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Shortening the Sovereign Balance Sheet: Treasury Bill Stock Share, Primary-Auction Absorption, and Carrying-Cost Pass-Through Across Quantitative Tightening Regimes

Thomas Merrifield[a], Sophie Hadfield[a], Nargiza Qodirova[a]

[a]Academy of Public Policy and Economics, London E1 0SG, United Kingdom

Corresponding author: Thomas Merrifield, thomas.merrifield@pe.ac.

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Abstract

Sovereign debt-management models posit an operational trade-off between shortening debt maturity to capture money-like convenience demand in primary auctions and exposing the fiscal balance sheet to faster interest-rate pass-through when policy rates rise. We evaluate both margins across Federal Reserve balance-sheet regimes from January 2015 through October 2026 by linking 4,136 primary-market auctions of U.S. Treasury bills and nominal coupon securities (1,774 unique securities across 142 year-months and 76 fine remaining-maturity tenors) with 142 monthly marketable debt and book interest-rate statements. Conditional on auction month and fine maturity tenor, competitive tenders expand less than proportionally with offering size: during the second quantitative tightening (June 2022–1 December 2025), the log competitive-tender elasticity for Treasury bills is 0.8792 (two-way clustered SE = 0.0314; wild cluster bootstrap p = 0.050 against unit proportionality) and declines to 0.7178 (SE = 0.0386) during post-runoff reserve management from December 2025 onward (regime difference = -0.1614, bootstrap p = 0.005), steepening the bill bid-to-cover slope from -0.4392 (bootstrap p = 0.041) to -0.9237 (bootstrap p = 0.002). Larger offerings during the second quantitative tightening coincide with higher indirect-bidder award shares (+7.0407 percentage points per log offering for bills, bootstrap p = 0.031; +7.5916 percentage points for coupons, bootstrap p = 0.017) and lower primary-dealer residual shares, although wild cluster bootstrap p-values soften above 0.05 under 15-benchmark-family clustering (0.090 and 0.094), without cash management bills (0.113), or outside extraordinary-measures periods (0.085 and 0.633). On the carrying-cost margin, published marketable average interest rates exclude inflation-protected and floating-rate principal and diverge from par-weighted fixed-rate reconstructions by 0.1936 basis points on average (0.8877 basis points maximum) due to net-carrying-value bill discounting. In dynamic monthly models (N = 138), an isolated 100-basis-point federal funds rate hike yields a direct four-lag coefficient sum of 15.10 basis points (HAC SE = 3.11) and, after autoregressive propagation (rho = 0.3507, p = 0.0047), a cumulative four-month impulse response of 22.84 basis points (delta-method HAC SE = 2.66, p < 0.0001; long-run multiplier 23.25 basis points), aligning closely with forward-controlled local projections (24.38 basis points at horizon h = 3). By contrast, the four-month differential for a 10-percentage-point higher bill stock share is statistically inconclusive (+6.72 basis points, HAC SE = 7.11, p = 0.3459; +1.21 basis points, p = 0.8967 under predetermined matched-lag shares), while symmetric shift-share decompositions confirm that 98.3% of direct four-lag policy pass-through operates through within-class rate resets.

Keywords: sovereign debt maturity; Treasury bill stock share; primary-market auctions; quantitative tightening; interest-rate pass-through; primary dealers

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1. Introduction

Sovereign debt managers confront a structural maturity trade-off whenever central banks shrink their balance sheets and raise policy interest rates simultaneously. Issuing short-term Treasury bills captures money-like convenience premia from liquidity-seeking investors and economizes on long-horizon term premia (Greenwood et al., 2015; Nagel, 2016), yet maintaining a larger short-term debt stock requires frequent rollover in primary auctions and exposes government interest obligations to faster repricing when policy rates climb (Shin, 2007; Nosbusch, 2008; Hall & Sargent, 2011). Between June 2022 and 1 December 2025, the Federal Reserve conducted its second balance-sheet runoff while maintaining elevated policy rates, before concluding runoff and transitioning to reserve-management purchases in December 2025 (Board of Governors of the Federal Reserve System, 2025). Over the entire January 2015–October 2026 cycle, three distinct issuance and stock margins evolved jointly: individual fixed-rate auction offering sizes ranged from \$0.03 billion to \$110.00 billion, gross monthly bill issuance accounted for 58.72% to 94.32% of gross marketable auction volume due to intra-year rollover, and the month-end outstanding Treasury bill share of nominal fixed-rate marketable debt varied between 11.19% and 28.32%—rising from 16.70% entering June 2022 to 23.5%–25.3% across 2024–2026 (U.S. Department of the Treasury, Office of Debt Management, 2025; U.S. Department of the Treasury, Bureau of the Fiscal Service, 2026).

Existing empirical scholarship examines the secondary-market yield effects of Treasury supply (Duffee, 1996; Krishnamurthy & Vissing-Jorgensen, 2012; D'Amico & King, 2013; Gourinchas et al., 2025) and primary-dealer balance-sheet frictions around individual auctions (Lou et al., 2013; Fleming et al., 2024), yet two joint questions central to fiscal-monetary coordination remain open across the completed 2022–2025 quantitative tightening cycle and its post-runoff aftermath. First, conditional on auction year-month and fine remaining-maturity tenors, how elastically do competitive tenders and non-dealer bidding channels scale with individual auction offering sizes across Federal Reserve balance-sheet regimes? Second, once official carrying-cost accounting conventions across security classes are audited and autoregressive dynamics are propagated properly, does a higher outstanding Treasury bill stock share measurably accelerate monthly pass-through from federal funds rate changes into the published average interest rate on marketable debt?

We evaluate both margins using a unified dataset spanning January 2015 through October 2026 that links 4,422 official U.S. Treasury marketable security auctions (4,136 fixed-rate bill and nominal coupon auctions across 1,774 unique securities, 142 year-months, and 76 fine remaining-maturity tenors, alongside 286 inflation-protected and floating-rate auctions) with 142 monthly public-debt and book interest-rate statements (U.S. Department of the Treasury, Bureau of the Fiscal Service, 2026; Federal Reserve Bank of St. Louis, 2026). Methodologically, we pair finite-sample-corrected two-way clustered covariances (Cameron et al., 2011) with restricted wild cluster bootstrap test inversion (MacKinnon et al., 2021) for auction-level conditional slopes, and combine autoregressive distributed-lag (ADL) impulse responses (Newey & West, 1987), forward-controlled cumulative local projections (Jordà, 2005; Teulings & Zubanov, 2014), and exact symmetric shift-share decompositions for monthly carrying rates.

Three empirical findings define our contribution. First, competitive primary-market tenders expand sub-proportionally with offering size within fine maturity buckets, and that marginal attenuation intensifies for Treasury bills after balance-sheet runoff ends. During the second quantitative tightening, the log competitive-tender elasticity for bills is 0.8792 (wild cluster bootstrap $p = 0.050$ against unit proportionality), declining by 0.1614 to 0.7178 in the post-runoff reserve-management regime from December 2025 onward (bootstrap $p = 0.005$ for the regime contrast) and steepening the within-tenor bill bid-to-cover slope from −0.4392 to −0.9237. Second, larger offerings during the second quantitative tightening co-

incide with higher indirect-bidder competitive award shares (+7.0407 percentage points per log offering for bills, bootstrap $p = 0.031$; +7.5916 percentage points for nominal coupons, bootstrap $p = 0.017$) and lower primary-dealer residual shares, driven in log-additive decompositions by super-proportional indirect dollar award elasticities (1.2726 for bills); at the same time, finite-cluster sensitivity checks show that wild cluster bootstrap p-values rise above 5% under 15-benchmark-family clustering ($p = 0.090$ and 0.094), when cash management bills are excluded ($p = 0.113$), or when statutory extraordinary-measures periods—when money market funds rotated heavily out of the Federal Reserve's Overnight Reverse Repurchase facility into bills—are omitted ($p = 0.085$ and 0.633). Third, an exact accounting audit establishes that Treasury's published total marketable average interest rate excludes inflation-protected and floating-rate principal, retains Federal Financing Bank obligations, and lies slightly below par-weighted fixed-rate reconstructions during high-rate periods (mean absolute gap 0.1936 basis points; maximum 0.8877 basis points) because zero-coupon bills enter official averages at net carrying value after subtracting unamortized discount. In dynamic monthly models, an isolated 100-basis-point federal funds rate hike generates a recursive four-month cumulative book-rate response of 22.84 basis points (HAC SE = 2.66, $p < 0.0001$; long-run multiplier 23.25 basis points) and a forward-controlled local-projection response of 24.38 basis points at horizon $h = 3$, whereas unconditioned local projections reach 51.59 basis points at $h = 3$ by compounding multi-meeting tightening cycles. Across both baseline and predetermined matched-lag specifications, the interaction between policy-rate changes and lagged bill stock share remains statistically inconclusive (+6.72 basis points over four months, HAC SE = 7.11, $p = 0.3459$; +1.21 basis points, $p = 0.8967$ with predetermined shares), while symmetric shift-share decompositions independently confirm that 98.3% of direct four-lag policy pass-through into reconstructed carrying rates operates through within-class rate resets.

These results connect three strands of scholarship. Relative to preferred-habitat and convenience-yield theories of government debt maturity (Greenwood et al., 2010; Krishnamurthy & Vissing-Jorgensen, 2015; Krishnamurthy et al., 2018; Vayanos & Vila, 2021; Cashin et al., 2023), we show that marginal within-tenor bill tender elasticities weakened measurably in 2026 even after balance-sheet runoff ended. Relative to auction microstructure studies of dealer intermediation, bid shading, and reopenings (Fleming, 2002; Fleming & Garbade, 2007; Goldreich, 2007; Tchuindjo, 2015; Hortaçsu et al., 2018; Boyarchenko et al., 2021), we decompose competitive routing shares into matched log numerator and denominator elasticities across five policy regimes while mapping exact finite-cluster inference boundaries. Finally, relative to analyses of dealer balance-sheet constraints and post-pandemic Treasury market liquidity (Vissing-Jorgensen, 2021; He et al., 2022; Klingler & Sundaresan, 2023), we pair primary-auction absorption diagnostics with an exact audit and dynamic reconciliation of sovereign carrying-cost pass-through.

2. Institutional Framework and Formal Analytical Hypotheses

2.1. Balance-Sheet Regimes and Primary Auction Rules

Marketable U.S. Treasury securities are issued via single-price auctions governed by the Uniform Offering Circular, 31 CFR Part 356 (U.S. Department of the Treasury, Bureau of the Fiscal Service, 2025). Competitive tenders are routed through three administrative channels: primary dealers obligated to bid pro rata across auctions, direct bidders submitting competitive tenders for their own house accounts, and indirect bidders placing competitive bids through a direct submitter or the foreign and international monetary authority facility. Because indirect bidding is an order-routing classification encompassing foreign official institutions, money market funds, institutional asset managers, and corporate treasuries, indirect award shares measure non-dealer competitive routing depth without isolating a single investor sector. System Open Market Account rollovers and foreign official noncompetitive add-ons are allotted outside the competitive pool.

To evaluate primary-auction absorption and carrying-cost pass-through across monetary policy cycles, we partition January 2015 through October 2026 into five contiguous regimes anchored to Federal Open Market Committee balance-sheet implementation dates (Board of Governors of the Federal Reserve System, 2019; Board of Governors of the Federal Reserve System, 2025): (1) before the first quantitative tightening (1 January 2015–30 September 2017; 33 monthly observations); (2) first quantitative tightening (1 October 2017–31 August 2019; 23 monthly observations); (3) reserve expansion and pandemic asset purchases (1 September 2019–31 May 2022; 33 monthly observations); (4) second quantitative tightening (1 June 2022–1 December 2025 on the daily auction calendar, corresponding to the 42 month-end statements from June 2022 through November 2025); and (5) post-runoff reserve management (2 December 2025–31 October 2026 on the daily auction calendar, corresponding to the 11 month-end statements from December 2025 through October 2026). Because the July 2019 implementation note ended runoff effective 1 August 2019 and the October 2025 implementation note ended runoff effective 1 December 2025, Section 5.1 verifies stability when 1–31 August 2019 and 1 December 2025 are reassigned to the exact FOMC implementation dates. All specifications also account for the seven statutory debt-ceiling suspension and extraordinary-measures episodes between March 2015 and July 2025, alongside $\pm$14-calendar-day windows around Treasury projected cash-exhaustion warnings (3 November 2015, 18 October 2021, 15 December 2021, and 5 June 2023).

2.2. *Carrying-Cost Accounting Scope and Testable Hypotheses*

Let $D_{k,t}$ denote month-end outstanding par principal in marketable security class $k \in \{B, N, L, T, F, G\}$, representing Treasury bills (B), Treasury notes (N), Treasury bonds (L), Treasury inflation-protected securities (T), floating-rate notes (F), and Federal Financing Bank obligations (G), with total marketable debt $D_t = \sum_{k\in\{B,N,L,T,F,G\}} D_{k,t}$. Official Treasury carrying-cost methodology excludes inflation-protected principal accretion and floating-rate indexation from the published total marketable average interest rate R_t, while retaining Federal Financing Bank obligations (U.S. Department of the Treasury, Office of Debt Management, 2025). Accordingly, the class-consistent nominal fixed-rate denominator and bill stock shares are

$$D_t^F = D_{B,t} + D_{N,t} + D_{L,t} + D_{G,t}, \qquad s_t^F = \frac{D_{B,t}}{D_t^F}, \qquad s_t^{\text{all}} = \frac{D_{B,t}}{D_t}. \tag{1}$$

Weighting the published class-specific average interest rates $r_{k,t}$ ($k \in \{B, N, L, G\}$) by month-end par shares $w_{k,t} = D_{k,t}/D_t^F$ defines the par-weighted fixed-rate average interest rate $\widetilde{R}_t$ and accounting reconciliation residual e_t:

$$\widetilde{R}_t = \sum_{k\in\{B,N,L,G\}} w_{k,t} r_{k,t}, \qquad w_{k,t} = \frac{D_{k,t}}{D_t^F}, \qquad e_t = R_t - \widetilde{R}_t. \tag{2}$$

Monthly changes in $\widetilde{R}_t$ satisfy an exact symmetric shift-share accounting identity separating within-class rate resets from between-class maturity-weight shifts:

$$\Delta\widetilde{R}_t = \sum_{k\in\{B,N,L,G\}} \frac{w_{k,t} + w_{k,t-1}}{2} \Delta r_{k,t} + \sum_{k\in\{B,N,L,G\}} \frac{r_{k,t} + r_{k,t-1}}{2} \Delta w_{k,t}. \tag{3}$$

Within this institutional and accounting structure, we evaluate two falsifiable empirical hypotheses without treating Treasury offering schedules as exogenous supply shocks:

- **Hypothesis 1 (Within-Tenor Primary-Auction Absorption and Routing Reallocation):** Conditional on auction year-month fixed effects, fine remaining-maturity tenor fixed effects (which absorb cash management bill status), reopening indicators, extraordinary-measures periods, and debt-ceiling deadline windows, larger individual auction offerings O_i expand total competitive tenders

sub-proportionally ($\partial \log B_i / \partial \log O_i < 1$), compress published bid-to-cover ratios, and coincide with higher indirect-bidder award shares and lower primary-dealer residual shares during quantitative tightening regimes.

- **Hypothesis 2 (Short-Maturity Stock Exposure and Dynamic Carrying-Cost Pass-Through):** In monthly ADL$(1, 3)$ and cumulative local-projection models linking changes in the published average interest rate ΔR_t to federal funds rate changes Δf_{t-j}, a higher predetermined fixed-rate bill stock share amplifies the dynamic cumulative pass-through of policy-rate hikes into sovereign book carrying costs.

3. Sample Construction, Carrying-Cost Accounting Audit, and Empirical Design

3.1. Primary Sample Construction and Net-Carrying-Value Accounting Audit

We assemble the complete universe of official U.S. Treasury marketable security auctions, Monthly Statements of the Public Debt, and monthly class-level average interest-rate schedules from January 2015 through October 2026 (U.S. Department of the Treasury, Bureau of the Fiscal Service, 2026), cross-verified against official October 2026 TreasuryDirect auction announcements and results through 27 October 2026 and paired with monthly interest-rate and central-bank holdings series (Federal Reserve Bank of St. Louis, 2026). Auctions are selected strictly by auction, issue, and record dates on or before 31 October 2026 with no upper bound on maturity dates, preserving all long-term notes and bonds. Among the 4,422 settled marketable auctions, 143 inflation-protected auctions and 143 floating-rate auctions occur at most once per month within their security class and are nearly absorbed by year-month fixed effects; excluding them from the within-month fixed-rate panel leaves a primary sample of $N = 4{,}136$ auctions (3,207 Treasury bills, including 482 bespoke-day cash management bills, and 929 nominal coupon notes and bonds across 1,774 unique security identifiers). Across these 4,136 auctions, securities span 15 benchmark maturity families—eight Treasury bill families (4-, 6-, 8-, 13-, 17-, 26-, and 52-week benchmark bills plus cash management bills) and seven nominal coupon families (2-, 3-, 5-, 7-, 10-, 20-, and 30-year notes and bonds)—and 76 exact remaining-maturity tenors distinguishing reopened coupon remaining months and exact cash management bill day counts. In all 4,136 auctions, competitive dollar awards to indirect bidders, direct bidders, and primary dealers sum identically to total competitive awards with zero discrepancy.

On the monthly panel ($N = 142$ consecutive month-end observations from January 2015 through October 2026), summing the six marketable principal classes reproduces published total marketable debt within \$1.00 million (exact published rounding precision). Reconciling the published total marketable average interest rate R_t against the par-weighted fixed-rate index $\widetilde{R}_t$ in Equation (2) yields a mean discrepancy e_t of -0.1617 basis points, a mean absolute discrepancy $|e_t|$ of 0.1936 basis points, and a maximum absolute gap of 0.8877 basis points (whereas erroneously weighting all six marketable classes including inflation-protected and floating-rate debt produces errors up to 18.4815 basis points). Official Treasury interest-rate accounting rules explain both the sub-basis-point magnitude and the negative sign of e_t during 2022–2026: marketable notes and bonds enter R_t at par face value, whereas zero-coupon Treasury bills enter at net carrying value—par principal $D_{B,t}$ minus unamortized discount—weighted by each security's computed annualized rate prior to three-decimal class rounding. Because subtracting unamortized discount strictly lowers the effective carrying-value weight on bills below their par share $w_{B,t}$ whenever bill discount rates are positive, $\widetilde{R}_t$ assigns slightly greater weight to bills than R_t, rendering $e_t = R_t - \widetilde{R}_t < 0$ whenever short-term bill rates exceed legacy coupon book rates ($r_{B,t} > \widetilde{R}_t$). We retain published R_t as our primary monthly dependent variable and verify stability using $\widetilde{R}_t$ in Section 5.1. Table 1 reports summary statistics across both panels.

Table 1. Descriptive statistics for primary-market Treasury auctions and monthly sovereign debt series, January 2015–October 2026.

Variable	Unit	*N*	Mean	SD	P25	Median	P75	Min	Max
Panel A: Primary-market fixed-rate auctions									
Offering amount	USD billions	4,136	48.21	21.17	32.00	44.00	63.00	0.03	110.00
Competitive tenders submitted	USD billions	4,136	140.29	58.23	100.21	129.37	181.32	0.07	312.99
Competitive awards accepted	USD billions	4,136	47.10	20.25	31.97	43.00	61.59	0.03	103.50
Published bid-to-cover ratio	Ratio	4,136	2.99	0.51	2.66	2.92	3.22	2.04	10.72
Indirect bidder competitive share	Percentage points	4,136	51.55	13.94	42.58	54.09	61.87	0.00	87.90
Direct bidder competitive share	Percentage points	4,136	7.92	6.14	3.64	5.87	10.14	0.00	41.93
Primary dealer competitive share	Percentage points	4,136	40.53	15.95	29.94	40.20	51.18	2.21	100.00
Central bank rollover add-on	USD billions	4,136	2.24	3.23	0.00	0.44	3.89	0.00	32.39
High minus median auction rate	Basis points	4,136	3.31	2.85	1.50	2.80	4.50	0.00	65.00
Panel B: Monthly debt and interest series									
Total marketable debt principal	USD trillions	142	20.60	6.21	14.49	20.84	26.20	12.48	32.15
Bill share of total marketable debt	Percent	142	17.19	4.31	13.58	16.07	21.61	9.94	25.52
Bill share of nominal fixed-rate debt	Percent	142	19.14	4.66	15.31	17.92	23.87	11.19	28.32
Published marketable average rate	Percent	142	2.40	0.66	2.00	2.22	3.14	1.42	3.57
Par-weighted fixed-rate average rate	Percent	142	2.40	0.66	2.00	2.22	3.15	1.43	3.57
Published minus reconstructed rate	Basis points	142	-0.16	0.24	-0.23	-0.11	-0.02	-0.89	0.24
Effective federal funds rate (mean)	Percent	142	2.12	1.90	0.26	1.63	3.88	0.05	5.33
Term spread (10-year minus 2-year)	Percentage points	142	0.48	0.61	0.17	0.50	0.94	-0.93	1.68
Federal Reserve outright Treasury holdings	USD trillions	142	3.73	1.28	2.46	4.21	4.73	2.09	5.77

Notes. Panel A covers all completed U.S. Treasury bill and nominal coupon (note and bond) auctions with auction and issue dates between 5 January 2015 and 27 October 2026; foreign and international monetary authority noncompetitive add-ons average $0.24 billion (SD = 0.45, range $0.00–$2.00 billion), while the 143 inflation-protected and 143 floating-rate auctions occur at most once monthly within class. Competitive bidder shares divide dollar awards in each routing

channel by total competitive awards and sum identically to 100.00%. Panel B spans all 142 month-end observations from January 2015 through October 2026 (the Secured Overnight Financing Rate, available for $N = 103$ months from April 2018, averages 2.70%, SD = 1.92%).

3.2. *Econometric Specifications and Dynamic Inference Protocols*

For auction i occurring in year-month $m(i)$ with fine remaining-maturity tenor $k(i)$, security group $g_i \in \{\text{Bill}, \text{Coupon}\}$, and balance-sheet regime r_i, we estimate the within-tenor conditional absorption regression

$$y_i = \alpha_{m(i)} + \gamma_{k(i)} + \sum_g \sum_r \beta_{gr} \mathbf{1}\{g_i = g, r_i = r\} \log O_i + \sum_{r \neq r_0} \delta_r \mathbf{1}\{g_i = \text{Bill}, r_i = r\} + X_i' \phi + u_i, \quad (4)$$

where O_i is offering size in billions of dollars, δ_r captures bill-specific regime intercepts relative to pre-tightening regime r_0, and X_i contains three active auction-level indicator controls: reopening status, statutory extraordinary-measures periods, and $\pm$14-day debt-ceiling deadline windows. Because $\gamma_{k(i)}$ assigns distinct fixed effects to exact day-count cash management bill tenors (56 irregular day-count and off-run reopening cells beyond the 20 regular benchmark tenors), cash management bill status is nested within and absorbed by $\gamma_{k(i)}$, just as quarterly refunding months are absorbed by the 142 year-month fixed effects $\alpha_{m(i)}$ (yielding an exact design rank of $142 + 76 - 1 + 10 + 4 + 3 = 234$). Conventional inference uses finite-sample-corrected two-way clustering by year-month and fine tenor (75 cluster degrees of freedom; Cameron et al., 2011), paired with restricted wild cluster bootstrap p-values and test-inverted 95% confidence sets using 999 Rademacher draws across tenor clusters studentized by the two-way covariance matrix (MacKinnon et al., 2021).

For monthly carrying-cost pass-through ($N = 138$ effective observations from May 2015 through October 2026 after first-differencing and three lags), let $z_{t-1} = (s^F_{t-1} - 0.20)/0.10$ measure lagged nominal fixed-rate bill stock share in 10-percentage-point increments centered at 20%, f_t denote the monthly mean effective federal funds rate, and q_{t-1} denote the lagged 10-year minus 2-year Treasury term spread. Our baseline ADL$(1,3)$ specification in first differences is

$$\Delta R_t = a + \lambda z_{t-1} + \sum_{j=0}^{3} \beta_j \Delta f_{t-j} + \sum_{j=0}^{3} \theta_j z_{t-1} \Delta f_{t-j} + \rho \Delta R_{t-1} + \psi q_{t-1} + \sum_{r \neq r_0} \eta_r \mathbf{1}\{r_t = r\} + \varepsilon_t, \quad (5)$$

estimated with six-month Bartlett-kernel Newey–West covariance matrices (122 residual degrees of freedom; Newey & West, 1987). Because Equation (5) includes the autoregressive feedback term $\rho \Delta R_{t-1}$, the direct distributed-lag sums $\sum_{j=0}^{3} \beta_j$ and $\sum_{j=0}^{3} \theta_j$ measure partial impact sums holding ΔR_{t-1} fixed; for an isolated permanent 100-basis-point policy-rate hike at $t = 0$ ($\Delta f_0 = 1$, $\Delta f_{h>0} = 0$) holding z constant, recursive substitution $d_0 = \beta_0$ and $d_h = \beta_h + \rho d_{h-1}$ defines the cumulative level response $\text{CIRF}_H = \sum_{h=0}^{H} d_h$ ($R_{t+H} - R_{t-1}$) and steady-state multiplier $(\sum_{j=0}^{3} \beta_j)/(1 - \rho)$, with analogous recursion for the +10-percentage-point bill-share differential (θ_j) and analytic delta-method Newey–West standard errors incorporating covariance with $\hat{\rho}$. Furthermore, because z_{t-1} in $z_{t-1}\Delta f_{t-j}$ ($j \geq 1$) reflects bill-issuance adjustments between $t - j$ and $t - 1$, we estimate a companion predetermined matched-lag ADL$(1,3)$ replacing $z_{t-1}\Delta f_{t-j}$ with $z_{t-j-1}\Delta f_{t-j}$ ($j = 0, \ldots, 3$). Finally, to reconcile parametric ADL dynamics with multi-horizon cumulative local projections $R_{t+h} - R_{t-1}$ ($h = 0, \ldots, 12$, Newey–West bandwidth $\max(6, h + 1)$; Jordà, 2005), we estimate both unconditioned local projections—which capture total realized rate trajectories across serially correlated tightening cycles—and forward-augmented local projections controlling for observed intermediate policy moves $\{\Delta f_{t+1}, \ldots, \Delta f_{t+h}\}$ to purge multi-meeting horizon bias (Teulings & Zubanov, 2014); at horizons $h = 11$ ($N_{11} = 127$) and $h = 12$ ($N_{12} = 126$), the post-runoff regime indicator is identically zero after horizon right-censoring at October 2026 and omitted explicitly.

4. Empirical Results: Primary-Auction Absorption and Dynamic Carrying-Cost Pass-Through

4.1. Maturity Evolution and Primary-Auction Absorption Elasticities

Figure 1 traces U.S. marketable debt maturity metrics and book interest rates across all five policy regimes. In Panel a, gross monthly bill issuance share remains elevated between 58.72% and 94.32% due to short-maturity rollover, whereas the outstanding bill share of nominal fixed-rate debt s_t^F rose from 11.19% in late 2015 to a pandemic peak of 28.32% in mid-2020, receded to 16.70% entering June 2022, and stabilized between 23.5% and 25.3% during 2024–2026. Panel b shows that the published marketable average interest rate R_t climbed from 1.424% in early 2022 to 3.570% by October 2026, tracking the par-weighted reconstruction $\widetilde{R}_t$ within 0.89 basis points while adjusting gradually toward the federal funds rate plateau.

Evaluating Hypothesis 1, Figure 2 and Table 2 document consistent sub-proportional competitive tender scaling within auction months and fine maturity tenors across the 4,136 fixed-rate auctions (R^2 = 0.9828, within-R^2 = 0.9283). During the second quantitative tightening, a 1% larger offering within a given year-month and fine tenor raises total competitive tenders by 0.8792% for Treasury bills (two-way clustered SE = 0.0314, wild cluster bootstrap p = 0.001 against zero) and by 0.8578% for nominal coupons (SE = 0.0345, bootstrap p = 0.001). Once balance-sheet runoff ended in December 2025, the nominal coupon tender elasticity held steady at 0.8496 (SE = 0.0342), whereas the Treasury bill tender elasticity declined sharply to 0.7178 (SE = 0.0386). Because competitive tender volumes expand less than one-for-one with offering size, published bid-to-cover ratios decline with offering size: during the second quantitative tightening, the within-tenor log offering slope is −0.4392 for bills (SE = 0.1055, bootstrap p = 0.041) and −0.4112 for coupons (SE = 0.1022, bootstrap p = 0.001), steepening to −0.9237 for bills during post-runoff reserve management (SE = 0.1382, bootstrap p = 0.002).

Bidding-channel reallocation operates primarily between indirect submitters and residual primary-dealer takedown. Across all 10 class-regime distributions in Figure 2 (Panel a) and dollar-weighted aggregates in Panel b, indirect bidders absorbed 34.63% of competitive bill awards before the first quantitative tightening, 58.56% during the second quantitative tightening, and 60.24% during post-runoff reserve management, while primary-dealer bill share declined from 59.22% to 33.92%. Conditional on year-month and fine tenor fixed effects (Table 2, Panel A3), a one-log-unit offering expansion during the second quantitative tightening coincides with a +7.0407-percentage-point higher indirect competitive share for bills (SE = 2.1188, bootstrap p = 0.031, bootstrap 95% CI [4.0695, 16.6512]) and a +7.5916-percentage-point higher share for nominal coupons (SE = 1.9475, bootstrap p = 0.017, bootstrap 95% CI [1.8387, 12.3156]), while direct-bidder share slopes remain small and statistically indistinct from zero across every regime (all bootstrap $p \geq 0.056$). Because the three competitive shares sum identically to 100%, primary-dealer award shares contract by −6.7116 percentage points per log offering for bills (SE = 1.6750, bootstrap p = 0.022) and by −8.8098 percentage points for coupons (SE = 1.9832, bootstrap p = 0.011) during the second quantitative tightening. Consistent with the finite-cluster inference limits examined in Section 5.1, these baseline bootstrap p-values rely on 76 exact day-count and remaining-month clusters; aggregating clusters to the 15 benchmark maturity families or omitting post-June-2023 debt-ceiling extraordinary-measures periods—when money market funds rotated over $2 trillion out of the Federal Reserve's Overnight Reverse Repurchase facility into large bill auctions via indirect bids—widens wild cluster bootstrap p-values above the 5% threshold (p = 0.090–0.094 and p = 0.085–0.633).

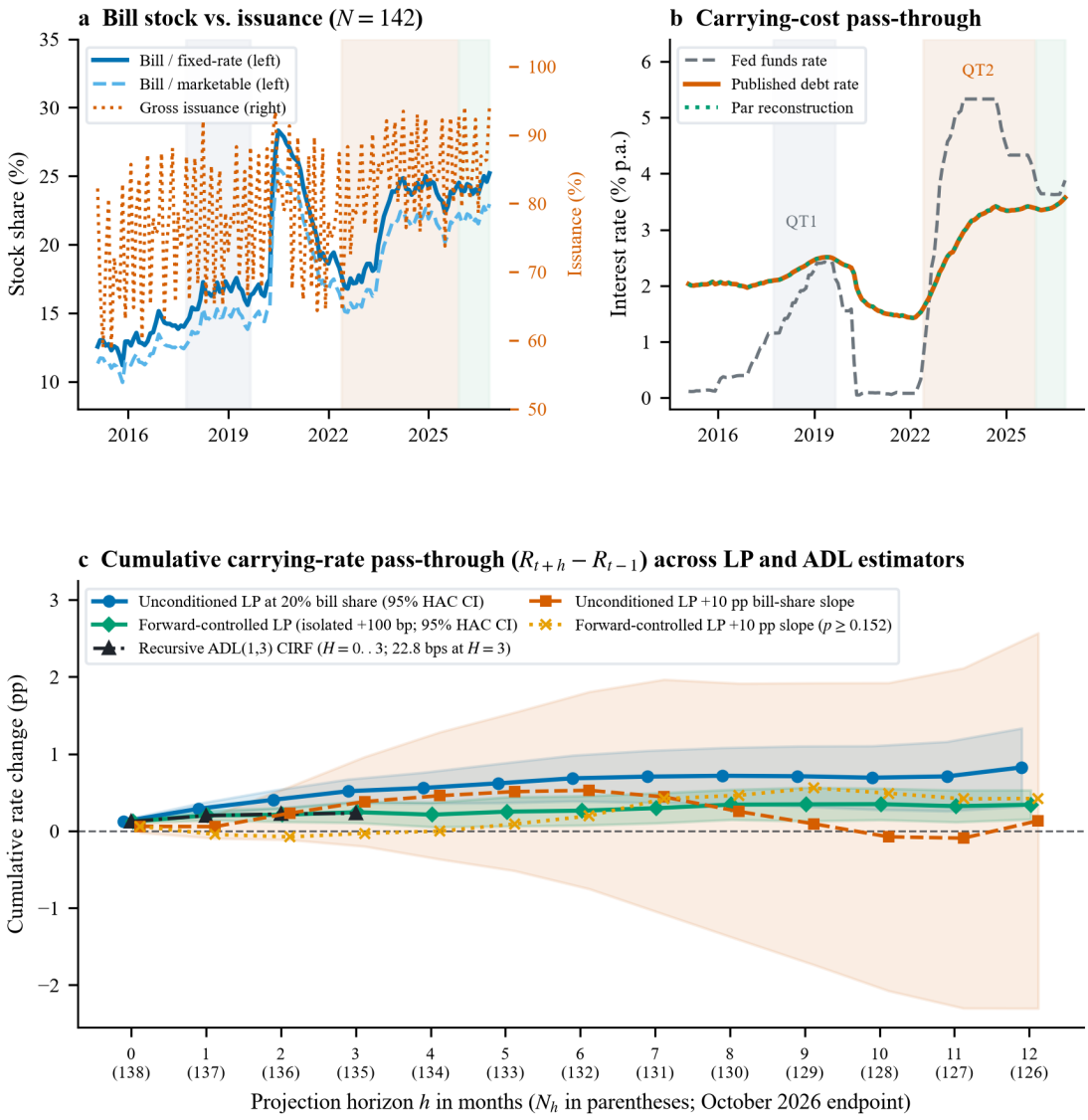


Figure 1. Sovereign bill shares, book carrying-cost pass-through, and reconciled local projections across Federal Reserve regimes, January 2015–October 2026.

Notes. Panel a plots monthly Treasury bill stock shares of nominal fixed-rate debt and total marketable debt (left axis) alongside gross monthly issuance share (right axis) across $N = 142$ months; shaded bands mark the first quantitative tightening (QT1), second quantitative tightening (QT2), and post-runoff reserve management (Post). Panel b compares the published marketable average interest rate, the par-weighted fixed-rate reconstruction (maximum monthly gap 0.89 basis points), and the monthly mean effective federal funds rate. Panel c plots cumulative carrying-rate responses $(R_{t+h} - R_{t-1})$ at a 20% bill share and +10-percentage-point lagged bill-share differentials across horizons $h = 0$ $(N_0 = 138)$ to $h = 12$ $(N_{12} = 126)$, comparing unconditioned local projections against forward-augmented local projections controlling intermediate policy changes $\{\Delta f_{t+1}, \ldots, \Delta f_{t+h}\}$ and the recursive ADL$(1, 3)$ cumulative impulse response $(H = 0, \ldots, 3)$; at $h = 11, 12$, the post-runoff regime indicator is zero after horizon trimming.

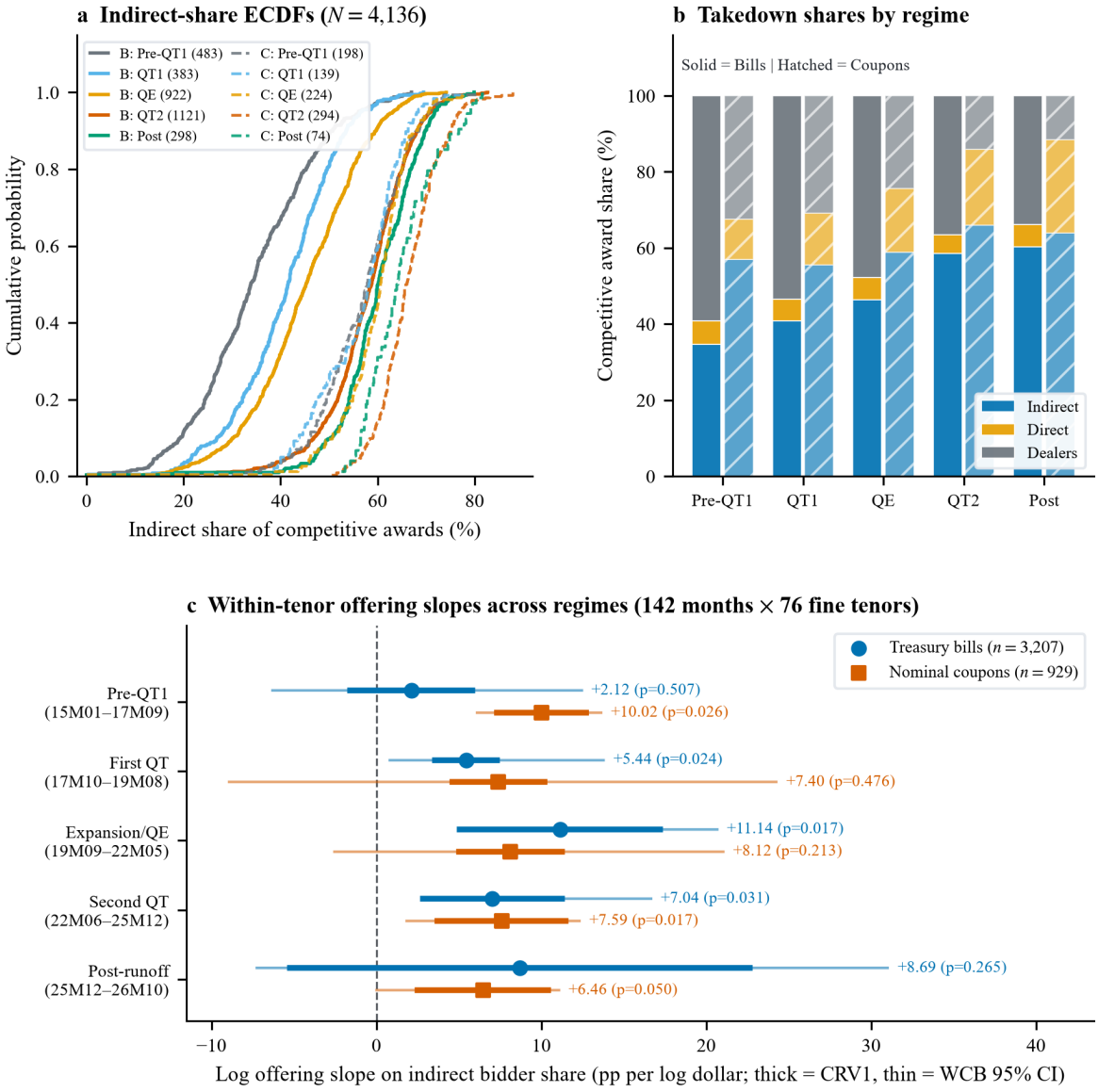


Figure 2. Primary-auction indirect award distributions across all 10 class-regime cells, aggregate takedown shares, and within-tenor offering slopes.

Notes. Panel a plots empirical cumulative distribution functions of indirect-bidder competitive award shares across all 10 security-by-regime cells summing to $N = 4{,}136$ fixed-rate auctions ($n = 3{,}207$ bills; $n = 929$ nominal coupons). Panel b displays aggregate dollar-weighted competitive award shares for indirect bidders, direct bidders, and primary dealers across regimes for bills (solid bars) and nominal coupons (hatched bars). Panel c plots within-tenor conditional slopes of indirect competitive award shares on log offering amount from Table 2 across exact daily regime windows, showing two-way clustered 95% confidence intervals (thick bars) and test-inverted wild cluster bootstrap 95% confidence intervals (thin capped bars; all 10 intervals in Panel c form connected acceptance sets).

Table 2. Baseline within-tenor primary-auction offering slopes and dynamic monthly carrying-cost pass-through estimates.

Security / Regressor	Regime/Horizon	Coef.	SE	95% CI	*p*-val.	WCB *p*
Panel A1: Log competitive tenders (N = 4,136)						
Treasury bills	Pre-QT1	0.8983	0.0421	[0.8145, 0.9820]	<0.0001	0.001
Nominal coupons	Pre-QT1	0.9387	0.0569	[0.8254, 1.0521]	<0.0001	0.014
Treasury bills	First QT	0.8839	0.0338	[0.8166, 0.9511]	<0.0001	0.001
Nominal coupons	First QT	0.9336	0.0143	[0.9051, 0.9621]	<0.0001	0.001
Treasury bills	QE period	0.8208	0.0374	[0.7463, 0.8953]	<0.0001	0.001
Nominal coupons	QE period	0.9018	0.0512	[0.7998, 1.0039]	<0.0001	0.001
Treasury bills	Second QT	0.8792	0.0314	[0.8166, 0.9419]	<0.0001	0.001
Nominal coupons	Second QT	0.8578	0.0345	[0.7890, 0.9266]	<0.0001	0.001
Treasury bills	Post-runoff	0.7178	0.0386	[0.6408, 0.7948]	<0.0001	0.001
Nominal coupons	Post-runoff	0.8496	0.0342	[0.7814, 0.9178]	<0.0001	0.001
Panel A2: Published bid-to-cover ratio (N = 4,136)						
Treasury bills	First QT	-0.4500	0.1054	[-0.6599, -0.2401]	0.0001	0.099
Nominal coupons	First QT	-0.1959	0.0425	[-0.2806, -0.1113]	<0.0001	0.334
Treasury bills	Second QT	-0.4392	0.1055	[-0.6495, -0.2290]	0.0001	0.041
Nominal coupons	Second QT	-0.4112	0.1022	[-0.6149, -0.2075]	0.0001	0.001
Treasury bills	Post-runoff	-0.9237	0.1382	[-1.1991, -0.6484]	<0.0001	0.002
Nominal coupons	Post-runoff	-0.4293	0.1002	[-0.6288, -0.2298]	0.0001	0.002
Panel A3: Indirect award share, pp (N = 4,136)						
Treasury bills	First QT	5.4448	0.9391	[3.5739, 7.3157]	<0.0001	0.024
Nominal coupons	First QT	7.4045	1.3952	[4.6251, 10.1838]	<0.0001	0.476
Treasury bills	Second QT	7.0407	2.1188	[2.8198, 11.2615]	0.0014	0.031
Nominal coupons	Second QT	7.5916	1.9475	[3.7120, 11.4711]	0.0002	0.017
Treasury bills	Post-runoff	8.6939	6.9956	[-5.2421, 22.6299]	0.2178	0.265
Nominal coupons	Post-runoff	6.4575	1.9852	[2.5027, 10.4122]	0.0017	0.050
Panel A4: Primary-dealer share, pp (N = 4,136)						
Treasury bills	Second QT	-6.7116	1.6750	[-10.0483, -3.3748]	0.0001	0.022
Nominal coupons	Second QT	-8.8098	1.9832	[-12.7606, -4.8591]	<0.0001	0.011
Panel B: Monthly ADL$(1,3)$ pass-through (N = 138, R^2 = 0.8526)						
Policy rate change Δf_t	Lag 0	0.1240	0.0103	[0.1036, 0.1445]	<0.0001	—
Bill share $z_{t-1} \times \Delta f_t$	Lag 0	0.0594	0.0412	[-0.0222, 0.1409]	0.1520	—
Bill share $z_{t-1} \times \Delta f_{t-1}$	Lag 1	-0.1138	0.0765	[-0.2652, 0.0377]	0.1395	—
Bill share $z_{t-1} \times \Delta f_{t-2}$	Lag 2	0.1019	0.0363	[0.0300, 0.1737]	0.0058	—
Bill share $z_{t-1} \times \Delta f_{t-3}$	Lag 3	0.0073	0.0172	[-0.0269, 0.0414]	0.6733	—
Lagged carrying-rate change ΔR_{t-1} (ρ)	Lag 1	0.3507	0.1217	[0.1097, 0.5917]	0.0047	—
Conditional policy lag sum $\sum_{j=0}^{3} \beta_j$	Lags 0–3	0.1510	0.0311	[0.0895, 0.2125]	<0.0001	—
Recursive 4-month policy response ($CIRF_3$)	$H = 3$	0.2284	0.0266	[0.1757, 0.2811]	<0.0001	—
Steady-state policy multiplier $\sum \beta_j/(1-\rho)$	Long run	0.2325	0.0263	[0.1805, 0.2845]	<0.0001	—

(continued)

Table 2 (continued)

Security / Regressor	Regime/Horizon	Coef.	SE	95% CI	p-val.	WCB p
Conditional interaction lag sum $\sum_{j=0}^{3} \theta_j$	Lags 0–3	0.0547	0.0496	[-0.0434, 0.1529]	0.2717	—
Recursive 4-month +10 pp share differential	$H = 3$	0.0672	0.0711	[-0.0734, 0.2079]	0.3459	—
Steady-state +10 pp share differential $\sum \theta_j/(1-\rho)$	Long run	0.0843	0.0689	[-0.0521, 0.2206]	0.2234	—

Notes. Panels A1–A4 report regime slopes from Equation (4) across $N = 4{,}136$ fixed-rate auctions controlling for 142 year-month fixed effects, 76 fine remaining-maturity fixed effects (which absorb cash management bill status), bill-by-regime intercepts, reopening status, extraordinary-measures periods, and $\pm$14-day debt-ceiling deadline windows (exact design rank = 234). Across all 50 regime-by-class slopes estimated across outcomes, all 10 WCB 95% confidence sets in Panel A3 form connected intervals, whereas 8 slopes outside Panel A3 produce disconnected test-inversion sets (reported as convex hulls) and 3 slopes exhibit 1–10 bootstrap draws with nonpositive two-way variance (evaluated on valid draws). Standard errors in Panels A1–A4 are two-way clustered by year-month and fine tenor ($df = 75$). Panel B reports six-month Bartlett Newey–West standard errors ($df = 122$) and analytic delta-method standard errors for recursive ADL$(1, 3)$ responses; $z_{t-1} = (s^F_{t-1} - 0.20)/0.10$.

4.2. Numerator-Denominator Decompositions, Dynamic Multipliers, and Local-Projection Reconciliation

Table 3 examines the mechanisms underlying primary-auction routing shifts and monthly carrying-cost dynamics. On positive-award samples ($\log(A^c_i/C_i) = \log A^c_i - \log C_i$, verified to $< 2.4 \times 10^{-14}$), competitive award denominators C_i scale one-for-one with offering size (elasticities 0.9738 to 1.0007). During the second quantitative tightening, Treasury bill indirect dollar awards expand with an elasticity of 1.2726 against a 1.0007 denominator elasticity, yielding a log indirect share elasticity of +0.2718 (SE = 0.0682, bootstrap $p = 0.001$) that remains at +0.3346 (SE = 0.1489, bootstrap $p = 0.005$) during post-runoff reserve management. Functional form matters for nominal coupons: their log indirect share elasticity during the second quantitative tightening is +0.0744 (bootstrap $p = 0.354$) alongside a significant negative direct-share log elasticity of −0.5234 ($p = 0.0115$, bootstrap $p = 0.024$), reflecting high baseline coupon indirect shares (65.98%). Formal covariance contrasts in Panel B reject unit tender proportionality ($\beta_{gr} = 1$) during the second quantitative tightening for coupons ($t = -4.12$, bootstrap $p = 0.001$) and at the 5% boundary for bills ($t = -3.84$, bootstrap $p = 0.050$), reject unit proportionality for both classes after runoff ended ($p \leq 0.002$), and confirm a −0.1614 post-runoff drop in bill tender elasticity (SE = 0.0343, bootstrap $p = 0.005$).

Table 3. Log award numerator-denominator decompositions, formal slope contrasts, and dynamic pass-through mechanisms.

Mechanism / Contrast	N	Estimate	SE	95% CI	p-val.	WCB p
Panel A: Log award share elasticities ($\log A^c_i - \log C_i$)						
Indirect share elasticity: Bills, Second QT (num. 1.2726, den. 1.0007)	4,127	0.2718	0.0682	[0.1359, 0.4078]	0.0002	0.001
Indirect share elasticity: Bills, Post-runoff (num. 1.3128, den. 0.9782)	4,127	0.3346	0.1489	[0.0378, 0.6314]	0.0277	0.005
Indirect share elasticity: Coupons, Second QT (num. 1.0734, den. 0.9991)	4,127	0.0744	0.0515	[-0.0283, 0.1771]	0.1531	0.354
Direct share elasticity: Coupons, Second QT (num. 0.4756, den. 0.9991)	4,121	-0.5234	0.2018	[-0.9257, -0.1212]	0.0115	0.024

(continued)

Table 3 (continued)

Mechanism / Contrast	N	Estimate	SE	95% CI	p-val.	WCB p
Primary-dealer elasticity: Bills, Second QT (num. 0.9079, den. 0.9998)	4,136	-0.0919	0.0358	[-0.1632, -0.0207]	0.0121	0.093
Primary-dealer elasticity: Coupons, Second QT (num. 0.8009, den. 0.9996)	4,136	-0.1987	0.0688	[-0.3357, -0.0618]	0.0050	0.023
Panel B: Formal auction contrasts and unit-elasticity tests						
Log tenders $\beta - 1$: Bills, Second QT	4,136	-0.1208	0.0314	[-0.1834, -0.0581]	0.0003	0.050
Log tenders $\beta - 1$: Bills, Post-runoff	4,136	-0.2822	0.0386	[-0.3592, -0.2052]	<0.0001	0.001
Log tenders: Bills, Post-runoff minus Second QT	4,136	-0.1614	0.0343	[-0.2298, -0.0931]	<0.0001	0.005
Bid-to-cover: Bills, Post-runoff minus Second QT	4,136	-0.4845	0.1097	[-0.7030, -0.2660]	<0.0001	0.001
Indirect share (pp): Bills minus Coupons, Second QT	4,136	-0.5509	2.8129	[-6.1544, 5.0526]	0.8453	0.873
High-minus-median rate dispersion (bps): Coupons, Second QT	4,136	2.1568	0.3846	[1.3907, 2.9229]	<0.0001	0.001
High-minus-median rate dispersion (bps): Bills, Second QT	4,136	-0.5729	0.9957	[-2.5565, 1.4108]	0.5668	0.563
Panel C: Monthly carrying-cost regimes, forward-controlled LPs, and shift-share components						
Contemporaneous Δf_t slope: Second QT minus First QT	138	-0.1242	0.0373	[-0.1982, -0.0503]	0.0012	—
Contemporaneous $z_{t-1} \times \Delta f_t$: Second QT	138	0.1728	0.0680	[0.0380, 0.3076]	0.0124	—
Forward-controlled LP policy response ($R_{t+3} - R_{t-1}$ at 20% share)	135	0.2438	0.0699	[0.1053, 0.3823]	0.0007	—
Forward-controlled LP +10 pp share differential ($R_{t+3} - R_{t-1}$)	135	-0.0301	0.1857	[-0.3980, 0.3378]	0.8715	—
Within-class rate reset: conditional lag sum $\sum_{j=0}^{3} \beta_j$	138	0.1524	0.0234	[0.1061, 0.1988]	<0.0001	—
Within-class rate reset: conditional interaction sum $\sum_{j=0}^{3} \theta_j$	138	0.0454	0.0374	[-0.0285, 0.1194]	0.2263	—
Maturity-composition shift: conditional interaction sum $\sum_{j=0}^{3} \theta_j$	138	0.0077	0.0316	[-0.0548, 0.0703]	0.8071	—

Notes. Panel A excludes zero-award auctions in the respective channel (9 indirect, 15 direct, 0 dealer). Panel B tests linear restrictions on the baseline two-way clustered auction covariance. Panel C reports Newey–West HAC estimates on monthly regime-interacted models, forward-augmented cumulative local projections controlling intermediate $\{\Delta f_{t+1}, \dots, \Delta f_{t+h}\}$, and symmetric shift-share components of $\Delta \widetilde{R}_t$.

On the fiscal pass-through margin (Hypothesis 2), Panel B of Table 2, Panel C of Table 3, and Figure 1 (Panel c) reconcile the dynamic estimators cleanly. Evaluated at a 20% fixed-rate bill stock share, a 100-basis-point federal funds rate hike raises ΔR_t by 12.40 basis points on impact (HAC SE = 1.03, $p < 0.0001$) and yields a direct conditional lag sum $\sum_{j=0}^{3} \hat{\beta}_j$ of 15.10 basis points (HAC SE = 3.11). Propagating an isolated one-time 100-basis-point hike recursively through $\hat{\rho} = 0.3507$ (HAC SE = 0.1217, $p = 0.0047$) generates monthly increments of +12.40, +7.44, +2.24, and +0.76 basis points across months $h = 0, \dots, 3$, producing a cumulative four-month impulse response (CIRF_3) of 22.84 basis points (HAC SE = 2.66, 95% CI [17.57, 28.11], $p < 0.0001$) and a steady-state multiplier of 23.25 basis points (HAC SE = 2.63, 95% CI [18.05, 28.45]). Unconditioned local projections reach 51.59 basis points at $h = 3$ ($N_3 = 135$, HAC SE = 7.85), 55.80 basis points at $h = 4$ ($N_4 = 134$, HAC SE = 10.16), and 82.53 basis points at $h = 12$ ($N_{12} = 126$, HAC SE = 25.64) because FOMC tightening cycles exhibit strong

positive serial correlation in Δf_t, compounding subsequent hikes over $(t+1, t+h)$. Once intermediate policy changes $\{\Delta f_{t+1}, \ldots, \Delta f_{t+h}\}$ are controlled (Teulings & Zubanov, 2014), forward-augmented local projections yield 24.38 basis points at $h = 3$ (HAC SE = 6.99, $p = 0.0007$), 21.14 basis points at $h = 4$ (HAC SE = 8.04), 26.33 basis points at $h = 6$ (HAC SE = 9.60), and 34.11 basis points at $h = 12$ (HAC SE = 9.54, $p = 0.0005$), matching the recursive ADL$(1, 3)$ trajectory closely.

Across all dynamic specifications, the interaction between policy-rate changes and lagged bill stock share is statistically unresolved. In the baseline ADL$(1, 3)$, a +10-percentage-point higher bill share yields a conditional lag sum of +5.47 basis points (HAC SE = 4.96, $p = 0.2717$), a recursive four-month cumulative differential of +6.72 basis points (HAC SE = 7.11, 95% CI $[-7.34, 20.79]$, $p = 0.3459$), and a long-run differential of +8.43 basis points (HAC SE = 6.89, $p = 0.2234$). Moreover, replacing post-shock z_{t-1} in $z_{t-1}\Delta f_{t-j}$ with predetermined z_{t-j-1} eliminates the isolated second-lag spike ($\hat{\theta}_2$ falls from +0.1019, $p = 0.0058$, to +0.0513, HAC SE = 0.0879, $p = 0.5603$) and reduces the recursive four-month share differential to +1.21 basis points (HAC SE = 9.28, 95% CI $[-17.16, 19.57]$, $p = 0.8967$; long-run differential +1.52 basis points, $p = 0.8910$), while forward-augmented local-projection share differentials remain insignificant at every horizon (−3.01 basis points at $h = 3$, $p = 0.8715$; all $p \geq 0.1520$). Independently of that inconclusive regression interaction, the symmetric shift-share decomposition of $\Delta\widetilde{R}_t$ (Table 3, Panel C; Figure 3, Panel a) establishes an accounting regularity: 98.3% (+0.1524 of +0.1551 percentage points) of direct four-lag policy pass-through operates via within-class bill and coupon rate resets, whereas contemporaneous between-class weight changes contribute +0.0027 percentage points ($p = 0.8690$).

5. Robustness, Sensitivity Diagnostics, and Methodological Limitations

5.1. Specification Stability Across Auction and Monthly Perturbations

Figure 3 and Table 4 evaluate sensitivity across sample definitions, lag structures, and cluster hierarchies. In the monthly carrying-cost panel (Figure 3, Panel b; Table 4, Panel B), replacing s^F_{t-1} with total marketable bill share s^{all}_{t-1} ($\sum \hat{\theta}_j = +0.0481$, $p = 0.3619$), replacing published R_t with par-weighted $\widetilde{R}_t$ (+0.0532, $p = 0.2938$), doubling the Newey–West bandwidth to 12 months ($p = 0.2837$), using month-end federal funds rates (+0.0485, $p = 0.3233$), adopting exact FOMC runoff boundary dates (+0.0578, $p = 0.2573$), excluding debt-ceiling deadline months (+0.0383, $p = 0.4591$), adding a one-month policy-rate lead ($\sum \hat{\theta}_j = +0.0034$, $p = 0.9512$; lead interaction +0.0833, $p = 0.1782$), and omitting individual regimes one at a time ($p \in [0.0878, 0.8103]$) uniformly yield statistically inconclusive bill-share interactions. At the same time, Table 4 (Panel B) documents regime and lag dynamics in baseline policy pass-through: extending lags to six months reveals fourth-lag reversion in the base policy slope ($\hat{\beta}_4 = -0.0512$, $p = 0.0082$) alongside a positive fourth-lag interaction ($\hat{\theta}_4 = +0.0554$, $p = 0.0306$; six-lag interaction sum +0.0778, $p = 0.1990$), while omitting the second quantitative tightening regime ($N = 96$) reduces $\hat{\rho}$ from 0.3507 to −0.0074 ($p = 0.9548$) and raises the direct policy lag sum $\sum_{j=0}^{3} \hat{\beta}_j$ from 0.1510 to 0.3415 (SE = 0.0543, $p < 0.0001$), reflecting faster single-month book-rate reflection during earlier lower-debt cycles (implied steady-state multiplier 0.3390 versus 0.2325 in the full sample).

On the primary-auction side (Figure 3, Panel c; Table 4, Panel A), adopting exact FOMC runoff end dates (+7.0127 for bills, bootstrap $p = 0.032$; +7.3378 for coupons, bootstrap $p = 0.016$), ending the sample in September 2026 ($N = 4{,}107$, bootstrap $p = 0.049$ and 0.020), or using original complete Fiscal Data rows ($N = 4{,}124$, bootstrap $p = 0.047$ and 0.021) confirms stability to the October 2026 cross-match. Conversely, four structural perturbations define the finite-cluster precision boundaries. Excluding all 482 cash management bills ($N = 3{,}654$) collapses total fine-tenor clusters from 76 to 20 (leaving only 7 active second-tightening bill support clusters) and raises the bill slope to +9.0968 (SE = 4.3805, conventional $p = 0.0516$, bootstrap $p = 0.113$). Excluding ±14-day debt-ceiling deadline windows ($N = 4{,}011$) yields

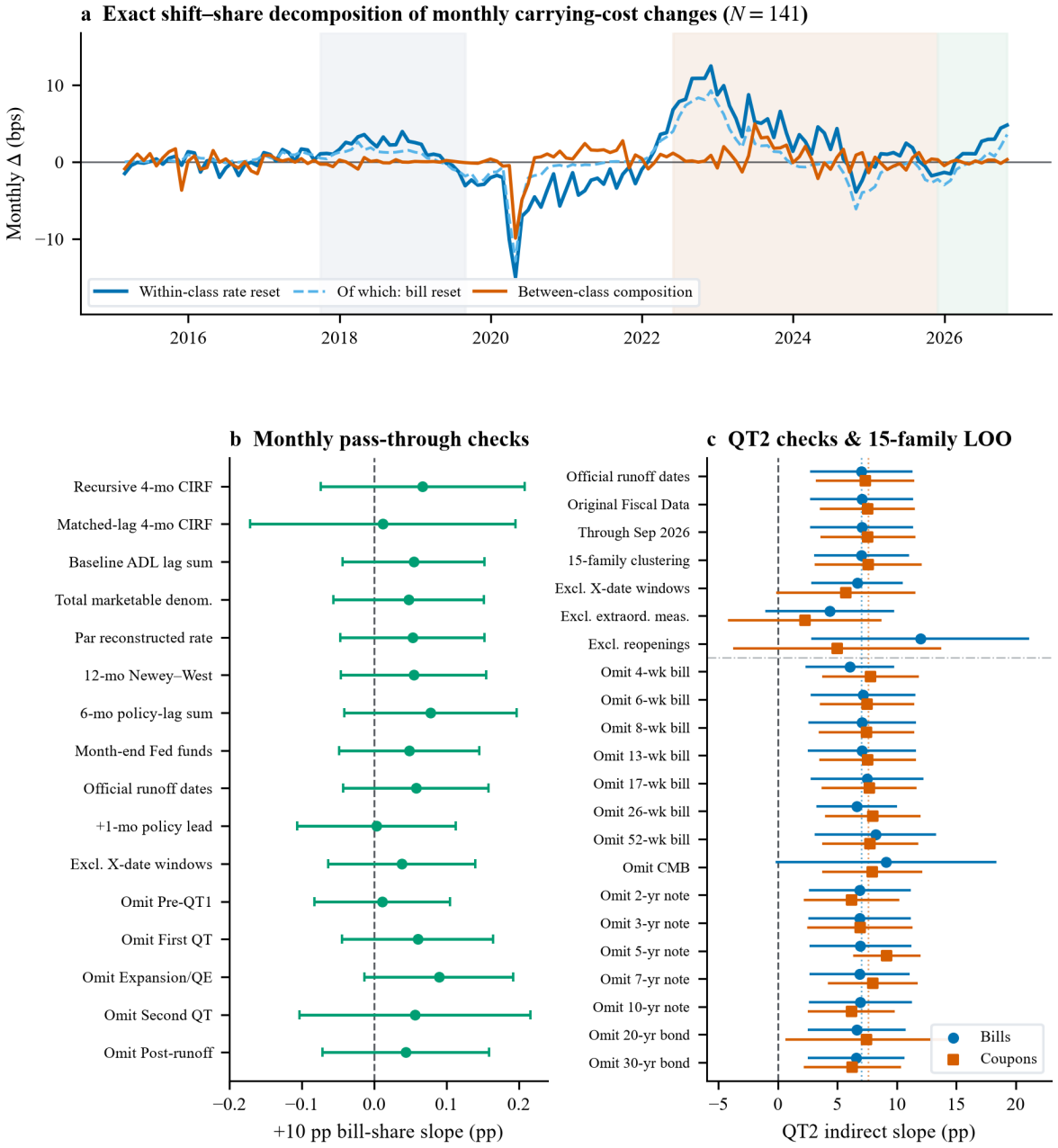


Figure 3. Shift-share carrying-cost decomposition, monthly interaction and CIRF stability, and all 15 maturity-family leave-out diagnostics.

Notes. Panel a plots the exact monthly symmetric shift-share decomposition of changes in the par-weighted fixed-rate average interest rate (N = 141 monthly changes, February 2015–October 2026) into total within-class rate resets, the Treasury bill reset sub-component, and between-class maturity-composition shifts. Panel b displays +10-percentage-point bill-share pass-through differentials and 95% Newey–West confidence intervals across the baseline and predetermined matched-lag four-month recursive $CIRF_3$ responses plus 14 conditional lag-sum specifications. Panel c plots second-quantitative-tightening indirect award share slopes and two-way clustered 95% confidence intervals across 7 sample and clustering checks (above the horizontal dash-dot line) and all 15 benchmark maturity-family leave-one-out regressions (30 estimates below the line; omitting cash management bills coincides identically with leaving out the cash management bill family).

+6.6649 for bills (bootstrap $p = 0.062$) and +5.7199 for coupons (bootstrap $p = 0.161$); excluding entire extraordinary-measures episodes ($N = 3{,}183$) attenuates slopes to +4.3486 for bills ($p = 0.1063$, bootstrap $p = 0.085$) and +2.2550 for coupons ($p = 0.4800$, bootstrap $p = 0.633$); and two-way clustering by the 15 benchmark maturity families yields bootstrap $p = 0.090$ for bills and 0.094 for coupons. Across all 15 leave-one-maturity-family-out regressions (all 30 estimates plotted in Figure 3, Panel c), point slopes remain positive everywhere—ranging from +6.0571 (leaving out 4-week bills) to +9.0968 (leaving out cash management bills) for bills and from +6.1871 (leaving out 10-year notes) to +9.1548 (leaving out 5-year notes) for coupons—while bootstrap p-values exceed 0.05 when omitting 4-week (0.123), cash management (0.113), 52-week (0.077), 13-week (0.073), 8-week (0.068), 26-week (0.061), or 17-week (0.060) bills, or 20-year (0.144), 30-year (0.067), or 10-year (0.057) coupons.

Table 4. Robustness checks across primary-auction perturbations (with active cluster counts) and monthly carrying-cost specifications.

Perturbation / Specification	Group/Metric	Sample (Clust.)	Estimate	SE	95% CI	p-val.	WCB p
Panel A: Second QT indirect share slope (pp)							
Official FOMC runoff boundary dates	Bills	4,136 (76/31)	7.0127	2.1139	[2.8016, 11.2238]	0.0014	0.032
Official FOMC runoff boundary dates	Coupons	4,136 (76/13)	7.3378	2.0243	[3.3051, 11.3705]	0.0005	0.016
Original complete Fiscal Data records	Bills	4,124 (75/31)	7.0413	2.1159	[2.8252, 11.2574]	0.0014	0.047
Original complete Fiscal Data records	Coupons	4,124 (75/13)	7.5353	1.9542	[3.6415, 11.4291]	0.0002	0.021
Excluding cash management bills	Bills	3,654 (20/7)	9.0968	4.3805	[-0.0716, 18.2653]	0.0516	0.113
Excluding cash management bills	Coupons	3,654 (20/13)	7.9403	1.9657	[3.8260, 12.0546]	0.0007	0.015
Excluding reopening auctions	Bills	1,734 (35/6)	11.9895	4.4602	[2.9253, 21.0536]	0.0110	0.010
Excluding reopening auctions	Coupons	1,734 (35/7)	4.9927	4.2642	[-3.6731, 13.6585]	0.2498	0.435
Excluding debt-ceiling deadline windows	Bills	4,011 (67/27)	6.6649	1.8790	[2.9133, 10.4164]	0.0007	0.062
Excluding debt-ceiling deadline windows	Coupons	4,011 (67/13)	5.7199	2.8882	[-0.0465, 11.4864]	0.0518	0.161
Excluding extraordinary-measures episodes	Bills	3,183 (54/19)	4.3486	2.6465	[-0.9596, 9.6569]	0.1063	0.085
Excluding extraordinary-measures episodes	Coupons	3,183 (54/13)	2.2550	3.1701	[-4.1034, 8.6134]	0.4800	0.633
Clustering by 15 benchmark maturity families	Bills	4,136 (15/8)	7.0407	1.8250	[3.1265, 10.9548]	0.0017	0.090

(continued)

Table 4 (continued)

Perturbation / Specification	Group/Metric	Sample (Clust.)	Estimate	SE	95% CI	*p*-val.	WCB *p*
Clustering by 15 benchmark maturity families	Coupons	4,136 (15/7)	7.5916	2.0488	[3.1973, 11.9858]	0.0024	0.094
Panel B: Monthly carrying-cost diagnostics (pp)							
Predetermined matched-lag share z_{t-j-1} ($\hat{\rho} = 0.4269$)	Policy CIRF	138	0.2290	0.0324	[0.1648, 0.2931]	<0.0001	—
Predetermined matched-lag share z_{t-j-1} ($\hat{\rho} = 0.4269$)	+10pp CIRF	138	0.0121	0.0928	[-0.1716, 0.1957]	0.8967	—
Total marketable debt denominator s_{t-1}^{all} ($\hat{\rho} = 0.3585$)	Int. sum	138	0.0481	0.0526	[-0.0560, 0.1522]	0.3619	—
Par-weighted reconstructed rate $\Delta\widetilde{R}_t$ ($\hat{\rho} = 0.3331$)	Int. sum	138	0.0532	0.0504	[-0.0466, 0.1529]	0.2938	—
Six-month policy-lag window, lags 0–6 ($\hat{\rho} = 0.3432$)	Int. sum	135	0.0778	0.0602	[-0.0415, 0.1970]	0.1990	—
Leave out expansion and pandemic QE regime ($\hat{\rho} = 0.1825$)	Int. sum	105	0.0896	0.0519	[-0.0135, 0.1927]	0.0878	—
Leave out second QT regime ($\hat{\rho} = -0.0074$)	Policy sum	96	0.3415	0.0543	[0.2335, 0.4495]	<0.0001	—
Leave out second QT regime ($\hat{\rho} = -0.0074$)	Int. sum	96	0.0564	0.0802	[-0.1031, 0.2159]	0.4837	—

Notes. In Panel A, column 3 lists total observations *N* alongside (total active tenor/family clusters / active Second QT slope-support clusters); all 30 leave-one-maturity-family-out estimates across the 15 benchmark families are plotted in Figure 3 (Panel c). Panel B reports six-month Bartlett Newey–West standard errors (and analytic delta-method standard errors for four-month predetermined matched-lag CIRF_3); base policy lag sums $\sum_{j=0}^{3} \hat{\beta}_j$ equal 0.1577 under s_{t-1}^{all}, 0.1551 under $\Delta\widetilde{R}_t$, and 0.1623 when omitting the pandemic QE regime.

5.2. Methodological and Accounting Limitations

Four interpretive boundaries govern our empirical findings. First, Treasury offering sizes and maturity stock shares respond endogenously to fiscal deficits, Treasury General Account cash rebuilds, Overnight Reverse Repurchase facility drainage, and primary-dealer advisory guidance; accordingly, our auction and monthly regressions identify conditional within-tenor slopes and dynamic time-series pass-through associations without claiming exogenous supply randomization. Second, auction administrative data classify competitive awards by order-submission routing channel, precluding direct decomposition of indirect awards across money market funds, foreign official accounts, and private asset managers, while high-minus-median auction rate dispersion lacks contemporaneous when-issued secondary quotes needed to measure true secondary-market auction tails. Third, although net-carrying-value bill discounting ac-

counts directionally for the negative published-minus-reconstructed rate gap (e_t down to −0.8877 basis points), public monthly summaries omit security-level unamortized discount schedules and exclude inflation-protected principal accretion, distinguishing book carrying rates from federal budget cash net interest outlays. Fourth, the post-runoff reserve-management regime comprises 11 monthly observations through October 2026, monthly bill-share interaction confidence intervals remain compatible with modest negative or positive effects ([−7.34, +20.79] basis points over four months), and multiway wild cluster bootstrap inference exhibits sensitivity to 15-family aggregation and extraordinary-measures windows.

6. Conclusion and Sovereign Debt-Management Implications

Linking 4,136 fixed-rate U.S. Treasury auctions with 142 monthly public-debt and carrying-cost statements from January 2015 through October 2026 clarifies both operational margins of sovereign balance-sheet shortening across quantitative tightening cycles. In the primary market, expanding individual offering sizes within auction months and fine maturity buckets scales competitive tenders sub-proportionally and compresses bid-to-cover ratios—most sharply for Treasury bills after balance-sheet runoff ended in December 2025, when the bill tender elasticity fell from 0.8792 to 0.7178—while larger offerings during the second quantitative tightening coincided with higher indirect-bidder routing shares and lower primary-dealer residual shares subject to finite-cluster and debt-ceiling-episode sensitivity. On the fiscal carrying-cost side, properly propagating autoregressive dynamics shows that an isolated 100-basis-point federal funds rate hike raises the published marketable average interest rate by 22.84 basis points over four months (23.25 basis points in steady state), reconciled closely by forward-controlled local projections (24.38 basis points at $h = 3$). Meanwhile, symmetric shift-share decompositions establish that 98.3% of direct four-lag policy pass-through operates via within-class rate resets, and historical variations in the Treasury bill stock share within the observed 11.19%–28.32% range yield no statistically resolved amplification of monthly carrying-rate pass-through under either baseline or predetermined matched-lag conditioning.

Three institutional prescriptions follow for sovereign debt management and fiscal reporting. First, public-debt statistical agencies should publish exact security-level net-carrying-value weights, unamortized bill discount adjustments, and class-consistent carrying-cost indices alongside headline average interest rates, eliminating the sub-basis-point reconciliation gap documented in Section 3.1 and separating fixed-rate coupon and discount resets from inflation-indexed and floating-rate cash obligations (U.S. Department of the Treasury, Office of Debt Management, 2025). Second, primary-market surveillance during post-runoff reserve-management regimes should track within-tenor competitive tender elasticities alongside headline bid-to-cover ratios and indirect routing shares so debt managers detect softening marginal bid depth per dollar offered even when aggregate indirect award shares remain above 60%. Third, sovereign debt-sustainability models evaluating bill-intensive issuance schedules should evaluate primary-auction rollover absorption capacity and money-market demand co-movements explicitly alongside dynamic carrying-cost trajectories instead of relying on partial static lag sums or unconditioned multi-horizon projections alone.

Statements

Data availability. Underlying security-level auction records, monthly marketable debt schedules, book interest-rate statements, and monetary policy series are publicly accessible through the U.S. Department of the Treasury Bureau of the Fiscal Service, TreasuryDirect, the Board of Governors of the Federal Reserve System, and the Federal Reserve Bank of St. Louis. Frozen input snapshots through October 2026, reconciled auction and monthly datasets, and deterministic scripts reproducing every table and figure are openly available via Zenodo (https://doi.org/10.5281/zenodo.24199682).

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