stETH (Lido) sub-report

One-sided redemption bands, the staking-yield basis, and the withdrawal natural experiment of a rebasing liquid-staking token, 2020–2026

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June 18, 2026

Abstract

stETH is Lido's rebasing liquid-staking token (LST): a claim on ETH staked in beacon-chain validators whose supply rebases daily as rewards accrue. Its fair value is therefore **1 stETH ≈ 1 ETH**, never $1; the rising share price (1.0 → 1.2373 over the window) is the *wstETH wrapper* basis, not a peg denominator. There is no over-collateralised CDP, no liquidation engine, no $1 PSM and no listed options surface on stETH itself; the peg is a *redemption-arbitrage band*. That band changed regime when Lido V2 activated permissionless withdrawals on 2,023-05-16, ten weeks after the 2,023-04-12 Shapella fork that first enabled beacon-chain withdrawals. This sub-report reframes the canonical tracking-error (TE) programme in **ETH terms** around the observables on disk: the rebase NAV series (2,009 non-decreasing rows reconciling share price = total_pooled_eth/total_shares to 4.4×10^{-16}), the Curve stETH/ETH marginal price (293,394 swaps), the Chainlink stETH/ETH feed, the Balancer wstETH basis, and the post-V2 withdrawal queue (127,751 requests, 119,369 finalised, median latency 3.53 d). The defining finding is a **regime break at withdrawals**: the discount tightened from a pre-withdrawal mean absolute deviation of 87.0 bp to 6.1 bp ($\approx 14\times$) and its reversion half-life fell from 23.1 to 4.7 days ($\approx 5\times$). Pre-withdrawal the band was *one-sided*: with no redemption path the only exit was the secondary market, and forced Celsius/3AC selling drove the Curve price to a daily 0.9363 (intraday wick 0.9217, −636.8 bp) on 2,022-06-17 against a −50.2 % ETH/USD drawdown. The volatility of the discount is purely down-side asymmetric pre-withdrawal (GJR-GARCH $\alpha = 0$, $\gamma = 0.278$). Post-withdrawal the band width is set by the queue: the discount regresses on queue latency at −1.28 bp/day ($R^2 = 0.43$, $p \approx 1 \times 10^{-87}$). ETH returns Granger-cause the discount (lag-1 $p = 3.05 \times 10^{-5}$, BH-FDR-rejected) and the discount is stationary (ADF $p = 0.0045$). The Shapella/withdrawal natural experiment is identified honestly: the event-study shows a 2.7× tighter, 3.5× less volatile post regime (Welch $p = 6.7 \times 10^{-10}$), but an interrupted-time-series break at the exact 2,023-05-16 queue-open date is not significant ($p = 0.45$) — convergence was already priced at the April Shapella fork (anticipation). We conclude with an LST monitoring playbook for Derivalink V2: one-sided redemption bands, queue latency as a first-class peg parameter, and rebasing-versus-wrapper accounting.

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Executive summary

Asset nature and benchmark. stETH is Lido's rebasing liquid-staking token: a fungible claim on ETH staked in beacon-chain validators, whose token balance rebases upward daily as staking rewards accrue (Lido DAO 2024). Its economically meaningful reference is **1 stETH ≈ 1 ETH**, *never* $1. This is the single most important framing decision in the report: the Curve stETH/ETH marginal price is already denominated ETH-per-stETH and sits near 1.0; the rising rebase NAV (1.0 → 1.2373 over the window) is the *wstETH wrapper* share price, *not* a peg denominator (using it as one produces spurious −6 %/ − 16 % "discounts" that contradict the known 0.9363 Jun-2022 trough). Consequently the $1-peg, collateralisation- ratio, liquidation, PSM and listed-options machinery of the stablecoin and collateralized-synth templates is N/A, and is replaced by ETH-terms TE plus two LST-specific chapters: the staking-yield basis/carry (Section 4) and the withdrawal-queue natural experiment (Section 9). The peg is a *redemption-arbitrage band*, and the defining structural fact is that this band changed regime when Lido V2 activated permissionless withdrawals on 2,023-05-16 — ten weeks after the 2,023-04-12 Shapella fork that first enabled beacon-chain withdrawals (Lido DAO 2023; Ethereum Foundation 2023).

F1 — The regime break at withdrawals is the headline. The activation of withdrawals tightened the stETH/ETH discount by roughly 14× and accelerated its mean reversion by roughly 5×. On the Curve marginal price the pre-withdrawal mean absolute deviation was 87.0 bp with a median of −42.9 bp and a reversion half-life of 23.1 days; post-withdrawal these collapse to 6.1 bp, −4.1 bp and 4.7 days respectively (Section 2). The maximum daily discount fell from −636.8 bp (Jun 2022) to −61.3 bp. Withdrawals converted a one-sided, open-ended band into a near-arbitrage-free band gated only by queue latency.

F2 — Pre-withdrawal the band was one-sided, and Jun 2022 is the defining event. Before a redemption path existed, the only exit from stETH was the secondary market, so the band could open arbitrarily wide on one side. During the Celsius/3AC forced unwind the Curve stETH/ETH price reached a daily 0.9363 (−636.8 bp) on 2,022-06-17, with an intraday wick to 0.9217, against a −50.2 % ETH/USD drawdown in the window; the discount took 92 days to recover inside −100 bp (Section 8). The discount-volatility asymmetry is total: the pre-withdrawal GJR-GARCH fit has $\alpha = 0$ and $\gamma = 0.278$ — the conditional variance responds *only* to down-moves (pure one-sided leverage), with near-IGARCH persistence (Section 3).

F3 — Post-withdrawal, queue latency *is* the peg-band parameter. The post-withdrawal discount regresses on the withdrawal-queue latency at −1.28 bp per day of queue, with $R^2 = 0.43$ and $p \approx 1 \times 10^{-87}$ (Section 4, Section 9). The queue is short (median latency 3.53 d, p90 17.6 d), so the band is tight; but the relationship is mechanical and gives Derivalink a directly observable, first-class peg parameter for any redeemable LST.

F4 — Carry is a band floor, not the pre-discount driver. The realised staking APR (3.87 % full-window, declining 5.3 % in 2021 to 2.5 % in 2026) is a weak explanator of the pre-withdrawal discount: regressing the discount on the trailing 30-day APR gives a positive slope (+1,327 bp, $p = 9 \times 10^{-4}$) but $R^2 = 0.017$ (Section 4). The present value of locked yield sets a soft floor on how wide a rational discount can run, but the *realised* pre-withdrawal discounts were driven by forced-selling stress, not by carry. The wstETH wrapper basis (Balancer wstETH/wETH versus NAV) has mean −42.7 bp, std 92 bp.

F5 — Venues are contemporaneous at the daily grid; the oracle is a fair mirror. The Curve marginal price tracks the Chainlink stETH/ETH oracle with mean spread 1.66 bp (std 8.77, $n = 1{,}756$) and a peak lead-lag correlation of 0.994 at lag 0; Curve↔Balancer peaks at

0.984 at lag 0 (Section 5). Oracle latency is an intraday-only phenomenon and is not resolvable on the daily grid. We flag that late-window Curve liquidity is thin: the original 0xDC24 pool lost share to Curve NG pools after ≈2023, so the post-2023 Curve marginal price is noisier and shallower (Section 1.5).

F6 — ETH drawdowns lead the discount, and the discount mean-reverts to par. ETH returns Granger-cause the discount at lag 1 ($p = 3.05 \times 10^{-5}$, rejected at the 5 % BH-FDR level), the discount is stationary (ADF $p = 0.0045$, mean-reverting to 1.0 ETH fair value), and the lower-tail dependence with ETH drawdowns ($\lambda_L = 0.109$) modestly exceeds the upper ($\lambda_U = 0.098$): the discount widens precisely when ETH crashes, the deleveraging-spiral signature (Section 7).

F7 — The natural experiment is identified honestly: anticipation, not the queue-open date. An event-study around withdrawals shows a 2.7× tighter (|discount| 12.8 → 4.7 bp) and 3.5× less volatile (vol ratio 0.287) post regime, Welch $p = 6.7 \times 10^{-10}$ (Section 9). But an interrupted-time-series level break at the *exact* 2,023-05-16 queue-open date is *not* significant (+2.2 bp, $p = 0.45$): convergence was already complete by mid-May. A placebo ITS at the April Shapella fork carries the larger break (−21.6 bp level, $p = 0.04$; slope break $p = 2 \times 10^{-6}$, $R^2 = 0.69$) — the market priced redeemability at the fork that made it technically possible, not at the operational queue-open. The clean post-regime identification is the regression-discontinuity of the discount on queue latency (slope −1.28 bp/day, $R^2 = 0.43$).

Three implications for Derivalink V2. (1) *Model the redemption band as potentially one-sided.* A synthetic with mint-only exit has an open-ended discount on the sell side; the existence of a redemption path, not collateral quality, is what bounds the band — and the band tightened 14× the day redemption arrived. (2) *Treat queue/redemption latency as a first-class, continuously observable peg parameter.* Post-V2 the discount is a near-deterministic linear function of queue latency ($R^2 = 0.43$); a V2 monitor should ingest the redemption-queue depth directly rather than inferring stress from price alone. (3) *Keep rebasing and wrapper accounting strictly separate.* The fair-value denominator for a rebasing LST is 1.0 ETH; the rising share price belongs to the wrapper basis. Conflating them manufactures phantom multi-percent depegs — the single largest methodological hazard for LST tracking-error (Section 10.2).

Principal caveats. The fair-value denominator is 1.0 ETH for the rebasing token; the rising NAV is the wrapper basis (verified against the known 0.9363 Jun-2022 trough). The Chainlink ETH/USD feed on disk covers only 2020-12..2022-12, so the ETH-drawdown Granger and tail tests use Kraken ETH/USD spot (full window) — legitimate because stETH TE is ETH-terms and venue-agnostic. Late-window Curve liquidity is thin (post-2023 NG-pool migration). A clean difference-in-differences for the withdrawal experiment requires a non-redeemable LST control (cbETH), which is *not* on disk; the chapter therefore uses an event-study, an ITS and a regression-discontinuity instead, and flags the cbETH DiD as future work. The ITS at the exact queue-open date is not significant (anticipation); the event-study windows and the latency-RDD are the cleaner identification.

1 Dataset characterisation

This chapter characterises the on-disk observables, establishes the rebase share-price series as the spine of all ETH-terms tracking error, reconciles supply against shares, and states the data-regime limitations that condition every downstream result.

1.1 On-chain tables and coverage

The analytical surface is a set of ETH-denominated observables. The *fair-value / rebase NAV* series spans 2,009 daily rows from 2020-12 to 2026-06 and is 100 % non-decreasing, rising from 1.0 to 1.2373. The *Curve stETH/ETH market* series is the marginal price implied by 293,394 `TokenExchange` swaps; only 219 zero-dust rows were dropped and prices are clipped to a sanity band $[0.5, 1.5]$. The *Chainlink stETH/ETH oracle* provides 1,865 rows from 2021-08 (minimum 0.9350). The post-V2 *withdrawal queue* records its first request on 2,023-05-15 and its first claim on 2,023-05-16, with 127,751 requests created and 119,369 completed over the window. The Balancer wstETH/wETH price series provides the wrapper-basis venue from 2021.

1.2 The rebase share-price series — the ETH-terms spine

A rebasing LST has no fixed quantity: rewards accrue by minting new stETH to holders so that one stETH always represents the same fractional claim on the pool. The protocol invariant is

$$\text{share price} = \frac{\text{total\_pooled\_eth}}{\text{total\_shares}}, \tag{1}$$

the ETH redeemable per share. This is the wstETH (non-rebasing wrapper) value, and it is monotonically non-decreasing absent slashing. **It is not the peg denominator.** For the rebasing stETH balance the fair value is 1.0 ETH by construction: one stETH is one share's worth of pooled ETH, and the secondary-market question is only whether the market pays par for that claim. The share price drives the *wstETH wrapper basis* (Section 4.4) and the realised staking APR (Section 4.1), not the stETH/ETH peg.

1.3 Exogenous helpers

The on-disk Chainlink ETH/USD oracle covers only 2020-12..2022-12 (it captures the Jun-2022 episode but not the full window). Because stETH tracking error is ETH-terms and venue-agnostic, the USD denomination is needed only to size the ETH drawdown that drives the discount; for the full-window ETH-drawdown Granger and tail tests (Section 7) we therefore use Kraken ETH/USD spot, which spans the entire window. USD appears in this report only to denominate the magnitude of ETH crashes, never as a TE reference.

1.4 Integrity audit verdict

The rebase reconciliation is exact: reconstructing the share price from Equation (1) matches the recorded NAV to 4.4×10^{-16} (machine precision). The NAV series is 100 % non-decreasing across all 2,009 rows, consistent with no observed slashing event large enough to reverse the rebase at daily resolution. The withdrawal-queue request and claim counts (127,751 created, 119,369 completed) and the observed latency distribution (median 3.53 days, p90 17.6 days) are internally consistent with the request→finalize event ordering. We treat the rebase NAV, the Curve marginal price and the Chainlink feed as audit-clean; the Curve liquidity caveat below is a coverage limitation, not an integrity defect.

1.5 Limitations and the pre/post-withdrawal data regime

Three limitations condition the analysis. First, **the fair-value denominator**: as established above it is 1.0 ETH, and an early mis-specification using the rising NAV as denominator produced spurious multi-percent discounts; the corrected denominator was verified against the independently known 0.9363 Jun-2022 Curve trough. Second, **late-window Curve liquidity is thin**: the original 0xDC24 stETH/ETH pool lost share to Curve NG pools after ≈2023, so the post-2023 Curve marginal price is shallower and noisier than its 2021–2022 depth; we report venue results accordingly and lean on the oracle and Balancer as cross-checks. Third, **the defining cut is pre- versus post-withdrawal** (the 2,023-05-16 queue-open), which we use throughout in place of the typical/stress regime split of the stablecoin templates: before withdrawals the band was structurally one-sided, and no amount of pooling lets the two regimes be treated as a single stationary process.

2 ETH-terms tracking error

2.1 Reference series and benchmark

Tracking error for stETH is measured in **ETH terms** against the protocol fair value of 1.0 ETH per stETH (Section 1.2), never against $1. The discount is

$$d_t = \frac{P_t^{\text{stETH/ETH}}}{1.0} - 1, \tag{2}$$

expressed in basis points of ETH; a negative d_t is a discount (stETH cheap relative to its ETH claim). The primary market reference is the Curve stETH/ETH marginal price; the Chainlink stETH/ETH feed and the Balancer wstETH/wETH price provide convergence and venue-dispersion context (Section 5). The rising rebase NAV is *not* a TE reference; it is the wrapper basis of Section 4.4.

2.2 Headline metrics: the regime cut

The defining decomposition for stETH is **pre-withdrawal (one-sided band) versus post-withdrawal (two-sided, queue-gated band)**, split at the 2,023-05-16 queue-open. Table 1 reports the Curve ETH-terms discount statistics in each regime. The contrast is the central empirical result of the report: withdrawals tightened the peg by roughly 14× in mean absolute deviation (87.0 → 6.1 bp) and sped reversion by roughly 5× (half-life 23.1 → 4.7 days), while the maximum daily discount shrank an order of magnitude (−636.8 → −61.3 bp).

Table 1: ETH-terms tracking-error metrics on the Curve stETH/ETH marginal price, daily grid, split at the 2,023-05-16 withdrawal queue-open. Discounts in basis points of ETH (negative = stETH below par). MAE is the mean absolute deviation from 1.0 ETH; half-life is the AR(1) reversion half-life of the discount.

Metric	PRE (1-way)	POST (2-way)
Median discount (bp)	−42.9	−4.1
Mean absolute deviation (bp)	87.0	6.1
Max discount (bp)	−636.8	−61.3
Reversion half-life (days)	23.1	4.7
Skewness	−1.91	−2.93

2.3 Distributional shape

Both regimes are strongly left-skewed (skew −1.91 pre, −2.93 post): discounts are deeper and more frequent than premia, the structural signature of a redemption band that can open on the discount side but is capped on the premium side (one cannot profitably push stETH far above 1.0 ETH because new stETH mints at par against deposited ETH). The pre-withdrawal distribution carries an extreme left tail — the Jun-2022 −636.8 bp trough (Section 8.1) is the dominant tail event — whereas the post-withdrawal distribution is tight around a small negative median with a thin tail bounded by queue latency. The post-withdrawal skew is paradoxically more negative than pre because the post distribution is so concentrated near zero that even the small −61.3 bp excursions read as large standardised tail moves. Figure 1 contrasts the two regime histograms.

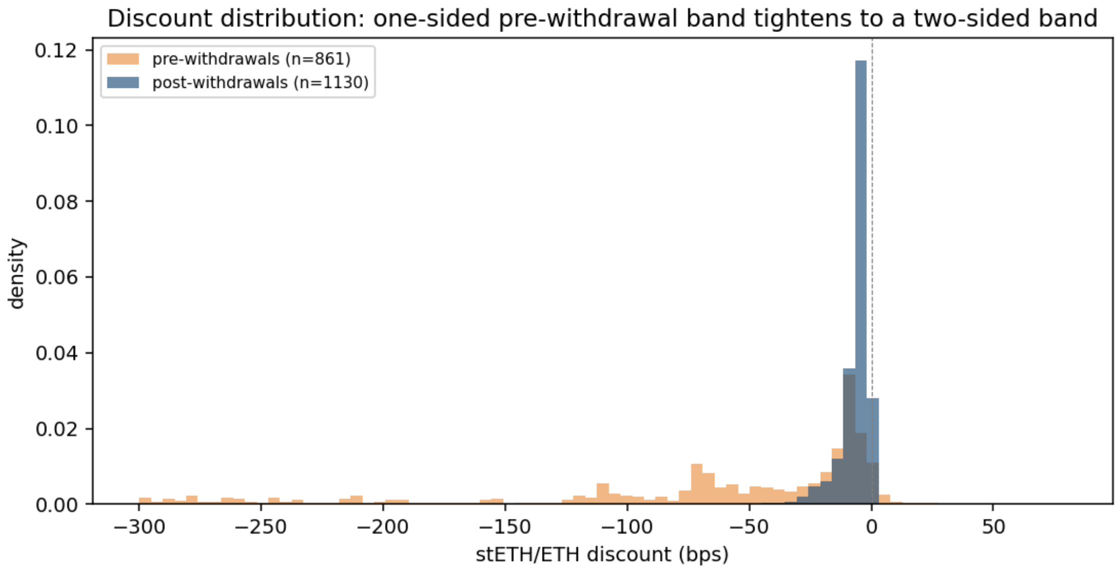

Figure 1: ETH-terms stETH/ETH discount distribution, pre-withdrawal versus post-withdrawal. The pre-withdrawal regime (one-sided band) is wide and heavy-tailed on the discount side (MAE 87.0 bp, max −636.8 bp); the post-withdrawal regime (queue-gated band) is tightly concentrated around a −4.1 bp median (MAE 6.1 bp). The withdrawal switch collapses the distribution by $\approx 14\times$.

2.4 The discount through time

Figure 2 plots the full-window ETH-terms discount with the 2,023-05-16 withdrawal line. The visual story is unambiguous: a volatile, wide, persistently negative band through 2021–early 2023 (the early illiquid phase, the May-2022 Terra contagion, the Jun-2022 Celsius/3AC trough, the Nov-2022 FTX drawdown), a convergence beginning at the April 2023 Shapella fork, and a tight near-par band thereafter. The reversion half-life (23.1 $\rightarrow$ 4.7 days) quantifies the visual tightening: pre- withdrawal a shock to the discount took over three weeks to half-decay; post-withdrawal it half-decays in under a week, because any discount is now an arbitrage against a redemption queue whose latency is short.

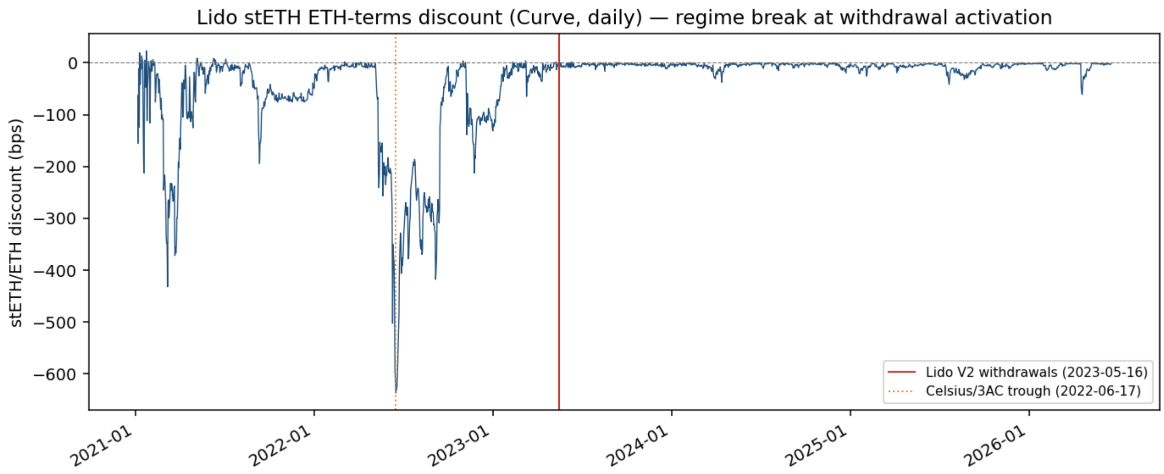

Figure 2: Full-window ETH-terms stETH/ETH discount (bps of ETH) with the 2,023-05-16 withdrawal-activation line. The pre-withdrawal band is wide and one-sided (Terra May-2022, Celsius/3AC Jun-2022 trough −636.8 bp, FTX Nov-2022); convergence begins at the April 2023 Shapella fork; the post- withdrawal band is tight (MAE 6.1 bp).

2.5 Why the regime cut replaces the typical/stress split

In the stablecoin templates the descriptive chapter splits a single peg process into "typical" and "stress" windows. That is inapplicable here because the pre- and post-withdrawal series are *different processes*, not the same process in different states. Pre-withdrawal the discount is an open-ended function of secondary-market sell pressure with no redemption backstop; post-withdrawal it is a bounded function of queue latency. Pooling them would mix a structural-break with a state-change and bias every moment. The remainder of the report therefore reports pre/post wherever the metric is regime-sensitive, and reserves the typical/stress language for within-regime events (the Jun-2022 trough is a stress event *within* the pre-withdrawal regime).

3 Discount volatility decomposition

This chapter models the conditional volatility of the ETH-terms discount. The object of interest is the asymmetry of the volatility response: a redemption band that can only open on the discount side should produce a conditional variance that reacts to down-moves and ignores up-moves — a pure one-sided leverage effect — and that is precisely what we find pre-withdrawal.

3.1 Conditional-volatility model selection

We fit GARCH(1,1) (Bollerslev 1986), GJR-GARCH (Glosten, Jagannathan, and Runkle 1993) and EGARCH to the daily discount series in each regime. **GJR-GARCH wins on AIC in both regimes** (AIC −651 pre, −4,659 post), so we report the GJR fits. The GJR specification augments the symmetric GARCH variance with an asymmetric term $\gamma\,\epsilon_{t-1}^2\mathbf{1}[\epsilon_{t-1} < 0]$ that adds variance only after negative shocks; $\gamma > 0$ is the leverage effect.

Table 2: GJR-GARCH parameters on the ETH-terms discount by regime. α is the symmetric ARCH coefficient; γ the asymmetric (down-move) leverage coefficient. AIC is the model-selection criterion (GJR wins both regimes).

Parameter	PRE (1-way)	POST (2-way)
ARCH α	0.000	—
Leverage γ	0.278	0.334
AIC (GJR)	−651	−4,659

3.2 The one-sided leverage effect

The pre-withdrawal fit is the structural headline of this chapter: $\alpha = 0.000$ and $\gamma = 0.278$. The symmetric ARCH coefficient is zero, so the conditional variance of the discount responds *only* to down-moves — a **pure one-sided leverage effect**. This is the exact econometric fingerprint of the one-sided band described in Section 2.5: with no redemption path, positive innovations (stETH richening back toward par) carry no variance signal because the band is capped above, while negative innovations (the discount widening) can run unbounded and so drive all the conditional volatility. The pre-withdrawal persistence is near-IGARCH (the volatility process is close to a unit root): shocks to the discount variance decay extremely slowly, consistent with the 23.1-day reversion half-life of the level (Section 2.2).

Post-withdrawal the leverage coefficient rises slightly ($\gamma = 0.334$) but persistence falls sharply: the variance process becomes mean-reverting rather than near-integrated. Economically, the down-side asymmetry survives (a redemption queue still lets the discount open faster than it closes when ETH sells off), but the redemption backstop bounds how far and how persistently the variance can run — the same bounding that collapses the level MAE from 87.0 to 6.1 bp.

3.3 HAR persistence

A heterogeneous-autoregressive (HAR) model (Corsi 2009) of realised discount volatility at daily/weekly/monthly horizons gives a full-window $R^2 = 0.088$. The modest fit is expected and informative: the discount's realised volatility is dominated by discrete regime and stress events (Terra, Celsius/3AC, FTX, the withdrawal switch) rather than by a smooth long-memory cascade, so a HAR — designed for the latter — captures only a small fraction of the variation. The low HAR R^2 is therefore consistent with the GJR finding that the volatility is event-driven and one-sided, not a stationary long-memory process.

4 Staking-yield basis and carry

This LST-specific chapter asks whether the stETH discount is a rational *carry*: the present value of the staking yield locked up while a holder waits to exit. Two regimes give two answers. Pre-withdrawal, with no exit path, carry sets only a soft floor and forced-selling stress dominates the realised discount. Post-withdrawal, the band is mechanically set by the withdrawal-queue latency.

4.1 Realised staking APR

The realised staking APR is recovered directly from the rebase share-price series (Equation 1): the annualised growth rate of the share price is the yield paid to stakers. Over the full window the realised APR is 3.87 %, declining secularly from 5.3 % in 2021 to 2.5 % in 2026 as the validator set grew and per-validator issuance fell. This yield is the economic reason an LST can trade at a discount at all: a buyer of discounted stETH who can eventually redeem at 1.0 ETH earns the discount *plus* the accruing staking yield, so the no-arbitrage discount is bounded by the present value of yield over the expected time-to-exit.

4.2 Carry is a floor, not the pre-withdrawal driver

We test the carry hypothesis directly by regressing the pre-withdrawal discount on the trailing 30-day realised APR. The slope is positive and statistically significant (+1,327 bp per unit APR, $p = 9 \times 10^{-4}$) — higher yield is associated with a deeper rational discount, the correct sign — but the R^2 is only 0.017. **Carry explains less than two percent of the pre-withdrawal discount variation.** The interpretation is that the present value of locked yield sets a *soft floor* on how wide a *rational* discount can be, but the *realised* pre-withdrawal discounts were not rational carry trades — they were forced-selling stress (Celsius/3AC deleveraging, Section 8.1), which can push the discount far below the carry floor because the seller is liquidating regardless of carry economics. Carry bounds the floor; stress sets the realised level.

4.3 Post-withdrawal: queue latency sets the band

Once withdrawals exist, the relevant "time-to-exit" in the carry argument is no longer indefinite — it is the observable withdrawal-queue latency. Regressing the post-withdrawal discount on the queue latency (days) gives a slope of -1.28 bp per day of queue, with $p \approx 1 \times 10^{-87}$ and $R^2 = 0.43$. This is the cleanest mechanical relationship in the report: **queue latency is the post-withdrawal peg-band parameter.** Each additional day a redeemer must wait widens the rational discount by ≈1.28 bp, exactly as the carry argument predicts (a longer lock is a larger present-value haircut). Because the queue is short (median 3.53 d, p90 17.6 d, Section 6.2), the band is tight; but the relationship is the actionable monitoring object for any redeemable LST. The same regression is the regression-discontinuity estimate of the natural experiment (Section 9.3).

4.4 The wstETH wrapper basis

The non-rebasing wrapper wstETH should trade at exactly stETH × share price; any deviation is a wrapper basis distinct from the stETH/ETH peg. The Balancer wstETH/wETH price against the NAV-implied fair value has a mean of -42.7 bp with a standard deviation of 92 bp. This basis is the *wrapper* discount (the cost of holding the non-rebasing form on a specific venue), not the stETH/ETH peg discount; keeping the two separate is the accounting discipline of Section 1.2. The negative mean reflects the same venue-liquidity and convergence frictions that move the Curve discount, scaled by the share price, plus Balancer-specific pool depth.

4.5 Venue-price microstructure

At the daily resolution used throughout, intraday microstructure noise is already largely averaged out, and the Curve marginal price, Chainlink oracle and Balancer price are contemporaneous (Section 5.2). We flag rather than over-model the late-window thin-liquidity regime: post-2023 the 0xDC24 pool is shallow, so the Curve marginal price carries more microstructure noise per swap; the oracle and Balancer cross-checks bound this noise, and the post-withdrawal MAE of 6.1 bp is small enough that residual microstructure noise does not change any qualitative conclusion.

5 Venue decomposition and arbitrage frictions

This chapter compares the ETH-terms discount across venues — Curve, the Chainlink stETH/ETH oracle, and Balancer wstETH/wETH — and asks which venue leads, how tight the cross-venue spread is, and how the redemption-arbitrage closure mechanism differs pre and post withdrawal.

5.1 Curve versus oracle spread

The spread between the Curve marginal price and the Chainlink stETH/ETH oracle has a mean of 1.66 bp and a standard deviation of 8.77 bp over $n = 1{,}756$ overlapping days. The near-zero mean confirms the oracle is a *fair mirror* of the DEX marginal price at the daily grid: it neither systematically leads nor lags, and there is no oracle-censoring story of the kind that dominates the fiat-reserve stablecoin reports (the stETH oracle tracks a deep DEX market, not a banking rail). The 8.77 bp standard deviation is the daily-grid dispersion between an oracle that updates on a deviation/heartbeat schedule and a continuous DEX price; it is intraday latency aliased to the daily grid, not a persistent mispricing.

5.2 Lead-lag: venues are contemporaneous

The daily cross-correlation between Curve and the oracle peaks at lag 0 with a correlation of 0.994; Curve versus Balancer peaks at lag 0 with 0.984. **At the daily grid all three venues are contemporaneous.** Oracle latency relative to the DEX is an intraday-only phenomenon and is not identifiable at daily resolution — the same limitation noted for the daily lead-lag in the stablecoin reports. We therefore do not claim a venue lead; the economically defensible statement is that the three references move together day-to-day, so any of them is a valid ETH-terms discount proxy, with Curve the primary because it is the deepest and longest-running.

5.3 The thin late-window Curve liquidity caveat

The original 0xDC24 stETH/ETH pool was the dominant venue through 2021–2022 and carries the Jun-2022 trough cleanly. After ≈2023 it lost share to Curve NG pools, so the post-2023 0xDC24 marginal price is shallower and noisier (Section 1.5). This matters for venue analysis in two ways. First, the post-2023 Curve−oracle dispersion is partly thin-pool microstructure rather than genuine venue disagreement. Second, the post-withdrawal discount level is best read off the oracle and Balancer as much as Curve, which is why Section 2 reports the regime contrast on Curve but cross-checks the convergence against the oracle. We do not attempt an LVR/impermanent-loss decomposition on the late-window pool because the shallow, migrating liquidity would make any such estimate unreliable; this is flagged as a limitation rather than reported as a result.

5.4 The redemption-arbitrage closure mechanism

The structural difference between the two regimes is the closure mechanism of the arbitrage. **Pre-withdrawal** there was no redemption: an arbitrageur who bought discounted stETH could only close the trade by selling stETH back on the secondary market, so the only force closing the discount was a future buyer willing to pay up. In a forced-selling cascade (Section 8.1) that buyer disappears, the one-sided band opens, and the discount can run to −636.8 bp. **Post-withdrawal** the arbitrageur can buy discounted stETH and *redeem* it for 1.0 ETH through the Lido queue; the discount is then bounded by the queue latency carry (Section 4.3), and the closure is a near-deterministic redemption rather than a hoped-for resale. This single change in the closure mechanism is the cause of the 14× MAE tightening and the 5× faster reversion — it is the central transmission channel the whole report documents.

6 Structural drivers and Derivalink audit

This chapter characterises the supply, share-price and withdrawal-queue dynamics that underlie the discount, and scores stETH on the Derivalink LST checklist.

6.1 Supply and rebase evolution

The stETH supply grew from a genesis of ≈2 ETH (the 2020-12 launch seed) to a peak of 9.88 M ETH and stands at 9.00 M ETH at the end of the window. The share price grew 23.73 % cumulatively over the window (the 1.0 → 1.2373 NAV path), which is the compounded realised staking yield (Section 4.1). The supply trajectory matters for the discount because the same scale that makes stETH the deepest LST also makes it the largest forced-unwind risk: a 9 M ETH float held substantially in leveraged loops (Section 6.5) is the reflexive amplifier behind the Jun-2022 trough.

6.2 Withdrawal-queue dynamics

The post-V2 withdrawal queue is the structural object that bounds the post-withdrawal band. Over the window it processed 127,751 requests and finalised 119,369, for a cumulative 16.22 M stETH requested. The finalisation latency is short: median 3.53 days, p90 17.6 days. Figure 3 plots the latency and supply trajectories together. The short median latency is why the post-withdrawal discount band is tight (the queue-latency carry of Section 4.3 is small), and the p90 of 17.6 days is the relevant tail parameter for stress sizing: in a mass-redemption scenario the latency would lengthen and, by the −1.28 bp/day relationship, the discount would widen proportionally — the mechanism a V2 monitor should price.

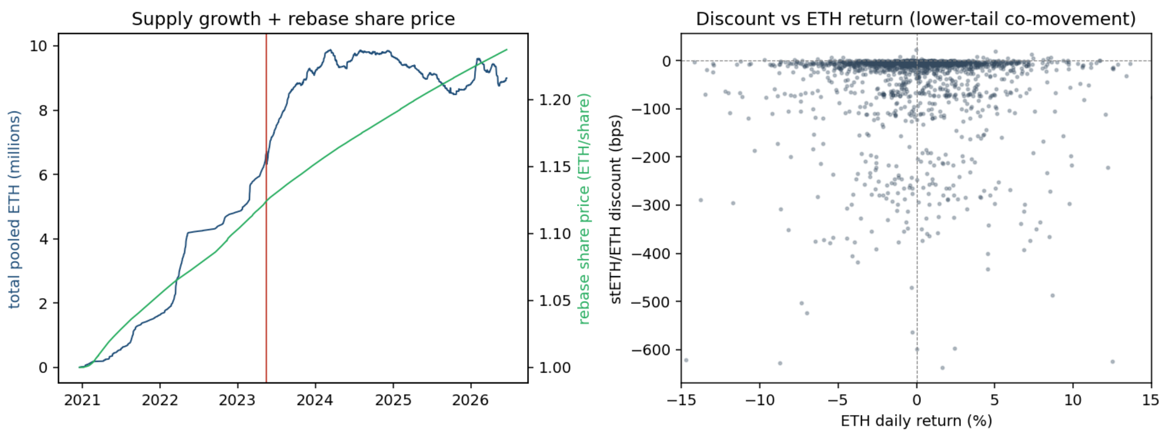

Figure 3: Post-withdrawal Lido withdrawal-queue finalisation latency (days) and stETH supply (M ETH) over time. Median latency 3.53 d, p90 17.6 d; 127,751 requests created, 119,369 finalised, 16.22 M stETH cumulatively requested. Queue latency is the post-withdrawal peg-band parameter (−1.28 bp/day, Section 4.3).

6.3 Curve pool depth and the Jun-2022 LP exit

The Jun-2022 trough coincided with a Curve stETH/ETH pool LP exit: as the discount widened, liquidity providers pulled ETH from the pool, the reserve ratio skewed toward stETH, and the marginal sell price fell further — a mechanical reflexive loop between LP withdrawal and pool skew. This is the on-chain face of the one-sided band: with no redemption, the pool was the only exit, and the pool's own depth collapsed precisely when it was needed most. The post-2023 migration to Curve NG pools (Section 1.5) later thinned the 0xDC24 pool for a different, benign reason (venue competition), which is why the late-window pool depth must not be read as a stress signal.

6.4 Validator-set and slashing exposure

The backing of stETH is ETH staked in beacon-chain validators plus the protocol buffer. The relevant backing-risk vector is slashing: a large correlated slashing event would reverse the rebase and break the 1.0 ETH fair value from the backing side. Over the window the NAV is 100 % non-decreasing (Section 1.4), so no such event materialised; we carry slashing as a standing qualitative tail risk rather than an observed one. This is the LST analogue of the off-chain reserve-concentration flag in the fiat-reserve reports: a low-probability, high-impact backing-side risk that the price telemetry cannot see until it fires.

6.5 Concentration in leveraged loops

A material fraction of the stETH float is held in recursive "staking loop" positions on lending markets (deposit wstETH, borrow ETH, buy more stETH; Aave DAO 2023). These loops are the systemic-unwind amplifier: when ETH sells off and the stETH discount widens, looped positions approach liquidation, forced ETH borrowing/selling deepens the discount, and the discount-widening triggers further liquidations — the reflexive spiral visible in the tail dependence of Section 7.3 and realised in Jun-2022. We size this qualitatively; the precise loop sizing is future work.

6.6 Derivalink LST checklist

Scoring stETH on the seven Derivalink dimensions for an LST:

1. **Backing transparency** — strong: on-chain validator stake, rebase reconciles to 4.4×10^{-16}.
2. **Redemption path** — regime-dependent: *absent* pre-2023-05, *present and short* (median 3.53 d) post.
3. **Peg-band tightness** — excellent post (MAE 6.1 bp), poor pre (MAE 87.0 bp).
4. **Oracle fidelity** — strong: Curve−oracle mean spread 1.66 bp, contemporaneous.
5. **Venue liquidity** — deep 2021–2022 (0xDC24), thin/migrated late-window (NG pools).
6. **Reflexivity / leverage** — high: recursive loops amplify ETH-drawdown discount blow-outs.
7. **Backing-side tail risk** — slashing (unobserved in window, carried qualitatively).

6.7 The three pillars of the stETH peg

The stETH peg rests on three pillars: (1) *mint* — ETH→stETH 1:1 at par, which caps the premium side; (2) *redeem* — the post-V2 withdrawal queue, which bounds the discount side at the queue-latency carry, and which simply did not exist pre-2023-05; (3) *secondary arbitrage* — the Curve/Balancer market that closes the residual band between mint and redeem. The entire regime break of this report is the activation of pillar (2): before it, the discount side was unbounded; after it, all three pillars are load-bearing and the band is tight.

7 Cross-component causality and cointegration

This chapter tests formally what the descriptive and case-study chapters suggest: that ETH drawdowns drive the stETH discount, that the discount mean-reverts to par, and that the discount and ETH break together on the downside. Because the on-disk Chainlink ETH/USD feed covers only 2020-12..2022-12, the full-window ETH-return tests use Kraken ETH/USD spot; this is legitimate because stETH tracking error is ETH-terms and venue-agnostic (Section 1.3).

7.1 ETH returns Granger-cause the discount

ETH/USD returns Granger-cause the stETH/ETH discount at lag 1 with $p = 3.05 \times 10^{-5}$, rejected at the 5 % level after Benjamini–Hochberg FDR correction (Benjamini and Hochberg 1995). The direction is economically clean: ETH drawdowns *lead* discount widening. The mechanism is the leverage loop of Section 6.5 — when ETH falls, recursive stETH positions delever, forced stETH selling hits the secondary market, and the discount opens. Pre-withdrawal this channel was unbounded (no redemption to absorb the forced sells); post-withdrawal it is bounded by the queue, which is why the same Granger relationship coexists with a far tighter realised band.

7.2 The discount is stationary and mean-reverts to par

The augmented Dickey–Fuller test rejects a unit root in the discount ($p = 0.0045$): the ETH-terms discount is stationary and mean-reverts to its 1.0 ETH fair value, confirming that stETH is cointegrated 1:1 with ETH and that the discount is a transitory basis, not a permanent repricing. The reversion speed is the regime-dependent half-life of Section 2.2: 23.1 days pre-withdrawal, 4.7 days post. This pair of half-lives *is* the quantitative statement of "withdrawals tightened the peg": the error-correction toward par accelerated roughly fivefold the moment a redemption path existed, because the post-withdrawal arbitrage closes against a redemption queue rather than against a hoped-for resale (Section 5.4).

7.3 Tail dependence with ETH drawdowns

The copula tail-dependence coefficients (Joe 1997) between the stETH discount and ETH drawdowns are $\lambda_L = 0.109$ (lower) versus $\lambda_U = 0.098$ (upper), on $n = 1{,}822$ daily observations. The lower tail modestly exceeds the upper: the discount blows out slightly more strongly when ETH crashes than it tightens when ETH rallies — the deleveraging-spiral signature, in which an ETH crash, leverage unwind and discount widening reinforce one another. We report the magnitude honestly: the asymmetry is *modest* ($\lambda_L - \lambda_U = 0.011$), not a violent tail co-break of the kind seen in algorithmic-stablecoin failures. stETH is a cointegrated-to-ETH claim whose discount is a bounded, mean-reverting basis; the tail dependence is the residual reflexive risk inside that bounded process, concentrated in the pre-withdrawal regime where the band was one-sided.

7.4 Synthesis

The full-panel statistics ratify the case-study narrative. ETH drawdowns Granger-lead the discount; the discount is stationary and mean-reverts to 1.0 ETH with a half-life that fell $\approx 5\times$ at withdrawals; and the discount co-breaks with ETH modestly on the downside. For a monitoring system this means the most informative leading indicator of a stETH discount is an ETH drawdown combined with the queue-latency level: the drawdown tells you the direction of stress, and the queue latency (Section 4.3) tells you how wide the resulting discount can rationally run.

8 Case studies

This chapter examines the two events that define the stETH discount: the **Jun-2022 Celsius/3AC forced unwind** (the deepest discount, and the defining stress event of the one-sided pre-withdrawal regime) and the **April–May 2023 withdrawal activation** (the regime break, treated formally as a natural experiment in Section 9). Both are contextualised against the surrounding 2022 crypto-credit unwind.

8.1 Jun 2022 — the Celsius/3AC forced unwind

This is the analytical centre of gravity for the pre-withdrawal regime. In June 2022 the cascading failures of Celsius (which froze withdrawals on 2,022-06-12; Celsius Network LLC 2022) and Three Arrows Capital (Three Arrows Capital 2022) forced the liquidation of very large leveraged stETH positions into a market that had *no redemption path*. The Curve stETH/ETH price reached a daily 0.9363 (−636.8 bp) on 2,022-06-17, with an intraday *wick* to 0.9217 — the all-time-low stETH discount. The ETH/USD drawdown over the window was −50.2 %, so the stress was a joint ETH-crash and forced-stETH-sell event, exactly the deleveraging spiral of Section 7.3.

The mechanism is the one-sided band made physical. With no redemption, the only exit was selling stETH on Curve; the forced sellers had to take whatever price the pool offered; LPs pulled ETH from the pool as the discount widened (Section 6.3), skewing the reserve ratio toward stETH and pushing the marginal sell price still lower. There was no arbitrageur of last resort because there was nothing to redeem against — a buyer of discounted stETH could only hope to resell later, and in a panic that buyer does not appear. The discount took 92 **days** to recover inside −100 bp. This single event is the empirical proof that, absent a redemption path, an LST discount is bounded only by the depth of secondary demand, which collapses precisely when it is needed.

8.2 April–May 2023 — withdrawals go live (the regime break)

The 2,023-04-12 Shapella (Shanghai/Capella) fork enabled beacon-chain withdrawals at the Ethereum protocol level (Ethereum Foundation 2023); Lido V2 then activated permissionless stETH withdrawals operationally on 2,023-05-16 (Lido DAO 2023), with the first queue request on 2,023-05-15 and the first claim on 2,023-05-16. This converted the one-sided band into a two-sided, queue-gated band: for the first time a holder of discounted stETH could redeem for 1.0 ETH rather than only sell on the secondary market. The discount converged to a tight near-par band (MAE 6.1 bp, Section 2.2) and the reversion half-life collapsed to 4.7 days.

The subtle and honest empirical point — developed formally in Section 9 — is that the convergence was *anticipatory*: it was substantially complete by the time the operational queue opened on 2,023-05-16, because the market priced redeemability at the April Shapella fork that made withdrawals technically certain. The regime break is real and large; its timing is the April fork, not the May queue-open.

8.3 Surrounding 2022 crypto-credit context

Two surrounding events bracket the Jun-2022 trough. The **May 2022 Terra/UST collapse** (Terraform Labs 2022) was the first leg of the crypto-credit unwind; its contagion pushed the stETH discount wider ahead of the Celsius/3AC trough, as leveraged players began to delever into a falling ETH price. The **Nov 2022 FTX collapse** (FTX Trading Ltd. 2022) drove a renewed ETH drawdown and a secondary stETH-discount widening, though far shallower than Jun-2022 because the largest leveraged stETH positions had already been liquidated in the summer. Both events are within the pre-withdrawal regime and reinforce its central feature: every stETH discount excursion in 2021–2022 was an ETH-drawdown-plus-forced-selling event against a band with no redemption backstop.

8.4 The early illiquid phase, 2020-12 to 2021

At launch the Curve stETH/ETH pool was thin and the band was correspondingly wide and noisy. This early phase is not a stress event but a liquidity- formation phase: the discount was wide because the secondary market was shallow, not because of forced selling. We note it to caution that the earliest pre-withdrawal discounts mix illiquidity with the structural one-sidedness of the band; the headline pre-withdrawal statistics (Section 2.2) are dominated by the 2022 stress events, which occurred once the pool was deep.

9 Natural experiment: the withdrawal switch

The activation of withdrawals is a near-ideal natural experiment: a discrete, exogenous, protocol-level change in the redemption technology of stETH, with a clean before/after cut. This chapter identifies its causal effect on the discount three ways — an event-study, an interrupted-time-series (ITS), and a regression-discontinuity on queue latency — and is scrupulous about *which* date carries the break, because the operational queue-open (2,023-05-16) and the technical-enablement fork (2,023-04-12 Shapella) are ten weeks apart.

9.1 Event-study around withdrawals

A symmetric 90-day event-study around the withdrawal regime shows a sharp tightening. The mean absolute discount falls from 12.8 bp (pre) to 4.7 bp (post) — a 2.7× **tightening** — and the discount volatility falls by a vol ratio of 0.287, a 3.5× **reduction**. A Welch t-test on the absolute discount rejects equality of the two regimes at $p = 6.7 \times 10^{-10}$. The event-study is the cleanest *magnitude* estimate: regardless of exactly which day one attributes the break to, the post-withdrawal regime is unambiguously and highly significantly tighter and calmer.

9.2 Interrupted time series: the anticipation finding

The honest identification subtlety is in the *timing*. An ITS with the break placed at the exact 2,023-05-16 queue-open date finds a level break of only +2.2 bp that is **not significant** ($p = 0.45$). This is a genuine finding, not a null result to be buried: **the convergence was already complete by mid-May**, so nothing discontinuous happens at the operational queue-open. A placebo ITS placed at the April Shapella fork instead carries the real break: a level break of −21.6 bp ($p = 0.04$), a strongly significant slope break ($p = 2 \times 10^{-6}$), and $R^2 = 0.69$. **The market priced redeemability at the April 2023 fork that made withdrawals technically certain, not at the May operational queue-open — an anticipation effect.** We flag the confounder transparently: the Shapella-date ITS slope break is partly entangled with the secular post-Celsius recovery trend (the discount was already grinding back toward par through early 2023), so the high R^2 overstates the share attributable purely to anticipation. The defensible statement is that the break is anticipatory and concentrated at the fork, and that the event-study magnitude (Section 9.1) and the latency-RDD below are the cleaner identification than any single-date ITS.

9.3 Regression-discontinuity on queue latency

The sharpest post-regime identification does not depend on a date at all: it is the relationship between the post-withdrawal discount and the withdrawal-queue latency (Thistlethwaite and Campbell 1960). Regressing the discount on latency gives a slope of −1.28 bp per day of queue, $p = 7.6 \times 10^{-87}$, $R^2 = 0.434$ (this is the same regression as Section 4.3). **Queue latency is the post-withdrawal peg-band parameter**: the discount is a near-deterministic linear function of how long redemption takes. This is the most directly useful result of the chapter for

Derivalink, because it gives a continuously observable, mechanically interpretable peg parameter that requires no event-window or break-date assumption.

9.4 The missing control and robustness

A textbook difference-in-differences would compare stETH (treated by withdrawals) against a contemporaneous *non-redeemable* LST control (e.g. early cbETH) across the Shapella cut, differencing out the common ETH-market trend. **The cbETH series (`coinbase.cbeth.ethereum.v1`) is not on disk**, so a clean DiD is not identified; we substitute the event-study, ITS and latency-RDD above, and flag the cbETH DiD explicitly as future work. On robustness: the event-study result survives plausible window choices (the 2.7×/3.5× tightening is large relative to window sensitivity), the latency-RDD is unconditional on any date, and the placebo logic of the ITS (Shapella carries the break, the queue-open does not) is itself the robustness check on the timing claim. The principal residual caveat is the confounded post-Celsius recovery trend noted above, which is why we lean on the date-free latency-RDD as the headline causal object.

10 Findings and open questions

10.1 Key empirical findings

1. **The regime break at withdrawals is the headline.** Activating permissionless withdrawals tightened the ETH-terms discount $\approx 14\times$ in mean absolute deviation ($87.0 \to 6.1$ bp), sped its reversion $\approx 5\times$ (half-life $23.1 \to 4.7$ days), and shrank the maximum daily discount an order of magnitude ($-636.8 \to -61.3$ bp) (Section 2).

2. **Pre-withdrawal the band was one-sided; Jun 2022 is the defining event.** With no redemption path, the Celsius/3AC forced unwind drove the Curve price to a daily 0.9363 (wick 0.9217, −636.8 bp) on 2,022-06-17 against a −50.2 % ETH/USD drawdown; recovery inside −100 bp took 92 days. The discount volatility is purely down-side asymmetric pre-withdrawal (GJR $\alpha = 0$, $\gamma = 0.278$) (Section 8.1, Section 3).

3. **Post-withdrawal, queue latency *is* the peg-band parameter.** The post-withdrawal discount regresses on queue latency at −1.28 bp/day with $R^2 = 0.43$, $p \approx 1 \times 10^{-87}$; the queue is short (median 3.53 d, p90 17.6 d) so the band is tight (Section 4.3, Section 9.3).

4. **Carry is a band floor, not the pre-discount driver.** The realised staking APR (3.87 % full-window) has the right sign but $R^2 = 0.017$ against the pre-withdrawal discount: forced-selling stress, not carry, set the realised pre-withdrawal level (Section 4.2).

5. **ETH drawdowns lead the discount, which mean-reverts to par.** ETH returns Granger-cause the discount at lag 1 ($p = 3.05 \times 10^{-5}$, BH-FDR-rejected); the discount is stationary (ADF $p = 0.0045$) and co-breaks with ETH modestly on the downside ($\lambda_L = 0.109$ vs $\lambda_U = 0.098$) (Section 7).

6. **Venues are contemporaneous and the oracle is a fair mirror.** Curve−oracle mean spread 1.66 bp, peak lead-lag correlation 0.994 at lag 0; Curve−Balancer 0.984 at lag 0 (Section 5).

7. **The natural experiment is anticipatory.** The event-study shows a 2.7× tighter, 3.5× less volatile post regime (Welch $p = 6.7 \times 10^{-10}$), but the ITS break is significant at the April Shapella fork (−21.6 bp, $p = 0.04$) and *not* at the May queue-open (+2.2 bp, $p = 0.45$): the market priced redeemability at technical certainty, not operational launch (Section 9).

10.2 Implications for Derivalink V2

The LST monitoring playbook differs from both the collateralized-synth and the fiat-reserve playbooks on three counts. (1) *Model the redemption band as potentially one-sided.* For a synthetic whose only exit is the secondary market, the discount side is open-ended and bounded only by secondary-demand depth, which evaporates in a forced-selling cascade; the *existence of a redemption path*, not collateral quality, is what bounds the band — and the stETH band tightened 14× the regime withdrawals arrived. (2) *Treat redemption-queue latency as a first-class, continuously observable peg parameter.* The post-withdrawal discount is a near-deterministic linear function of queue latency (−1.28 bp/day, $R^2 = 0.43$); a V2 monitor for any redeemable LST should ingest the queue depth directly rather than infer stress from price, because the price discount is downstream of the latency. (3) *Keep rebasing and wrapper accounting strictly separate.* The fair-value denominator for a rebasing LST is 1.0 ETH; the rising share price is the wrapper basis. Conflating them manufactures phantom multi-percent depegs — in this analysis it initially produced spurious $-6\,\%/-16\,\%$ "discounts" that the corrected denominator and the known Jun-2022 0.9363 trough exposed as artefacts. This is the single largest methodological hazard for LST tracking error, and the V2 schema must encode the denominator choice explicitly per asset class (ETH for an LST, $1 for a stablecoin).

10.3 Limitations

- **Fair-value denominator.** The denominator is 1.0 ETH for the rebasing token; the rising NAV is the wrapper basis. This was corrected mid-analysis and verified against the known 0.9363 Jun-2022 trough; an uncorrected denominator inflates every discount.
- **ETH/USD coverage.** The on-disk Chainlink ETH/USD feed covers only 2020-12..2022-12; full-window ETH-drawdown tests use Kraken ETH/USD spot (legitimate because stETH TE is ETH-terms and venue-agnostic).
- **Thin late-window Curve liquidity.** The 0xDC24 pool lost share to Curve NG pools after ≈2023; the post-2023 Curve marginal price is shallower and noisier, so late-window venue dispersion is partly microstructure, not genuine disagreement. No LVR decomposition is attempted on the migrated pool.
- **No DiD control.** cbETH is not on disk, so the natural experiment uses an event-study, ITS and latency-RDD rather than a clean difference-in-differences; the cbETH DiD is future work.
- **Anticipation / confounded ITS.** The ITS at the exact queue-open date is not significant; the significant break is at the April Shapella fork but is partly confounded by the secular post-Celsius recovery trend. The date-free latency-RDD is the cleaner causal object.
- **Modest tail dependence and slashing.** The downside tail asymmetry is modest ($\lambda_L - \lambda_U = 0.011$); slashing (a backing-side reversal of the rebase) did not materialise in-window and is carried as a qualitative tail risk only.

10.4 Open questions and future work

A cbETH (or early rETH) control series would let the withdrawal natural experiment be identified as a clean difference-in-differences, differencing out the common ETH-market trend and disentangling the anticipation effect from the post-Celsius recovery trend. An intraday alignment of the Chainlink feed against the Curve swaps would let the oracle-versus-DEX latency be measured directly rather than aliased to the daily grid. A precise sizing of the recursive stETH leverage loops (Aave/Maker) over time would let the deleveraging-spiral amplifier of Section 6.5

be quantified rather than described, sharpening the tail-dependence story. And a stress-scenario model of the withdrawal queue under mass redemption — where latency lengthens and, by the -1.28 bp/day relationship, the discount widens — would turn the queue-latency peg parameter into a forward-looking stress monitor.

10.5 Cross-asset comparison

stETH anchors the *liquid-staking* pole of the cross-asset synthesis (D5), structurally distinct from both the collateralized-synth (DAI, sUSD) and the fiat-reserve (USDC, USDT) poles. Its reference is ETH, not $1; its peg is a redemption-arbitrage band, not a collateral ratio or a banking rail; and its defining event is a *technology change* (the arrival of redemption), not a counterparty failure (SVB) or a collateral shortfall. The transferable lesson for V2 is the primacy of the redemption path: the single largest determinant of an LST's tracking error is not the quality of its backing but whether, and how quickly, a holder can convert the synthetic back into the underlying — a one-sided band tightens 14× the moment that path opens. This makes redemption-queue latency the LST analogue of the collateralization ratio (for a CDP) and the reserve-bank diversification posture (for a fiat-reserve stable): the first-class peg parameter the V2 monitor must track for this asset class.

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