. The government budget can still be written as

$$B_t + T_t = R_t^b B_{t-1} + G^*, \tag{20}$$

but the real return on bonds R_t^b depends on the nominal bond price Q_t which in turn is determined by the expected path of short-term nominal rates:

$$R_t^b = \frac{1+\delta Q_t}{Q_{t-1}} \frac{1}{\pi_t}, \qquad Q_t = \mathbb{E}_t \left[\frac{1+\delta Q_{t+1}}{R_t^n} \right]. \tag{21}$$

The dependence on future short rates can completely change the response of the bond return to a monetary tightening. In the benchmark model ($\delta = 0$, implying $R_t^b = R_{t-1}^n/\pi_t$), a monetary shock revalues public debt only through the inflation it generates on impact. In the conventional region, monetary tightening lowers inflation, which benefits bondholders at the expense of the government. With long bonds, asset-price redistribution goes in the opposite direction. The bond price falls in response to the unanticipated upward shift of the yield curve—households lose and the government gains (see Figure F.1).

Accounting for the long duration of public debt has three implications for our results. First, monetary tightening lowers inflation more than in the

benchmark model (see Table 10). This is because the initial bond revaluation drags down aggregate demand, as even high-wealth households have relatively high MPCs (see Figure 4). Second, matching the estimated BETR path requires a substantially higher ϕ_B coefficient, which implies that government disburses some of its gains from the bond revaluation in the form of *lower taxes* in the short run, before hiking taxes to stabilize debt in the face of persistently high interest rates (see Figure F.1). Third, the fiscal reaction becomes a less important channel of monetary policy overall, because the initial revaluation offsets some of rise in the government's debt service costs caused by monetary tightening. Accordingly, the extended model implies that the post-COVID decline in the fiscal reaction weakens monetary policy less than in the benchmark model: 9–16 percent vs 28–79 percent, as shown by Table 10.

4.2 Earnings heterogeneity

Our benchmark model assumes that households are uniformly exposed to fluctuations in aggregate income induced by monetary policy shocks. To relax this assumption, let the pre-tax income of a household with productivity z be

$$y(z, Y_t) = zY^* \left(\frac{Y_t}{Y^*}\right)^{\gamma(z)}, \tag{22}$$

where $\gamma(z)$ is the elasticity of individual income y to aggregate income Y_t. The motivation of this extension is that earnings heterogeneity can alter the effects of monetary policy on aggregate demand (Auclert, 2019).

The $\gamma(\bullet)$ function may be calibrated directly to the "worker betas" that Guvenen et al. (2017) estimate from U.S. administrative earnings records. As Amberg et al. (2022) show, the unconditional elasticities of individual earnings to GDP line up well with the redistributive effects of monetary policy shocks, which makes them appropriate for our analysis. Appendix F.3 describes the implementation details, visualizes the calibrated $\gamma(\bullet)$ function, and tabulates the changes in the inflation responses to monetary policy.

Accounting for earnings heterogeneity has a modest effect on our results. Guvenen et al.'s estimates imply a U-shaped exposure, whose net effect is to make income inequality more *procyclical* than in the benchmark economy. The impact on the model's multiplier are moderate, and are mitigated further by the progressive tax and transfer system. As a result, the set of (ϕ_π, ϕ_B) implying a unique bounded equilibrium expands and the inflation response to monetary policy for a given policy regime is dampened, but only a little. The dampening is not uniform across the pre-COVID and post-COVID regimes: the extended model implies a slightly larger weakening of monetary policy than our benchmark model, as shown by Table 10.

Table 10: Inflation Response Across Model Variants

	Benchmark ϕ_B (0.13/0.10)			Recalibrated ϕ_B		
Horizon	pre	post	weakening	pre	post	weakening
A. Benchmark model						
$h = 1$	−0.037	−0.027	28%			
$h = 8$	−0.016	−0.003	79%			
B. Long-term debt ($\phi_B = 0.51/0.29$)						
$h = 1$	−0.044	−0.045	−3%	−0.055	−0.050	9%
$h = 8$	−0.017	−0.015	10%	−0.032	−0.027	16%
C. Cyclical risk ($\phi_B = 0.14/0.10$)						
$h = 1$	−0.035	−0.025	29%	−0.037	−0.025	31%
$h = 8$	−0.014	−0.002	87%	−0.015	−0.002	87%

Notes: Each cell reports the model's inflation response to a 25-basis-point contractionary monetary policy shock with quarterly persistence of 0.8, in percent, on impact ($h = 1$) and averaged over the first eight quarters ($h = 8$). For each variant and horizon, "pre" and "post" give the response in the pre- and post-COVID regimes, and "weakening" is $1 - \text{post/pre}$, the proportional decline in the disinflationary effect of monetary tightening. The left block holds the fiscal reaction at the benchmark-calibrated values; the right block re-estimates ϕ_B within each extension (see values in the panel headings).

5 Conclusion

We develop a novel high-frequency measure of the expected fiscal reaction to monetary policy from the spread between taxable Treasuries and tax-exempt municipal bond ETFs, and use it to provide the first high-frequency evidence that contractionary monetary shocks raise expected taxes; markets expect fiscal policy to back monetary tightening. This reaction has changed markedly since COVID: it has roughly halved and no longer rises with government indebtedness. These changes suggest a drift from a regime of passive fiscal policy toward one in which debt is increasingly expected to be inflated away rather than repaid through taxes. Feeding these estimates into a HANK model with non-Ricardian households, we find that the weaker post-COVID fiscal reaction makes monetary tightening materially less disinflationary—by about a quarter on impact and 80 percent at a two-year horizon—a sizable attenuation of monetary policy's power to contain inflation.

More broadly, our strategy can recover the expected fiscal reaction to any high-frequency shock, opening the door to studying legislative actions, elections, or rare disasters. Studying these may shed further light on how these fiscal expectations and reactions are formed, a poorly understood topic. These expectations can shift quickly and in ways standard models do not predict. Bassetto and Miller (2025) describe one such transition, in which a worry that taxes will not cover the debt in real terms triggers heightened sensitivity of bond prices to fiscal news and possibly a sudden inflation. Since debt must eventually be repaid or inflated away, the responsiveness of tax expectations to monetary shocks may serve as a warning metric for which path the government is expected to pursue.

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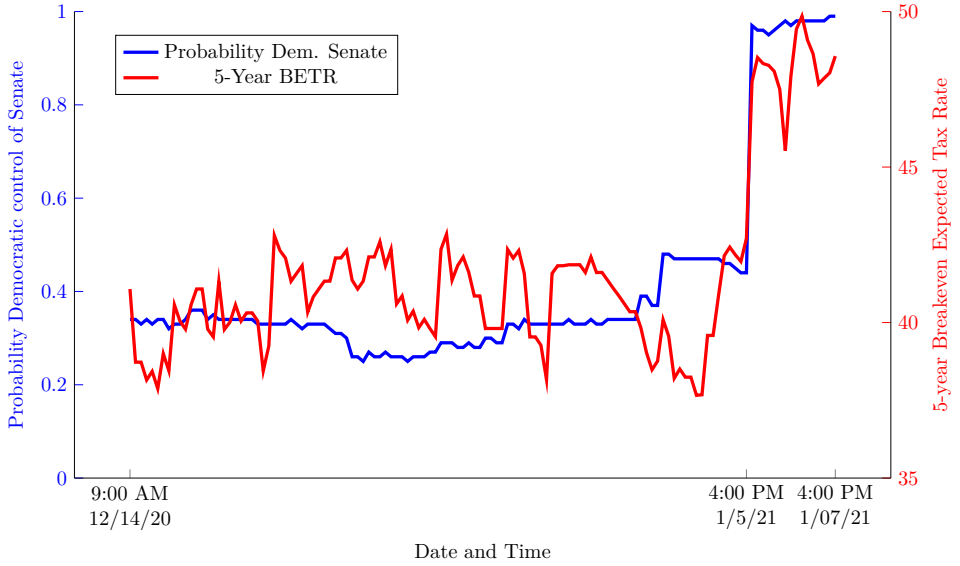
A BETR around 2020 Georgia Election Runoff

The Georgia Senate runoff election of 2020 offers a good test of whether the BETR moves in expected ways in response to shocks. The Federal elections on November 3rd, 2020 resulted in the election of President Biden and a Democratic House, while control of the Senate was undetermined. Control of the Senate depended on a Georgia runoff election, scheduled for January 5th, 2021. As Democrats put forth large spending plans, Hazell and Hobler (2024) argue that substantial differences in expectations of future fiscal policy hinged on the election. To the extent the BETR forecasts future tax rates and individuals expect spending to be repaid, changes in the likelihood of Democratic control of the Senate should lead to positive changes in expected future taxes.

Figure A.1 shows the hourly 5-year BETR during market hours calculated using Bloomberg's BVAL AAA Municipal Curve and the 5-Year Treasury converted to zero-coupon yields. The impact of the election is clear. The BETR and the probability of Democratic control of the Senate (provided by PredictIt) rise sharply between the close of markets on January 5th and the open on January 6th. (Notably, the average 5-year BETR before the election in Figure A.1 is 40.6%, almost equal to what we now know, 5 years later, was the actual 5-year BETR of 40.8% that came from not allowing the 2017 TJCA rate cuts to expire in 2025, and the additional 3.8% from the Net Investment Income Tax (NIIT).)

We follow Hazell and Hobler (2024) and calculate the impact of changing probabilities of Democratic control of the Senate on the BETR using daily probabilities between November 3rd, 2020, the day after the general election, and January 7th, 2021, the day after the runoff election. (The results are robust to any reasonable selection of dates.) Controls are the yield on the 5-year Treasury interacted with change in the probability of Democratic control of the Senate (to control for the non-linearity in the BETR calculation), and changes in the MOVE index that measures Treasury volatility, the Markit MCDX index that measures CDS prices for municipal bonds, the VIX index that measures equity volatility, and the convenience yield on the

Figure A.1: Election Probability and 5-Year BETR around the January 5th Georgia Runoff



The blue line corresponding to the left-hand side y-axis is the probability that Democrats win the majority of seats (counting the Vice-President) in the U.S. Senate. The red line corresponding to the right-hand side y-axis is the 5-year breakeven expected tax rate. The data is hourly, available during market hours; overnight hours are dropped.
Source: Authors' calculations, PredictIt, Bloomberg

Table A.1: Impact of changes in probability of Democratic control of Senate on changes in the 5-Year BETR

	d(5-Year BETR)
d(Probability of Democratic control of Senate)	5.856***
	(2.008)
Controls	Yes
Num.Obs.	43
R2 Adj.	0.312

Note: * p <0.1, ** p <0.05, *** p <0.01
Newey-West standard errors in parentheses.
Source: Authors' calculations, PredictIt, Bloomberg

5-Year Treasury.

Table A.1 shows the results of regressing the change in the 5-year BETR on the change in the probability of Democratic control of the Senate. The coefficients are expressed in percentage points: a 1 percentage point increase in the probability of a Democratic Senate is associated with a roughly 6 bps rise in the 5-year expected tax rate. To illustrate this magnitude using A.1, as the probability of a Democratic sweep rose from about 40% to 100% between January 5th and January 6, 2021, the regression implies the increase in the 5-year BETR should be 4 ppt, while in data it was about 6 ppt.

B Data Construction

Equation 3 defines the change in BETR given information on Treasuries, municipal bonds, and ETFs. In this section, we go through the data used in the regressions that estimate the impact of monetary policy shocks on the change in the BETR. The ETF prices come from WRDS, the rest of the data was accessed through the Bloomberg Terminal.

Looking at the components of Equation 3, for Treasury yield, we use

the yields of Treasuries at 3-month, 2-year, 5-year, 7-year, and 10-years maturities. Using the coupons of the Treasuries, we translate from maturity to duration, then use the Svensson (1994) model to build a Treasury yield curve to match the duration of the ETFs. For the yield on municipal bonds, we use yields from the Bloomberg BVAL AAA Municipal curve at 3-month, 2-years, 5-years, 7-years, and 10-years maturities. Using the 5% coupon on the bonds, we translate from maturity to duration, then build a municipal yield curve to match the duration of the ETFs. Because the BVAL AAA Municipal indexes are hourly but our high-frequency windows do not start on the hour, we will update the yield at an ETF's duration using the price change from the nearest hour and Equation 3. For example, the FOMC statement release window begins at 1:50 pm. We find the 2 pm yield at an ETF's duration from the BVAL AAA Municipal curve, then use the change in price of the ETF from 1:50 pm to 2 pm to calculate the implied 1:50 pm yield.

For ETF prices, we use WRDS to download price data on days with regularly scheduled FOMC meetings. For ETF duration, we use the effective duration of the ETFs, available at a daily frequency from Bloomberg. While municipal bonds usually have call options after 10 years which is not reflected in the effective duration calculation, the majority of municipal bonds held by these ETFs are of shorter maturities and the callability will be reflected in prices and controlled for using the discount to net asset value. There is a separate measure of ETF duration available from a Morningstar survey of ETF managers at a monthly frequency; results are similar as most of the ETFs do not change maturity much on a monthly frequency.

For the regressions, we include a number of risk and liquidity measures as controls. The Bloomberg CDX.NA.IG 5Y index is a market measure of CDS prices on investment grade debt with a 5 year horizon. We use estimates of an ETF's net asset value (NAV) from Bloomberg, and calculate the change in the discount to NAV using the price data. We calculate the convenience yield on Treasuries at an ETF's duration using Treasury data and an OIS curve constructed from 3-month, 2-year, 5-year, 7-year, and 10-year maturities. When needed, we construct expected inflation at an

ETF's duration using inflation swaps at 2-year, 5-year, 7-year, and 10-year maturities.

For monetary policy shock data, we use the Monetary Policy Surprises database available from the Federal Reserve Bank of San Francisco Federal Reserve Bank of San Francisco, Center for Monetary Research (2026). This database contains meeting dates, times for the release of the FOMC statement and press conference, as well as a wide variety of monetary policy shocks. Due to the relatively recent introduction of municipal bond ETFs, and data limitations regarding Bloomberg's duration and net asset value data, the dataset consists of regularly scheduled meetings from 2016 to 2025. The dataset includes non-overlapping windows around both the release of the FOMC statement, from 1:50 pm to 2:20 pm, and, when held, the Chair's press conference that follows from 2:20 pm to 3:30 pm. These windows match the windows in the Monetary Policy Surprises database. All analysis is robust to considering only FOMC statement releases.

C Real and Expected Inflation Shocks

For these regressions, we interact both real and inflation shocks with the yield on the ETF-maturity Treasury and recenter all shocks for each sample.

$$\begin{aligned}\Delta\tau_{ETF,t} = \alpha_{ETF} &+ \beta_1 Y^T_{ETF,t} \\ &+ \beta_2 \text{Real Shock}_t + \beta_3(\text{Real Shock}_t \times Y^T_{ETF,t}) \\ &+ \beta_4 \text{Inflation Shock}_t + \beta_5(\text{Inflation Shock}_t \times Y^T_{ETF,t}) \\ &+ \gamma \text{Controls}_{ETF,t} + \epsilon_{ETF,t}\end{aligned} \tag{23}$$

Table C.1 presents the relevant coefficients for the ETF MUB for the full 2016-2025 sample, the Pre-COVID, and post-COVID sample for both the 10- and 2-Year Treasury shocks. (Running a Bai-Perron test on the new regression results in similar breakpoints as earlier in Table 7.) The real shocks are highly significant for all periods for both shocks. These shocks have halved in magnitude post-COVID, similar to the finding in Section

Table C.1: MUB: Effect of Monetary Policy Shocks on BETR

	Full sample	Pre-COVID	Post-COVID	Full sample	Pre-COVID	Post-COVID
Real 10-Year Treasury Shock	0.438***	0.529***	0.247***			
	(0.063)	(0.079)	(0.024)			
10-Year Inflation Swap	0.385***	0.534***	0.258***			
	(0.081)	(0.132)	(0.040)			
Real 2-Year Treasury Shock				0.210***	0.296***	0.120***
				(0.022)	(0.048)	(0.020)
2-Year Inflation Swap				0.188***	0.223	0.147***
				(0.034)	(0.135)	(0.050)
Real Shock x Y^T_{MUB}	−0.084**	−0.524***	−0.020	−0.054***	−0.219*	−0.006
	(0.036)	(0.114)	(0.026)	(0.013)	(0.109)	(0.015)
Inflation Swap x Y^T_{MUB}	−0.054	−0.328	0.028	0.007	0.007	0.006
	(0.067)	(0.198)	(0.038)	(0.032)	(0.182)	(0.030)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Num.Obs.	130	54	57	130	54	57
R2 Adj.	0.544	0.835	0.804	0.390	0.656	0.707

Note: * p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.
Source: Authors' calculations, Bloomberg

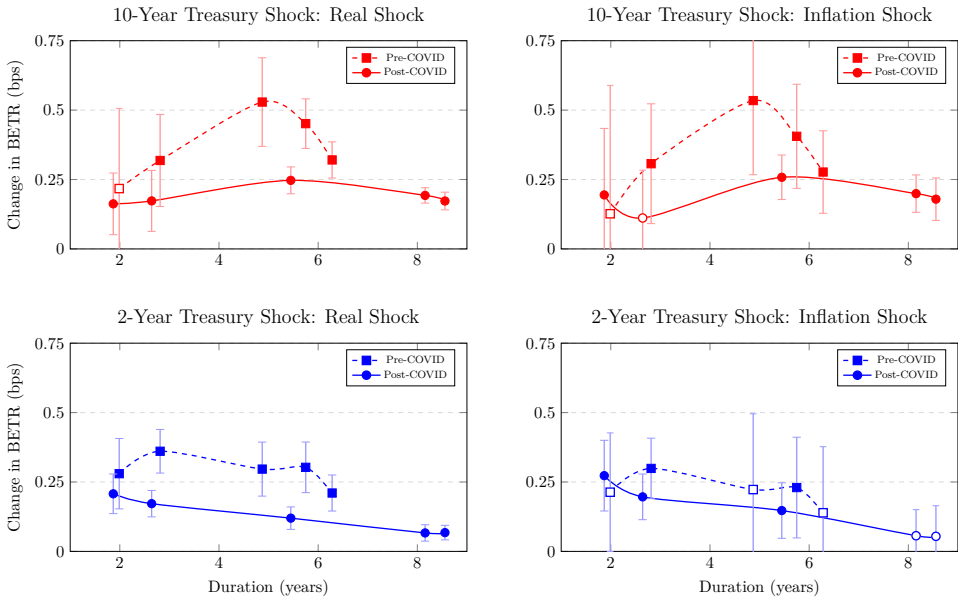
2.3. Inflation shocks are significant for the 10-year Treasury shock and show the same halving in magnitude as the real shocks. For the 2-Year Treasury shock, nominal shocks are significant post-COVID and in the full sample.

Expanding our focus from MUB to all five ETFs, Figure C.1 plots the coefficient on the real and inflation components of the 10- and 2-Year Treasury shocks. The fall in magnitude between pre- and post-COVID periods is apparent across the ETFs. The 2-year Treasury shock induces statistically insignificant changes in the BETR post-COVID while the real shock survives, albeit at a lower magnitude than the 10-year Treasury shock.

D Further measures of Indebtedness

In the main text, Table 9 shows measures of government indebtedness using par government debt at a monthly frequency while GDP remains quarterly. Par debt is released publicly at a monthly frequency. For robustness, we show that the same positive relationship between indebtedness and tax rates pre-COVID, and lack of relationship post-COVID is displayed using quarterly measures of indebtedness, and using the CBO's measure of quarterly

Figure C.1: Marginal Effect of Real and Nominal Monetary Policy Shocks at Average Yield on the BETR: Pre- vs. Post-COVID



This figure plots the estimated marginal effects of the real and inflation components of a 1-basis-point monetary policy shock on the Breakeven Expected Tax Rate (BETR) across municipal ETFs. The marginal effects are evaluated at the average ETF-maturity matched Treasury yield specific to each subsample (pre-COVID and post-COVID). Error bars represent 95% confidence intervals estimated using robust standard errors. Hollow markers indicate non-statistically significant coefficients. Smoothed lines added for readability. Source: Authors' calculations, Bloomberg

potential GDP rather than actual GDP.

Table D.1 uses quarterly debt measures rather than monthly.

Table D.1: Coefficients on Real 10-Year Treasury Shock x Quarterly Debt Measures Pre- and Post-COVID

	SUB	SHM	MUB	PZA	HYMB
Pre-COVID					
Debt-to-GDP	0.034	−0.084	0.032***	0.005	0.042***
	(0.056)	(0.051)	(0.006)	(0.016)	(0.014)
WAM Debt-to-GDP	0.051***	−0.008	0.009***	−0.005	0.000
	(0.013)	(0.010)	(0.002)	(0.005)	(0.002)
Net Int-to-GDP	1.261***	0.675***	0.052	−0.046	0.114
	(0.409)	(0.144)	(0.162)	(0.190)	(0.079)
Post-COVID					
Debt-to-GDP	0.002	−0.015	0.011	0.009	0.001
	(0.013)	(0.016)	(0.007)	(0.006)	(0.007)
WAM Debt-to-GDP	−0.003	−0.003	0.001	0.002	0.003
	(0.009)	(0.006)	(0.004)	(0.003)	(0.003)
Net Int-to-GDP	0.033	0.024	0.070**	0.042	0.010
	(0.061)	(0.076)	(0.026)	(0.041)	(0.043)

* p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.

Table D.2 uses measures of debt relative to potential GDP rather than actual GDP. Potential GDP is preferred in these applications as recessions cause substantial deviations of GDP from potential. Using actual GDP causes debt ratios to rise due to the denominator, possibly biasing results when compared to normal times where actual GDP is near potential.

Table D.2: Coefficients on Real 10-Year Treasury Shock x Quarterly Debt Measures Pre- and Post-COVID

	SUB	SHM	MUB	PZA	HYMB
Pre-COVID					
Debt-to-Pot. GDP	0.065	0.038	0.048***	0.012	0.021
	(0.043)	(0.045)	(0.014)	(0.011)	(0.014)
WAM Debt-to-Pot. GDP	0.020*	0.011*	0.008**	0.000	0.005
	(0.010)	(0.006)	(0.004)	(0.003)	(0.004)
Net Int-to-Pot. GDP	3.176***	1.515***	0.554*	0.013	0.399*
	(0.475)	(0.367)	(0.312)	(0.351)	(0.228)
Post-COVID					
Debt-to-Pot. GDP	0.005	−0.012	0.010	0.007	−0.000
	(0.012)	(0.015)	(0.006)	(0.005)	(0.006)
WAM Debt-to-Pot. GDP	−0.001	−0.003	0.002	0.001	−0.000
	(0.008)	(0.006)	(0.004)	(0.002)	(0.002)
Net Int-to-Pot. GDP	0.043	0.000	0.067**	0.031	−0.020
	(0.075)	(0.084)	(0.031)	(0.046)	(0.054)

* p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.

E ETF-Inflation Expectations

Because the U.S. tax code applies to nominal rather than real income, the value of the municipal tax exemption is mechanically sensitive to expected inflation, the Darby-Feldstein effect. In this section, we isolate shifts in changes in BETR from the mechanical effect of inflation expectations by controlling for those changes in inflation expectations. The control is constructed to match the duration of the underlying municipal ETF, rather than decomposing the aggregate monetary policy shock itself. This approach isolates inflation-driven changes to the BETR rather than separating real vs. nominal shocks.

To construct the inflation expectations control, we estimate a zero-

Table E.1: MUB: Effect of Monetary Policy Shocks on BETR with Inflation Control

	(1)	(2)	(3)	(4)
10-Year Treasury Shock	0.462***	0.335***		
	(0.063)	(0.082)		
MPS Shock			0.262***	0.057
			(0.049)	(0.037)
Inflation Swap		0.092***		0.181***
		(0.026)		(0.024)
10-Year Treasury Shock x Y^T_{MUB}	−0.080***	−0.077**		
	(0.029)	(0.029)		
MPS Shock x Y^T_{MUB}			−0.091***	−0.064***
			(0.025)	(0.019)
Controls	Yes	Yes	Yes	Yes
Num.Obs.	130	130	130	130
R2 Adj.	0.544	0.577	0.291	0.449

* p <0.1, ** p <0.05, *** p <0.01
Robust standard errors in parentheses.

coupon inflation swap curve using data at 2-year, 5-year, 7-year, and 10-year maturities. We then find the change in the inflation swaps at the maturity of each ETF on each date. By including this matched inflation swap as a covariate, we hold the inflation-related tax premium constant over the values of the ETF.

Table E.1 reports the results of including this ETF-matched inflation control for the MUB baseline. Models 1 and 3 reproduce the baseline results from Table 1 for comparison, while Models 2 and 4 introduce the inflation swap control.

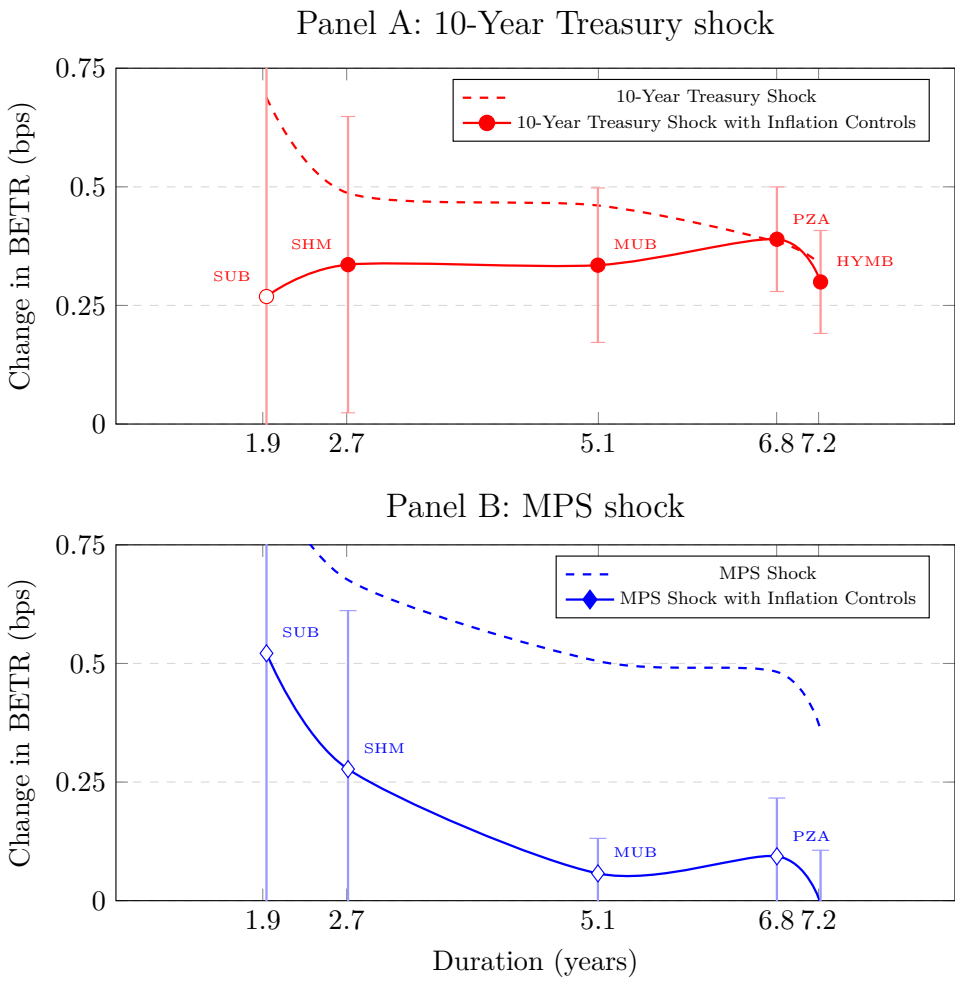
The inclusion of the inflation control yields a statistically significant positive coefficient and meaningfully increases the adjusted R^2 across both shock specifications. Notably, while the coefficient on the 10-Year Treasury shock is modestly attenuated in Model 2, it retains strong statistical significance. In contrast, the coefficient on the MPS shock in Model 4 drops substantially and loses all statistical significance.

Figure E.1 confirms that this separation holds across the maturity spec-

trum of municipal ETFs: the 10-Year Treasury shock continues to exert a significant impact on the BETR net of inflation controls, whereas the MPS shock does not.

The elimination of statistical significance in the MPS results seen in Figure E.1 once inflation expectations are included in the controls, suggests that the prior significance seen in Figure 1 is driven by the Darby-Feldstein effect rather than a shift in real fiscal expectations. Mechanically, because taxes are levied on nominal rather than real income, a rise in expected inflation reduces the after-tax real return on Treasuries unless yields rise more than one-for-one $\Delta y^T \approx \frac{\Delta \pi}{1-\tau} > 1$. Tax-exempt municipal bonds do not require this additional movement. Consequently, a monetary policy shock that raises inflation expectations will mechanically widen the spread between Treasuries and municipal bonds, appearing as an increase in BETR. The elimination of the MPS shock's significance when controlling for ETF-maturity inflation expectations suggests its baseline effect is largely driven by this Darby-Feldstein effect. Conversely, the robustness of the 10-Year Treasury shock implies that it affects tax expectations through a distinct channel. This real channel is consistent with the tightening of the government's intertemporal budget constraint via a higher real interest-on-debt burden.

Figure E.1: Marginal Effect of Monetary Policy Shocks at Average Yield on the BETR: With vs. Without Inflation Controls



This figure plots the estimated marginal effect of a 1 basis point contractionary monetary policy shock on the Breakeven Expected Tax Rate (BETR) across municipal ETFs with and without inflation controls. In Panel A, the shock is the 10-Year Treasury, in Panel B the shock is the MPS Shock. The marginal effects are evaluated at the average ETF-matched maturity Treasury yield for each ETF. Error bars represent 95% confidence intervals estimated using robust standard errors. Hollow markers indicate statistical insignificance.

F Additional Model Details and Extensions

Section F.1 defines the model-implied moments that we use to calibrate the fiscal rule. Section F.2 provides additional details for the long-bonds extension. Section F.3 provides additional details for the earnings-heterogeneity extension.

F.1 Construction of Model-Implied Moments

Top marginal tax rate. The marginal tax rate faced by a household with pre-tax income y is

$$\text{MTR}(y, \tau_t) \;=\; \frac{\partial \mathcal{T}(y, \tau_t)}{\partial y} \;=\; 1 - (1 - \tau_t)(1 - \lambda)\, y^{-\lambda}. \tag{24}$$

Evaluating at pre-tax income $y = Y_t z$ and averaging over the top 1% of the productivity distribution—those with $z > z_{99}$, the 99th percentile of the stationary distribution of z—gives the top marginal tax rate

$$\text{MTR}_t^{\text{top}} \;=\; 1 - (1 - \tau_t)(1 - \lambda)\, \mathbb{E}\Big[(Y_t z)^{-\lambda} \,\Big|\, z > z_{99}\Big]. \tag{25}$$

Because the fiscal rule moves only the level shifter τ_t, the impulse response of the top marginal tax rate is linear in the response of τ_t,

$$d\text{MTR}_t^{\text{top}} \;=\; (1 - \lambda)\, \mathbb{E}\Big[(Y^* z)^{-\lambda} \,\Big|\, z > z_{99}\Big]\, d\tau_t, \tag{26}$$

where the income base is held at its steady-state value Y^*.

Ten-year treasury rate. The model's short nominal rate R_t^n implies a 10-year nominal yield as the geometric average of the short rate over the next 40 quarters (10 years),

$$R_t^{n,10} \;=\; \left(\prod_{j=0}^{39} R_{t+j}^n\right)^{1/40}. \tag{27}$$

F.2 Long Bonds

Let Q_t denote the nominal price of a newly-issued unit and N_t the number of units outstanding at the end of period t. No arbitrage requires that the expected return on the bond between period t and $t+1$ equals the short-term nominal rate set by the central bank:

$$R_t^n = \mathbb{E}_t \left[\frac{1 + \delta Q_{t+1}}{Q_t} \right]. \tag{28}$$

The government budget is

$$\underbrace{Q_t \left(N_t - \delta N_{t-1} \right)}_{\text{value of new issuance}} + \underbrace{P_t T_t}_{\text{tax revenues}} = \underbrace{N_{t-1}}_{\text{coupon payments}} + \underbrace{P_t G^*}_{\text{spending}} \tag{29}$$

Letting $P_t B_t = Q_t N_t$ denote the nominal value of debt, as in the benchmark model, we can rewrite the budget as

$$P_t B_t + P_t (T_t - G^*) = (1 + \delta Q_t) N_{t-1} = \left(\frac{1 + \delta Q_t}{Q_{t-1}} \right) P_{t-1} B_{t-1} \tag{30}$$

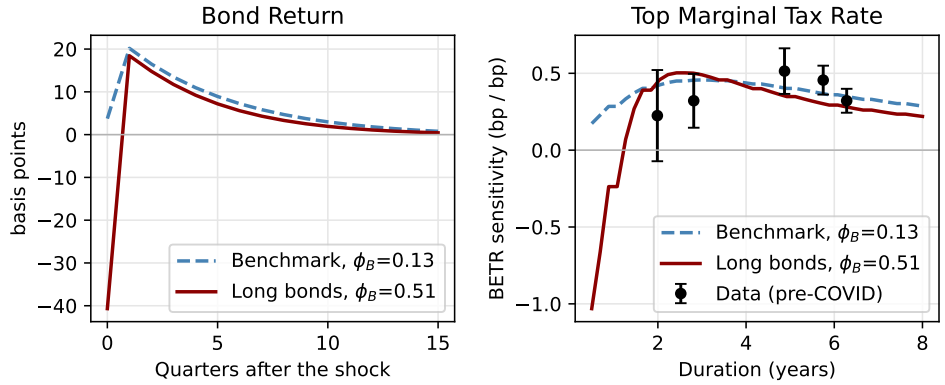
before dividing by the price level to obtain budget from the main text

$$B_t + T_t = \underbrace{\left(\frac{1 + \delta Q_t}{Q_{t-1}} \right) \frac{1}{\pi_t}}_{\equiv R_t^b} B_{t-1} + G^*. \tag{31}$$

Conditional on a given path of nominal interest rates and inflation, no-arbitrage and perfect foresight implies the return on a one-period bond ($\delta = 0$) is the same as a return on a long bond ($\delta > 0$) for all $t > 0$, since both are perceived as riskfree. What long bonds change is the one-time revaluation in response to an unanticipated monetary policy shock in period 0. The left panel of Figure F.1 shows that monetary tightening—with $\phi_\pi = 2$ and ϕ_B calibrated to match the estimated path of BETR—increases the real return on one-period bonds but devalues long bonds. The right panel shows that matching the observable path of BETR requires a substantially higher ϕ_B. The government must quickly disburse its gains from the initial fall in bond

prices, and then raise taxes to finance its obligations as it rolls over debt at higher interest rates.

Figure F.1: Asset-Price Redistribution in the Long-Bond Extension



Notes: The figure compares the benchmark model with one-period debt ($\delta = 0$, dashed) to the long-bond extension calibrated to a five-year duration ($\delta = 0.96$, solid), each at its own pre-COVID calibration ($\phi_\pi = 2$; $\phi_B = 0.13$ in the benchmark, 0.51 under long debt). The left panel shows the realized real return on government bonds following a 25-basis-point contractionary monetary policy shock. The right panel shows the model-implied BETR sensitivity across bond durations against the pre-COVID empirical cross-section (markers, with ± 2 standard-error bars).

F.3 Earnings Heterogeneity

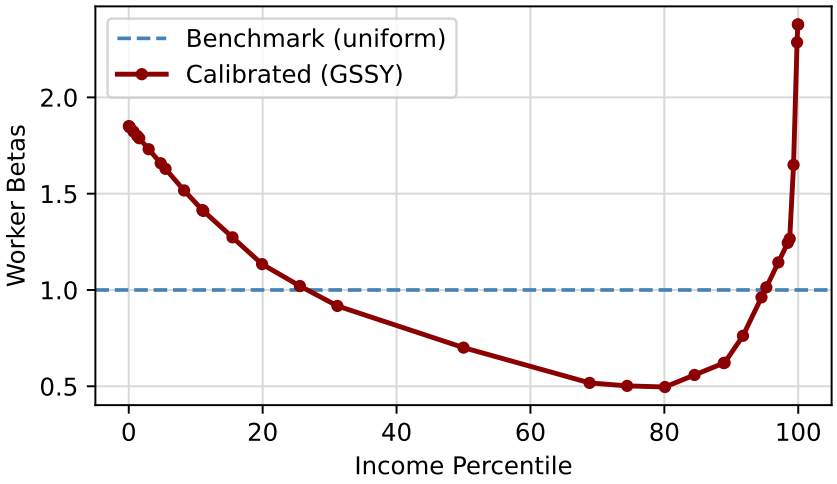
The only restriction on $\gamma(z)$ is that it satisfies the adding-up constraint

$$Y_t = \int zY^* \left(\frac{Y_t}{Y^*}\right)^{\gamma(z)} dD_t(z, a_{-1}). \tag{32}$$

We calibrate $\gamma(z)$ to the estimates of Guvenen et al. (2017) (GSSY). Specifically, we take their GDP betas for males aged 36–45, linearly interpolate them to obtain a $\hat{\gamma}(z)$ for every income grid point, and scale by a common multiplicative factor, $\gamma(z) = \text{const} \cdot \hat{\gamma}(z)$, to satisfy the adding-up constraint.

Figure F.2 plots the resulting $\gamma(z)$ vector against the income percentiles. The elasticities display a U-shape, with the bottom 27% and top 5% of households being more exposed than the average household.

Figure F.2: Earnings Elasticities in the Cyclical-Risk Extension



Notes: The figure plots the calibrated earnings elasticities $\gamma(z)$ against income percentiles.