USDC (Circle) sub-report

Push-oracle censoring, the peg-arbitrage band, and the SVB depeg forensics of a fiat-reserve stablecoin, 2021–2026

Derivalink R&D

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Abstract

USDC is a fully fiat-reserve-backed stablecoin issued by Circle, redeemable 1:1 against attested cash and short-dated Treasuries through a KYC-gated primary market. There is no on-chain collateral, no collateralisation ratio, no liquidation engine, no perpetual and no listed options surface on USDC itself; the peg is defended by primary-market mint/redeem arbitrage. This sub-report therefore reframes the canonical tracking-error (TE) programme around the observables that exist on disk: the Chainlink USDC/USD push oracle (4,033 mainnet updates, 2021–2026), a 2,356,863-row Bitstamp USDC/USD spot tape, the Curve 3pool USDC weight, and the USDC/USDT and USDC/DAI bases. Over the full window USDC holds the peg with a daily mean bias of -0.25 bp (oracle) and a mean absolute deviation of 1.43 bp (oracle) / 1.98 bp (Bitstamp), but the distribution is violently heavy-tailed (oracle excess kurtosis 1,410) and the entire tail is the March 2023 SVB episode. The defining structural finding is *push-oracle censoring*: the 0.25 % deviation-threshold feed floored at 0.88 during SVB while the Bitstamp tape printed an intraday wick of 0.81029 (697 bp below the oracle floor), and across the full window 60 % of CEX days with $|\text{dev}| > 25$ bp were structurally invisible to the oracle. A clear banking-hours/weekend effect (3.30 vs 1.45 bp absolute deviation, 2.28×) confirms the US-bank redemption rail. The SVB forensics reconstruct the oracle–market dislocation, a 41-hour trough-to-repeg recovery (AR(1) half-life 5.6 h) after the Fed/FDIC backstop, a 3pool USDC weight spike $0.33 \to 0.50$, and the contagion path USDC$\to$DAI (PSM, basis near zero) $\to$USDT (flight-to-safety premium +149 bp). USDC, DAI and USDT are full-rank cointegrated (Johansen trace 1172/485/115), with USDC Granger-leading DAI through the PSM. We conclude with a centralised-reserve tail-risk monitoring playbook for Derivalink V2.

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Executive summary

Asset nature and scope. USDC is a fully fiat-reserve-backed stablecoin issued by Circle, redeemable 1:1 against attested cash and short-dated US Treasuries through a KYC-gated primary market (Circle Internet Financial 2025). The peg is held by primary-market mint/redeem arbitrage, not by on-chain over-collateralisation or an algorithmic mechanism. Consequently the collateralisation-ratio, liquidation, perpetual and listed-options machinery of the collateralized-synth template is conceptually N/A, and the level-1 σ-decomposition of the DAI/sUSD template (which requires an on-chain collateral series) is replaced here by a dedicated *oracle-behaviour and censoring* chapter (Section 3). Our analytical surface is the set of observables that exist on disk: the Chainlink USDC/USD push oracle (4,033 mainnet updates, 2021–2026), a 2,356,863-row Bitstamp USDC/USD spot tape, the Curve 3pool USDC weight, and the USDC/USDT and USDC/DAI bases. The defining tracking-error event is the **Silicon Valley Bank (SVB) depeg of 10–13 March 2023**, when \$3.3 B of Circle's reserves were briefly stranded at the failed bank (Circle Internet Financial 2023); the on-disk Chainlink USDC/USD feed bottoms at 0.88.

F1 — Peg fidelity is excellent in the central tendency, and the entire tail is one event. On the full 2021–2026 daily grid USDC trades at par: oracle mean bias −0.25 bp, Bitstamp −0.62 bp, mean absolute deviation 1.43 bp (oracle) and 1.98 bp (Bitstamp), with an annualized log-return TE of 0.0174 / 0.0190 (Section 2). The deviation distribution is extreme: oracle skewness −35.5 and excess kurtosis 1,410, both driven almost entirely by the SVB excursion. Days outside ±25 bp: 0.11 % (oracle). Mean reversion is fast (deviation half-life 0.67 days oracle, 0.57 days Bitstamp). The left (discount) tail is fatter than the right, the redemption-gate-asymmetry signature.

F2 — Push-oracle censoring is the structural headline. The Chainlink feed updates on a 0.25 % deviation threshold plus a 24-hour heartbeat (Chainlink Labs 2024); it therefore cannot see sub-threshold stress. Across 1,898 overlapping days, 5 had Bitstamp $|\text{dev}| > 25$ bp while the oracle stayed pinned within band on 3 of them — **60 % of CEX stress days were structurally invisible to the oracle** (Section 3). During SVB this became physical: the oracle *floored* at 0.88 while the Bitstamp tape wicked to 0.81029, 697 bp below the oracle floor (Section 6). The push oracle reports a censored peg by construction; the secondary market shows the true depth.

F3 — The banking-hours/weekend effect is real and large. Absolute peg deviation is 3.30 bp on weekends versus 1.45 bp on weekdays, a 2.28× **ratio** (Section 4). This is the empirical signature of a US-bank redemption rail that closes on weekends: when primary redemption is unavailable, the secondary market is free to drift. The within-day US-banking-hours split is, by contrast, flat (2.00 vs 1.97 bp), so the effect is at the day-of-week, not hour-of-day, granularity.

F4 — The peg-arbitrage band is tight but asymmetric. The oracle−CEX spread has a mean of 0.41 bp and a 90 % no-arb band width of 9.36 bp (99 % width 26.35 bp, Section 5). The market is below the oracle 51.3 % of the time and the CEX deviation skew is −31.6 bp: the left (redemption-gated) tail is wider than the right (mint-fast) tail by ≈ 1 bp at the 1/99 percentiles — the structural consequence of fast minting versus KYC-gated redemption. At daily resolution oracle and market are contemporaneous (peak correlation 0.91 at lag 0); a sub-daily market-leads-oracle test is not identifiable on the daily grid.

F5 — SVB: the censored depeg, the backstop recovery, and the contagion router. The oracle troughed at 0.88 (−1,200 bp, 2,023-03-11 07:51 UTC) with a first sub-par (< 0.99) print at 01:54 UTC — 5.9 hours after Circle's disclosure (Section 6). Recovery to ≥ 0.995 took 41 hours (trough-to-repeg) after the joint Fed/FDIC/Treasury backstop (Federal Deposit

Insurance Corporation 2023; Board of Governors of the Federal Reserve System 2023); the AR(1) half-life was 5.6 hours. The 3pool USDC weight spiked from 0.33 to 0.50 as USDC was dumped into the pool. Contagion ran along two distinct channels: USDC→DAI was a near-one-for-one PSM co-move (USDC−DAI basis mean −7.6 bp, DAI itself depegging to 0.889), while USDC→USDT was a flight-to-safety with USDT carrying a +149 bp oracle premium and a USDC−USDT basis trough of −414 bp.

F6 — The stable complex is full-rank cointegrated and breaks together on the downside. {USDC, DAI, USDT} are cointegrated at full rank (Johansen trace 1,172/485/115, all $\gg$ the 29.8/15.5/3.84 critical values); Engle–Granger confirms USDC−DAI ($p < 1 \times 10^{-3}$, robust) and USDC−USDT ($p = 1.7 \times 10^{-15}$). After BH-FDR correction, USDC Granger-leads DAI (the PSM direction, $p = 1.2 \times 10^{-5}$, with DAI→USDC failing at $p = 0.22$), while USDC↔USDT is bidirectional (Section 7). Lower-tail dependence exceeds upper ($\lambda_L = 0.20$ vs $\lambda_U = 0.14$ for USDC–DAI): the complex breaks together on the downside.

Three implications for Derivalink V2. (1) For a fiat-reserve stable the monitoring layer must *not* trust the push oracle as a depeg detector — 60 % of stress is censored below the 0.25 % threshold; ingest a CEX/AMM secondary tape in parallel. (2) The USDC−USDT basis sign is a contagion router (negative = USDC under stress; flips positive when USDT is the casualty), and the USDC−DAI basis is a near-rigid PSM tether that propagates any USDC shock straight into DAI. (3) Carry the off-chain reserve concentration as a standing qualitative flag: the SVB root cause ($3.3 B of ≈$40 B at a single bank) was invisible to every on-chain series until the disclosure, and no quantitative telemetry substitutes for reserve-bank diversification monitoring (Section 8).

Principal caveats. The daily-grid TE minima (Section 2) smooth the intraday SVB wick: the authoritative depeg depth is in the case study (oracle 0.88, Bitstamp 0.81029), not the descriptive table. The Curve *price* tape is a partial backfill ending 2023-08; only the 3pool *reserve*/weight panel spans the window. The Polygon oracle covers only 2021-05..2021-07 (no SVB), so multi-chain consistency is established on mainnet versus Arbitrum (945-day overlap, mean spread −0.11 bp). Daily lead-lag is contemporaneous and cannot resolve a sub-daily market lead. Reserve composition is off-chain and addressed only qualitatively.

1 Dataset characterisation

1.1 What we observe and what we explicitly do not

USDC is a centralised fiat-reserve stablecoin: Circle holds the reserve off-chain (cash plus short-dated US Treasuries) and redeems 1:1 against it through a KYC-gated primary market (Circle Internet Financial 2025). There is therefore no on-chain reserve state, no collateralisation ratio, no collateralized debt position, no liquidation engine, no perpetual contract on USDC and no listed options surface. 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 — and is replaced in this report by a dedicated oracle-behaviour and censoring chapter (Section 3). Our analytical surface is the set of direct USD observables and cross-stable bases that exist on disk, summarised in Table 1.

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

Series	Source	Rows	Coverage / role
USDC/USD oracle	Chainlink (Ethereum)	4,033	2021-03 to 2026-05; primary direct USD observable; floor 0.88
USDC/USD spot	Bitstamp tape	2,356,863	raw secondary-market tape; intraday extremes
USDC/USD oracle (Arbitrum)	Chainlink (Arbitrum)	2,697	from 2023-03; multi-chain consistency, covers SVB
USDC/USD oracle (Polygon)	Chainlink (Polygon)	32,839	2021-05..2021-07 only; *no* SVB; flagged partial
USDT/USD oracle	Chainlink (Ethereum)	4,033	the USDC/USDT basis leg (flight-to-safety)
DAI/USD oracle	Chainlink (Ethereum)	—	the USDC/DAI basis leg (PSM co-move)
3pool reserves	Curve (Ethereum)	2,063	USDC weight as the depeg-stress signal
3pool price tape	Curve (Ethereum)	140,937	*partial* 2020-09 to 2023-08 (secondary)

1.2 The USDC/USD Chainlink oracle and its heartbeat/threshold config

The Chainlink USDC/USD feed on Ethereum is the only direct, continuous USD-denominated observable for USDC on disk, spanning 2021-03 to 2026-05 across 4,033 mainnet updates. The feed is a *push* oracle: it writes a new answer when the price moves by at least a 0.25 % deviation threshold, or otherwise at least once every 24 hours (the heartbeat), whichever comes first (Chainlink Labs 2024). The empirical inter-update interval has a median of 12,100 s ($\approx$ 3.4 h) and a maximum gap of 1.003 days: the heartbeat is honoured throughout with no multi-day stalls. 42.0 % of updates sit within $\pm$10 % of the 24-hour heartbeat, and only 12.7 % are deviation-triggered (a step $\geq$ 0.25 %). The recorded oracle price ranges from 0.88 (the SVB trough) to 1.02901. The structural consequence — that sub-threshold intraday moves are not recorded, so the oracle is a *censored* representation of the peg — is the subject of Section 3.

1.3 The Bitstamp USDC/USD spot tape

To recover the intraday extremes that the push oracle censors we use the raw Bitstamp USDC/USD spot tape, 2,356,863 rows. Unlike the USDT Bitstamp tape (which carried obvious data errors up to $2,960), the USDC tape is already clean: applying a sanity band of $[0.5, 1.5]$ drops *zero* rows. The recorded range is 0.81029 (the SVB intraday wick) to 1.1. Because reading the full 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 minimum is recovered in the windowed SVB statistics of Section 6.

1.4 The Curve 3pool reserve series and the cross-stable legs

The Curve 3pool (DAI/USDC/USDT) is the deepest on-chain stable venue. We track the USDC reserve leg and construct the *USDC weight* $w_{\mathrm{USDC}} = R_{\mathrm{USDC}}/(R_{\mathrm{DAI}} + R_{\mathrm{USDC}} + R_{\mathrm{USDT}})$. The filtered reserve panel has 2,063 daily observations with a median USDC weight of 0.366 — close to the balanced one-third, confirming the pool sits near equilibrium in normal conditions.

A 3pool-*implied* USDC price (proportional to $\frac{1}{3}$ divided by the USDC weight) is *degenerate* near pool launch when the USDC leg is thin (its TE blows out to 235 % with a deviation range $-4{,}764/+31{,}437$ bp); it is written for parity but is **not** a usable TE series. The USDC weight itself is the robust on-chain depeg signal — it spikes from 0.33 to 0.50 during SVB (Section 6). For cross-stable causality we use the Chainlink USDT/USD and DAI/USD oracles as the USDC/USDT (flight-to-safety) and USDC/DAI (PSM co-move) basis legs.

1.5 Integrity audit verdict

The mainnet oracle series passes range, null and heartbeat-gap checks (max gap 1.003 days, prices within $[0.88, 1.02901]$, no negative or zero answers; 804 duplicate-timestamp updates are within-block multi-write artefacts and are deduplicated). The Bitstamp tape is fully within band (0 glitch rows). The 3pool reserve panel satisfies the reserve-sum sanity check (minimum total reserve \$10.3 M, no negative legs) and the USDC weight is bounded in $[0.080, 0.637]$ throughout. The Arbitrum feed (2,697 rows from 2023-03, floor 0.881) covers SVB and is used for the multi-chain consistency check; the Polygon feed is explicitly partial (2021-05..2021-07, no SVB) and is excluded from any SVB claim.

1.6 Limitations

Four limitations are structural and carried throughout. First, the push oracle is the only *continuous* direct USD observable, and by construction it censors all sub-0.25 % intraday stress (Section 3); the Bitstamp tape supplies intraday detail but is a single CEX venue. Second, the Curve *price* tape is a partial backfill ending 2023-08; only the *reserve* (weight) panel spans the full window, so the on-chain microstructure signal is anchored on the weight. Third, the Polygon oracle predates SVB, so multi-chain consistency is established on mainnet versus Arbitrum only. Fourth, and most importantly, the reserve composition is off-chain: no on-chain metric reconstructs the share of reserves at any single banking counterparty, so the SVB root-cause and the reserve-concentration risk are addressed only qualitatively (Section 6, Section 8).

2 Tracking error vs the \$1 peg

2.1 Reference series and benchmark

For a fiat-reserve 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 USDC/USD Chainlink oracle and the Bitstamp USDC/USD spot tape. The 3pool-implied price is reported in Section 1.4 but, being degenerate near pool launch, is not used as a TE series — the USDC weight is treated as the on-chain stress signal (Section 6) instead. The USDC/USDT and USDC/DAI bases are deferred to Section 7.

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 -0.25 bp (oracle) and -0.62 bp (Bitstamp), mean absolute deviation 1.43 bp and 1.98 bp respectively — but the distribution is violently heavy-tailed and *left*-skewed (deviation defined so that a discount is negative). Crucially, almost the entire tail mass is a single event: the March 2023 SVB depeg (Section 6). The oracle excess kurtosis of 1,410 and skewness of -35.5 are dominated by that excursion.

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 $\sqrt{365}$. Tail asymmetry > 0 means the left (discount) tail is wider than the right.

Metric	Oracle	Bitstamp
Annualized log-return TE	0.0174	0.0190
Mean bias (bp)	−0.25	−0.62
Mean absolute deviation (bp)	1.43	1.98
Deviation half-life (days)	0.67	0.57
Skewness	−35.5	—
Excess kurtosis	1,410	—
Frac. days outside ±25 bp	0.0011	0.0039
Frac. days outside ±100 bp	0.0005	—
Tail asymmetry (bp)	2.33	3.60
Persistence outside ±25 bp (days)	2.0	—
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 1,410 is roughly fifty times that of the comparatively "ordinary" USDT tape (28), reflecting a near-par mode with one catastrophic, isolated excursion rather than a continuum of moderate shocks. This is the cleanest illustration in the stable complex of why a Gaussian VaR is useless for a fiat-reserve peg: outside the SVB window USDC is essentially riskless against \$1, and inside it the move is a −1,200 bp cliff. Mean reversion is very fast — AR(1) deviation half-lives of 0.67 days (oracle) and 0.57 days (Bitstamp) — consistent with an effective primary-market arbitrage that re-pegs within a day once the redemption rail is available.

2.4 Left-tail (redemption-gate) asymmetry

The tail-asymmetry statistic is positive on both series (2.33 bp oracle, 3.60 bp Bitstamp): the left/discount tail is wider than the right/premium tail. This is the empirical signature of the asymmetric primary market. Minting USDC is fast (deposit dollars, receive tokens), which caps premia tightly because authorized participants mint and sell into any richness; redemption, by contrast, is KYC-gated and settles on US business days, so the secondary market can run a persistent discount of tens of basis points before redemption clears it. The structural mechanics of this asymmetry — the no-arbitrage band and the access asymmetry — are quantified in Section 5; the day-of-week imprint of the weekend-closed redemption rail is in Section 4.

2.5 The daily-grid caveat and the true intraday extreme

The metrics in Table 2 are computed on a *daily* last-observation grid, adopted to bound memory on the 2,356,863-row Bitstamp series. This smooths the intraday SVB trough: the daily-grid oracle minimum understates the true depth. The authoritative SVB extremes are the oracle floor of 0.88 (−1,200 bp) and the Bitstamp intraday wick of 0.81029 (−1,897 bp), recovered in the windowed statistics of Section 6. This is the single most important caveat in the report: the descriptive distribution understates tail severity, and the SVB case study, not this table, carries the true depeg magnitude.

3 Oracle behaviour and censoring

This chapter replaces the level-1 σ-decomposition of the DAI/sUSD template, which has no analogue for a fiat-reserve token with no on-chain collateral. Instead it characterises the one piece of monitoring infrastructure that *does* sit on-chain — the Chainlink USDC/USD push oracle — and quantifies what it structurally cannot see.

3.1 Inter-update interval: heartbeat versus deviation triggers

The feed writes a new answer when the price moves by $\geq 0.25\,\%$ (the deviation threshold) or otherwise at least every 24 hours (the heartbeat) (Chainlink Labs 2024). Empirically, across 4,032 inter-update intervals, the median gap is 12,100 s ($\approx$ 3.4 h), the 25th percentile 29 s (clusters of rapid deviation writes), the 75th percentile 86,389 s ($\approx$ 24 h), and the maximum 86,638 s (1.003 days). 42.0 % of updates fall within $\pm$10 % of the 24-hour heartbeat. The distribution is thus strongly bimodal: a heartbeat mode at 24 h and a deviation mode at sub- hour spacing, with little in between.

3.2 Deviation-triggered versus heartbeat updates

Classifying each update by its step size, 511 of 4,032 updates (12.7 %) are deviation-triggered (step $\geq$ 0.25 %) and the remaining 3,521 (87.3 %) are heartbeat or sub-threshold writes. The step-size distribution is highly concentrated: median absolute step 0.56 bp, 95th percentile 31.9 bp, 99th percentile 53.4 bp, maximum 104.9 bp. The implication is direct — in normal conditions the oracle is writing near-identical $1.000x answers on the heartbeat, and it only conveys information when a deviation trigger fires, which by definition cannot happen until the price has already moved a quarter of a percent.

3.3 What the push oracle cannot see: sub-threshold censoring

The central finding of this chapter is that the push oracle structurally *censors* sub-threshold stress. Across 1,898 days where both the oracle and the Bitstamp tape are observed, 5 days had Bitstamp $|\mathrm{dev}| > 25$ bp; on 3 of those 5 the oracle stayed pinned within $\pm$25 bp — so **60 % of CEX 25-bp-stress days were invisible to the oracle**. A monitoring layer that trusts the on-chain feed as its depeg detector therefore misses the majority of secondary-market stress events, because the events were smaller than the threshold that would have caused the oracle to write them. This is the quantitative motivation for ingesting a CEX/AMM secondary tape in parallel with the oracle (Section 8).

3.4 Oracle staleness and step-size during SVB

The censoring property has a benign face in calm markets and a dangerous one in a crisis. During the SVB window the oracle behaved as designed but slowly relative to the secondary market. The first sub-par print (< 0.99) landed at 2,023-03-11 01:54:47 UTC, 5.9 **hours after** Circle's $\approx$20:00 UTC 10-March disclosure of its SVB exposure (Circle Internet Financial 2023); the within-window median update gap tightened to 240 s as deviation triggers fired in cascade, and the largest single step was 86.9 bp. The deviation-threshold mechanism did eventually fire fast, but only *after* the price had already crossed the threshold — it cannot anticipate, only confirm. The full oracle-vs-market reconciliation is in Section 6.

3.5 Multi-chain oracle consistency

We test whether the USDC oracle is consistent across chains using the mainnet and Arbitrum feeds, which overlap for 945 days (the Arbitrum feed begins 2023-03 and so covers SVB; the

Polygon feed is 2021-05..2021-07 only and is excluded). The mainnet−Arbitrum spread has a mean of −0.11 bp, a standard deviation of 1.22 bp, and a maximum absolute spread of 11.7 bp. The feeds are effectively the same series up to deviation-threshold timing jitter: there is no chain-specific oracle divergence, and the SVB trough is mirrored on Arbitrum (floor 0.881). A cross-chain monitor can therefore treat any single USDC feed as representative of the others, but inherits the same sub-threshold censoring on every chain.

4 Temporal patterns

USDC differs from a crypto-native stable in one structurally important way: its redemption rail is a US bank, which closes on weekends and outside US business hours. The canonical microstructure machinery of the DAI template (naive-RV / TSRV / Parzen realized kernels on a fixed grid, Zhang, Mykland, and Aït-Sahalia 2005) is N/A here because the oracle is an event series, not a uniform grid; we therefore work with bucketed absolute peg deviation in event time.

4.1 The banking-hours / weekend effect

The headline temporal result is a clear *weekend* effect. Mean absolute peg deviation is 3.30 bp on weekends versus 1.45 bp on weekdays — a 2.28× **ratio** (Table 3). This is the empirical fingerprint of the US-bank redemption rail: when primary redemption cannot settle (weekends, bank holidays), arbitrage that would pull the secondary price back to $1 is suspended, so the market is free to drift, and the deviation widens. The weekend dispersion is also far larger (standard deviation 36.7 bp vs 3.4 bp on weekdays), because the worst SVB days (10–11 March 2023) fell on a weekend — the failure was seized by the FDIC on a Friday and the backstop announced on Sunday.

4.2 Within-day banking hours

By contrast, the within-day US-banking-hours split (14:00–21:00 UTC, i.e. ≈09:00–16:00 ET) is essentially flat: 2.00 bp of mean absolute deviation inside banking hours versus 1.97 bp outside. Redemption settlement operates at a daily, not intraday, cadence — a redemption requested mid-afternoon does not clear materially faster than one requested overnight — so the effect lives at the day-of-week granularity (can I redeem *today*?) rather than the hour-of-day granularity. This is a useful negative result: the actionable temporal signal for a USDC monitor is the calendar (weekend / bank-holiday), not the clock.

Table 3: Absolute peg deviation by temporal bucket (Bitstamp tape, full window). The weekend effect is large; the within-day banking-hours effect is negligible.

Bucket	Mean |dev| (bp)	Std (bp)
Weekend	3.30	36.68
Weekday	1.45	3.45
US banking hours (14–21 UTC)	2.00	18.35
Off banking hours	1.97	20.43

4.3 Deviation conditional on realized-vol regime

Conditioning on a realized-volatility regime (split at the 80th percentile of 30-day RV) recovers the expected monotonicity: in the typical regime mean absolute deviation is 0.94 bp (oracle) / 1.26 bp (Bitstamp), and in the stress regime it rises to 3.40 bp (oracle) / 4.67 bp (Bitstamp). The stress-regime deviation is small in absolute terms — again, almost all of the genuinely dangerous tail mass is the single SVB window rather than a recurring elevated-vol state. The practical reading is that an RV-conditioned alarm would flag mild widening continuously but would not, on its own, have distinguished the SVB cliff from ordinary stress; the secondary-market level itself (Section 3.3) and the 3pool weight (Section 6) are the sharper signals.

4.4 Microstructure-noise note

We deliberately avoid the fixed-grid realized-kernel estimators of the DAI template. The push oracle is an event series whose spacing is itself informative (Section 3.1), so resampling it to a uniform grid would either fabricate observations (forward-fill) or discard the deviation-trigger structure. All temporal statistics here are event-time absolute deviations on the native observation times; the only regularisation applied is the daily last-observation grid for the distributional metrics of Section 2, with its intraday-smoothing caveat carried explicitly.

5 Peg-arbitrage band and venue frictions

5.1 Oracle versus secondary-market spread

The peg of a fiat-reserve stable is enforced by primary-market arbitrage: when USDC trades rich, authorized participants mint at $1 and sell; when it trades cheap, they buy and redeem at $1. Frictions — redemption fees, KYC onboarding, US-business-day settlement — define a no-arbitrage band inside which the secondary price can deviate without it being economic to act. We measure the band through the oracle−CEX spread on 1,898 overlapping days. The spread has a mean of 0.41 bp, a median of 0.04 bp, a standard deviation of 3.35 bp, and an absolute mean of 1.81 bp; its skewness is 1.42 and its range is $[-35.9, 33.4]$ bp. In the central tendency the oracle and the market agree to within a basis point.

5.2 Empirical no-arbitrage band width

Reading the empirical no-arb band off the spread quantiles, the 90 % band runs from −3.63 bp to +5.73 bp (width 9.36 bp) and the 99 % band from −9.95 bp to +16.40 bp (width 26.35 bp). The band is therefore narrow relative to USDT's mint/redeem facility (which tolerates tens of basis points), consistent with USDC's lower minimum redemption size and tighter institutional arbitrage. Crucially the band is *asymmetric*: the upper bound exceeds the lower in absolute terms at both the 90 % and 99 % levels (e.g. +16.4 versus −9.95 bp at 99 %), reflecting the access asymmetry below.

5.3 Primary-market access asymmetry

The mint side is fast and the redeem side is gated. The empirical signature is twofold. First, the market sits *below* the oracle 51.3 % of the time versus *above* it 47.2 %: a persistent mild discount bias, because the redemption that would clear a discount is slower than the minting that clears a premium. Second, the CEX deviation skew is −31.6 bp and the left/right tail asymmetry at the 1/99 percentiles is +1.0 bp (−10.0 bp left tail versus +9.0 bp right tail): the redemption-gated (left) tail is structurally wider than the mint-fast (right) tail. This is the same redemption-gate asymmetry that produces the left-heavy distribution of Section 2 and the weekend effect of Section 4, seen here through the arbitrage band.

5.4 Lead-lag at daily resolution

Cross-correlating the oracle and CEX deviation series, the peak correlation is 0.91 at lag 0: at daily resolution the oracle and the secondary market are *contemporaneous*. We do *not* claim a measured market-leads-oracle relationship, because the push oracle's deviation threshold means any sub-daily lead is folded into the same calendar day on a daily grid; resolving a genuine sub-daily lead would require intraday alignment of the oracle event times against the Bitstamp tape, which we flag as future work. What the daily grid *can* establish — and what matters for monitoring — is that the two series agree closely in level (correlation 0.91) except precisely when the oracle censors a sub-threshold move (Section 3.3).

5.5 Oracle-latency exposure

The deviation-threshold window is also an oracle-extractable-value (OEV) surface: between the moment the true price crosses the threshold and the moment the feed writes the new answer, any on-chain protocol pricing USDC off the stale feed is mispriced. During SVB this window was the 5.9 hours-to-first-break latency of Section 3.4 compounded by the 697 bp gap between the oracle floor (0.88) and the true CEX depth (0.81029, Section 6). A protocol that liquidated or redeemed against the floored oracle during that window transacted at a price the secondary market had already left — the practical cost of trusting a censored push feed in a tail event.

6 The SVB depeg forensics

This is the analytical centre of gravity of the report. The March 2023 Silicon Valley Bank failure is the single event that produces essentially the entire tail of the USDC deviation distribution (Section 2), and it is the cleanest natural experiment in the dataset for two questions: how does a push oracle behave when the true peg breaks, and how does a USDC shock propagate through the stable complex?

6.1 Timeline

On Friday 10 March 2023 the California regulator closed Silicon Valley Bank and the FDIC took it into receivership. Late that evening (≈20:00 UTC) Circle disclosed that \$3.3 B of USDC reserves — roughly 8 % of the ≈\$40 B backing — were held at SVB (Circle Internet Financial 2023). The market repriced overnight. On Sunday 12 March the US Treasury, Federal Reserve and FDIC jointly announced that all SVB depositors would be made whole and launched the Bank Term Funding Program (Federal Deposit Insurance Corporation 2023; Board of Governors of the Federal Reserve System 2023); USDC re-pegged through 13 March. Our window for the forensics is 8–16 March 2023.

6.2 Oracle trough and the censoring made physical

Within the window the Chainlink USDC/USD oracle troughed at 0.88 (−1,200 bp) at 2,023-03-11 07:51:23 UTC. The Bitstamp tape, however, printed an hourly close low of 0.86267 and an intraday *wick* low of 0.81029 (−1,897 bp). The wick is therefore 697 **bp below the oracle floor**. This is the censoring of Section 3.3 made physical: the 0.25 %-deviation push oracle reported a floored 0.88, while the secondary market revealed the true depth at 0.81. Figure 1 shows the three oracle legs (USDC, DAI, USDT) and the Bitstamp tape over the window; the gap between the oracle floor and the CEX wick is the visual signature of the censoring.

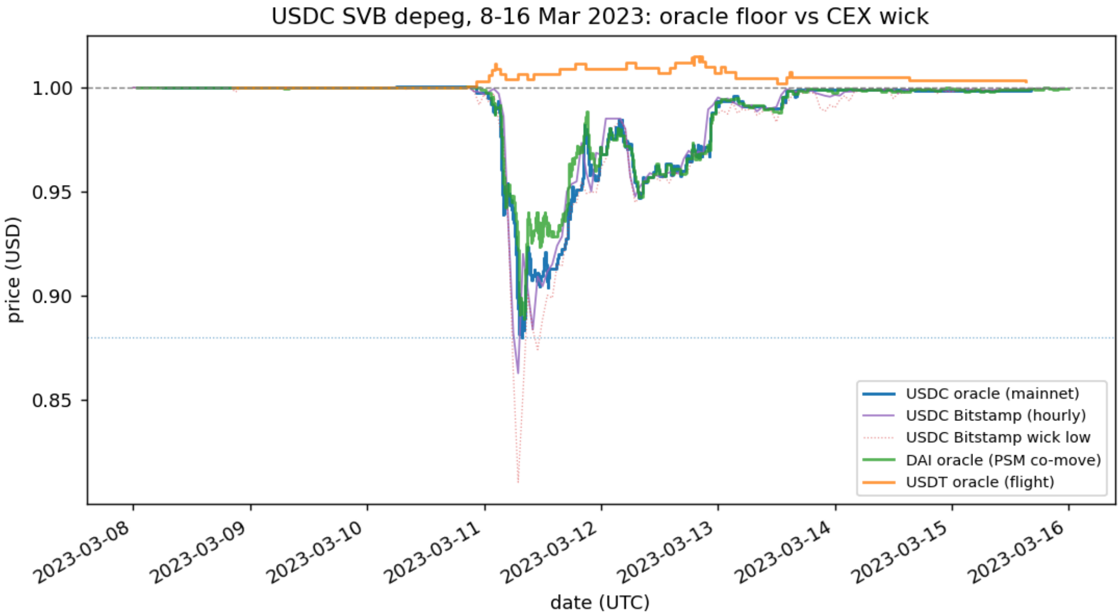

Figure 1: SVB window (8–16 March 2023). The USDC oracle floors at 0.88; DAI co-moves to 0.889 via the PSM; USDT holds a premium (flight-to-safety); the Bitstamp USDC tape wicks to 0.81029, 697 bp below the oracle floor. The oracle–market gap is the push-oracle censoring made physical.

6.3 Recovery dynamics and the backstop

Recovery was driven by the policy backstop, not by primary-market arbitrage clearing the discount. The trough on the hourly tape was 0.86267 at 2,023-03-11 07:00 UTC; the first hourly close back at ≥ 0.995 was 2,023-03-13 00:00 UTC, a 41-**hour** trough-to-repeg interval bracketing the Sunday-evening Fed/FDIC announcement (Board of Governors of the Federal Reserve System 2023). An AR(1) fit on the in-window deviation gives a half-life of 5.6 hours — once the backstop removed the reserve-loss fear, the convergence was fast. The asymmetry between the slow 41-hour calendar recovery and the fast 5.6-hour statistical half-life reflects that the market did not begin mean-reverting until the policy signal arrived; before it, the discount was a rational repricing of a possible reserve loss, not a mispricing to be arbitraged.

6.4 Reserve-concentration root cause

The root cause was off-chain and invisible to every on-chain series until the disclosure: $3.3 B of the reserve was concentrated at a single banking counterparty whose deposits were uninsured above the FDIC limit. No on-chain metric — not the oracle, not the 3pool weight, not the basis — could have flagged the concentration ex ante, because the reserve-bank breakdown is not published in real time; Circle's reserve attestation is a *monthly* report by an external auditor (Circle Internet Financial 2025), not a live feed. This is the irreducible transparency gap of a fiat-reserve stable: the quantitative peg telemetry is excellent right up to the moment an off-chain counterparty fails, at which point only the qualitative reserve-diversification posture matters. We carry this as a standing limitation (Section 8).

6.5 Secondary-market dislocation: the 3pool

On-chain, the dislocation is legible in the Curve 3pool composition. The USDC weight spiked from its ≈ 0.333 baseline to 0.5015 — participants dumped USDC into the pool and pulled out DAI and USDT, exactly the rotation a flight-from-USDC implies. Figure 2 shows the weight trajectory. We flag a data limitation: the 3pool net-directional-flow field is null throughout the SVB window (`net_flow_all_null=true` in the phase-6 output), so the figure degrades gracefully to a weight-only view; the weight spike alone is, however, an unambiguous stress tell, and it is the on-chain signal a monitor would have fired on in real time.

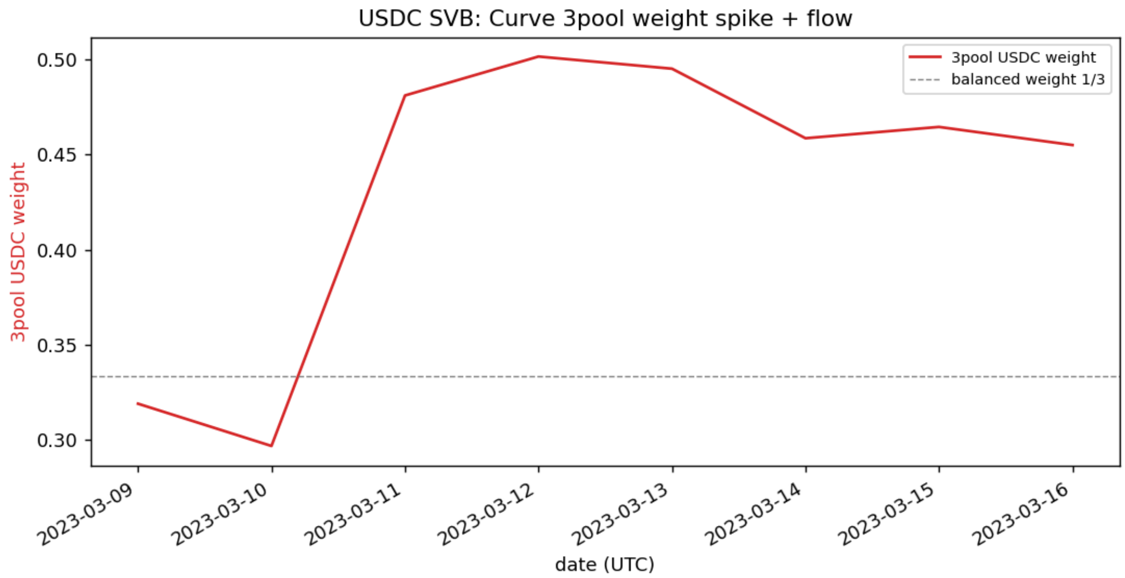

Figure 2: SVB window: the Curve 3pool USDC weight spikes from its ≈ 0.333 baseline to 0.5015 as USDC is dumped into the pool and DAI/USDT are withdrawn — the on-chain signature of a flight from USDC. The net-directional-flow field is null in-window, so the panel is weight-only.

6.6 Contagion: USDC → DAI → USDT

The shock propagated along two structurally distinct channels. **USDC → DAI** was a near-rigid PSM co-move: DAI is partly backed by USDC through the MakerDAO Peg Stability Module (MakerDAO 2021), so DAI fell almost one-for-one with USDC, troughing at 0.889 ($-1{,}112$ bp) within minutes of the USDC trough. The USDC$-$DAI basis stayed near zero in-window (mean -7.6 bp, range $[-31.8, +12.9]$ bp): DAI was not a safe haven from USDC, it was mechanically tethered to it. **USDC → USDT** was the opposite — a flight to safety. USDT held a premium of up to $+149.2$ bp on the oracle, and the USDC$-$USDT basis went strongly negative (mean -96.7 bp, trough -413.6 bp): USDC traded at a discount to USDT as capital rotated out of the impaired token into the unimpaired one. The Arbitrum USDC feed mirrors the mainnet trough (floor 0.881), confirming the contagion is an asset-level, not chain-level, phenomenon.

6.7 Counterfactual: would a streaming oracle have helped?

The 697 bp gap between the oracle floor and the true CEX depth (Section 6.2), and the 5.9-hour latency to the first sub-par print (Section 3.4), are both artefacts of the push/deviation-threshold design. A pull-based or streaming oracle that tracked the secondary market continuously would have priced the $-1{,}897$ bp wick rather than censoring it at $-1{,}200$ bp. Whether that would have *improved* downstream outcomes is ambiguous: a faster, deeper price would have triggered more liquidations in protocols that hold USDC as collateral, potentially amplifying the cascade, but would also have removed the OEV window (Section 5.5) in which stale-feed mispricing was exploitable. The honest conclusion is that the censoring is a *design trade-off*, not a pure defect: it damps liquidation cascades at the cost of hiding true depth and creating an OEV surface.

6.8 Lessons for a centralised-reserve monitor

Three lessons carry to Derivalink V2. First, the on-chain oracle is not a sufficient depeg detector for a fiat-reserve token — it floored 697 bp above the true price and lagged disclosure by 5.9 hours; ingest a secondary tape in parallel. Second, the 3pool USDC weight fired in real time (spike to 0.50) and is the actionable on-chain signal. Third, and most importantly, the root cause was an off-chain reserve concentration that no quantitative series could see; a centralised-reserve monitor must carry a qualitative reserve-bank-diversification flag alongside its peg telemetry, because the next SVB will again be invisible until disclosed.

7 Cross-component causality and contagion

The SVB forensics (Section 6) establish the contagion path qualitatively in one window. This chapter tests it formally across the full 2021–2026 daily panel, treating {USDC, DAI, USDT} as a system.

7.1 Stationarity and cointegration

Each peg deviation series is stationary by the augmented Dickey–Fuller test (USDC ADF -20.7, $p \approx 0$; DAI -6.0, $p = 1.7 \times 10^{-7}$; USDT -7.5, $p = 4.6 \times 10^{-11}$). Pairwise the prices are cointegrated: Engle–Granger (Engle and Granger 1987) rejects the no-cointegration null for USDC$-$DAI ($p < 1 \times 10^{-3}$, robust across daily-grid constructions) and USDC$-$USDT ($p = 1.7 \times 10^{-15}$). The Johansen test (Johansen 1991) on the triple finds *full-rank* (rank 3) cointegration: the trace statistics 1,172.0/484.7/115.0 all dominate the 29.8/15.5/3.84 95 % critical values, and the max-eigenvalue statistics 687.3/369.6/115.0 likewise dominate 21.1/14.3/3.84. The three stablecoins move as a single tightly-linked system, which is exactly what one expects of a complex whose members are mutually arbitraged and partly cross-collateralised (the DAI PSM holds USDC).

7.2 Granger causality

Granger-causality tests on the deviation series, with Benjamini–Hochberg FDR correction across the four directed pairs at lag 1 (Benjamini and Hochberg 1995), give a clean directional story (Table 4). **USDC leads DAI** ($p = 1.2 \times 10^{-5}$, reject) while **DAI does not lead USDC** ($p = 0.22$, fail to reject): this is the PSM direction — a USDC shock propagates into DAI through the peg-stability module, not the other way around. **USDC and USDT are bidirectional** (USDC→USDT $p = 9.9 \times 10^{-6}$, USDT→USDC $p = 2.1 \times 10^{-3}$, both reject): the flight-to-safety channel runs in both directions depending on which token is under stress, consistent with the sign-flipping basis of Section 6.6.

Table 4: Granger causality at lag 1 on the daily deviation series, BH-FDR-corrected. "Reject" = the source Granger-causes the target at the 5 % FDR level.

Direction	p-value (lag 1)	Decision
USDC → DAI	1.2×10^{-5}	reject (PSM direction)
DAI → USDC	0.220	fail
USDC → USDT	9.9×10^{-6}	reject
USDT → USDC	2.1×10^{-3}	reject

7.3 Impulse response

A VAR(p) on the three deviation series, with z-scored impulse responses, confirms the same ordering: a unit USDC shock produces a large, persistent DAI response (the PSM tether) and a smaller, opposite-signed USDT response (the flight-to-safety premium), with both decaying back toward zero within a handful of days — consistent with the fast deviation half-lives of Section 2. The IRF magnitudes are reported in the phase-7 output (`var_irf.json`); they are not the headline object, because the more economically interpretable statements are the cointegration rank and the Granger directions above.

7.4 Lower-tail dependence

The cointegration and Granger results describe the conditional mean; the copula tail-dependence coefficients describe the joint extremes that matter for contagion. For USDC−DAI the lower-tail dependence is $\lambda_L = 0.20$ versus an upper-tail $\lambda_U = 0.137$; for USDC−USDT, $\lambda_L = 0.168$ versus $\lambda_U = 0.137$ (Joe 1997). In both pairs the lower tail exceeds the upper: the stable complex **breaks together on the downside** more than it rallies together on the upside — the empirical statement that joint depegs are more likely than joint premia. The asymmetry is mild (it does not cross the built-in 0.1 flag threshold, so the phase-7 output marks `asymmetric=false`), and we report it as such: a present-but-modest left-skew in the joint dependence, dominated by the SVB co-move that pulled USDC and DAI down together.

7.5 Synthesis

The full-panel statistics ratify the SVB narrative. The complex is full-rank cointegrated; USDC leads DAI one-directionally through the PSM and co-leads USDT bidirectionally through the flight channel; and the joint extremes are concentrated on the downside. For a monitoring system this means a USDC shock is the most contagious node — it propagates rigidly into DAI and rotates capital into/out of USDT — and that the USDC−DAI basis should be read as a near-fixed tether (any USDC depeg is a DAI depeg) while the USDC−USDT basis sign routes the direction of the flight.

8 Findings and open questions

8.1 Key empirical findings

1. **Excellent central peg, single-event tail.** Over 2021–2026 USDC holds the \$1 peg with a mean bias of −0.25 bp (oracle) and −0.62 bp (Bitstamp) and a 1.43–1.98 bp mean absolute deviation, but with extreme excess kurtosis (1,410 oracle) and skew (−35.5) driven almost entirely by the SVB window, and a fast ≈ 0.6-day mean-reversion half-life (Section 2).

2. **Push-oracle censoring is the structural headline.** The 0.25 %-deviation feed cannot price sub-threshold stress: 60 % of CEX 25-bp-stress days were invisible to the oracle, and during SVB the feed floored at 0.88 while the CEX wicked to 0.81029, 697 bp below (Section 3, Section 6).

3. **The weekend redemption-rail effect is real and large.** Absolute peg deviation is 2.28× wider on weekends (3.30 bp) than weekdays (1.45 bp), the signature of a US-bank redemption rail that closes on weekends; the within-day banking-hours effect is by contrast negligible (Section 4).

4. **The arbitrage band is tight but asymmetric.** The oracle−CEX spread has a 9.36 bp 90 % width; the market sits below the oracle 51.3 % of the time and the redemption-gated

left tail is wider than the mint-fast right tail — the structural redemption asymmetry (Section 5).

5. **SVB: censored depeg, backstop recovery, contagion router.** Oracle trough 0.88 (5.9 h after disclosure); 41-h trough-to-repeg after the Fed/FDIC backstop (AR(1) half-life 5.6 h); 3pool USDC weight spike $0.33 \to 0.50$; contagion USDC→DAI (PSM, basis ≈ 0, DAI to 0.889) and USDC→USDT (flight, +149 bp premium, basis to −414 bp) (Section 6).
6. **Full-rank cointegration, downside co-break.** {USDC, DAI, USDT} are full-rank cointegrated (Johansen trace 1,172/485/115); USDC Granger-leads DAI one-directionally (PSM) and co-leads USDT bidirectionally; lower-tail dependence exceeds upper (Section 7).

8.2 Implications for Derivalink V2

The centralised-reserve monitoring playbook differs fundamentally from the collateralized-synth playbook. (1) *Do not trust the push oracle as a depeg detector*: it censors 60 % of sub-threshold stress and floored 697 bp above the true price in the one tail event that mattered. Ingest a CEX/AMM secondary tape in parallel and alarm on the secondary level, not the oracle. (2) *Read the basis pair as a contagion router*: the USDC−DAI basis is a near-rigid PSM tether (any USDC depeg is a DAI depeg, so monitor them jointly), and the USDC−USDT basis sign identifies the direction of an intra-complex flight. (3) *Carry the off-chain reserve concentration as a standing qualitative flag*: the SVB root cause was invisible to every on-chain series, so a fiat-reserve monitor must track reserve-bank diversification posture from the monthly attestations, accepting that this dimension can never reach on-chain verifiability. The general lesson, shared with the USDT report, is that a uniform monitoring schema cannot span DAI (fully on-chain collateralised), USDe (partially observable) and the fiat-reserve pair USDC/USDT (off-chain reserve); the framework must select its signals by the asset's observability class.

8.3 Limitations

- The TE distribution metrics are computed on a daily last-observation grid (memory-bounded for the 2,356,863-row Bitstamp tape), which smooths the intraday SVB trough; the case study carries the true depth (oracle 0.88, Bitstamp wick 0.81029).
- The push oracle censors all sub-0.25 % intraday stress by construction; the daily oracle minimum understates intraday depth, and the authoritative SVB figures are the phase-6 intraday values.
- The Curve *price* tape is a partial backfill (2020-09 to 2023-08); only the 3pool *reserve*/weight panel spans the window. The 3pool-implied price is degenerate near launch and is not used as a TE series; the net-directional-flow field is null in the SVB window, so that figure is weight-only.
- Daily lead-lag is contemporaneous (peak correlation 0.91 at lag 0); a sub-daily market-leads-oracle test is not identifiable on the daily grid.
- Multi-chain consistency uses mainnet versus Arbitrum only (the Polygon feed predates SVB); tail-dependence asymmetry is present but mild and does not cross the flag threshold.
- Reserve composition is off-chain; the reserve-concentration root cause and reserve-bank risk are irreducibly qualitative.

8.4 Open questions and future work

An intraday alignment of the oracle event times against the Bitstamp tape (and additional CEX venues) would let a genuine sub-daily market-leads-oracle lead-lag be measured, sharpening the OEV-window estimate of Section 5.5. A multi-chain USDC supply/mint-burn series would supply a primary-market redemption-flow proxy that the 3pool weight only partially captures. And a structured ingestion of Circle's monthly reserve attestations (Circle Internet Financial 2025) would let the reserve-composition and counterparty-concentration trajectory be tracked quantitatively between disclosures, even though it can never reach the verifiability of an on-chain series.

8.5 Cross-asset comparison

USDC anchors, with USDT, the fiat-reserve pole of the cross-asset synthesis (D5). Relative to USDT it is the *cleaner* fiat-reserve case: tighter arbitrage band, smaller central deviation, and a single well-documented tail event (SVB) rather than a recurring opacity discount. The decisive contrast is the censoring chapter (Section 3) — which has no analogue in the collateralized-synth (DAI, sUSD) or delta-neutral (USDe) reports — and the PSM tether to DAI, which makes USDC the most contagious node in the on-chain stable complex. Together with the USDT basis-sign-flip finding, this gives the V2 design its fiat-reserve monitoring template.

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