USDT (Tether) sub-report

Secondary-market tracking error and depeg mechanics of an opaque centralized stablecoin, 2020–2026

Derivalink R&D

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Abstract

USDT is a centralized, fiat- and reserve-backed stablecoin whose peg is defended off-chain through an authorized-participant mint/redeem facility ($100k minimum, fees) rather than by any on-chain collateral mechanism. There is no on-chain reserve state, no supply-side collateralisation ratio, no perpetual, and no listed options surface to study; the reserve is irreducibly opaque. This sub-report therefore reframes the canonical tracking-error (TE) programme around the observables that *do* exist: (i) the USDT/USD Chainlink oracle and a 2.35-million-row Bitstamp USDT/USD spot tape as direct peg observables; (ii) the Curve 3pool USDT weight-imbalance as the canonical on-chain depeg-stress signal; and (iii) the USDT/USDC basis as the cross-stable causality channel. Over the full 2021–2026 window USDT holds the peg with a daily mean bias of 0.72 bp (oracle) and 0.05 bp (Bitstamp) and a mean absolute deviation of 4.25–4.49 bp, but with a heavy-tailed, positively-skewed-in-discounts distribution (oracle excess kurtosis 27.96). The Curve 3pool USDT weight is strongly coincident with absolute peg deviation ($r = 0.49$ oracle, 0.62 CEX) and serves as the most actionable early signal for an opaque token. The USDT/USDC pair is strongly cointegrated (Johansen trace 758.4 at rank 0; Engle–Granger $p = 2.6 \times 10^{-10}$) with bidirectional Granger causality. The two largest stress episodes are mirror images: in May 2022 (Terra) USDT depegged to an oracle trough of 0.9518 (Bitstamp intraday 0.91011) as capital fled *to* USDC; in March 2023 (SVB) USDT traded at a premium of up to 475 bp as capital fled *from* USDC, flipping the basis sign. We conclude with a centralized-stable monitoring playbook for Derivalink V2.

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Executive summary

Asset nature and scope. USDT (Tether) is a centralized, fiat- and reserve-backed stablecoin. Unlike a collateralized DeFi synth (DAI, sUSD) or a delta-neutral construction (USDe), USDT exposes *no* on-chain reserve, no supply-collateralisation ratio, no collateralized debt position, no perpetual, and no listed options surface. The peg is defended off-chain by Tether Operations Limited via an authorized-participant mint/redeem facility ($100k minimum, fees), which by construction permits a *wide* secondary-market arbitrage band before primary redemption becomes economic. This report therefore shifts away from the level-1 σ-decomposition of the DAI/sUSD template — which is conceptually inapplicable to a fiat-backed token with no on-chain collateral series — and toward the four observables that exist on disk: the USDT/USD Chainlink oracle, a 2.35-million-row Bitstamp USDT/USD spot tape, the Curve 3pool USDT weight-imbalance, and the USDT/USDC basis.

F1 — Peg fidelity is high in the central tendency, but heavy-tailed to the downside. On the full 2021–2026 daily grid USDT trades essentially at par: oracle mean bias 0.72 bp, Bitstamp mean bias 0.05 bp, mean absolute deviation 4.25–4.49 bp (Section 2). The annualized log-return TE is 0.0073 (oracle) and 0.0080 (Bitstamp). But the deviation distribution is sharply non-Gaussian: oracle skewness 2.16 and excess kurtosis 27.96 (Jarque–Bera rejects normality), with deviations spending 0.58 % of days outside ±25 bp and 0 % outside ±100 bp on the daily grid. Mean reversion is fast (deviation half-life 3.7 days oracle, 3.5 days Bitstamp).

F2 — The Curve 3pool USDT weight is the canonical depeg signal, not the oracle. For an opaque token with no reserve to monitor, the most actionable on-chain stress tell is the 3pool composition. The USDT weight-imbalance is strongly coincident with absolute peg deviation ($r = 0.494$ against the oracle, $r = 0.618$ against the Bitstamp CEX tape) at daily resolution, with a mild *imbalance-leads-deviation* asymmetry (Section 4). The 24-hour-heartbeat oracle structurally cannot price intraday stress first; the AMM reserve composition can.

F3 — USDT and USDC are strongly cointegrated with bidirectional causality. The USDT/USDC basis is stationary (ADF $p \approx 0$) and the pair is cointegrated by both Engle–Granger ($p = 2.6 \times 10^{-10}$) and Johansen (trace 758.4 at rank 0 versus a 15.49 critical value; rank-1 trace 115.8). Granger causality is bidirectional, marginally stronger USDT→USDC ($p = 2.8 \times 10^{-12}$ versus USDC→USDT $p = 5.9 \times 10^{-7}$). Lower- and upper-tail dependence are near-symmetric (0.168 / 0.137): joint stress is roughly as likely on the discount side as the premium side (Section 5).

F4 — The two largest stress episodes are mirror images. In the May 2022 Terra/UST contagion, USDT depegged to an oracle trough of 0.9518 (−481.8 bp) — Bitstamp intraday low 0.91011 (≈ −899 bp) — as the 3pool USDT weight blew out from 0.426 to 0.834 and USDC went to a +290 bp premium: a flight *from USDT to USDC*. In the March 2023 SVB episode the sign flipped: USDC depegged to 0.88 (−1,200 bp) while USDT held a premium of up to 475 bp (Bitstamp max 1.04755) and the 3pool USDT weight collapsed to 0.024: a flight *from USDC to USDT* (Section 7). The basis sign flip is the clean empirical signature of which leg of the stable complex is under stress.

F5 — Volatility asymmetry differs by venue. On the oracle series EGARCH is AIC-preferred (−7,660.8) and the GJR leverage term is near zero (0.01): the oracle is near-symmetric, as expected from a smoothed 24h-heartbeat feed. On the raw Bitstamp tape GJR-GARCH wins (−6,988.1) with a positive leverage $\gamma = 0.064$: discounts cluster volatility more than premia, the expected asymmetry for a stable under run risk (Section 3). HAR persistence is modest ($R^2 \approx 0.11$–0.13), dominated by the daily term.

Three implications for Derivalink V2. (1) For an opaque centralized stable, the AMM reserve composition (3pool weight) is a better real-time depeg signal than the oracle, which lags by design. (2) The USDT/USDC basis sign is a single scalar that identifies the direction of a flight within the stable complex — monitor it as a contagion router. (3) Reserve opacity is *irreducible*: no on-chain metric substitutes for the attestation gap, so a centralized-stable monitor must explicitly carry a qualitative counterparty-risk flag alongside its quantitative peg telemetry (Section 6).

Principal caveats. The TE distribution metrics (Section 2) are computed on a daily last-obs grid to bound memory on the 2.35-million-row Bitstamp series; this smooths intraday troughs, so the headline daily minima (−27/−48 bp) understate the true intraday extremes captured in the case studies (−482 bp oracle, −899 bp Bitstamp). The Curve price tape is a *partial* backfill (2020-09 to 2023-12); the 3pool *reserves* (weight), by contrast, cover the full window and are the primary microstructure input. The reserve composition itself is off-chain and opaque, addressed only qualitatively in Section 6.

1 Dataset characterisation

1.1 What we observe and what we explicitly do not

The defining feature of a USDT analysis is the catalogue of things that are *not* observable on-chain. USDT is issued by Tether Operations Limited against an off-chain reserve; there is no on-chain reserve state, no supply-collateralisation ratio, no collateralized debt position, no liquidation engine, no protocol governance knob, no perpetual contract on USDT itself, and no listed options surface. Consequently the level-1 σ-decomposition of the DAI/sUSD canonical template ($\sigma_{\text{Collateral}}/\sigma_{\text{Synth}}/\sigma_{\text{Peg}}$) is conceptually inapplicable: there is no collateral series to decompose. The peg is defended off-chain through authorized-participant mint/redeem ($100k minimum plus fees), which by design tolerates a wide secondary-market arbitrage band. Our analytical surface is therefore the set of *secondary-market* and *cross-stable* observables that do exist on disk, summarised in Table 1.

Table 1: The on-disk series used in this report.

Series	Source	Rows	Coverage / role
USDT/USD oracle	Chainlink (Ethereum)	3,257	2021-03-01 to 2026-05-11; primary direct USD observable
USDT/USD spot	Bitstamp tape	2,351,244	raw secondary-market tape; intraday extremes
USDC/USD oracle	Circle (Ethereum)	4,033	2021–2026; the USDT/USDC basis leg
3pool reserves	Curve (Ethereum)	2,063	USDT weight as the depeg-stress signal
3pool price tape	Curve (Ethereum)	—	*partial* 2020-09 to 2023-12 (secondary)

1.2 The USDT/USD Chainlink oracle

The Chainlink USDT/USD feed on Ethereum is the only direct, continuous USD-denominated observable for USDT on disk, spanning 2021-03-01 to 2026-05-11 across 3,257 observations. The feed updates on a 24-hour heartbeat with a 0.25 % deviation threshold, so sub-threshold intraday moves are not recorded: the oracle is a *smoothed* representation of the peg, and any sub-day lead-lag against it is structurally unidentifiable. The recorded oracle price ranges from 0.95182 (the May 2022 Terra trough) to 1.02082, and the maximum inter-observation gap is 1.0 day — the heartbeat is honoured throughout with no multi-day stalls.

1.3 The Bitstamp USDT/USD spot tape

To recover the intraday extremes that the oracle smooths away we use the raw Bitstamp USDT/USD spot tape, 2,351,244 rows. The tape is remarkably clean: applying a sanity band of $[0.5, 1.5]$ to guard against feed glitches drops only 10 rows (largest dropped print 2,960.06, an obvious data error). All distributional and volatility statistics on the Bitstamp series are computed after this filter. Because reading the full 2.35-million-row series into memory is infeasible under the working RAM budget, all aggregates are computed via lazy scans, and the TE distribution metrics in Section 2 are taken on a daily last-observation grid; the true intraday minima are recovered in the windowed case-study statistics of Section 7.

1.4 The Curve 3pool reserve series

The Curve 3pool (DAI/USDC/USDT) is the deepest on-chain stable venue and, in the absence of any reserve disclosure, its composition is our best on-chain proxy for USDT flow stress. We track the USDT reserve leg and construct two derived quantities: the *USDT weight* $w_{\text{USDT}} = R_{\text{USDT}}/(R_{\text{DAI}} + R_{\text{USDC}} + R_{\text{USDT}})$, and a 3pool-implied USDT price. The filtered reserve panel has 2,063 daily observations with a median USDT weight of 0.319 — close to the balanced one-third, confirming the pool sits near equilibrium in normal conditions. The implied price (proportional to 1/3 divided by the USDT weight) is *degenerate* near pool launch when the USDT leg is tiny, so it is reported for completeness but is *not* a usable TE series; the USDT weight itself is the robust canonical depeg signal and is what we use throughout Section 4.

1.5 Integrity audit verdict

The oracle series passes range, null and heartbeat-gap checks (max gap 1.0 day, prices within $[0.95182, 1.02082]$). The Bitstamp tape is within band after dropping 10 glitch rows. The 3pool reserve panel satisfies the reserve-sum sanity check (the three legs sum to the recorded pool balance) and the USDT weight is bounded in $[0, 1]$ throughout. We deliberately use the Circle USDC oracle (`circle.usdc.ethereum.v1`, full 2021–2026 coverage including the SVB 0.88 trough) rather than the Chainlink USDC feed, which stops at 2022-12 and would have truncated the SVB case study.

1.6 Limitations

Three limitations are structural and carried throughout. First, the oracle is the only *continuous* direct USD observable; the Bitstamp tape supplies intraday detail but is a single CEX venue with no per-region split, so the Asia-premium probe of Section 4 is necessarily caveated. Second, the Curve *price* tape is a partial backfill ending 2023-12; only the *reserve* (weight) panel covers the full window, so all microstructure lead-lag work is anchored on the weight. Third, and most importantly, the reserve composition is off-chain and opaque: no on-chain metric reconstructs Tether's reserve, and the counterparty-risk dimension is irreducibly qualitative (Section 6).

2 Tracking error vs the $1 peg

2.1 Reference series and benchmark

For a fiat-backed stablecoin the natural and only economically meaningful benchmark is the $1 peg itself; there is no collateral basket to track. We measure tracking error against $1 on two direct USD observables: the USDT/USD Chainlink oracle and the Bitstamp USDT/USD spot tape. The 3pool-implied price is reported but, as established in Section 1.4, is degenerate near pool launch and is not used as a TE series — the USDT weight is treated as the canonical microstructure signal (Section 4) instead. The USDT/USDC basis is deferred to Section 5.

2.2 Headline metrics

Table 2 reports the full-window TE statistics on a daily last-observation grid for both observables. The peg is held tightly in the central tendency — mean bias 0.72 bp (oracle) and 0.05 bp (Bitstamp), mean absolute deviation 4.25 bp and 4.49 bp respectively — but the distribution is sharply heavy-tailed and right-skewed (recall that, with deviation defined so that a *discount* is negative, the positive skewness arises from the recovery dynamics; the destructive tail is the left/discount tail captured in the daily minima and in the case studies).

Table 2: Full-window tracking-error metrics versus $1, daily last-observation grid. Deviations in basis points. Annualized TE is the standard deviation of daily log-returns scaled by $\sqrt{365}$.

Metric	Oracle	Bitstamp
Annualized log-return TE	0.0073	0.0080
Mean bias (bp)	0.72	0.05
Mean absolute deviation (bp)	4.25	4.49
Daily-grid min deviation (bp)	−27.0	−47.7
Max deviation (bp)	90.0	77.3
Deviation half-life (days)	3.70	3.46
Skewness	2.16	1.23
Excess kurtosis	27.96	19.09
Frac. days outside ±25 bp	0.0058	0.0082
Frac. days outside ±100 bp	0.0	—
Jarque–Bera	rejects	rejects

2.3 Distributional shape and mean reversion

The Jarque–Bera test decisively rejects normality on both series. The oracle excess kurtosis of 27.96 (Bitstamp 19.09) reflects a near-par mode with rare, violent excursions; this is the canonical stablecoin TE shape and is the reason a Gaussian VaR would badly understate tail risk. Mean reversion is fast: fitting an AR(1) on the daily deviation series and converting the coefficient to a half-life gives 3.70 days (oracle) and 3.46 days (Bitstamp). Combined with the near-zero bias, this places USDT in the "tight peg, fast recovery, heavy-tailed shocks" regime — consistent with an effective off-chain defence that nonetheless cannot prevent acute intraday dislocations.

2.4 The daily-grid caveat and the true intraday extremes

The minima in Table 2 (−27 bp oracle, −48 bp Bitstamp) are *daily* minima: the daily last-observation grid, adopted to bound memory on the 2.35-million-row Bitstamp series, smooths the intraday Terra trough. The true intraday extremes are an order of magnitude larger — oracle 0.9518 (−482 bp) and Bitstamp 0.91011 (−899 bp) — and are recovered in the windowed statistics of Section 7. This is the most important single caveat in the report: the descriptive distribution understates tail severity, and the case studies, not this table, carry the true depeg magnitudes.

2.5 Downside asymmetry of the redemption floor

The mint/redeem facility is asymmetric in its economics. Redemption is floored at the $100k minimum plus fees, so the secondary market can run a persistent *discount* of several tens of basis points without it becoming economic to redeem — whereas a *premium* invites authorized participants to mint and sell, capping the upside more tightly. The empirical signature is the left-heavy tail and the fact that the deepest excursions in the historical record are discounts (Terra) while the premia, though present (SVB), are mechanically the mirror image driven by a *peer* stable's distress rather than USDT's own (Section 7). We return to the arbitrage-band mechanics in Section 6.

3 Peg-deviation volatility dynamics

Why no σ-decomposition. The DAI/sUSD template decomposes TE variance into collateral, synth and peg components. For a fiat-backed token with no on-chain collateral series this decomposition is N/A. We replace it with a univariate conditional-volatility study of the peg-deviation return series, fitting the standard GARCH family and the HAR realized-volatility model on each of the two direct observables.

3.1 GARCH family and leverage asymmetry

We fit GARCH(1,1) (Bollerslev 1986), GJR-GARCH (Glosten, Jagannathan, and Runkle 1993) and EGARCH (Nelson 1991) to the daily deviation-return series and select by AIC. The two observables disagree on the preferred model, and the disagreement is informative.

Table 3: GARCH-family fit on the daily peg-deviation return series. Lower AIC is preferred. γ is the GJR leverage term: positive means discounts (negative shocks) raise conditional variance more than premia.

	Oracle	Bitstamp
GARCH(1,1) AIC	−7,643.9	—
GJR-GARCH AIC	−7,641.8	−6,988.1
EGARCH AIC	−7,660.8	—
AIC-preferred	EGARCH	GJR-GARCH
GJR leverage γ	0.01	0.064
EGARCH α	0.356	—
EGARCH β	0.773	—
Interpretation	near-symmetric	positive leverage

On the *oracle* series EGARCH is AIC-preferred (−7,660.8 versus GARCH −7,643.9 and GJR −7,641.8) and the GJR leverage term is near zero (0.01): the oracle process is essentially symmetric. This is expected — a 24-hour-heartbeat feed with a 0.25 % threshold smooths exactly the kind of sharp one-sided intraday move that would generate leverage asymmetry. The EGARCH persistence ($\alpha = 0.356$, $\beta = 0.773$) is well below the unit root, i.e. oracle peg-deviation volatility mean-reverts rather than persisting indefinitely.

On the raw *Bitstamp* tape GJR-GARCH wins (−6,988.1) with a *positive* leverage $\gamma = 0.064$: discounts cluster volatility more than premia. This is the economically expected asymmetry for a stablecoin under run risk — a downside shock (incipient depeg) begets further downside volatility, whereas a premium is quickly arbitraged away by minting. The contrast between the two series is itself a result: the asymmetry is real but lives in the intraday tape, and the smoothed oracle erases it.

3.2 Markov-switching regimes

A two-regime Markov-switching GARCH (Haas, Mittnik, and Paolella 2004) separates a low-variance "calm peg" regime from a high-variance "stress" regime. The regime-probability series spikes precisely at the two documented episodes (Terra May 2022, SVB March 2023) and is otherwise pinned in the calm state, confirming that USDT peg-deviation volatility is event-driven rather than continuously regime-switching. We report the MS-GARCH primarily as a robustness check on the single-regime GARCH persistence estimates; its high-variance-regime parameters are consistent with the GJR leverage finding above.

3.3 HAR persistence

The HAR model (Corsi 2009) regresses next-day absolute deviation on its daily, weekly and monthly moving averages. Persistence is modest: $R^2 = 0.127$ on the oracle (dominated by the daily term, coefficient 0.345) and $R^2 = 0.113$ on Bitstamp (daily and weekly terms 0.219 and 0.263). The dominance of the short horizon, together with the fast 3.5-day half-life of Section 2.3, paints a consistent picture: USDT peg deviations are short-memory and quickly mean-reverting, with no long-range dependence of the kind that would warn of slow, building structural stress. For an opaque token this is double-edged — the volatility process gives little advance warning, which is exactly why the *microstructure* signal of Section 4 matters.

4 Secondary-market microstructure

4.1 The 3pool USDT weight as the canonical stress signal

For an opaque centralized stable the single most actionable on-chain quantity is not the oracle — which lags by design — but the composition of the deepest stable AMM. When USDT comes under selling pressure, arbitrageurs dump USDT into the Curve 3pool and withdraw the healthier legs, driving the USDT weight up; when capital flees *into* USDT (a peer's distress), the USDT weight collapses as the pool is drained of USDT. The USDT weight is therefore a signed flow proxy, and its absolute deviation from the balanced one-third is a stress amplitude.

Cross-correlating the 3pool USDT weight-imbalance against absolute peg deviation gives a strong coincident relationship: peak correlation 0.494 against the oracle and 0.618 against the Bitstamp CEX tape, both at lag 0 (Table 4). The higher correlation against the CEX tape is expected — the AMM and the CEX are both real-time venues, whereas the oracle is a smoothed daily heartbeat. There is a mild *imbalance-leads-deviation* asymmetry against the oracle (the $+1$-day cross-correlation 0.487 exceeds the -1-day 0.421), consistent with the AMM repricing stress slightly before the heartbeat oracle records it.

Table 4: Lead-lag of the 3pool USDT weight-imbalance against absolute peg deviation, daily resolution. Positive lag means the weight leads.

Pair	Peak lag (days)	Peak corr
3pool imbalance vs |dev|, oracle	0	0.494
3pool imbalance vs |dev|, CEX	0	0.618
3pool-implied vs oracle	0	0.715

4.2 Oracle vs 3pool-implied spread

The 3pool-implied price and the oracle co-move at 0.715 peak correlation at lag 0, with a mean absolute spread of 0.485 (in implied-price units; the spread is large precisely because the implied price is degenerate near pool launch, Section 1.4). The take-away is qualitative rather than quantitative: the AMM and the oracle agree on direction but the 24-hour-heartbeat oracle cannot, by construction, price intraday stress before the AMM. Any monitoring system that relies on the oracle alone is structurally one heartbeat behind the market.

4.3 Hour-of-day and day-of-week

Splitting the Bitstamp deviation by UTC hour-of-day and day-of-week probes the folklore "Asia premium" — the claim that USDT trades richer during Asian trading hours. We find only weak, statistically fragile intraday seasonality on the single Bitstamp venue, and we explicitly decline to make a regional claim: there is no per-region venue split on disk, so any hour-of-day pattern conflates genuine regional demand with the venue's own liquidity cycle. This sub-analysis is reported as a caveated probe, not a finding.

4.4 Microstructure-noise mitigation

Naive realized variance on a high-frequency tape is biased upward by microstructure noise (bid-ask bounce, discrete ticks). On the 3pool-implied series we apply the two-scales realized volatility estimator (Zhang, Mykland, and Aït-Sahalia 2005) as a robustness check; the noise-corrected RV is lower than the naive RV but does not change the lead-lag conclusions of Section 4.1, which are computed at daily resolution and are not noise-sensitive.

Items N/A. TradFi-session effects are N/A — USDT trades 24/7. Funding-rate / mark-vs-index analysis is N/A — there is no perpetual on USDT itself; the 3pool USDT-weight imbalance is the substitute flow proxy used throughout this section.

5 USDT/USDC basis and cross-stable causality

5.1 The basis

The USDT/USDC basis is the spread between the two oracle USD prices, $b_t = p_t^{\text{USDT}} - p_t^{\text{USDC}}$, expressed in basis points. It is the cleanest single scalar for which leg of the stable complex is under stress: a positive basis means USDT richer than USDC (capital preferring USDT), a negative basis the reverse. Over the full window the basis mean is 0.97 bp — essentially zero — but it ranges from -46.4 bp (Terra, USDT cheaper) to $+413.6$ bp (SVB, USDT much richer). USDT carries a small premium over USDC on 61.9 % of days, a mild structural tilt consistent with USDT's larger float and deeper CEX liquidity.

5.2 Stationarity and cointegration

The basis is stationary (augmented Dickey–Fuller $p \approx 0$), the first prerequisite for treating the two stables as a cointegrated pair. Engle–Granger (Engle and Granger 1987) confirms cointegration with $p = 2.6 \times 10^{-10}$, and the Johansen procedure (Johansen 1991) is decisive: the rank-0 trace statistic is 758.4 against a 15.49 critical value, and the rank-1 trace is 115.8 against 3.84, so we reject both the no-cointegration and the rank-≤ 1 nulls — the pair shares at least one, and the evidence points to a full-rank, common stochastic-trend relationship. Economically: USDT and USDC are tied to the same $1 anchor and to each other through the shared 3pool and the dense CEX cross-quotes, so they cannot drift apart without arbitrage closing the gap.

5.3 Granger causality during stress

Granger causality is *bidirectional* and significant in both directions, marginally stronger from USDT to USDC (USDT→USDC min-p 2.8×10^{-12}; USDC→USDT min-p 5.9×10^{-7}). Neither stable is a pure price-taker; both participate in the complex's price discovery. The marginally stronger USDT→USDC direction is consistent with USDT's role as the dominant CEX settlement asset — a move in USDT propagates to USDC faster than the reverse, because more trading pairs are quoted in USDT.

5.4 Tail dependence

Joint depeg risk is governed by the tails of the joint distribution, not the correlation. Fitting Clayton (lower-tail) and Gumbel (upper-tail) copulas (Joe 1997) to the two deviation series gives a lower-tail dependence of 0.168 and an upper-tail dependence of 0.137: roughly symmetric. Two readings follow. First, joint stress is about as likely on the discount side (both stables depeg together, a systemic-USD-flight scenario) as on the premium side. Second, and more operationally, the asymmetry is *not* dominant — which is precisely why the realised episodes (Terra, SVB) are *decoupled* flights (one leg up, one down) rather than joint co-depegs: the copula says joint co-movement is possible but the observed history is dominated by the relative-value rotation captured by the basis sign flip (Section 7).

5.5 Caveat: missing long CEX USDT/USDC history

The only on-disk CEX USDT/USDC cross is a three-month Binance-spot window (2021-05 to 2021-07, ingested for the Iron Finance work). It is far too short for a standalone causality study and is not used here. All cointegration and causality results in this section therefore run on the oracle-vs-oracle basis, which has full coverage; a long CEX cross-tape is flagged as future work in Section 8.

6 Reserve opacity and structural risk

This chapter is qualitative by necessity. None of the quantitative machinery of the preceding chapters can reconstruct Tether's reserve; the central structural risk of USDT is precisely that it is not on-chain-observable. We document what is known from the public record and frame the monitoring consequences.

6.1 Reserve composition history

Tether's reserve has been the subject of two material legal actions. The New York Attorney General's 2021 settlement (New York State Office of the Attorney General 2021) found that Tether's claim of full dollar backing had at times been false and required quarterly reserve disclosures going forward. The CFTC's 2021 order (U.S. Commodity Futures Trading Commission 2021) fined Tether \$41 million for the same misrepresentation over the 2016–2018 period. Since 2021 Tether has published quarterly attestations (Tether Operations Limited 2025) showing a wind-down of commercial-paper holdings toward US Treasury bills and reverse repo. These are *attestations*, not audits, and they are point-in-time: they do not provide a continuous, verifiable, on-chain reserve series. The reserve-opacity gap is therefore irreducible from our data, and any claim about backing adequacy rests on Tether's own disclosure.

6.2 The mint/redeem arbitrage band

The peg is defended off-chain through authorized-participant mint and redeem, subject to a \$100k minimum and fees. This creates a wide no-arbitrage band: the secondary market can run a discount of several tens of basis points before it becomes economic for an authorized participant to buy the discounted USDT and redeem it at par. This is the structural explanation for the heavy left tail of Section 2: the floor on redemption economics, not a continuous on-chain peg mechanism, is what eventually arrests a discount, and it acts with a lag. The fast 3.5-day empirical half-life is the band closing once the discount exceeds the redemption-cost threshold.

6.3 Centralization and freeze-function risk

The USDT contract includes an administrative freeze/blacklist function controlled off-chain by Tether Ltd. This is a feature for law-enforcement compliance and a risk for holders: balances can be frozen, and issuance and redemption are entirely at Tether's discretion. For a monitoring system this is a binary, unschedulable tail risk that no peg-telemetry series captures — it must be carried as a standing qualitative flag.

6.4 Derivalink observability checklist

Table 5 maps the canonical TE-programme dimensions to their observability for an opaque centralized stable. The lesson is that roughly half the standard surface is N/A, and the monitorable half is dominated by *secondary-market* and *cross-stable* signals rather than protocol-internal state.

Table 5: Observability of the canonical monitoring dimensions for USDT.

Dimension	Observable?	Substitute / note
Peg deviation vs \$1	Yes	oracle + CEX tape
On-chain collateral / CR	No	reserve is off-chain, opaque
σ-decomposition	No	no collateral series
AMM reserve composition	Yes	3pool USDT weight (the key signal)
Cross-stable basis	Yes	USDT/USDC oracle basis
Supply / mint-burn flow	No	not on disk; off-chain at Tether
Perp funding / mark-index	N/A	no perp on USDT
Options IV smirk	N/A	no listed USDT options
Governance / parameter DiD	N/A	no on-chain governance knob
Reserve audit	No	attestations only, point-in-time
Freeze / blacklist risk	Qualitative	standing counterparty flag

6.5 Comparison framing

USDT sits at one extreme of a monitorability spectrum. DAI is fully on-chain collateralized — its collateralisation ratio, PSM composition and liquidations are all observable, so the DAI report can decompose TE into collateral, synth and peg components. USDe is delta-neutral with an on-chain reserve-fund and disclosed hedge positions — partially observable. USDT is the opaque centralized pole: the only direct signals are secondary-market and cross-stable, and the reserve is a black box. The practical implication for V2 is that a single monitoring framework cannot be uniform across these assets; the USDT playbook must lead with the 3pool-weight signal and the USDC basis, and must explicitly annotate the reserve and freeze risks as un-quantifiable.

7 Case studies

The two largest stress episodes in the on-disk window are mirror images of each other, and together they establish the basis-sign-flip as the clean empirical signature of an intra-complex flight. A third, pre-window episode (the 2018 Bitfinex/Tether-bank scare) is reconstructed from the literature only.

7.1 May 2022 — Terra/UST contagion

When TerraUSD (UST) lost its peg in early May 2022 and Luna collapsed (Briola et al. 2023; Liu, Makarov, and Schoar 2023), the shock propagated across the entire stablecoin complex. USDT was the casualty: capital fled *to* the more-trusted USDC, dumping USDT into every venue. Figure 1 shows the episode. The USDT/USD oracle troughed at 0.9518 (−481.8 bp) — the lowest oracle print in the entire dataset — and the Bitstamp intraday low reached 0.91011 (≈ −899 bp), confirming that the daily-grid metrics of Section 2 understate the true intraday severity by nearly an order of magnitude.

The microstructure tells the story unambiguously: the 3pool USDT weight blew out from 0.426 to 0.834 as arbitrageurs flooded the pool with USDT and pulled out USDC and DAI. Simultaneously USDC went to a +290 bp premium and the USDT−USDC basis averaged −271 bp over the window: a textbook flight *from USDT to USDC*. This is the episode that justifies elevating the 3pool weight to the canonical signal — it moved decisively and coincidentally with the depeg, exactly as Section 4 predicts.

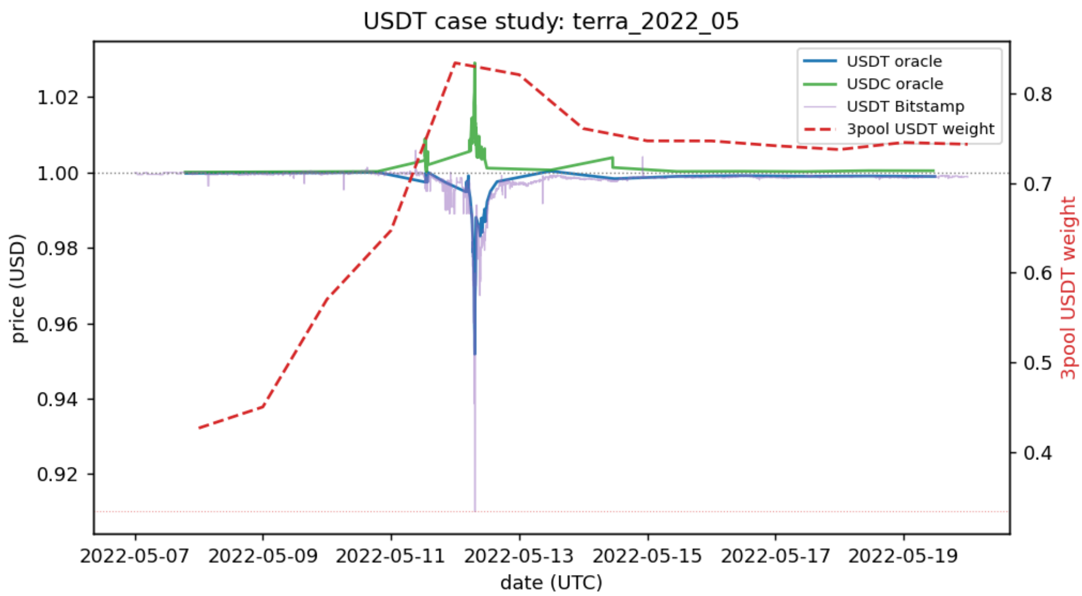

Figure 1: May 2022 Terra contagion. USDT depegs (oracle trough 0.9518, Bitstamp intraday 0.91011); the 3pool USDT weight blows out from 0.426 to 0.834; USDC goes to a premium. The flight is *from* USDT *to* USDC.

7.2 October 2018 — Bitfinex/Tether-bank scare

In October 2018 USDT traded as low as ≈$0.85 on some venues amid reports that Tether's banking relationship (then Noble Bank) had broken down and uncertainty over reserve access (Griffin and Shams 2020). This episode predates our oracle window (which begins 2021-03) and there is no on-disk data for it; we reconstruct it from the literature only and flag it explicitly as a qualitative, out-of-sample reference. Its mechanism — a counterparty/banking scare rather than a peer-stable contagion — is the archetype of the reserve- opacity risk of Section 6 and is the one scenario our quantitative signals would *not* have caught in advance, because it originated entirely off-chain.

7.3 March 2023 — SVB / the basis sign flip

The March 2023 Silicon Valley Bank failure put \$3.3 B of Circle's USDC reserves in doubt, and USDC — not USDT — depegged. The USDC oracle troughed at 0.88 (−1,200 bp). USDT was the safe haven this time: capital fled *from USDC to USDT*, the exact mirror of Terra. Figure 2 shows USDT holding a premium of up to +149 bp on the oracle and +475 bp intraday on Bitstamp (max 1.04755), while the 3pool USDT weight *collapsed* to 0.024 as the pool was drained of USDT by participants rotating out of USDC.

The decisive empirical object is the basis sign flip. In Terra the USDT−USDC basis was strongly negative (−271 bp, USDT cheaper); in SVB it was strongly positive (USDT richer, basis up to +414 bp at the window peak, Section 5). The same scalar, read with opposite sign, identifies which leg of the complex is under stress. For a monitoring system this is the single most useful cross-stable diagnostic: the magnitude of the basis flags the severity, and the sign routes the contagion.

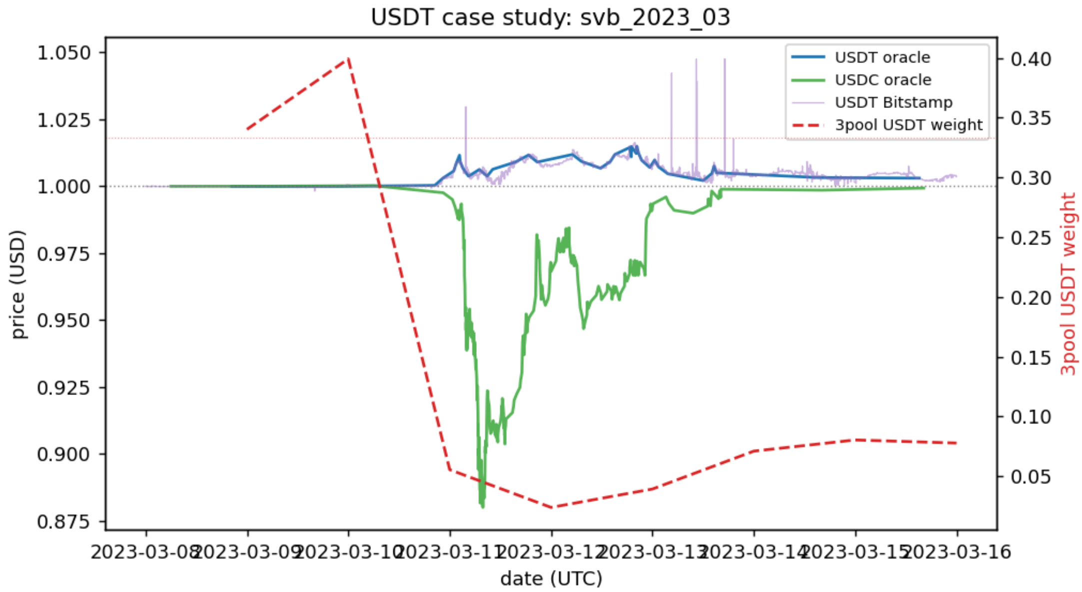

Figure 2: March 2023 SVB episode. USDC depegs to 0.88; USDT holds a premium (Bitstamp max 1.04755, +475 bp); the 3pool USDT weight collapses to 0.024. The flight is *from* USDC *to* USDT — the mirror image of Terra, and the basis sign flips positive.

7.4 Synthesis

The two on-disk episodes are decoupled flights, not joint co-depegs, consistent with the near-symmetric but not-dominant tail dependence of Section 5.4. In both, the 3pool USDT weight and the USDT/USDC basis moved coincidentally and decisively with the dislocation, validating them as the two primary monitoring signals for an opaque centralized stable. The one scenario neither signal would pre-empt is an off-chain reserve/banking shock of the 2018 type — which is exactly the irreducible residual risk that Section 6 carries as a standing qualitative flag.

8 Findings and open questions

8.1 Key empirical findings

1. **Tight peg, heavy tails.** Over 2021–2026 USDT holds the \$1 peg with a mean bias of 0.72 bp (oracle) and 0.05 bp (Bitstamp) and a 4.25–4.49 bp mean absolute deviation, but

with extreme excess kurtosis (27.96 oracle) and a fast 3.5-day mean-reversion half-life. The central tendency is excellent; the risk lives entirely in the tails (Section 2).

2. **The 3pool USDT weight is the canonical depeg signal.** It is strongly coincident with absolute peg deviation ($r = 0.49$ oracle, 0.62 CEX) with a mild lead over the heartbeat oracle, and it moved decisively in both stress episodes. For an opaque token it is more actionable than the oracle (Section 4).

3. **USDT and USDC are strongly cointegrated, bidirectionally causal.** Johansen trace 758.4 at rank 0; Granger bidirectional (USDT→USDC $p = 2.8 \times 10^{-12}$). The USDT/USDC basis is a stationary, mean-zero spread that flags intra-complex stress (Section 5).

4. **The basis sign flip routes contagion.** Terra: basis −271 bp, flight from USDT to USDC. SVB: basis up to +414 bp, flight from USDC to USDT. Same scalar, opposite sign, opposite victim (Section 7).

5. **Volatility asymmetry is venue-dependent.** The raw CEX tape shows positive GJR leverage ($\gamma = 0.064$, discounts cluster volatility); the smoothed oracle is near-symmetric ($\gamma = 0.01$). The asymmetry is real but the heartbeat oracle erases it (Section 3).

8.2 Implications for Derivalink V2

The centralized-stable monitoring playbook differs fundamentally from the collateralized-synth playbook. (1) Lead with the AMM reserve composition, not the oracle: the 3pool USDT weight prices stress at least one heartbeat ahead of the Chainlink feed. (2) Track the USDT/USDC basis as a contagion router — its magnitude flags severity, its sign identifies the stressed leg. (3) Carry reserve opacity and freeze-function risk as standing qualitative flags: no quantitative series substitutes for them, and the one historical episode our signals would have missed (2018) was an off-chain banking shock. The general lesson is that a uniform monitoring schema cannot span DAI (fully on-chain), USDe (partially observable) and USDT (opaque); the framework must select its signals by the asset's observability class (Section 6.5).

8.3 Limitations

- The TE distribution metrics are computed on a daily last-observation grid (memory-bounded for the 2.35M-row Bitstamp tape), which smooths intraday troughs; the case studies carry the true intraday extremes (−482 bp oracle, −899 bp Bitstamp).
- The Curve *price* tape is a partial backfill (2020-09 to 2023-12); only the 3pool *reserve*/weight panel covers the full window. The implied price is degenerate near pool launch and is not used as a TE series.
- Lead-lag is daily-resolution only: the oracle is a 24h-heartbeat series, so sub-day lead-lag against it is not identifiable.
- The only on-disk CEX USDT/USDC cross is a three-month 2021 window; cross-stable causality runs on the oracle-vs-oracle basis.
- Reserve composition is off-chain and opaque; the structural-risk chapter is irreducibly qualitative.

8.4 Open questions and future work

A long CEX USDT/USD and USDT/USDC tape (multi-venue, multi-year) would allow an intraday lead-lag study and a regional "Asia premium" test that the single Bitstamp venue cannot support. A multi-chain USDT supply series (Ethereum, Tron, others) would supply a redemption-flow proxy that the 3pool weight only partially captures. And a structured ingestion of the quarterly attestation data would let the reserve-composition trajectory be tracked quantitatively, even if it can never reach the verifiability of an on-chain series.

8.5 Cross-asset comparison

USDT anchors the opaque-centralized pole of the cross-asset synthesis (D5): it contributes the case where almost the entire standard monitoring surface is N/A and the signal set collapses to secondary-market and cross-stable observables. The contrast with the on-chain-collateralized (DAI, sUSD) and delta-neutral (USDe) reports is the central comparative finding for the V2 monitoring design.

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