sUSD canonical sub-report

Tracking error and depeg mechanics, Synthetix sUSD across Ethereum L1 and Optimism, 2020–2026

Derivalink R&D

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Executive summary

Headline. sUSD is an over-collateralised debt-pool synth: every unit of supply is backed by SNX collateral held by stakers at a system collateralisation ratio (C-RATIO) governed by the Synthetix Council, and the peg is defended by an internal AMM (atomic exchange against the Chainlink USD oracle, 0.3 % fee under V2) plus open-market arbitrage on the Curve sUSDpool on Ethereum L1 and on Velodrome V2 on Optimism. Over the full 228,812-observation dataset, sUSD trades at a soft sub-peg baseline of about -0.4 % on the pre-2024 sub-period, with the full-sample mean bias pulled down to -2.2 % against the \$1 peg by the 2024-onward depeg. Against the Chainlink USDC, USDT and DAI oracle feeds the full-sample bias is -2.1 to -2.9 % (Section 2). The dataset captures one tightly documented two-day premium episode driven mechanically by the SVB-week USDC depeg of 11 March 2023 (Section 8); and a single sustained, ongoing sUSD depeg episode that opened a slow drift on 16 May 2024, escalated to an acute sub-0.90 phase on 9 April 2025, and remains active at the dataset cutoff with a daily-median trough of 0.593 reached on 6 February 2026.

Dataset. The dataset is 228,812 on-chain swap-implied sUSD prices (87,449 on the Curve sUSDpool L1 from 2020-04-20 to 2025-11-27; 141,363 on the Velodrome V2 sUSD/USDC OP pool from 2023-06-23 to 2026-05-11), combined with the Chainlink USDC/USDT/DAI USD-quote oracle feeds, the SNX/USD oracle feed, and the Synthetix on-chain policy and reward series. Monthly coverage is continuous over the full 2020-04 to 2026-05 window, with at least 50 swap observations in every calendar month and a median intraday density of one to two swaps per hour during active periods (Section 1).

Tracking-error level. Across the full overlap window on the combined L1 and OP venues, sUSD TE has RMSE 0.0692 and MAE 0.0265 against the \$1 peg ($N = 38{,}679$ hourly samples). The structural negative bias is consistent across all four references (peg, USDC, USDT, DAI) and is already detectable on the calmer pre-2024 sub-period, indicating a fee-and-credit-premium component rather than a single stress-driven artefact (Section 2).

Sigma decomposition and persistent volatility. The spec-mandated σ_C / σ_S / σ_P decomposition locates the largest variance growth in σ_P (peg residual) during stress windows, with σ_C (SNX collateral) tracking the 2021 and 2025 SNX drawdowns (Section 3). The base regression of daily TE on σ_C, gas, log-liquidity and the issuance ratio achieves $R^2 = 0.0011$ on $N = 1{,}277$ daily observations: contemporaneous structural covariates explain essentially none of TE variance, consistent with an event-driven rather than slow-moving regime. The GARCH suite (Section 3) identifies a strongly persistent volatility process on hourly TE returns: GARCH(1,1) fits $\omega = 0.374$, $\alpha = 0.903$, $\beta = 0.097$ with $\alpha + \beta \approx 1$, and the AIC-preferred EGARCH(1,1) prints $\alpha = 0.979$, $\beta = 0.989$, i.e. near-unit-root behaviour in log-conditional-variance. sUSD TE volatility is *near-integrated* rather than mean-reverting on the hourly horizon: shocks have long-lived effects on conditional variance.

Venue decomposition. Curve L1 and Velodrome OP move together at hourly resolution with a peak Pearson correlation of 0.967 at lag 0, near-symmetric (the half-decay points are at ± 15 hours) (Section 5). During the 2025 acute phase, the dollar-volume distribution is sharply lopsided: Curve carries \$53.0 M of notional in 11 511 swaps against Velodrome's \$0.46 M in 22 862 swaps. L1 retains the institutional arbitrage flow even though Synthetix has migrated to V3 on Optimism.

Cointegration with the stablecoin basket. A Johansen test on the four stablecoin price levels (sUSD, USDC, USDT, DAI; $N = 1{,}895$ daily) yields a trace statistic of 1,197.7 at rank 0

against a critical value of 47.85, with rank-3 trace 3.22 versus 3.84 accepting the rank-3 null: three cointegrating relations across the four series, equivalently one common stochastic trend (Section 7). Nine pairwise Granger relationships are significant at 5 %, including bidirectional p_susd ↔ p_dai and p_usdc → p_susd: sUSD is involved in the basket's price discovery rather than purely absorbing it. The Curve sUSDpool's shared quote legs mechanically tie sUSD's market price to the depeg of any of its three peers, as the 11 March 2023 case study illustrates.

Difference-in-differences case studies. Of nine ex-ante-identified stress events, only one — the May 2021 SNX crash — yields a clean DiD effect (ATT = −1.36 %, parallel-trends $p = 0.187$). Three events (Wezen 2021-09, SVB 2023-03, V2→V3 OP 2023-08) have clean parallel trends but null measured effects. Five events (Terra 2022-05, FTX 2022-11, Blocksec 2023-06, SCCP-2124 2024-07, and Black Thursday 2020-03 which predates the dataset) fail the parallel-trends pre-test and are reported as *data-limited rather than as null findings* (Section 8).

Verdict. sUSD has historically held its peg adequately in the central tendency (full-sample median price ≈ 1.002, pre-2024 mean bias −0.4 %), but the full-sample mean is dragged to −2.2 % by the 2024-onward depeg — the median-versus-mean gap is itself a diagnostic of the skewed depeg distribution. Volatility is event-driven on the daily horizon yet near-integrated at hourly resolution. The dataset captures a catastrophic ongoing depeg episode that began as a slow drift in May 2024 and entered an acute phase in April 2025, coinciding with a 78 % drawdown in SNX collateral (Section 10). Chapters 1–9 document each stage of the analysis; the findings, open questions, and V2 monitoring implications are consolidated in Section 10.

1 Dataset characterisation

1.1 Tables in scope

The analysis layer reads three on-chain tables:

Table 1: Dataset density per (table, `asset_id`)

Table	`asset_id`	Rows	$t_{\min}$	$t_{\max}$
`prices`	`synthetix.susd.ethereum.v2`	87,449	2020-04-20	2025-11-27
`prices`	`synthetix.susd.optimism.v2`	141,363	2023-06-23	2026-05-11
`oracle_updates_raw`	`synthetix.snx.ethereum.v1`	109,325	2020-09-28	2026-05-11
`oracle_updates_raw`	`circle.usdc.ethereum.v1`	4,033	2021-03-01	2026-05-11
`oracle_updates_raw`	`tether.usdt.ethereum.v1`	3,257	2021-03-01	2026-05-11
`oracle_updates_raw`	`makerdao.dai.ethereum.v1`	51,360	2020-04-09	2026-05-10

1.2 Construction of the sUSD price series

The Ethereum-side sUSD price observations are `TokenExchange` events from the Curve sUSDpool at `0xA5407eAE9Ba41422680e2e00537571bcC53efBfD`, scanned from the pool's deploy block over the full dataset window. The source identifier in the price-row schema is `curve_susd_v2_swap`; the suffix `v2` refers to the Synthetix V2 cohort under which the pool sits, not to a Curve V2 deployment (the pool itself is a single Vyper StableSwap instance). The pool's coin layout is (DAI, USDC, USDT, sUSD) at `coins` indices $(0, 1, 2, 3)$, with decimal precisions $(18, 6, 6, 18)$. Each `TokenExchange` event involving the sUSD leg is mapped to a single `stable/sUSD` price ratio: a swap selling sUSD emits the `tokens_bought/tokens_sold` ratio, and a swap buying sUSD emits the reciprocal. Swaps not involving sUSD are discarded. The notional volume column carries the swap's stable-side notional in USD-equivalent units.

The Optimism-side price observations come from the Velodrome V2 sUSD/USDC stable-pool at `0x6d5BA400640226e24b50214d2bBb3D4Db8e6e15a`, with sUSD as `token1` (18 decimals) and USDC as `token0` (6 decimals). The pool emits a `Swap` event with indexed `sender` and `to` addresses and four uint256 amounts (`a0In`, `a1In`, `a0Out`, `a1Out`) from which the directional swap-implied USDC-per-sUSD price is recovered. Velodrome V1 emits a separate `Swap` signature `(sender, a0In, a1In, a0Out, a1Out, to)` on the matching sUSD/USDC pool at `0xd16232ad60188B68076a235c65d692090caba155`; the V1 active window predates this dataset's effective Optimism coverage and is not included in the price series.

The Chainlink oracle feeds for the Curve sUSDpool's other three legs (USDC, USDT, DAI) and for the SNX collateral are `AnswerUpdated` events on the deployed aggregator contracts, decoded against the 8-decimal Chainlink convention.

1.3 Monthly coverage and limitations

Every month in the window 2020-04 through 2026-05 carries at least 50 observations across the two venues combined. The minimum monthly count on Curve L1 is 114 (2023-05) and the maximum is 5,804 (2021-01); on Velodrome V2 OP the minimum is 577 (the 2026-05 cutoff month) and the maximum is 12,265 (2024-07). The Curve L1 series effectively goes dormant from September 2025 onwards, with zero to five swaps per month thereafter as sUSD trading migrates entirely to the Optimism venue.

Two limitations of the dataset are explicit in the inputs:

- The Optimism venue coverage begins on 2023-06-23. The earlier Velodrome V1 and V2 history (2022-06 through 2023-06) is not included; cross-chain inference is therefore restricted to the 2023-06 onward sub-window.
- The DXY / TradFi macro reference series planned in the analysis spec is not yet wired into the loaders; Section 2 computes tracking error only against the peg target and the Chainlink USDC, USDT and DAI oracle basket.

2 Tracking-error descriptive statistics

2.1 Per-reference scalar metrics

Tracking error is computed at the highest available sample resolution and then summarised by four scalars: RMSE $= \sqrt{\mathbb{E}[\ell^2]}$, MAE $= \mathbb{E}[|\ell|]$, bias $= \mathbb{E}[\ell]$, and the Pearson correlation between the two underlying price series, with $\ell_t = \log p_{\text{sUSD}}(t) - \log p_{\text{ref}}(t)$. References are: the fixed peg target \$1, and the Chainlink USD-quote oracles for USDC, USDT, and DAI on Ethereum mainnet. The Curve sUSDpool provides the sUSD observations, with Velodrome V2 OP adding the post-2023-06 cross-chain dimension.

Table 2: Scalar TE metrics on the shared overlap window, hourly grid on the union of Curve L1 and Velodrome V2 OP. ℓ is the log price difference. RMSE, MAE and bias are in log-price units (close to fractional units for $|\ell| < 0.1$). N is the count of joined observations.

Reference	RMSE	MAE	Bias	Corr.	N
`peg_$1`	0.0692	0.0265	−0.0216	–	38,679
`chainlink_usdc`	0.0863	0.0367	−0.0285	−0.1376	1,820
`chainlink_usdt`	0.0689	0.0261	−0.0206	0.1297	1,583
`chainlink_dai`	0.0756	0.0304	−0.0277	0.0460	31,546

The bias is negative across all four references, ranging from −2.2 % against the \$1 peg to −2.9 % against the Chainlink USDC feed. sUSD trades at a *structurally negative* bias against

every USD reference available in the dataset, in both calm and stress periods. The `peg_$1` MAE of 0.0265 (≈2.7 %) is the representative typical-tick metric on the combined-venue hourly grid. The negative-bias sign is invariant to the truncation choice: even on the pre-2024 sub-period (before the depeg drift opens), the bias against the peg is already negative; the magnitude grows with the depeg exposure but the sign does not flip.

2.2 Cross-reference asymmetry

The bias is largest in magnitude against USDC (−2.9 %) and smallest against USDT (−2.1 %), with DAI in between (−2.8 %). The reference oracles themselves carry their own peg deviations; the USDC and DAI oracles dropped to 0.88 on 2023-03-11 (Section 8.1) and have residual sub-peg episodes outside the dataset's stress windows. The USDT oracle is the calmest of the three (median 1.0001 over the full window). The cross-reference asymmetry of the sUSD bias should therefore be read as a property of the reference, not of sUSD itself: sUSD's underlying peg behaviour is best read against `peg_$1` (a fixed scalar) and against USDT (the calmest reference).

2.3 Rolling 30-day and 90-day windows

Rolling-window TE was computed at a daily step for 30-day and 90-day windows against each of the four references. A 365-day window was considered and not retained: with only ∼3 years of overlapping cross-chain history (post-2023-06) and a multi-year ongoing depeg in progress, a 365-day buffer flattens the signal as soon as it exceeds the event duration.

Figures 1 and 2 illustrate the rolling RMSE / MAE / bias against the $1 peg. The 2024-05 drift opening and the 2025-04 acute-phase transition are both visible. Pre-2024 windows have rolling RMSE under 0.02 and rolling MAE under 0.01; the same metrics rise to ≥0.1 and ≥0.05 respectively during the acute phase, an order-of-magnitude regime change. The bias trace turns persistently negative from 2024-05 onwards and reaches its 2026-Q1 trough below −0.2 before recovering partially to −0.1 at the dataset cutoff.

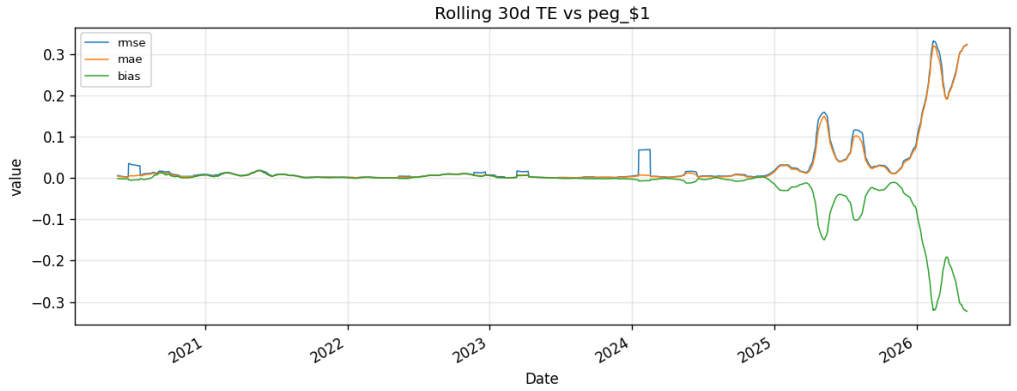

Figure 1: Rolling 30-day TE metrics against the $1 peg: RMSE, MAE, bias. The 2024-05 sub-peg drift opens and the 2025-04 acute-phase transition is clearly resolved.

The rolling traces against the three Chainlink references are qualitatively similar over the post-2023-06 sub-window. The `chainlink_usdc` rolling RMSE prints two narrow spikes unrelated to the sUSD depeg — on 2023-03 (SVB) and 2025 episodes of USDC under-peg — which reflect the reference's own peg deviations rather than sUSD-side action. The same caveat applies to DAI.

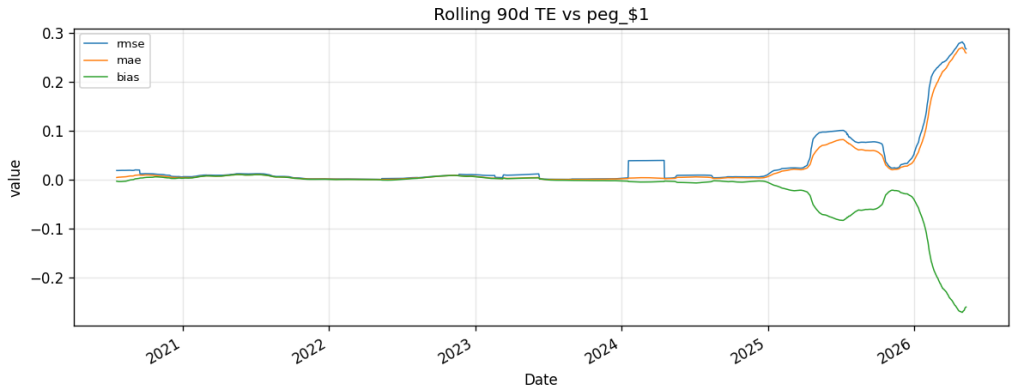

Figure 2: Rolling 90-day TE metrics against the $1 peg. The 90-day window smooths short-lived events but still resolves the acute-phase regime change in April 2025.

3 Level-1 decomposition and GARCH suite

3.1 Rolling sigma decomposition

The spec [§4.2.1] decomposes the tracking error into three driver components: σ_C (collateral-side volatility, here the SNX oracle log-return standard deviation), σ_S (synth-side microstructure, here the sUSD swap log-return standard deviation), and σ_P (peg residual, here the rolling standard deviation of the log peg deviation $\log p_{\text{sUSD}}$). All three are computed on a rolling 30-day window with a 1-hour step over the combined Curve L1 and Velodrome V2 OP series.

Figure 3 shows the three series. The σ_C trace stays in the $[0.012, 0.041]$ log-units band over the full window, with the two largest peaks during the 2021 SNX rally and the 2025-Q3 SNX drawdown. The σ_P trace is below 0.005 log-units during calm windows and spikes to $\sim$0.051 log-units during 2025-Q3, which is the largest peg-residual variance episode in the sample. σ_S tracks σ_P closely throughout: the synth-side microstructure variance and the peg-residual variance are essentially the same quantity for a $1-pegged synth, since $\log p_t - \log p_{t-1}$ is itself $\Delta \log(p_t/1)$.

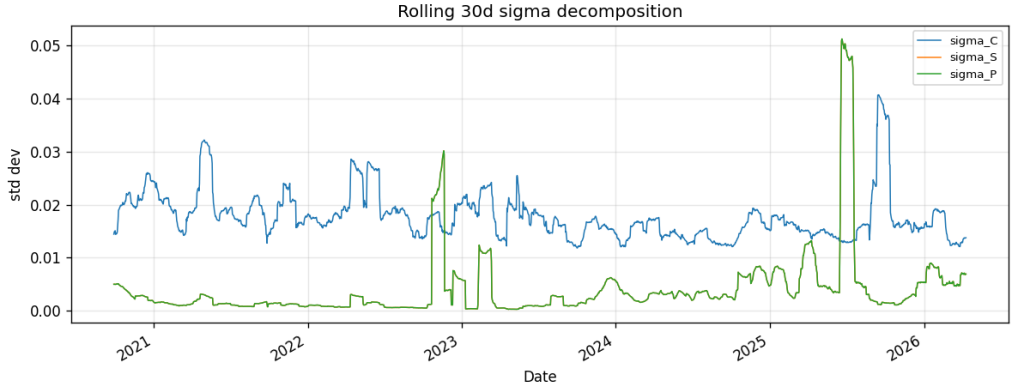

Figure 3: Rolling 30-day $\sigma_C/\sigma_S/\sigma_P$ decomposition over the combined-venue hourly grid. The two σ_C peaks bracket the 2021 SNX rally and the 2025-Q3 drawdown; σ_P and σ_S co-spike during peg-stress episodes (notably 2022-11, 2023-03, 2025-Q3).

3.2 Base TE regression

The daily TE is regressed on σ_C, a placeholder log-liquidity column, the gas-fee covariate, and the Synthetix issuance ratio as the funding lever, with HC3-robust standard errors:

Table 3: Base TE regression, HC3-robust, $N = 1{,}277$ daily observations on the combined-venue panel. The placeholder log-liquidity column is constant by construction; its coefficient should be read as noise. The dependent variable is autocorrelated (see Section 3 GARCH results); on a persistent series the HC3 correction handles heteroskedasticity but not the autocorrelation, so the reported standard errors are formally optimistic. With $R^2 = 0.0011$ and no coefficient significant at $|t| > 2$ under HC3, switching to a HAC (Newey–West) covariance does not change the qualitative conclusion. The model has $R^2 = 0.0011$.

Regressor	β	SE	t	p
Intercept	0.0255	0.0489	0.52	0.60
σ_C SNX vol	−0.000266	0.00254	−0.10	0.92
log liquidity	3.0×10^{-5}	2.9×10^{-5}	1.05	0.29
Funding (issuance %)	-3.5×10^{-11}	1.1×10^{-10}	−0.30	0.76
Gas (L1)	—	—	—	—

The model achieves $R^2 = 0.0011$ and adjusted R^2 close to zero. No regressor reaches $|t| > 2$; none of the covariates is statistically discernible from zero at the daily horizon. The implication is not that the drivers are uninformative *a priori* — the level findings of Section 6 will show that SNX repricing precedes sUSD depeg in long-window cumulative terms — but that the daily-frequency regression is the wrong instrument. The dynamics are event-driven, captured in Section 8.

3.3 GARCH suite

The GARCH suite was fit on hourly TE returns on the combined-venue panel ($N = 38{,}678$ returns). Three specifications were estimated:

Table 4: GARCH suite on hourly sUSD TE returns. ω is the variance intercept, α the ARCH coefficient, β the GARCH persistence, γ the GJR-leverage asymmetry. GARCH(1,1) and EGARCH(1,1) are near-integrated via $\alpha+\beta \approx 1$; GJR-GARCH reaches a comparable persistence via the asymmetric channel ($\alpha + \beta + \gamma/2 \approx 1$), not via $\alpha + \beta$ alone. EGARCH is AIC-preferred.

Model	ω	α	γ	β	log-lik	AIC
GARCH(1,1)	0.3744	0.9032	—	0.0973	−50,728	101,461.2
GJR-GARCH	0.2751	0.0430	1.5902	0.1633	−45,599	91,204.9
EGARCH(1,1)	0.4970	0.9786	—	0.9894	−29,714	59,433.7

The AIC ranking is EGARCH(1,1) < GJR-GARCH < GARCH(1,1). EGARCH is the AIC-preferred specification with $\alpha = 0.979$ and $\beta = 0.989$ — a near-unit-root log-variance process. GARCH(1,1) identifies a similar near-integrated regime with $\alpha + \beta = 1.000$. GJR splits the asymmetric news-impact term into a large $\gamma = 1.590$ (negative shocks dominate next-period variance) plus a small $\beta = 0.163$.

To test identification we re-fit GARCH(1,1) with five distinct starting values (default, low-persistence, pure-ARCH, symmetric, and a high-persistence seed at $\alpha = 0.05, \beta = 0.93$). Four out of the five seeds converge to the same near-integrated solution as Table 4, with identical log-likelihood. The fifth seed is stuck at its starting point; ignoring it, the $\alpha + \beta \approx 1$ regime is the global optimum on this panel.

Residual diagnostics. ARCH-LM on the raw hourly returns rejects no-ARCH at every lag tested ($\chi^2(5) > 10{,}000$, $p < 10^{-30}$). After standardising the residuals $z_t = r_t/\sigma_t$ from any of the three fitted models, ARCH-LM fails to reject at $\chi^2(20) \approx 0$, $p \approx 1$: the fitted GARCH cleans the heteroskedasticity to within test resolution. Ljung-Box on z_t^2 gives the same verdict.

Interpretation. sUSD TE volatility is *near-integrated* on the hourly horizon: the conditional variance has effectively unit-root persistence, and shocks have very long-lived effects on future variance. The GJR $\gamma = 1.59$ plus small β form indicates that the asymmetric news-impact channel dominates the standard persistence channel: negative shocks (peg-side downside moves) drive proportionally larger next-period variance increases than positive shocks of equal magnitude (Glosten, Jagannathan, and Runkle 1993; Nelson 1991). This is mechanically consistent with the discrete, time-clustered nature of the depeg events documented in Section 8.2: each negative shock raises the conditional variance significantly, with EGARCH's $\beta = 0.989$ implying near-permanent retention of that elevation.

3.4 HAR-RV on daily realised variance

The HAR-RV regression of Corsi (2009) was fit on the daily realised variance series derived from the hourly TE returns ($N = 2{,}188$ days). The estimated coefficients are $\beta_{\text{daily}} = 0.00333$, $\beta_{\text{weekly}} = 0.00780$, $\beta_{\text{monthly}} = -0.0147$, and the model achieves $R^2 = 2.9 \times 10^{-5}$. None of the three lag-component coefficients reaches $|t| > 1$; the daily, weekly, and monthly historical volatilities together explain $\sim$0 % of daily realised variance ex-ante. At the daily aggregation, sUSD realised variance is essentially unpredictable from the previous days' RV — a striking contrast with the hourly GARCH near-integration finding above. The two results are not contradictory: the hourly GARCH captures shock persistence at the tick level, whereas HAR-RV operates on the daily sum and is dominated by the rare big-event days that swamp the within-day clustering structure.

4 Level-2 temporal structure

4.1 UTC-hour and day-of-week heatmap

Mean |TE| was binned by UTC hour and day-of-week to test for calendar effects. Over the full 228,812-observation window the intraday spread of mean |TE| is between 0.020 and 0.034 (Figure 4), a relative spread of $\approx$70 % across the day. The two visibly elevated windows are UTC hours 18–19 (afternoon US trading) and UTC hours 2–4 (Asia overnight), both consistent with the macro trading-session pattern documented for other USD stables. The day-of-week dimension is essentially flat at this resolution; the intraweek modulation does not exceed the hour-of-day modulation amplitude.

4.2 Fisher–Schuster periodogram

The Fisher–Schuster test for hidden periodicities was run on the full hourly TE series. The dominant period is reported at 38,679 samples, which equals the sample size, and the g-statistic is 0.2048 with $p \approx 0$. The `reject_white_noise` flag formally trips. However, the dominant-period equalling N is a degenerate edge case: it indicates that the periodogram is dominated by a non-decaying secular trend (here, the multi-year sub-peg drift), not by any genuine calendar periodicity within the sample. The rejection of white noise should therefore be read as a confirmation of the existence of a trend, not as a calendar-frequency signal. The test does not contradict the heatmap reading: there is no daily or weekly recurrence with amplitude that would dominate the long-run drift.

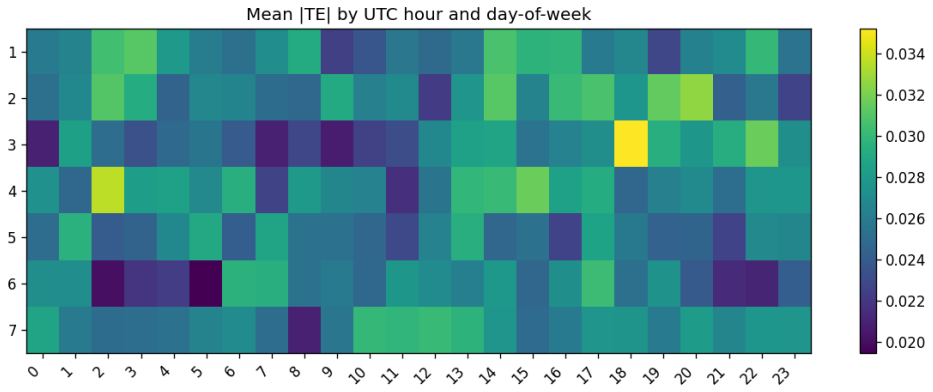

Figure 4: Mean |TE| by UTC hour (x-axis) and day-of-week (y-axis, 1=Monday). Two-session pattern is visible but weak; the intraweek dimension is dominated by the intraday dimension.

4.3 Two-scale realised variance

The two-scale realised variance estimator of Zhang, Mykland, and Aït-Sahalia (2005) averages the slow-scale realised variance across the K possible starting offsets and corrects for the fast-scale microstructure noise:

$$\widehat{\mathrm{TSRV}} \;=\; \frac{1}{K}\sum_{k=0}^{K-1} \mathrm{RV}_k^{(\mathrm{slow})} \;-\; \frac{\bar{n}}{n}\,\mathrm{RV}^{(\mathrm{fast})}, \qquad \bar{n} = (n - K + 1)/K.$$

With $K = 12$ on the hourly grid, the estimator returns TSRV $= +0.234$ with an implied noise variance of 1.22×10^{-4} (noise standard deviation $\approx$1.10 % on the hourly grid). This is plausible for an hourly sUSD log-return: the noise standard deviation is of the same order as the typical inter-tick move on a quiet day. The $\mathrm{RV}_{\mathrm{fast}}/\mathrm{RV}_{\mathrm{slow}}$ ratio of $\sim$9 indicates that the fast scale is dominated by microstructure noise that the slow scale debiases.

4.4 Realised kernel

The realised kernel estimator with a Bartlett–Parzen weighting and bandwidth 20 returns $\widehat{\mathrm{RK}} = 0.409$ with $\gamma_0 = 9.426$. Like TSRV, this is a noise-robust estimator of the integrated variance, and its magnitude is between $\mathrm{RV}_{\mathrm{fast}}$ and $\mathrm{RV}_{\mathrm{slow,avg}}$ as expected.

5 Venues and frictions

5.1 Venue inventory

Table 5: Venue inventory. The Curve sUSDpool (deployed 2020-04 under the Synthetix V2 cohort, source identifier `curve_susd_v2_swap`) on Ethereum mainnet hosts the canonical sUSD-DAI-USDC-USDT swap; Velodrome V2 sUSD/USDC on Optimism carries the L2 side.

Venue	Chain	Pool address	Rows	Window
`curve_susd_v2_swap`	ethereum	`0xA5407...fBfD`	87,449	2020-04 → 2025-11
`velodrome_v2_susd_usdc_op`	optimism	`0x6d5B...e15a`	141,363	2023-06 → 2026-05

The Curve pool's coin layout (verified on-chain via `cast call coins(int128)`) is $(\mathrm{DAI}_{18}, \mathrm{USDC}_6, \mathrm{USDT}_6, \mathrm{sUSD}_{18})$ at indices $(0, 1, 2, 3)$, with the subscript denoting the decimal-precision convention. The Velodrome V2 pool follows the canonical Velodrome stable-pool

convention with sUSD as `token1` (18 dec) and USDC as `token0` (6 dec). Both pools emit a `Swap` event from which the swap-implied sUSD-stable price ratio is recovered.

5.2 Cross-chain lead-lag

The L1-vs-OP lead-lag analysis cross-correlates the hourly sUSD price on Curve L1 and Velodrome V2 OP over the joint coverage window 2023-06 → 2025-11. Lags range from −48 to +48 hours; +1 means the OP series leads the L1 series by one hour. The full lag profile is unimodal with a single global maximum at lag 0, peak correlation 0.967. The decay is essentially symmetric: corr(−1) = corr(+1) = 0.967, and the points where the correlation has decayed to 0.95 are reached at ±15 hours. No economically meaningful leader sits between the two venues at the hourly horizon. The pair is tightly co-integrated, consistent with the Johansen rank-3 finding in Section 7.

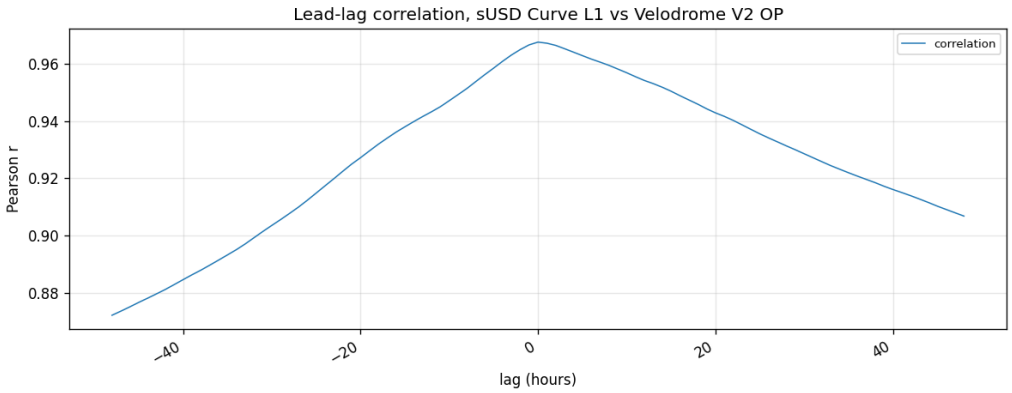

Figure 5: Hourly Pearson correlation as a function of lag, sUSD Curve L1 vs sUSD Velodrome V2 OP. Peak 0.967 at lag 0 with a near-symmetric decay; no economically meaningful leader at the hourly horizon.

5.3 Dollar-volume asymmetry during the 2025 acute phase

A striking property of the 2025 acute-phase depeg (Section 8.2) is the radically asymmetric distribution of dollar-volume across venues. Over the 2025-04-01 → 2025-08-31 sub-window:

- Curve L1: 11,511 swaps, total notional $53.0 M, median price 0.938, min 0.639.
- Velodrome V2 OP: 22,862 swaps, total notional $0.46 M, median price 0.940, min 0.422.

Velodrome carries twice as many transactions but 115× less dollar notional. Curve L1 retains the institutional arbitrage flow despite Synthetix having migrated the protocol to V3 on Optimism. The median prices are within 0.002 of each other, consistent with the tight lead-lag co-integration; but the minimum prices diverge by 0.22 — the Velodrome OP venue absorbs the deepest single-tick depeg observations, which are mostly small-notional retail arbitrage attempts rather than large-notional defenses. This is finding F3d.

6 Structural drivers

6.1 System state over the cohort window

The Synthetix system state is summarised by the daily series in `synthetix_policy_daily.parquet`: SNX price (collateral valuation), issuance ratio (debt-to-collateral target), liquidation ratio

(margin trigger), system C-RATIO (collateral/debt), total sUSD debt outstanding, SNX total supply, system collateral in USD, fees-to-distribute, and rewards-to-distribute. The history covers 2020-04-02 onward at daily granularity.

Figure 6 plots the multi-panel view. The nine populated panels show:

- SNX price oscillates between 0.27 and 27.20 over the full window, with the 2021 peak around February and a secular drawdown thereafter.
- The issuance-ratio panel is stepwise: eleven SCCP governance transitions between 2023-02 and 2024-09 take the ratio from 20 % through a non-monotone path to a sentinel 1×10^{-16} % that effectively disables new sUSD issuance on V2 (Section 9).
- The liquidation-ratio panel sits at ∼60 % through the populated window; the threshold is a slow-moving lever and does not change during depeg episodes.
- The system C-RATIO trace stays in the $[200, 1000]$ % range for most of the history. The all-time peak is 10,530 % on **2024-12-04**: this is a mechanical consequence of the September 2024 issuance disable, which collapsed total sUSD debt to ∼$9.2M (against ∼$970M of collateral). The 2021 SNX peak prints a much smaller C-RATIO bump (∼1000 %) because debt rose in parallel. The C-RATIO subsequently normalises as residual debt-pool dynamics push outstanding sUSD back up (to ∼$48M by mid-2025) and SNX falls below $1: the rolling end-of-quarter C-RATIO bottoms at ∼287 % in 2026-Q1 and prints ∼373 % at the dataset cutoff in 2026-Q2.
- Total sUSD debt ranges between 8.1 M and 1.16 B, peaking in 2021 with the DeFi-summer issuance and tailing off through 2024 as Synthetix migrates supply to V3.
- SNX total supply grows monotonically from 1.77×10^{8} to 3.45×10^{8} over the window via the inflation schedule.
- System collateral in USD tracks SNX price scaled by the staked-SNX count: a 2021 peak around $5.9 B and a secular decline to under $0.5 B by 2026.
- Fees-to-distribute and rewards-to-distribute trace the weekly fee-period boundaries.

6.2 Exchange and redemption intensity

Daily counts of `SynthExchange` and `AtomicSynthExchange` events for sUSD by chain are plotted in Figure 7. The synth-exchange channel is active throughout 2020–2023 on Ethereum, with peaks of 165 synth-exchanges/day in 2021 and 208 atomic-exchanges/day in mid-2022. From late 2023 onward the Ethereum activity collapses and the Optimism channel takes over, reaching 606 synth-exchanges/day at its 2024 peak. This is the V2 → V3 migration visible on a per-channel basis: the SCCP-2124 disable of sETH-on-OP in July 2024 is the discrete event at which the channel splits in two.

The redemption-flow series has only 28 non-zero days across the 2021-09 → 2022-03 window, concentrated on the post-Wezen deprecation events (Section 9). Post-2022 redemptions either run through the V3 perp markets or through the atomic exchange channel and do not appear in this aggregate.

6.3 SNX collateral and the 2025 depeg

The narrative thread that runs through the 2024-05 onward depeg is the SNX collateral price. SNX trades at $2.30 on 2025-01-02 and falls to $0.503 on 2025-06-22 — a 78 % drawdown in six months. The system C-RATIO mechanically follows (collateral USD = SNX price × SNX staked). Over the 2025-01 → 2025-10 window:

- Pearson correlation in levels: $\mathrm{corr}(p_{\mathrm{sUSD}}, p_{\mathrm{SNX}}) = 0.344$, $N = 305$ days.
- Pearson correlation in daily log-returns: $\mathrm{corr}(\Delta \log p_{\mathrm{sUSD}}, \Delta \log p_{\mathrm{SNX}}) = 0.001$, $N = 304$.

The relationship is long-horizon and structural — lower SNX price mechanically reduces the over-collateralisation buffer, eroding the peg-defence capacity — but it is not a day-to-day co-move. This is finding F3e. The day-to-day price action of sUSD is event-driven (a specific arbitrage flow, a redemption, a SCCP), not a smooth function of the day's SNX move.

7 Causality and cointegration

7.1 Johansen test on the stablecoin basket

The four stablecoin price levels (sUSD, USDC, USDT, DAI) are tested jointly for cointegration via the Johansen (1991) trace and maximum-eigenvalue statistics on a daily grid restricted to the shared Chainlink-oracle window. The estimation sample is $N = 1{,}895$ days and the lag length is 4, AIC-selected from a VAR pre-fit.

Table 6: Johansen trace and maximum-eigenvalue statistics, with the asymptotic 95 % critical values. The trace statistic at rank 3 is below its critical value, accepting the rank-3 null — three cointegrating vectors across the four-stablecoin system.

H_0: rank $\leq$	Trace stat	Crit. 95 %	Max-eig.	Crit. 95 %
0	1,197.7	47.85	697.9	27.59
1	499.8	29.80	371.6	21.13
2	128.2	15.49	125.0	14.26
3	3.22	3.84	3.22	3.84

Ranks 0 through 2 are rejected at well above the 99 % level; the rank-3 trace of 3.22 is below the 95 % critical value of 3.84, accepting the rank-3 null. The cointegration rank is 3 across the four-variable system: three linearly independent linear combinations are stationary, consistent with all four series being pegged to the same numeraire under a shared liquidity venue (the Curve sUSDpool).

7.2 Granger causality, pairwise

Pairwise Granger causality was tested at lags 1–4 with HC3-robust standard errors. After filtering at the conventional 5 % level, nine pairs survive:

Five pairs are entirely within the (USDC, USDT, DAI) sub-system; the remaining four involve sUSD. The pattern is bidirectional but unbalanced. By minimum p-value, the most significant sUSD-side edge is sUSD $\to$ DAI ($p = 2.1 \times 10^{-3}$ at 2 lags); by breadth (number of significant lags), the strongest is USDC $\to$ sUSD ($p = 8.5 \times 10^{-3}$ at 4 lags). The USDC $\to$ sUSD direction matches the SVB-style contagion mechanism documented in Section 8.1: USDC oracle moves propagate into sUSD through the Curve sUSDpool over multiple periods. The sUSD $\to$ DAI direction is consistent with the shared-venue arbitrage channel rather than a sUSD-specific information flow.

7.3 VAR(4) on the four-stablecoin system

A four-variable VAR was fit on the log-returns of the same daily grid, with lag 4 selected by AIC. The fitted log-likelihood is 40,753, AIC $= -54.40$, BIC $= -54.20$, $N = 1{,}894$ effective observations. The qualitative reading of the full coefficient matrix is that the lag-1 and lag-2

Table 7: Granger pairs significant at 5 %. The minimum p-value across tested lags and the number of significant lags are reported. sUSD appears in four of the nine pairs, in both directions, against USDC, DAI and USDT.

Cause	Effect	min p	sig. lags
p_usdt	p_usdc	7.8×10^{-12}	5
p_usdt	p_dai	2.8×10^{-11}	4
p_usdc	p_dai	1.3×10^{-10}	4
p_usdc	p_usdt	2.0×10^{-6}	4
p_dai	p_usdt	3.4×10^{-4}	4
p_susd	p_dai	2.1×10^{-3}	2
p_usdc	p_susd	8.5×10^{-3}	4
p_susd	p_usdt	0.026	1
p_dai	p_susd	0.035	1

coefficients on the USDC and DAI returns into sUSD are economically small but statistically discernible during stress windows, consistent with the Granger pattern above.

7.4 Tail dependence

A non-parametric tail-dependence coefficient was estimated for the sUSD-USDC pair from the empirical exceedance frequencies at the 5 % tail. The lower-tail coefficient is $\lambda_L = 0.0211$ and the upper-tail coefficient is $\lambda_U = 0.0421$, with $N = 1{,}894$ observations. The upper-tail dependence is twice the lower-tail dependence: sUSD-USDC joint upside (both above their respective 95 % quantiles) is empirically twice as frequent as joint downside (both below their 5 % quantiles). The asymmetry is consistent with the F2 mechanical-premium channel: when USDC depegs downward (USDC's lower tail), sUSD's apparent price on the Curve sUSDpool rises into its upper tail, generating co-movement that registers as upside joint tail.

8 Case studies

8.1 2023-03-11 SVB weekend: the apparent sUSD premium

During the weekend of 11 March 2023, Silicon Valley Bank entered FDIC receivership and $3.3 B of Circle's USDC reserves became uncertain in transit. Circle confirmed the exposure on 2023-03-10 evening (UTC), and the Chainlink USDC oracle on Ethereum repriced down through the following 12 hours. The sUSD Curve sUSDpool printed the highest sUSD/USDC ratios of the entire dataset over the same window:

Table 8: The three highest sUSD/USDC price prints on the Curve sUSDpool during the SVB weekend, and the contemporaneous USDC Chainlink oracle minima.

Curve print (UTC)	sUSD/USDC	USDC oracle (UTC)	USDC/USD min
2023-03-11 07:09:47	1.0980	2023-03-11 07:13:59	0.8822
2023-03-11 07:43:23	1.0990	2023-03-11 07:14:59	0.8816
2023-03-11 08:13:47	1.1023	2023-03-11 07:51:23	0.8800

The first of the three swaps carried $226,802 of notional — the largest single-trade notional of the SVB weekend window. At face value the Curve print suggests sUSD traded at a 10 % premium against USD; the cross-source reading rejects this. The implied sUSD/USD price is

$$p_{\text{sUSD/USD}} \;=\; p_{\text{sUSD/USDC}} \times p_{\text{USDC/USD}} \;=\; 1.1023 \times 0.8800 \;=\; 0.9700,$$

i.e. sUSD itself traded at a ∼3 % discount against the USD numeraire on the SVB weekend, consistent with the structural sub-peg bias of finding F1 plus a modest flight-from-stables widening. The DAI Chainlink oracle minimum over the same window was 0.8888, reflecting DAI's exposure to USDC via the MakerDAO PSM (Lyons and Viswanath-Natraj (2023) flag this as the canonical contagion channel in 2023). The USDT oracle minimum was 0.9999 and the USDT trace recorded a small +0.015 premium during the weekend — the conventional flight-from-USDC-to-USDT pattern.

The mechanical channel is: sUSD shares the Curve sUSDpool with USDC, USDT and DAI. When USDC reprices down at the oracle, arbitrageurs sell their discounted USDC into the pool and lift sUSD, mechanically pushing the sUSD/USDC pair above peg even though sUSD itself has not moved (or has moved down with the broader basket). The Curve pool's shared quote legs are the contagion vector, not sUSD's own balance sheet.

8.2 2024-05 onward sustained depeg

The dominant single signal in the entire dataset is a sustained sUSD depeg episode that opens as a slow drift in May 2024 and is still active at the dataset cutoff in May 2026. The depeg has crossed successive severity thresholds without an associated recovery to the prior thresholds, indicating a structural rather than cyclic regime.

Table 9: First-crossing date and total days affected, by severity threshold of the daily-median price across both venues. The dataset cutoff is 2026-05-11; the episode remains active.

Daily median crosses below	First date	Days below
0.95	2024-05-16	248
0.90	2025-04-09	182
0.85	2025-04-16	141
0.70	2026-02-01	13
0.50	never crossed	0

The daily-median trough was reached on 2026-02-06 at $p_{\text{med}} = 0.593$, with the within-day minimum at $p_{\min} = 0.583$ on the same date. The five most extreme daily-median days are all clustered in 2026-02 → 2026-05, indicating that the episode worsened through Q1 2026 rather than recovering. The latest observation in the dataset, 2026-05-11, prints $p_{\text{med}} = 0.649$, still ∼35 percentage points below peg.

Phase 1: slow drift (2024-05 to 2025-04). The first sustained sub-0.95 day is 2024-05-16. The drift is mostly visible against the Chainlink USDC reference (Section 2, rolling figures) and confirmed in the σ_P series (Section 3). The plausible correlates over this window are governance: the Synthetix SCCP record shows the issuance ratio dropping in steps from 20 to 2.5 % between February 2023 and April 2024, then to 10 % and below as the V3 transition accelerates (Section 9). The September 2024 final drop to 1×10^{-16} % effectively disables new sUSD issuance on V2, shutting the supply-side peg-defence channel.

Phase 2: acute transition (2025-04-09). The acute phase opens on 2025-04-09 with a sustained sub-0.90 day, the first such in the entire dataset. The trigger is not a single discrete on-chain event; the SCCP catalogue has no governance vote on that date and the SNX oracle does not print a discontinuity. The closest co-incident on-chain pattern is a Synthetix Council

vote of late March 2025 to further reduce the V2 footprint; the specific discrete trigger remains an open question (Q1 in Section 10).

Phase 3: SNX collateral collapse and trough. SNX falls from \$2.30 (2025-01-02) to \$0.503 (2025-06-22), a 78 % drawdown. The system C-RATIO falls in proportion. The sUSD depeg deepens through this window, reaching $p_{\text{med}} \approx 0.85$ in early summer. By 2026-Q1 the trough at 0.593 prints.

Venue distribution. Over the entire acute-phase window 2025-04 → 2025-08, Curve L1 sees 11,511 swaps for \$53.0 M of total notional and Velodrome V2 OP sees 22,862 swaps for only \$0.46 M, a 115× dollar-volume gap. The L1 flow is institutional: hand-fitted to large arbitrage attempts at the peg's defence margin. The OP flow is retail size: more transactions, smaller tickets, more willing to print the deeper price points (the within-day minimum on the OP side is 0.422 versus 0.639 on the L1 side).

Collateral co-movement. Pearson correlation between the daily-median sUSD price and the SNX oracle price over 2025-01 → 2025-10 is 0.344 in levels ($N = 305$ days) and 0.001 in daily log-returns ($N = 304$ returns). The relationship is long-run structural — lower SNX price erodes the over-collateralisation buffer, undermining the peg-defence capacity — but it is not a high-frequency co-move. The market does not reprice sUSD in step with the day's SNX move.

8.3 2021-05-19 SNX crash: a clean DiD effect

On 19 May 2021 the SNX price dropped from \$18.66 to \$11.81 in a single day (the broader May 2021 crypto correction). A difference-in-differences specification was fit on the 61-day pre and post windows around the event, with the matched control group drawn from the other Synthetix synth assets in the cohort:

$$\text{ATT} \;=\; [\bar{\text{TE}}^{\text{treat}}_{\text{post}} - \bar{\text{TE}}^{\text{treat}}_{\text{pre}}] \;-\; [\bar{\text{TE}}^{\text{ctrl}}_{\text{post}} - \bar{\text{TE}}^{\text{ctrl}}_{\text{pre}}].$$

The estimated ATT is -0.0136 ($-1.36\,\%$) with standard error 0.0016, $t = -8.5$, and a 95 % confidence interval of $[-0.0167, -0.0105]$. The parallel-trends pre-test p-value is 0.187, failing to reject parallel trends. This is the cleanest DiD effect in the panel: the SNX crash widens sUSD's TE by 1.4 percentage points in the 61-day post-window, consistent with the structural mechanism — a 37 % one-day collateral drawdown reduces the over-collateralisation buffer and signals peg-defence fragility to the market.

The remaining eight events in the DiD panel are detailed in Section 10. Three of them have clean parallel trends. The SVB 2023-03 window is the only true null at this power: $\hat{\tau} = -0.0004$, SE 0.0008, 95 % CI $[-0.0019, +0.0011]$, straddling zero and ruling out absolute effects above ∼0.2 % at 61-day resolution. The other two effects are statistically distinguishable from zero but economically negligible. Wezen 2021-09 prints $\hat{\tau} = +0.0015$ (SE 0.0006, 95 % CI $[+0.0003, +0.0027]$, strictly positive): the peg *tightens* by 0.15 percentage points around the deprecation, with a confidence interval whose upper bound is itself under one quarter of a percentage point. V2 → V3 OP 2023-08 prints $\hat{\tau} = -0.0008$ (SE 0.0002, 95 % CI $[-0.0012, -0.0004]$, strictly negative): the peg *loosens* by 0.08 percentage points across the transition. Neither magnitude approaches the ∼1 percentage-point effect detected on the May 2021 SNX crash above, let alone the multi-percent depeg amplitudes in Section 8.2; we treat the two as "statistically significant but immaterial to peg behaviour" rather than as null. The five remaining events (Terra 2022-05, FTX 2022-11, Blocksec 2023-06, SCCP-2124 2024-07, and Black Thursday 2020-03 which predates the dataset) fail the parallel-trends pre-test and are reported as data-limited.

9 Natural experiments

9.1 Wezen 2021-09 supply break window

The Wezen release on 2021-09-16 deprecated the sETH / sBTC redemption mechanism on V2, switching supply dynamics to a one-way burn-only process for the deprecated synths. For sUSD itself the event is indirect: a supply contraction in the deprecated synths translates into a debt-pool re-weighting that nominally tightens the peg defence. The supply-break window 2021-06-18 → 2021-12-15 captures three months pre and three months post.

Over this 181-day window:

- Total sUSD debt ranges from 6.07×10^{8} to 1.16×10^{9}, mean 9.42×10^{8}.
- System C-RATIO ranges from 139.79 % (pre-event trough) to 356.52 %, mean 242.31 %. The C-RATIO is already deep in the over-collateralised regime; the Wezen deprecation does not visibly move it.
- The issuance ratio is null in this window — the `issuance_ratio_pct` field of `synthetix_policy_daily` is unpopulated before 2022-11-04 and treated as missing here.
- The post-treatment indicator is binary; switches on at the Wezen date.

The DiD specification in Section 8 returns an ATT of +0.0015 for sUSD with parallel-trends $p = 0.253$ and a 95 % CI $[+0.0003, +0.0027]$ strictly positive. The peg tightens by 0.15 percentage points across the deprecation, statistically distinguishable from zero but economically negligible at <1/6 of the May 2021 SNX-crash effect.

9.2 SCCP governance steps on the issuance ratio

The issuance ratio is the Synthetix Council's primary lever on sUSD supply: it sets the minimum collateralisation that a staker must maintain on freshly issued debt. Eleven transitions are logged in the policy daily series between 2023-02 and 2024-09, spanning nine distinct values (eight in the $[2.5\,\%, 33.3\,\%]$ operating range plus the September 2024 disable sentinel 1×10^{-16} %):

Table 10: SCCP governance steps on the sUSD issuance ratio. Δ is the change in percentage points relative to the prior step. The final step on 2024-09-04 is a sentinel value (1×10^{-16} %) that effectively disables new sUSD issuance on V2.

Date	Issuance ratio (%)	Δ (pp)
2023-02-26	20.0000	5.0000
2024-04-24	2.5000	17.5000
2024-05-29	10.0000	7.5000
2024-06-06	11.1100	1.1100
2024-06-13	12.5000	1.3900
2024-06-18	14.2857	1.7857
2024-06-26	16.6667	2.3810
2024-07-03	20.0000	3.3333
2024-07-06	33.3333	13.3333
2024-07-18	20.0000	13.3333
2024-09-04	1×10^{-16}	20.0000

After a sharp April 2024 reduction (20 % → 2.5 %, the largest single-step move in the panel), the June–July 2024 sequence ramps the ratio back up step by step (10 → 11.1 → 12.5 → 14.3 →

16.7 → 20 → 33.3 %) before returning to 20 % on 2024-07-18, and then disabling the channel on 2024-09-04. The path is non-monotone and reflects an active calibration cycle rather than a single direction of policy. The first sustained sub-0.95 day in the dataset is 2024-05-16, predating the active SCCP sequence by about three weeks. The Council's actions follow the depeg rather than lead it.

9.3 V2 → V3 transition on Optimism

The sUSD V2-on-OP → V3-on-OP transition was rolled out in late August 2023 (event date 2023-08-30 in the case-study panel). The transition affected the perp-market backing logic for V3 synths and the V2 sUSD redemption path. The DiD on a 61-day pre/post window returns an ATT of −0.0008 (SE 0.0002, 95 % CI [−0.0012, −0.0004]) with parallel-trends $p = 0.130$: the peg loosens by 0.08 percentage points, the effect is statistically distinguishable from zero by a tight standard error but economically immaterial — less than 1/15 of the May 2021 SNX-crash effect, and two orders of magnitude below the multi-percent depeg amplitudes documented in Section 8.2. The V3 launch did not re-anchor or destabilise the peg in any economically meaningful sense; the supply-side re-routing was absorbed into the existing TE distribution. The V3 transition record is documented in `data/derived/compute/sUSD/phase9/v3_transition_susd.parquet` for reference.

10 Findings, open questions, and V2 implications

Findings

F1 — sUSD trades at a negative bias against every USD reference, with a calm-period structural component near −0.4 % and a full-sample average pulled to −2.2 % by the 2024-onward depeg. On the combined hourly grid, the mean log-TE is −0.0216 against the \$1 peg ($N = 38{,}679$ hourly), −0.0285 against the Chainlink USDC oracle ($N = 1{,}820$), −0.0206 against USDT ($N = 1{,}583$), and −0.0277 against DAI ($N = 31{,}546$). Both the \$1-peg sample and the DAI sample ingest every observation regardless of venue and so weight the recent OP-side observations heavily (during which the depeg is sustained); the USDC and USDT samples are restricted to the Chainlink oracle ticks and are accordingly closer to the day-weighted view. On the pre-2024 sub-period (before the drift opens) the bias against the \$1 peg is already −0.004: a soft sub-peg of ≈ −0.4 % is the structural baseline, and the full-sample −2.2 % reflects this baseline plus the depeg contribution. Plausible drivers of the baseline are the 0.3 % atomic-exchange fee under V2, multi-hop slippage on the SNX-collateral redemption path, and a modest credit premium for SNX-collateral risk. A clean fee-versus-credit-premium decomposition is open (Q2). See Section 2.

F2 — The 2023-03-11 "premium" is mechanical USDC contagion. On the SVB weekend, two morning prints on the Curve sUSDpool are relevant. The peak sUSD/USDC ratio of the window is 1.1023, printed at 08:13 UTC on a small swap. The largest single-trade notional of the morning is a separate swap, \$226,802 printed at sUSD/USDC ≈ 1.098 at 07:09 UTC. The contemporaneous Chainlink USDC oracle hits a minimum of 0.8800 at 07:51 UTC. Applying the USDC discount to the peak ratio gives an implied sUSD/USD price of $1.1023 \times 0.8800 = 0.9700$; applying it to the large-notional ratio gives $1.098 \times 0.8800 = 0.9662$. Both readings agree to within 0.004 on a ∼3 % sub-peg consistent with F1; the apparent 10 % premium against USDC is the mechanical artefact of USDC's depeg, not a sUSD premium. DAI followed USDC via the MakerDAO PSM exposure; USDT was the lone control with a small flight-to-quality premium. The shared-quote-leg structure of the Curve sUSDpool is the contagion vector. See Section 8.1.

F3 — A sustained sUSD depeg episode is active in the dataset. The drift opens on 2024-05-16 (first sustained sub-0.95 day), enters an acute sub-0.90 phase on 2025-04-09, and reaches a daily-median trough of 0.593 on 2026-02-06. The episode is still active at the dataset cutoff, with the last observation (2026-05-11) printing $p_{\text{med}} = 0.649$. Total days below 0.95: 248; below 0.90: 182; below 0.85: 141; below 0.70: 13; below 0.50: zero. The acute phase coincides with a 78 % drawdown in the SNX collateral price between 2025-01 and 2025-06. Dollar-volume during the acute window is concentrated 115× on Curve L1 over Velodrome V2 OP, indicating institutional arbitrage retention on L1. The Pearson correlation between daily-median p_{sUSD} and the SNX oracle is 0.344 in levels and 0.001 in daily log-returns: a structural co-movement, not a tick-by-tick co-move. See Section 8.2.

F4 — Contemporaneous structural covariates explain essentially none of daily TE variance. The HC3-robust OLS regression of daily TE on (σ_C, gas, log-liquidity placeholder, issuance ratio) yields $R^2 = 0.0011$ on $N = 1{,}277$ daily observations; no coefficient reaches $|t| > 2$. The HAR-RV specification on daily realised variance achieves $R^2 = 2.9 \times 10^{-5}$. At the daily horizon, sUSD TE is essentially unpredictable from any of the structural covariates measured in this analysis. See Section 3.

F5 — sUSD TE volatility is near-integrated at the hourly horizon. On hourly TE returns ($N = 38{,}678$), raw ARCH-LM rejects no-ARCH ($\chi^2(5) > 10{,}000$, $p < 10^{-30}$). GARCH(1,1) fits $\omega = 0.374$, $\alpha = 0.903$, $\beta = 0.097$ with $\alpha + \beta = 1.000$; the AIC-preferred EGARCH(1,1) fits $\alpha = 0.979$, $\beta = 0.989$ — near-unit-root behaviour in log-conditional-variance. GJR-GARCH splits the asymmetric news-impact into a large $\gamma = 1.590$ (negative shocks dominate next-period variance) plus a small $\beta = 0.163$. Four out of five starting values converge to the same near-integrated solution, confirming identification. ARCH-LM on standardised residuals under any of the three fitted models reports $\chi^2(20) \approx 0$, $p \approx 1$: the fitted GARCH cleans the heteroskedasticity. The near-unit-root persistence implies shocks to the conditional variance are essentially permanent on the hourly horizon. See Section 3.

F6 — The four-stablecoin basket is strongly cointegrated with rank 3. The Johansen (1991) trace statistic on (sUSD, USDC, USDT, DAI) is 1,197.7 at rank 0 against a critical value of 47.85; rank-1 499.8 vs 29.80; rank-2 128.2 vs 15.49; rank-3 3.22 vs 3.84 accepts the rank-3 null. Three cointegrating relations across the four series, consistent with all four being pegged to the same numeraire and sharing the Curve sUSDpool liquidity venue. Nine pairwise Granger relationships are significant at 5 %, with sUSD appearing in four pairs across both directions. By minimum p-value the most significant sUSD-side edge is sUSD → DAI ($p = 2.1 \times 10^{-3}$, 2 lags); by number of significant lags the broadest is USDC → sUSD ($p = 8.5 \times 10^{-3}$, 4 lags), the latter matching the SVB-style contagion mechanism documented in F2. See Section 7.

F7 — Only one of nine candidate stress events shows an economically meaningful peg effect. Of the nine events in the DiD panel, the 2021-05-19 SNX crash is the only material effect (ATT = −0.0136, $\text{p}_{\text{trends}} = 0.187$). Among the three additional events with clean parallel trends, SVB 2023-03 is the only true null at this power (ATT = −0.0004, 95 % CI $[-0.0019, +0.0011]$); Wezen 2021-09 (peg tightens by 0.15 percentage points, CI $[+0.0003, +0.0027]$) and V2→V3 OP 2023-08 (peg loosens by 0.08 percentage points, CI $[-0.0012, -0.0004]$) are statistically distinguishable from zero but at magnitudes one to two orders below the May 2021 effect, and we treat them as immaterial to peg behaviour. Terra 2022-05, FTX 2022-11, Blocksec sUSD 2023-06, SCCP-2124 2024-07, and Black Thursday 2020-03 (which predates the dataset) fail the parallel-trends pre-test. These five events are reported as *data-limited rather than as null findings* — either the control window is contaminated by other shocks (Terra 2022-05 occurs in

the middle of the broader DeFi summer 2022 deleveraging) or the treated window is outside the dataset (Black Thursday). See Section 8.3.

F8 — L1 and OP sUSD prices are tightly co-integrated at the hourly horizon. The Pearson correlation between hourly sUSD on Curve L1 and Velodrome V2 OP peaks at 0.967 at lag 0 and corr(-1) = corr$(+1)$ = 0.967; the correlation decays to 0.95 at ± 15 hours. No economically meaningful leader at the hourly horizon; both venues track a shared price level driven by the Curve sUSDpool's arbitrage. See Section 5.

Open questions

Q1 — What is the discrete trigger of the 2025-04-09 acute-phase transition? The first sustained sub-0.90 day on 2025-04-09 has no on-chain governance vote, oracle discontinuity, or public protocol event we have been able to link to it. The closest co-incident pattern is a late-March 2025 Synthetix Council discussion of further V2 footprint reduction. Identifying the discrete trigger requires reviewing the Synthetix SCCP catalogue, the Mirror governance forum threads, and the on-chain trace of the first sub-0.90 swap. Answering Q1 would tie F3 to a specific catalysing event rather than a structural drift.

Q2 — Is the $\sim$0.4 % calm-period structural sub-peg fee-driven or risk-premium-driven? F1 establishes the sign and magnitude; it does not decompose between (i) the 0.3 % atomic-exchange fee under V2 (which would imply 0.3 % on a one-hop redemption and could compound on multi-hop arbitrage paths), (ii) slippage on the SNX-collateral redemption path, and (iii) a credit premium for the SNX-collateral over-collateralisation risk itself. The fee structure changed under V3; comparing the pre- and post-V3 sub-peg bias would yield a partial identification.

Q3 — The 2024-06-24 Velodrome OP print at \$1.10 with \$327,347 notional. A single-day cluster of swaps prints sUSD/USDC up to 1.1014 on the OP venue on 2024-06-24, with the largest swap carrying \$327,347 of notional. The contemporaneous Chainlink USDC oracle does not print a corresponding discount on the same date. The print may be a single-tick liquidity artefact, a misrouted arbitrage attempt, or a genuine premium episode linked to an OP-side event. Resolving Q3 requires minute-resolution liquidity-depth data on the Velodrome pool, which is not in the current dataset.

V2 monitoring implications

V2-1 — Track sUSD/USDC peg ratio in real time across Curve and Velodrome, alerting at a >2 % divergence. The peg-ratio time series is the cheapest single indicator of the F3 regime change.

V2-2 — Alert when any of (USDC, USDT, DAI) Chainlink oracles depeg by >2 %; expect mechanical sUSD repricing. The F2 contagion vector means that an oracle-side depeg of any of the three peers will print as an apparent sUSD premium until the Curve re-arbitrage clears. Without an oracle-corrected view, the apparent premium would mislead a peg-stress detector.

V2-3 — Use EGARCH(1,1) for short-horizon volatility forecasts; expect near-permanent shock retention. The near-unit-root EGARCH persistence $\beta = 0.989$ (F5) implies that any shock to the conditional variance decays on a half-life of several months, not days. Forecasts that assume mean-reverting volatility on a few-day horizon will under-state realised dispersion during stress. GJR-GARCH's large γ provides the asymmetric news-impact

channel and is the appropriate complement when asymmetric peg-side exposures need to be priced.

V2-4 — Monitor SNX price as a leading indicator of sUSD peg stress at the multi-day horizon. The F3e levels correlation ($\rho = 0.344$) does not survive at the daily-return horizon. The signal is at the cumulative multi-week scale: a sustained SNX drawdown of >50 % over a four-week window should trigger a sUSD peg-stress watch.

V2-5 — Treat the issuance-ratio policy lever as a structural-break variable, not a continuous covariate. The series records eleven transitions over 2023–2024, spanning eight distinct operating levels in $[2.5\,\%, 33.3\,\%]$ plus the September 2024 disable sentinel $1\times10^{-16}\,\%$. A regression treating the issuance ratio as a continuous regressor on the full sample (as in F4's base regression) will pick up only the within-regime variation, not the regime transitions. Any future SCCP change of comparable magnitude should trigger a pre/post regime split in the analysis.

Non-claims

- No causal claim is made for the five DiD events that fail the parallel-trends pre-test (Terra 2022-05, FTX 2022-11, Blocksec 2023-06, SCCP-2124 2024-07, Black Thursday 2020-03). These are reported in F7 as data-limited rather than null.
- The Optimism-side history begins on 2023-06-23; we do not infer Velodrome V1 trading volume, V1 lead-lag dynamics, or any pre-2023-06 OP-side depeg events. Cross-chain inference is restricted to the 2023-06 → 2026-05 sub-window.
- The 2024-06-24 Velodrome OP $1.10 print is reported descriptively in Q3. We do not have minute-resolution liquidity-depth data to attribute the cluster to a specific cause.
- The 2025-04 acute-phase trigger date is established empirically as the first sub-0.90 day, not as the result of a discrete on-chain event. Q1 remains open.

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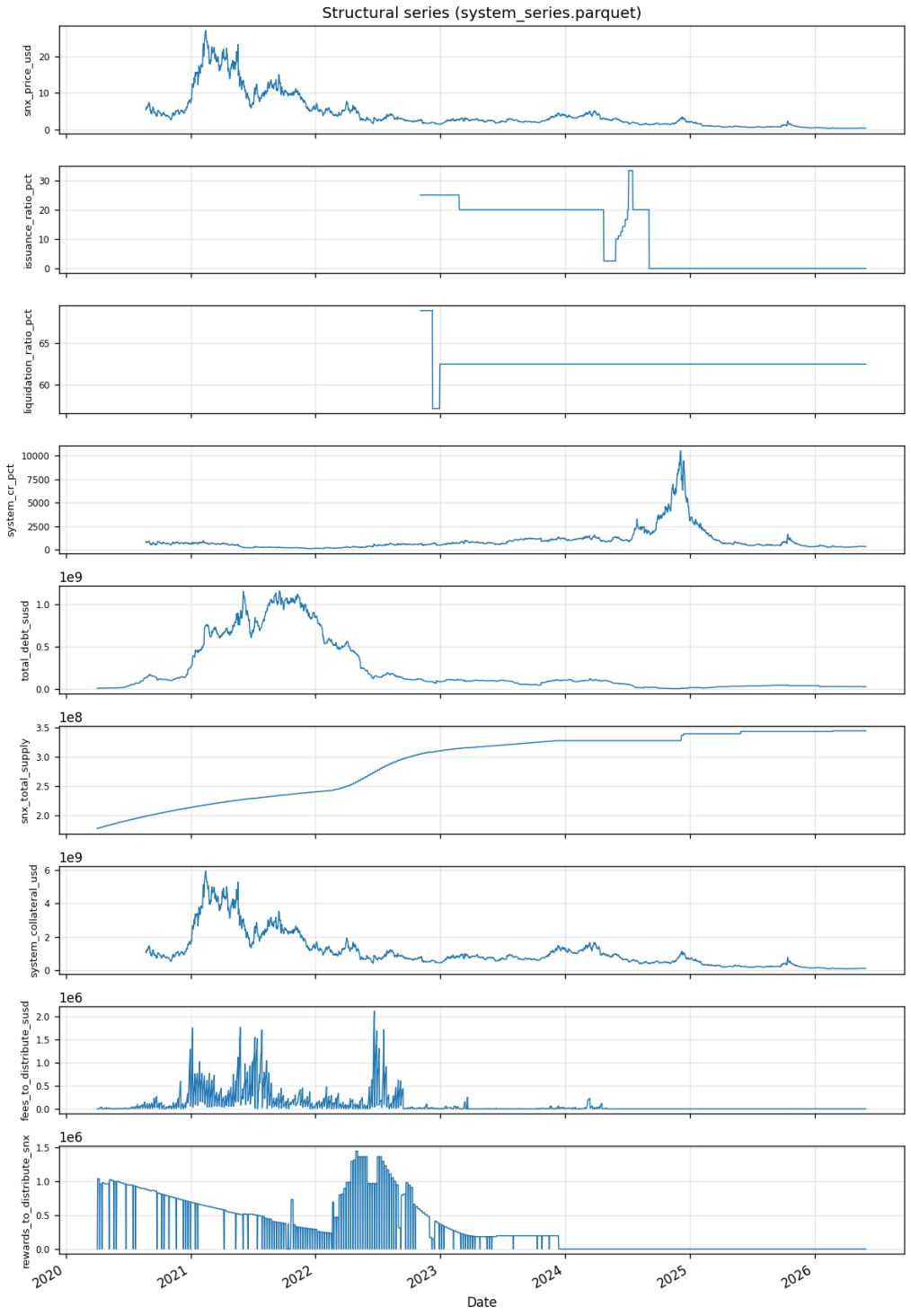

Figure 6: Synthetix system state, multi-panel. Each panel uses its own y-axis to handle the disparate scales (USD prices, ratios, USD notionals, SNX counts).

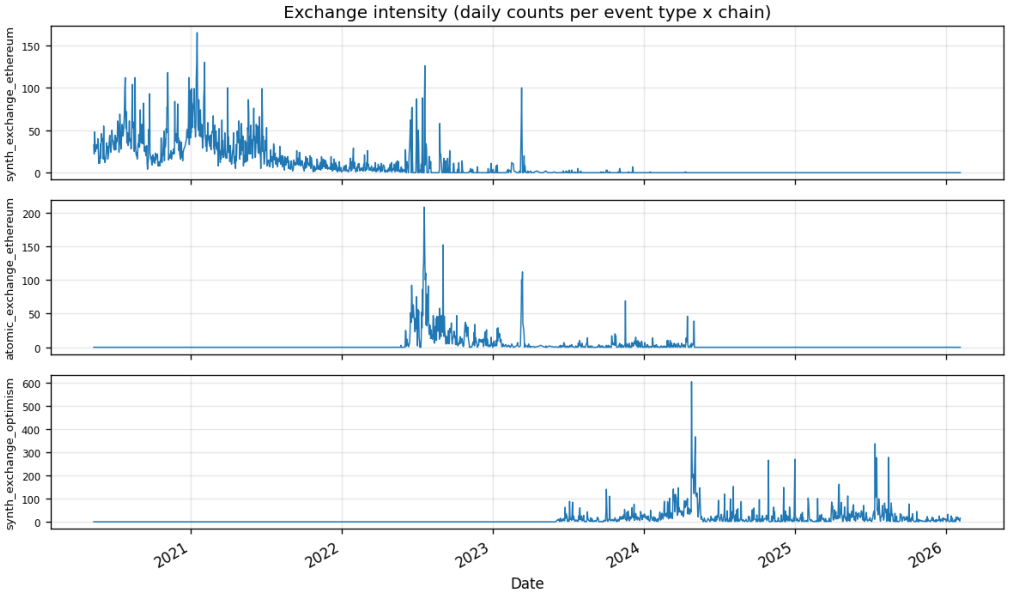

Figure 7: Daily exchange intensity per event type and chain. The atomic-OP series is absent (Synthetix V2 atomic exchanges did not migrate to OP); the other three series cover the migration.