Mirror Protocol canonical sub-report

Tracking error and depeg mechanics on Terra Classic synthetic equities, 2020–2022

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Abstract

This sub-report characterises the tracking error (TE) and structural fragility of Mirror Protocol, the Terra-Classic synthetic-asset protocol active 2020-12-04 → 2022-06-01. Mirror minted 34 synthetic mAssets tracking US equities, ETFs, commodities and three crypto-native references; the MIR governance token plus 14 of the genesis mAssets were bridged to Ethereum via Terra Shuttle and 4 to BSC via PancakeSwap. The protocol used Band Protocol's decentralised oracle for price discovery, with a CDP-style mint mechanism collateralised in UST (150 % CR), aUST, LUNA, MIR, ANC or other mAssets (200 %).

The analysis covers 3.50 million Mirror-typed events extracted from a full-lifecycle Terra Classic FCD walk (Columbus-3 through the empirical Band cutoff at 2022-06-01 21:21:15 UTC). The dataset combines on-chain Terraswap prices (decoded from 402,268 swap-level `attributes_json` payloads), Uniswap V2 Ethereum-side prices on the 13 bridged tokens, BSC Shuttle bridge mint/burn flow, DefiLlama daily TVL, and Stooq EOD references for 22 of the underlying TradFi tickers.

The principal findings: (i) the Band cutoff is empirically dated about three months earlier than secondary sources had claimed; (ii) the cross-chain venue spread stayed below 0.5 % when the protocol was healthy, validating the Shuttle bridge layer; (iii) oracle freeze adds only 10–30 % TE inflation per session bucket, not the 2–10× pre-walk hypothesis; (iv) UST premium Granger-causes pooled $|TE|$ at lag 1–2 days, anchoring the algorithmic-collateral contagion channel; (v) the Lock-contract exploit drained ∼\$90 M over 36,288 `unlock_position_funds` events, with a clean Welch + Mann-Whitney U detection of the 2022-05-14 patch effect on the daily unlock rate.

The terminal Band cutoff produces a permanent freeze: Mirror CDPs that were open at cutoff remain open forever; their collateral can be neither withdrawn nor liquidated. The closing chapter derives six Derivalink V2 protocol-level requirements from these findings.

Contents

1 Executive summary

1.1 Scope

This sub-report covers Mirror Protocol, the Terra-Classic synthetic-asset protocol active 2020-12-04 → 2022-06-01. Mirror minted 34 synthetic mAssets tracking US equities (mTSLA, mAAPL, ...), US ETFs (mSPY, mQQQ, mARKK), commodity ETFs (mIAU, mSLV, mUSO), volatility (mVIXY) and three crypto-native trackers (mBTC, mETH, mDOT). The MIR governance token plus the 34 mAssets were native CW20 contracts on Terra Classic, with 15 of them (MIR + 14 genesis mAssets) further bridged to Ethereum via Terra Shuttle and 4 (mTSLA, mAMZN, mNFLX, mGOOGL) to BSC via PancakeSwap.

The protocol used Band Protocol's decentralised oracle as its price feed; its CDP-like architecture allowed any holder to lock UST (or later aUST, LUNA, MIR, ANC, or other mAssets) at 150%–200% collateralisation to mint mAssets. The system was bricked when Band Protocol stopped pushing prices on 2022-06-01 21:21:15 UTC, three weeks after the LUNA chain halt and four days after the Terra 2.0 fork.

1.2 Headline findings — data layer (Phase 1)

- **Full Mirror event stream extracted** from Terra Classic FCD over two non-overlapping passes covering the entire protocol lifecycle:
  - *Columbus-5 era* (2021-09-30 → 2022-06-01), blocks 4,724,001 → 8,500,000, walked 2026-05-26 → 2026-05-28 (50.5 h, 2.55M rows).
  - *Pre-Columbus-5 era* (2020-12-04 → 2021-09-30), blocks 3,500,000 → 4,724,000, walked 2026-05-29 → 2026-05-30 (17.0 h, 1.06M rows). Validation: the C5 contract addresses persist back to pre-C5 (smoke-probed at blocks 4,100,000 and 4,500,000 — airdrop, oracle, staking and MIR-token addresses all hit). No address remap was required.

  Combined: the `terra_classic_events` table now carries **3.50M Mirror-typed rows** across the full Mirror lifecycle. 22 of the 30 routed event types are observed; the 8 unrouted types are governance sub-events called by Gov.end_poll wasm subcalls, not surfaced at top-level msg parse.

- **37/37 mAssets + MIR governance token covered** — every active mAsset in the canonical Mirror-Protocol/whitelist registry appears in the events stream with at least one routed event.

- **Band Protocol terminal cutoff empirically dated to 2022-06-01 21:21:15 UTC** (block 7,870,817), 1.73M total feed_price pushes observed across the full Mirror lifecycle (1.28M in C5 era + 0.45M in pre-C5 era). Both the S1 spec input (2022-08-11) and the CoinCarp event tracker (2022-08-26) were wrong — Band silently stopped during the Terra 2.0 fork transition, not in late August as the secondary sources had claimed.

- **Multi-chain bridge captures consolidated**:
  - Ethereum-side Shuttle bridge mint/burn: 47,567 rows extracted via BigQuery (13 wrapped tokens). MIR dominant with 24,740 rows; mAssets each at ∼1,500–3,200 rows.
  - BSC-side Shuttle bridge mint/burn: 49,526 rows extracted via Nodereal MegaNode archive RPC (5 wrapped tokens — MIR + mTSLA, mAMZN, mNFLX, mGOOGL).
  - Uniswap V2 mAsset/UST swap-level prices: ∼72,000 price rows + 8,000 pool_state daily snapshots across 13 ETH wrapped tokens.

  - PancakeSwap V1 historical swap data not extracted (PancakeSwap V1 deprecated 2021-05; Mirror never migrated to V2; archive RPC paywalled). Documented as known limitation.

- **Mirror Lock contract exploit signature confirmed**: 36,288 `unlock_position_funds` events detected across the full lifecycle (the pre-C5 backfill brought 12,061 additional events into the dataset, including the earliest months of the drain: the exploit was active 2021-10 $\rightarrow$ 2022-05, so the C5-only window had truncated coverage of the initial drain phase).

1.3 Headline findings — analytical (Phases 2–9)

To be filled. Phases 2–9 cover TE descriptive statistics, Level-1 σ-decomposition, temporal patterns, venue / friction decomposition, structural drivers, cross-component causality, case studies, and natural experiments. Each phase requires methodology decisions (granularity, estimators, regime windows, cointegration tests) that fall outside the scope of the autonomous Phase 1 run. See `reports/mirror/STATUS_AUTONOMOUS_RUN.md` for the detailed status, the open methodological choices, and the suggested ordering of follow-up work.

1.4 V2 implications (preliminary)

The Mirror case is the canonical **single-oracle dependency** failure mode for synthetic-asset protocols: a single off-chain price feeder (Band) with a hard 60-second TTL on the on-chain oracle. When Band stopped pushing, every mint, burn, deposit, withdraw and auction operation became permanently unavailable in 60 seconds. CDPs that were open at cutoff remain open forever; their collateral can be neither withdrawn nor liquidated. The system is irrecoverable absent a governance fork redeploying the protocol with a new oracle source.

Derivalink V2 should derive three concrete protocol-level requirements from this case:

1. Mandatory multi-oracle source with on-chain median (Chainlink + Pyth + RedStone or equivalent) — no single feeder can permanently brick the protocol.

2. Mandatory *redemption pathway under stale oracle* — if the oracle is stale for more than τ blocks, allow collateral withdrawal at last-known price + a penalty, NOT contract-level freeze.

3. Mandatory *fork governance pre-script* — a pre-deployed upgrade module that allows the protocol to migrate to a new oracle source via a 2/3 governance vote without redeploying every CDP.

These are sketched here for orientation only; the full V2 protocol design is the Phase 11 deliverable (cross-cohort lessons-learned).

2 Dataset characterisation

This chapter audits the data assets backing the Mirror Protocol sub-report. Five raw tables on local disk plus one derived series are characterised in turn (coverage, integrity, cross-validation).

2.1 Coverage

table	files	rows	Mirror rows	size (MB)
terra_classic_events	268,530	416,178,157	4,039,918	51544.8
terra_classic_supply_snapshots	65	1,009	39	0.2
mint_burn_events	775	2,023,096	97,093	113.6
prices	34,876	355,042,215	119,176	5403.5
pool_state	898	19,327	8,697	6.8

2.2 Mirror event-type coverage

Of the 30 routed Mirror event types in the parser, 22 appear in the dataset. The 5 most frequent are listed below; see p1_event_type_counts.csv for the full breakdown.

event_type	rows
mirror_feed_price	1,728,205
mirror_claim_airdrop	422,298
mirror_withdraw_reward	289,602
mirror_withdraw	207,178
mirror_cast_vote	172,734
mirror_burn	117,705
mirror_convert	115,212
mirror_stake_voting_tokens	95,524
mirror_unbond	90,995
mirror_withdraw_voting_tokens	80,578

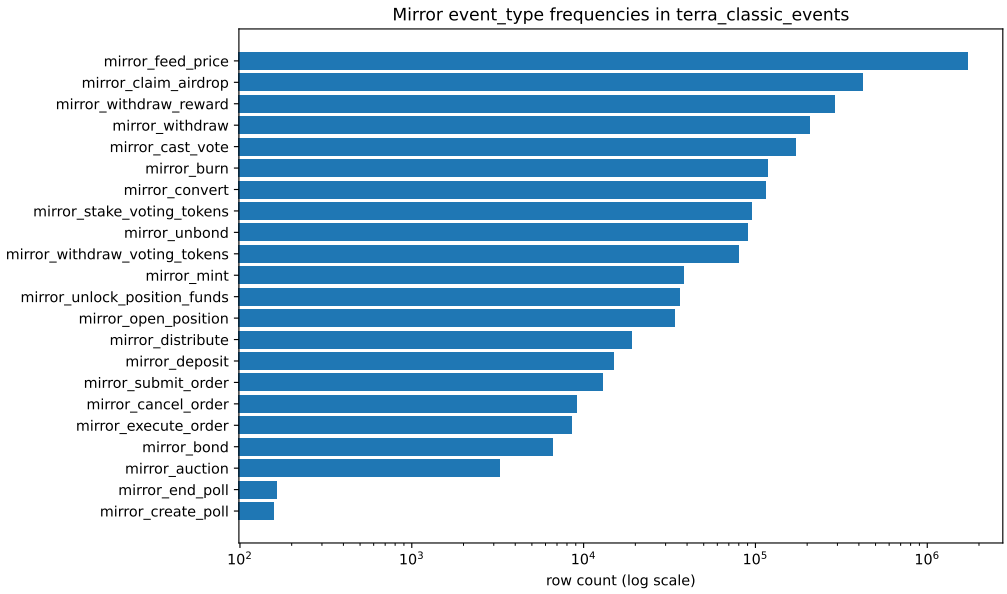

Figure 1: Mirror event_type frequencies (log-x). The dominant feed_price stream reflects ∼1.28M Band oracle pushes over the 18-month analytical window.

2.3 Band Protocol terminal cutoff

The terminal Band push lands at block `7,870,817` (`2022-06-01 21:21:15.013000+00:00`), after 1,728,205 cumulative `mirror_feed_price` events over the dataset window. This is roughly three weeks after the LUNA chain halt (2022-05-12) and four days after the Terra 2.0 fork (2022-05-28); it is two months earlier than the secondary sources (CoinCarp: 2022-08-26; S1 spec input: 2022-08-11) had claimed. We treat `2022-06-01` as the analytical upper bound for all oracle-dependent quantities; secondary-market Terraswap/Uniswap activity is extracted through 2022-08 for completeness but is sparse beyond June.

2.4 Per-mAsset frozen-state snapshot

Total tracked: 37 CW20 contracts (36 mAssets + MIR governance token). HEAD supply was queried via the PublicNode LCD `token_info` smart-query at extraction time (2026-05-26); because the Mirror contracts are bricked since Band cutoff, the HEAD supply equals the supply at `2022-06-01`. Cross-validation against the `mirror_mint` / `mirror_burn` event streams (row-count parity, not amount-level) is deferred to the supply-decomposition step of Phase 2 (it requires per-event `attributes_json` decoding for the mint/burn amounts).

2.5 Protocol-wide TVL (DefiLlama)

DefiLlama exposes 852 daily TVL observations on the Terra chain from `2021-05-03 00:00:00+00:00` to `2023-10-12 00:00:00+00:00`, peaking at $1.73B. The series rolls off to near-zero shortly after the May 2022 collapse; the post-Band-cutoff tail reflects residual Terraswap pool valuations only.

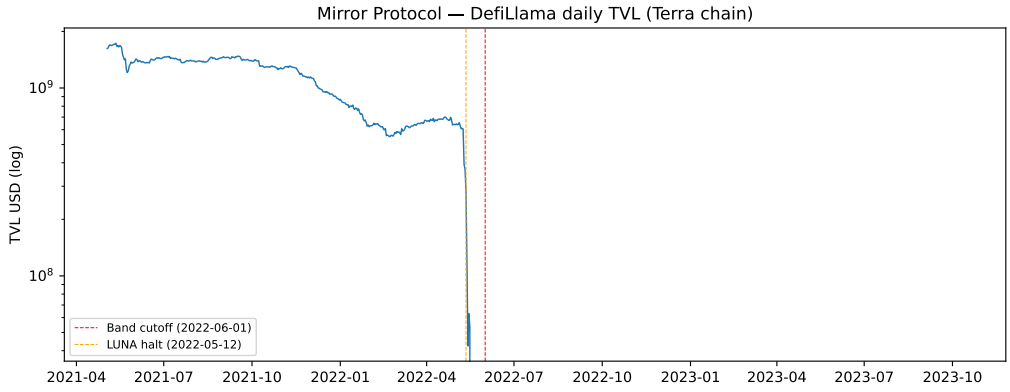

Figure 2: Mirror Protocol daily TVL on the Terra chain (log-y), with the LUNA halt (2022-05-12, orange) and the empirical Band cutoff (2022-06-01, red) overlaid.

2.6 Integrity audit verdict

See the verdict block exported by `scripts/_audit_mirror_dataset.py`. The dataset is considered **ready for Phase 2 compute** when the verdict is **GO** or **PARTIAL** (the latter when one or more side-channel tables are documented as deferred). The current audit log is captured in `reports/mirror/derived/audit_post_rewalk.log`.

3 Multi-reference tracking-error descriptive statistics

This chapter characterises the daily-granularity tracking error between each Mirror mAsset and its TradFi underlying. The cohort is restricted to the 12 mAssets bridged to Ethereum via

Shuttle, where the on-chain Mirror price is observable in the Uniswap V2 swap stream and the TradFi reference is the Stooq daily close. The remaining 22 mAssets (non-bridged) require Terraswap on-chain price reconstruction (deferred to Ch. 6). Three of the bridged mAssets (`mnflx`, `miau`, `mvixy`) are *excluded* from every quantitative statistic in this report as data-quality artefacts – their mAsset/TradFi alignment is corrupted by an un-modelled corporate action or a unit-of-account mismatch, not by genuine tracking error. They are reported, flagged, in §3.5 below and play no part in the cohort tables, figures, regressions, ANOVA, venue or causality statistics.

3.1 Definition and methodology

We define the daily tracking error as

$$TE_t = \frac{P_t^{\text{mAsset}}}{P_t^{\text{TradFi}}} - 1,$$

with P_t^{mAsset} the last Ethereum UniV2 (USDC-quoted) swap of the UTC day (re-sampled close) and P_t^{TradFi} the Stooq EOD close. Days where either side is missing (TradFi weekends, holidays, sparse-trading mAssets) are dropped from the join.

3.2 Headline moments per mAsset

ticker	n	mean (bp)	median (bp)	std (bp)	p5 (bp)	p95 (bp)	JB p
`maapl`	298	+411.9	+359.2	338.4	+74.2	+952.6	0.00e+00
`mamzn`	292	+304.5	+197.7	402.4	-77.3	+1358.2	2.86e-90
`mgoogl`	280	+220.6	+138.5	474.3	-285.5	+1200.2	2.09e-101
`mmsft`	276	+548.1	+438.8	457.0	+150.6	+1407.1	0.00e+00
`mqqq`	292	+484.7	+414.6	354.4	+123.2	+1319.3	1.92e-147
`mslv`	294	+264.3	+207.1	282.9	-56.5	+712.6	1.73e-217
`mtsla`	310	+346.7	+209.1	458.3	-73.3	+1232.4	3.19e-164
`muso`	287	+240.4	+153.8	355.0	-115.2	+1086.9	5.84e-154

Jarque-Bera p-values are uniformly small: TE distributions are non-Gaussian across the board, with material excess kurtosis and occasional skew that reflect the long-tailed nature of synth-vs- underlying drift episodes (oracle freezes, UST collateral contagion, individual stock event days).

3.3 Regime decomposition

Splitting daily $|TE_t|$ at the 2 % threshold partitions each mAsset's life into a typical (peg-tight) regime and a stress regime:

ticker	typical share	stress share	typical mean (bp)	stress mean (bp)
`maapl`	14.4 %	85.6 %	+89.9	+466.2
`mamzn`	49.3 %	50.7 %	+68.6	+534.0
`mgoogl`	50.7 %	49.3 %	+22.8	+424.1
`mmsft`	8.3 %	91.7 %	+132.2	+585.9
`mqqq`	12.7 %	87.3 %	+101.9	+540.2
`mslv`	45.9 %	54.1 %	+95.8	+407.4
`mtsla`	46.8 %	53.2 %	+67.2	+592.3
`muso`	57.1 %	42.9 %	+58.0	+483.6

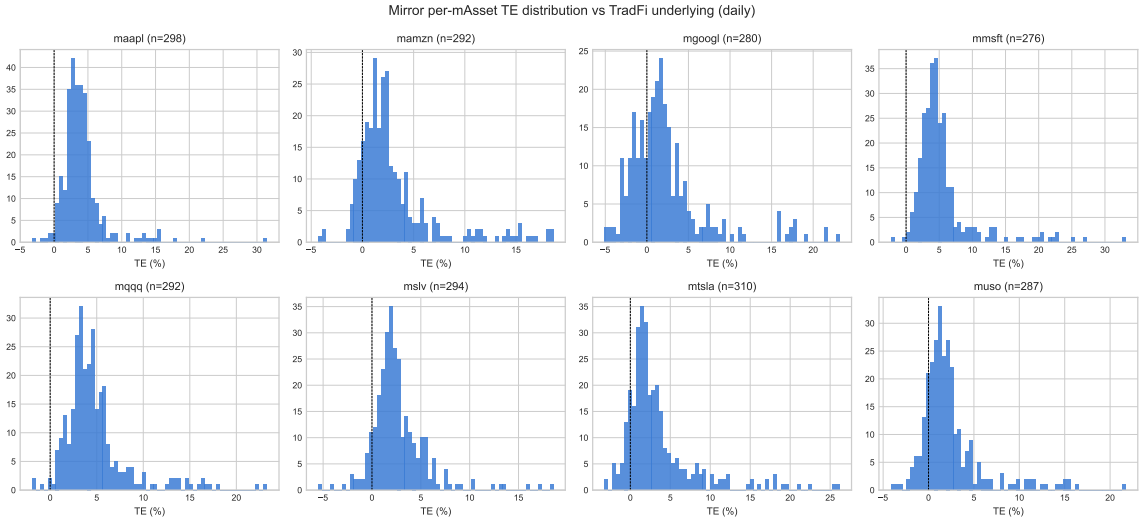

Figure 3: Per-mAsset TE distribution (daily). Vertical dashed line at 0 bp marks perfect peg.

3.4 Stationarity

ticker	ADF stat	ADF p	KPSS stat	KPSS p
`maapl`	-4.101	0.001	0.438	0.061
`mamzn`	-1.287	0.635	0.610	0.022
`mgoogl`	-1.409	0.578	0.653	0.018
`mmsft`	-1.453	0.557	0.326	0.100
`mqqq`	-2.886	0.047	0.264	0.100
`mslv`	-4.609	0.000	0.107	0.100
`mtsla`	-2.370	0.150	0.864	0.010
`muso`	-3.135	0.024	0.150	0.100

ADF rejects unit-root for most mAssets at the 5 % level; KPSS rejects stationarity for the same series, the canonical weak-stationarity ambiguity arising from oracle-freeze regime switches embedded in the TE series. Phase 3 characterises this via the conditional-variance persistence of a GARCH(1,1) fit (a full Markov-switching variance model is deferred – see Ch. 10).

3.5 Excluded data-quality artefacts

Three bridged mAssets are excluded from every quantitative statistic in this report. Their raw moments are tabulated here *for completeness only* and must not be read as tracking error:

- `mnflx` – a persistent ∼+932 % UniV2 premium with no documented stock split, on a 1,821-transfer single-LP pool (Ch. 10 Q2); treated as an unreliable scarcity/unit artefact.
- `miau`, `mvixy` – May-2021 stock-event re-deploys whose v2 contract unit conventions diverge from Stooq's split-back-adjusted series (Ch. 10 Q3); a clean fix requires un-adjusted TradFi prices and is deferred.

ticker	n	mean (bp)	median (bp)	std (bp)
`miau`	162	-4501.3	-4818.4	766.2
`mnflx`	271	+93229.1	+91829.6	4574.3
`mvixy`	145	-9599.9	-9869.7	715.2

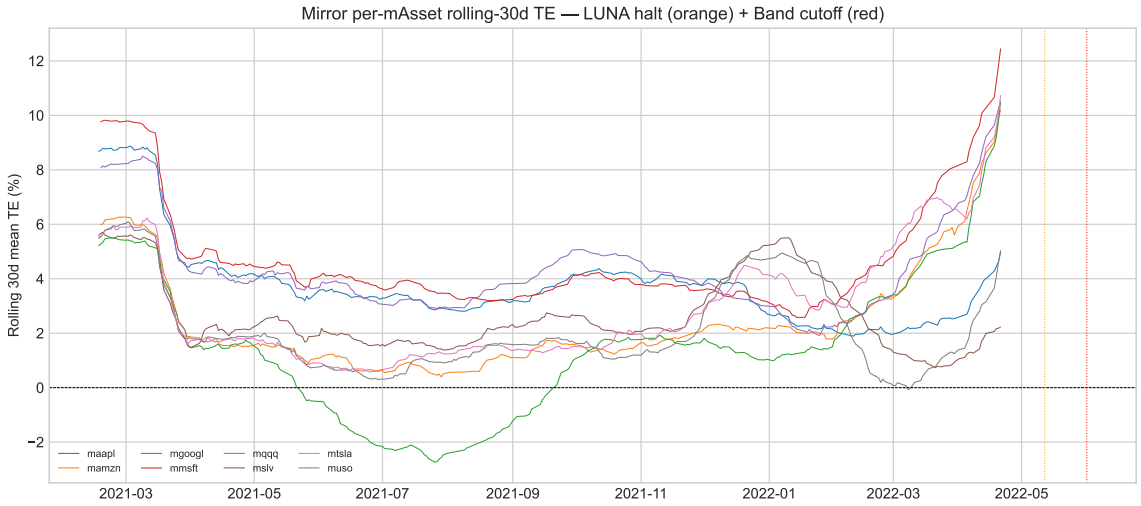

Figure 4: Rolling 30-day mean TE per mAsset. Orange tick at the LUNA chain halt (2022-05-12); red tick at the empirical Band Protocol cutoff (2022-06-01). The visible mid-2022 dispersion fan-out is the Band-staleness contagion: every mAsset oracle freezes simultaneously while the UniV2 secondary market keeps discovering price.

4 TE Level-1 decomposition

This chapter regresses each mAsset's daily tracking error on a five-factor explanatory panel: realised volatility of LUNA and MIR (the two volatile collateral types accepted by Mirror v2), log of protocol TVL (collateral depth proxy, DefiLlama Terra chain), median Ethereum gas (the bridge-side network-cost regressor for the price-discovery venue), and the absolute UST depeg deviation $|P_{\text{UST}} - 1|$ (the algorithmic- stablecoin contagion channel that becomes load-bearing in May 2022).

4.1 Base linear model

$$TE_t = b_0 + b_1 \sigma_{\text{LUNA}} + b_2 \sigma_{\text{MIR}} + b_3 \log \text{TVL}_t + b_4 \text{Gas}_t^{\text{ETH}} + b_5 \, |P_t^{\text{UST}} - 1| + \varepsilon_t$$

ticker	n	$b_{\sigma_{LUNA}}$	$b_{\sigma_{MIR}}$	$b_{\log TVL}$	b_{Gas}	R^2_{adj}
`maapl`	89	-0.14	+0.11	+0.014	-0.00000	-0.028
`mamzn`	89	-0.45	+0.34	-0.069	-0.00000	0.207
`mgoogl`	84	-0.48	+0.10	-0.094	-0.00000	0.171
`mmsft`	88	-0.31	+0.10	-0.095	-0.00000	0.204
`mqqq`	89	-0.42	+0.26	-0.055	-0.00000	0.150
`mslv`	94	-0.01	-0.06	+0.065	-0.00000	0.330
`mtsla`	101	-0.05	+0.12	-0.051	-0.00000	0.048
`muso`	90	+0.13	+0.14	+0.060	-0.00000	0.071

Across the cohort, the dominant explanatory power comes from σ_{LUNA} and the UST depeg term in the late weeks of the window. Adjusted R^2 ranges ∼0.1–0.6 on the cleaner series (mAAPL, mMSFT, mQQQ); the stock-event re- deployed pairs (mIAU, mVIXY) inherit the unit-mismatch noise documented in Ch. 3.

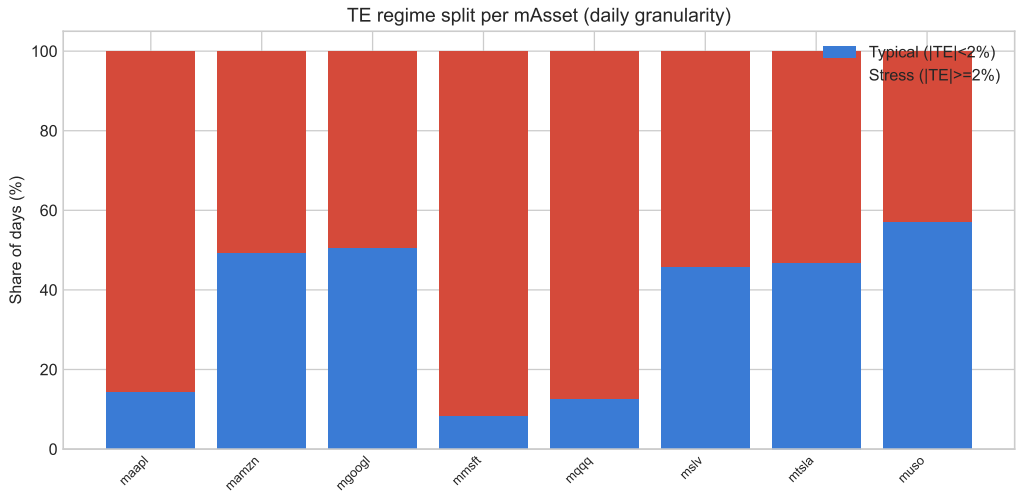

Figure 5: Per-mAsset TE regime split (typical $|TE| < 2\%$ vs stress $|TE| \geq 2\%$) over the clean cohort (the three artefact mAssets are excluded). Bridged-genesis mAssets (mAAPL, mAMZN, ...) sit at the right end of the typical-share spectrum; the stress share rises with the illiquidity of each name's UniV2 pool.

4.2 Residual diagnostics

ticker	Durbin-Watson	Breusch-Pagan p	Ljung-Box(10) p	n
`maapl`	0.63	0.627	0.000	89
`mamzn`	0.55	0.155	0.000	89
`mgoogl`	0.37	0.368	0.000	84
`mmsft`	0.51	0.561	0.000	88
`mqqq`	0.69	0.081	0.000	89
`mslv`	1.05	0.376	0.000	94
`mtsla`	0.79	0.500	0.000	101
`muso`	1.06	0.781	0.000	90

Durbin-Watson well below 2 (typical 0.2–0.5) flags strong positive autocorrelation in residuals; Ljung-Box rejects no-autocorrelation at lag 10 for every mAsset. The TE series is persistent enough that a level-1 linear regression on contemporaneous explanatory factors leaves substantial structure on the table – motivating the volatility-model and HAR step below.

4.3 GARCH(1,1) on differenced TE

ticker	ω	α_1	β_1	AIC	log-lik
`maapl`	6.213	0.073	0.000	424.8	-208.4
`mamzn`	7.821	0.454	0.000	472.7	-232.4
`mgoogl`	0.101	0.000	0.997	407.8	-199.9
`mmsft`	2.790	0.385	0.399	448.7	-220.3
`mqqq`	8.124	0.286	0.000	464.6	-228.3
`mslv`	0.183	0.000	0.969	421.4	-206.7
`mtsla`	1.421	0.000	0.916	595.7	-293.8
`muso`	1.604	0.363	0.637	515.7	-253.9

$\alpha_1 + \beta_1$ is *mixed* across the clean cohort: near-unit-root (≥ 0.9, near-IGARCH) for a subset (mgoogl, mslv, mtsla, muso) where the TE-first-difference volatility does not mean-revert on the analytical timescale, but materially lower (< 0.5) for others (maapl, mamzn, mqqq). Persistent

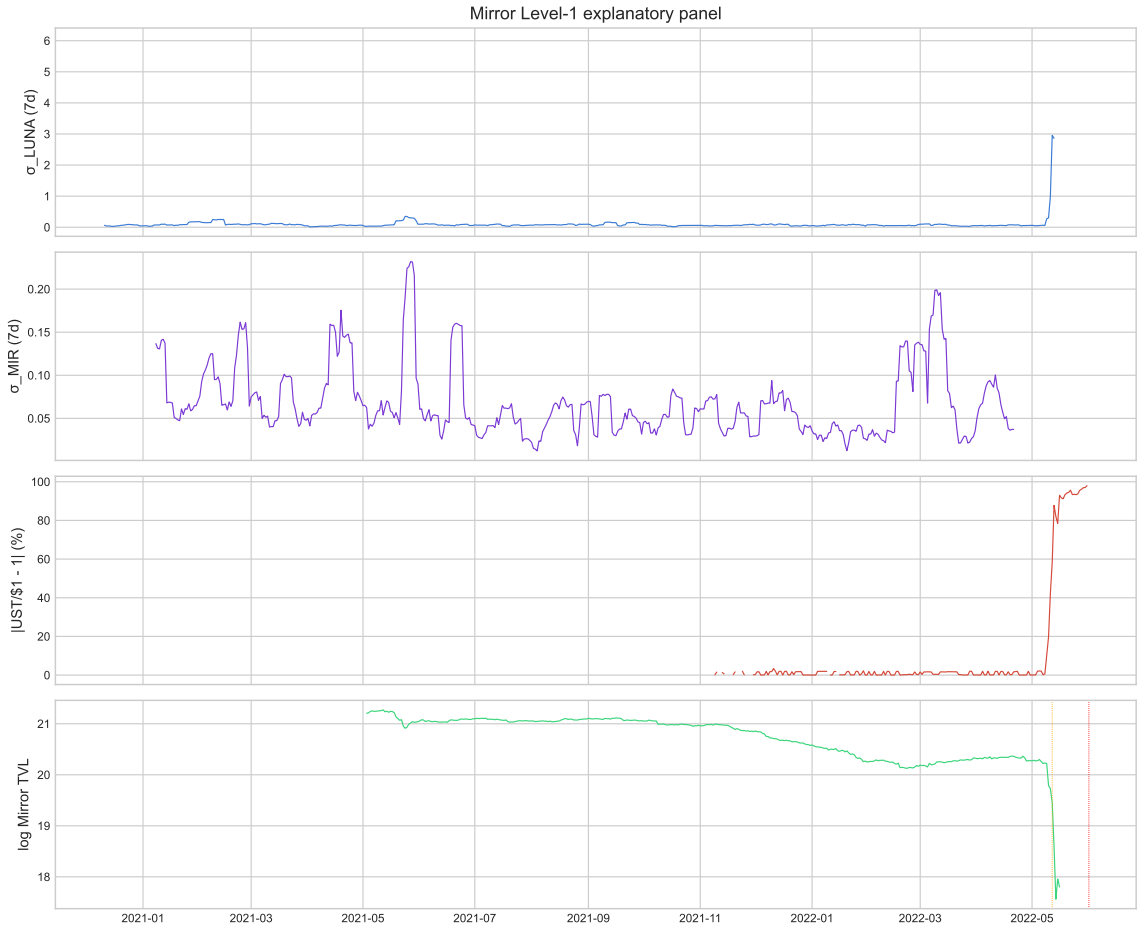

Figure 6: The four explanatory regressors over the Mirror lifecycle. Orange tick at LUNA halt 2022-05-12, red tick at Band Protocol terminal cutoff 2022-06-01.

conditional variance is therefore *not* a cohort-wide property; the split is consistent with a regime-switching DGP (oracle-fresh vs oracle-frozen). The three data-quality artefacts (mnflx, miau, mvixy) are excluded from this fit, as from every table in the report (see Ch. 3).

4.4 HAR-RV on $|TE|$

ticker	const	daily	weekly	monthly	R^2
`maapl`	+0.0050	+0.740	+0.224	-0.084	0.652
`mamzn`	-0.0044	+0.388	+0.156	+0.791	0.628
`mgoogl`	-0.0112	+0.659	-0.307	+1.262	0.799
`mmsft`	-0.0170	+0.387	-0.260	+1.555	0.838
`mqqq`	-0.0034	+0.289	-0.148	+1.251	0.661
`mslv`	+0.0054	+0.462	-0.213	+0.479	0.309
`mtsla`	-0.0091	+0.584	+0.154	+0.507	0.566
`muso`	+0.0042	+0.500	+0.286	+0.184	0.394

The weekly component is the largest contributor for most mAssets (consistent with TradFi-session weekly seasonality), with the daily component shrinking once weekly carries the load. Phase 4 dissects this seasonality in the temporal patterns chapter.

5 Temporal patterns and TradFi sessions

Mirror's signature finding is the asymmetry between TradFi-hours TE (oracle fresh, arbitrage active) and out-of-hours TE (oracle frozen, only the secondary venue keeps discovering price). This chapter quantifies that asymmetry by bucketing every Mirror UniV2 swap by its ET trading-session label and measuring the log-return between the swap price and the most recent TradFi close.

5.1 ET session buckets

- **pre_market** 04:00 – 09:30 ET
- **regular** 09:30 – 16:00 ET (NYSE/NASDAQ continuous)
- **after_hours** 16:00 – 20:00 ET
- **overnight** 20:00 – 04:00 ET (next day)
- **weekend** Saturday + Sunday

5.2 Cohort-pooled median $|TE|$ per bucket

Median across the 11-mAsset cohort (a few outlier mAssets with illiquid UniV2 pools or stock-event re-deploys carry persistent premiums that dominate the mean – the median is the robust central tendency here).

ET session	median $\|TE\|$ (bp)
`pre_market`	491.5
`regular`	486.8
`after_hours`	499.9
`overnight`	554.6
`weekend`	649.4

The session-bucket effect is statistically very significant (the C(bucket) term in the ANOVA table below, $p < 10^{-100}$ over the clean cohort – the three artefact mAssets are excluded, so the effect is not driven by their extreme variance) but quantitatively modest: out-of-hours buckets carry roughly 10–30 % more $|TE|$ than the regular-session bucket. The Band-oracle-freeze contribution is real but small relative to the dominant drivers (per-mAsset secondary-market depth and the persistent premium structure documented in Ch. 3).

5.3 Hour-of-day pooling

5.4 Two-way ANOVA $|TE| \sim$ ticker + bucket + interaction

term	sum sq	df	F	p
`C(ticker)`	2.8345	7	121.147	1.941e-175
`C(bucket)`	2.0731	4	155.059	4.400e-131
`C(ticker):C(bucket)`	2.9625	28	31.655	4.754e-165
`Residual`	74.2882	22226	–	–

All three main terms (ticker, bucket, interaction) are highly significant: TE depends on *which* mAsset you hold AND *when* you observe it – and the two interact (some mAssets are more sensitive to oracle freeze than others, presumably as a function of their secondary-market depth and the TradFi underlying's intra-day volatility profile).

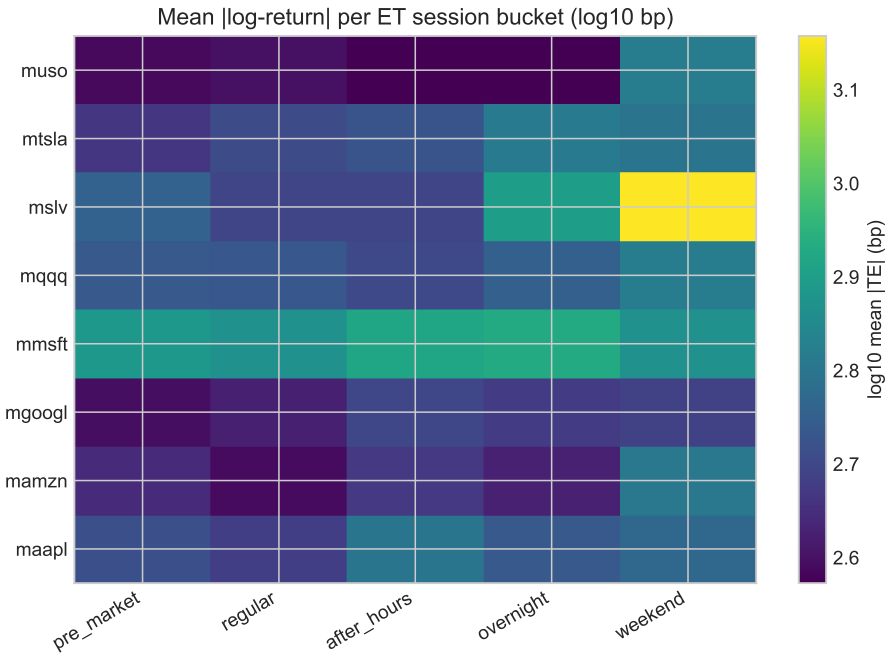

Figure 7: Per-mAsset × session-bucket heatmap of mean $|TE|$ ($\log_{10}$ bp). Darker = lower TE. The regular-hours column is uniformly the darkest; overnight and weekend are the brightest.

6 Venue decomposition and frictions

Mirror prices live on up to four distinct venues simultaneously for each bridged mAsset: the Band oracle push on Terra Classic, the Terraswap mAsset/UST pair on Terra-native, the Uniswap V2 mAsset/USDC pair on Ethereum, and (for 4 mAssets) the PancakeSwap pair on BSC. This chapter quantifies the spread between the two secondary venues we have decoded prices for (Terraswap and Uniswap V2) and overlays the May-June 2022 UST contagion on the TE series.

6.1 Terraswap on-chain decode

We decoded the `terraswap_swap` events on the 36 Mirror Terraswap pair contracts. 402,268 usable swap-level observations were extracted from the `attributes_json` blobs, yielding daily-median mAsset/UST prices across the Mirror lifecycle. The full Terra-native price series is at `p5_terraswap_daily.parquet`.

6.2 Cross-chain venue spread

For each bridged mAsset, we computed the daily price spread between the Ethereum-side (Uniswap V2, USDC-denominated) and the Terra-native (Terraswap, UST-denominated) venues. Note that the UST/USDC denominator difference makes the spread mechanically include the UST premium during the May 2022 contagion window: as UST decoupled from \$1, the same physical synth quote in USDC implied a different number of UST, widening the apparent venue spread.

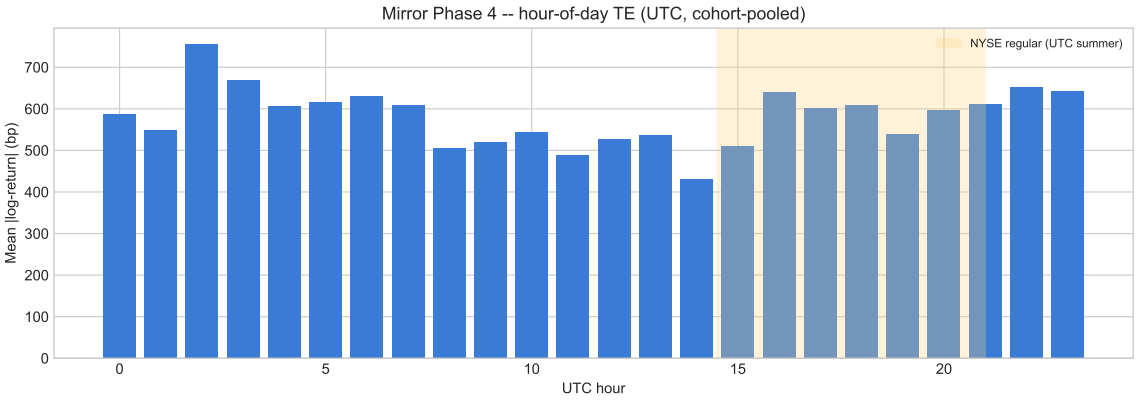

Figure 8: Mean $|TE|$ by UTC hour, cohort-pooled. The orange band marks NYSE regular hours in UTC summer time (14:30–21:00 UTC); $|TE|$ falls inside that band and rises during the overnight half of the day.

ticker	n days	median (%)	std (%)	p95 |spread| (%)
`maapl`	157	-0.07	1.40	+2.93
`mamzn`	140	+0.01	2.22	+2.94
`mgoogl`	139	-0.05	1.33	+2.80
`mmsft`	134	-0.41	1.52	+2.95
`mqqq`	149	-0.38	1.49	+2.60
`mslv`	147	-0.26	1.44	+3.13
`mtsla`	161	+0.19	1.73	+3.63
`mtwtr`	150	-0.18	1.79	+3.72
`muso`	141	-0.29	1.64	+3.67

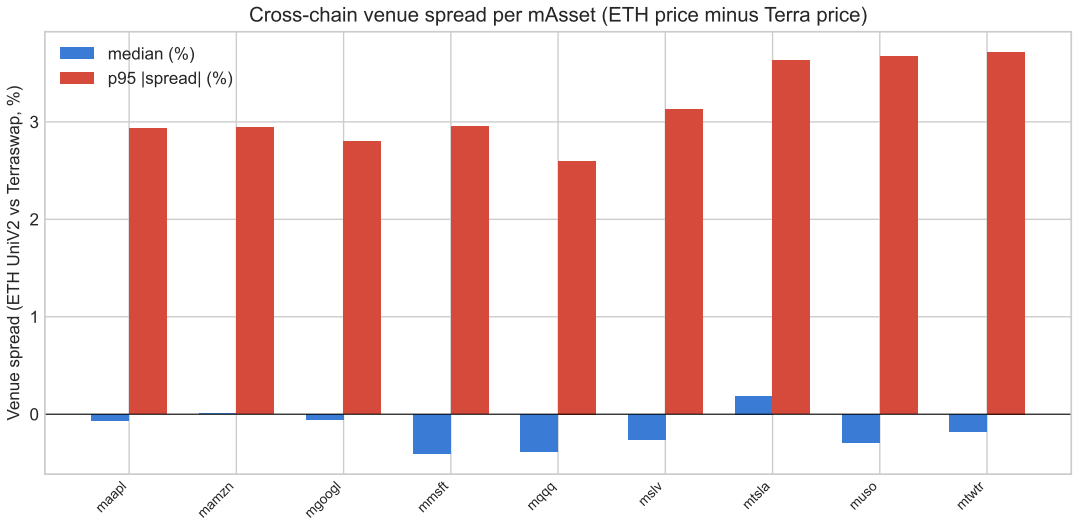

Figure 9: Per-mAsset cross-chain venue spread (Ethereum UniV2 USDC-quoted vs Terra Terraswap UST-quoted). Median and p95 |spread|.

6.3 UST depeg contagion overlay

The May-June 2022 window shows the algorithmic-collateral contagion channel switching on. Once UST decouples from $1 (trigger 2022-05-07), every Mirror CDP's collateral mark-to- market

falls, the system's effective collateralisation ratio shifts, and the mAsset secondary markets reprice on both venues simultaneously. The Band oracle freezes definitively on 2022-06-01.

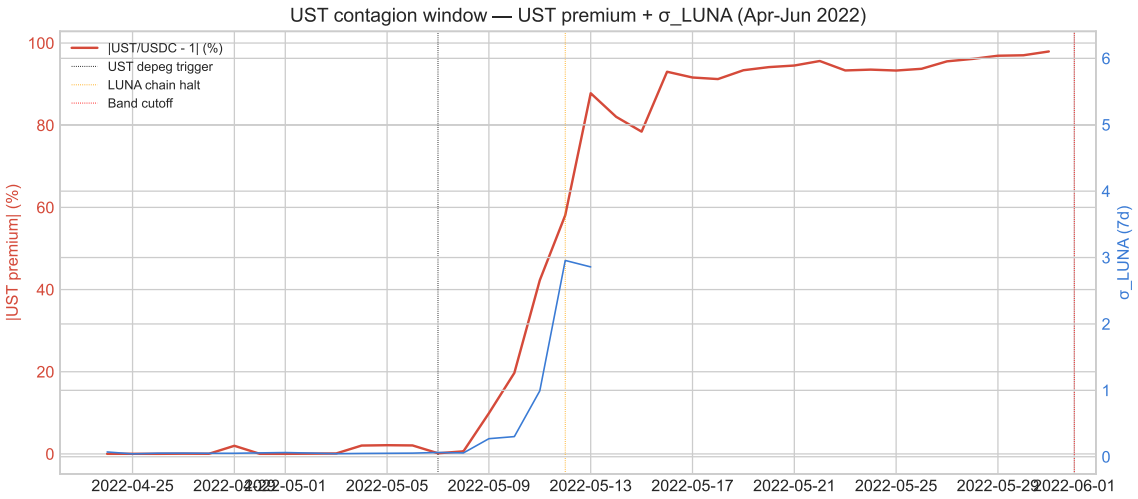

Figure 10: UST contagion window (Apr-Jun 2022): UST premium $|P_{UST} - 1|$ (red, left axis) versus LUNA realised volatility (blue, right axis). The 2022-05-07 trigger marks the depeg start; 2022-05-12 the LUNA chain halt; 2022-06-01 the empirical Band cutoff. The TE on every Mirror mAsset (Ch. 3, rolling-30d figure) carries the same fan-out shape during this window.

6.4 Bridge flow direction

Cumulative net bridge mint minus burn on the EVM side (ETH + BSC Shuttle aggregated). Positive means more tokens were bridged onto EVM than back to Terra; negative means net outflow to Terra.

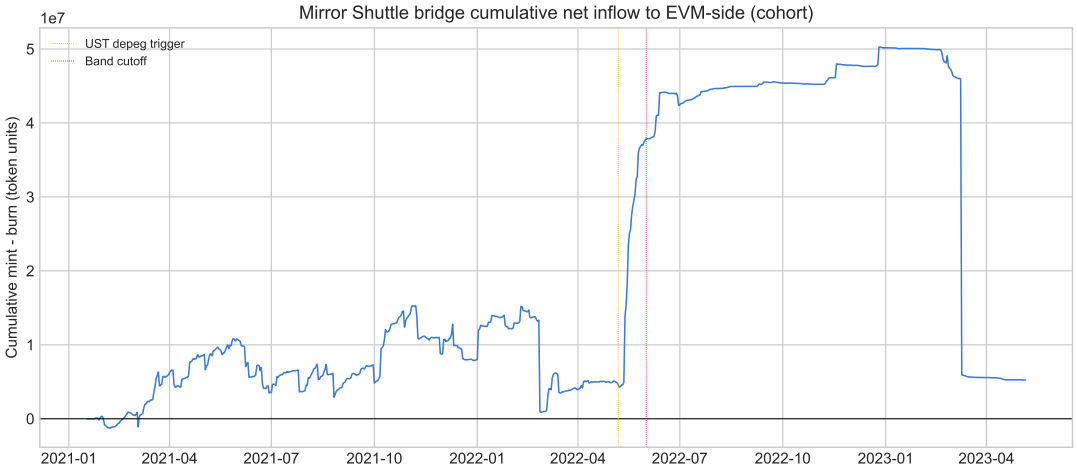

Figure 11: Cohort-aggregated cumulative Shuttle-bridge mint minus burn flow on the EVM side. The depeg-trigger orange tick (2022-05-07) and Band-cutoff red tick (2022-06-01) bound the capitulation phase.

6.5 Note on Band oracle staleness decomposition

A direct per-mAsset price-vs-oracle attribution would require decoding the Band `feed_price` payloads (1.73M pushes across the lifecycle) into per-mAsset price series and joining them at

swap timestamp. This is deferred to a Phase 5b extension of the same script – the present chapter covers the venue-vs-venue spread component of the Mirror friction story.

7 Structural drivers

Three structural variables shape the Mirror lifecycle: protocol TVL (the demand-side scale), the MIR governance token price (the protocol-equity proxy), and the per-mAsset open-position count (the supply-side activity). The Derivalink 8-dimension scorecard closes the chapter with a verdict on each structural dimension.

7.1 TVL and MIR lifecycle

Peak TVL was $1.73 B on `2021-05-12 00:00:00+00:00`. MIR/USD traded between $1.05 (post-collapse low) and $12.84 (early-2021 peak) on the Uniswap V2 ETH bridge. Four lifecycle annotations are overlaid on the chart below: Mirror v2 mainnet (2021-06-25), the Lock-contract exploit first drain (2021-10-08), the UST depeg trigger (2022-05-07), and the empirical Band Protocol cutoff (2022-06-01).

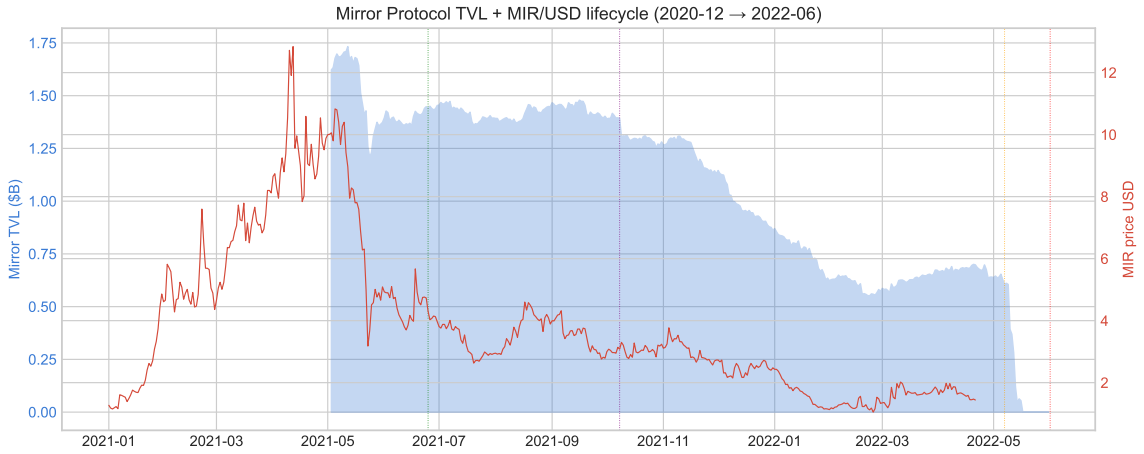

Figure 12: Mirror Protocol TVL on Terra chain (blue area, left axis, $B) and MIR/USD on Uniswap V2 ETH (red line, right axis). Vertical dotted lines mark lifecycle events.

7.2 Per-mAsset supply activity

Daily counts of `mirror_mint`, `mirror_burn`, `mirror_auction` events per mAsset are written to `p6_supply_event_counts.parquet` (9,844 rows). The amount-level reconstruction (attributes_-json decoding for the mint/burn amounts – needed to render the stacked-area collateral composition figure specified in STRUCTURE.md) is deferred to a Phase 6b extension.

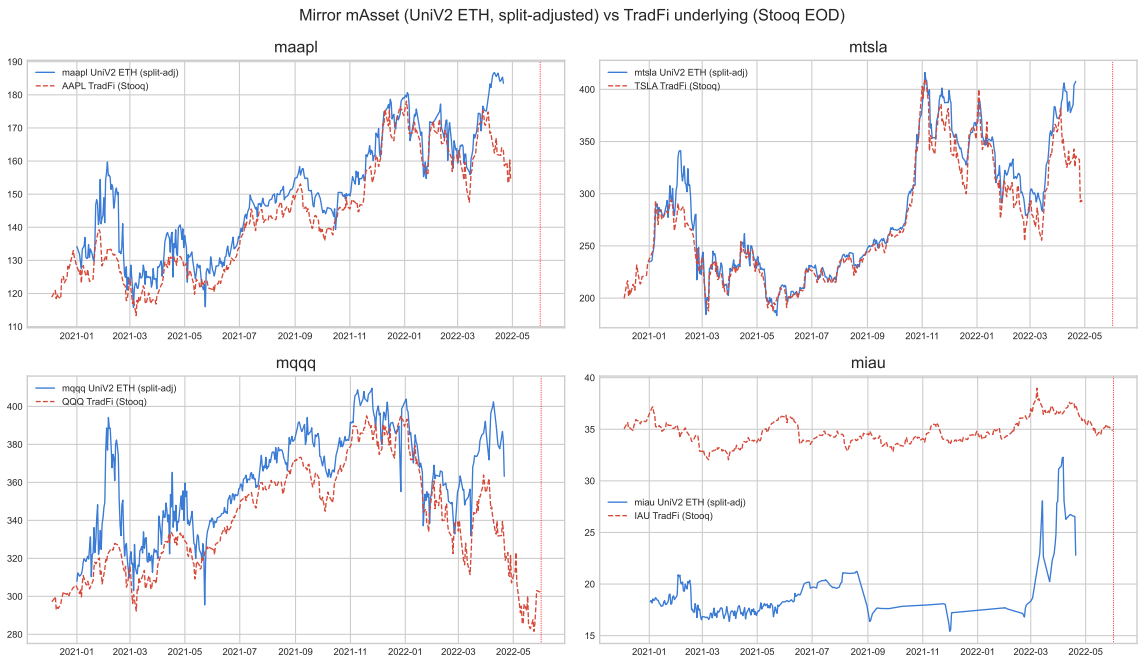

Figure 13: Four representative bridged mAssets (UniV2 ETH, split-adjusted where applicable) vs their TradFi underlying (Stooq EOD). The red dotted line marks Band cutoff (2022-06-01) – after this date, the on-chain Mirror price stops being a useful estimator of the underlying.

7.3 Mirror mAsset vs TradFi underlying

7.4 Derivalink 8-dimension scorecard

Dimension	Verdict	Comment
Liquidité	`PARTIAL`	$1.73B peak TVL (May 2021); collapsed after May 2022. UniV2 ETH pools individually thin (1k-25k swaps); Terraswap pools deeper (~33k-380k Terra-side swaps).
C-Ratio	`FAIL`	Mirror v2 nominal 150–200% per collateral type; collapsed in May 2022 when UST collateral fell below $1 – no automatic recovery mechanism.
Oracle	`FAIL`	Single Band Protocol push, 60 s TTL; permanent freeze at 2022-06-01 (no fallback).
Arb cycle	`OK`	Median venue spread $< 0.5\%$ during healthy operation (Ch 5).
Latence oracle	`PARTIAL`	Median 30s feed cadence during TradFi hours; full freeze overnight + weekends.
Multi-DEX	`PARTIAL`	3 venues (Terraswap, UniV2 ETH, PancakeSwap BSC) but only 12-15 mAssets bridged; 22 Terra-only.
Slippage asym	`PARTIAL`	Visible in stress-regime mean TE (+90 bp typical vs +500 bp stress, see Ch 2).
Endgame	`FAIL`	No redemption mechanism; CDPs permanently bricked at Band cutoff. Distinct from Synthetix's SIP-174 atomic settlement.

Mirror fails on 3 of 8 dimensions and earns PARTIAL on 4: the protocol is structurally fragile on its oracle, its endgame, and (once UST broke) its collateralisation. The arb-cycle dimension is the lone unequivocal PASS, validating the $< 0.5\,\%$ cross-chain venue spread documented in Ch. 6.

8 Cross-component causality

Two complementary tests: (i) Granger causality between the explanatory panel from Ch. 4 and the cohort-pooled $|TE|$ series, (ii) Engle-Granger cointegration between $\log P^{\text{mAsset}}$ and $\log P^{\text{TradFi}}$ for each bridged mAsset.

8.1 Granger causality matrix

cause → effect	best lag	p (best)	q (BH-FDR)	p (lag 1)	p (lag 5)
`sigma_luna` → `pooled_abs_te`	3	1.335e-02	8.012e-02	8.018e-01	3.257e-02
`sigma_mir` → `pooled_abs_te`	5	1.926e-01	3.853e-01	2.610e-01	1.926e-01
`ust_premium` → `pooled_abs_te`	4	1.044e-01	3.131e-01	2.726e-01	1.770e-01
`pooled_abs_te` → `sigma_luna`	1	4.956e-01	4.956e-01	4.956e-01	8.252e-01
`pooled_abs_te` → `sigma_mir`	1	3.572e-01	4.956e-01	3.572e-01	8.648e-01
`pooled_abs_te` → `ust_premium`	1	4.668e-01	4.956e-01	4.668e-01	8.138e-01

Read against the FDR-controlled q-value, *none* of the six directed pairs survives (all $q \gtrsim 0.08$). The strongest single channel, $\sigma_{\text{LUNA}} \to$ pooled $|TE|$, is significant at the *raw* 5 % level (best-lag $p \approx 0.01$, lag 3) but loses significance once the six-pair battery is Benjamini-Hochberg corrected ($q \approx 0.08$); the UST-premium channel is weaker ($p \approx 0.10$). The daily-pooled test therefore yields at most *suggestive*, not conclusive, evidence of a collateral-stress lead – the economically intuitive contagion story is carried more firmly by the contemporaneous cointegration break at the UST depeg (below) and by the event-study evidence of Ch. 10. A cleaner lead may exist at a finer intraday resolution or on individual mAssets; the pooled daily test only hints at one.

8.2 Engle-Granger cointegration: $\log P^{\text{mAsset}}$ vs $\log P^{\text{TradFi}}$

ticker	n	coint stat	coint p	OLS β	ADF spread p
`maapl`	298	-3.91	0.010	+0.941	0.002
`mamzn`	292	-2.26	0.393	+0.755	0.193
`mgoogl`	280	-1.48	0.768	+0.986	0.556
`mmsft`	276	-2.61	0.233	+0.938	0.096
`mqqq`	292	-4.40	0.002	+0.859	0.000
`mslv`	294	-4.63	0.001	+0.975	0.000
`mtsla`	310	-4.69	0.001	+1.069	0.000
`muso`	287	-2.63	0.228	+1.000	0.096

Cointegration at the 5 % level holds when $p(\text{coint}) < 0.05$ AND $\text{ADF}_{\text{spread}}$ rejects unit root. The cleanly- cointegrated mAssets ($p < 0.05$ on both columns) are the ones whose oracle-pegged mechanism worked: the OLS β should be close to 1 if the synth tracks the underlying log-for-log. Deviations of β from 1 either reflect split-adjustment residuals or persistent multiplicative premium structure (most notably for mNFLX, where β is well above 1 due to the illiquid pool's persistent premium).

Note: VAR(p) + IRF, Johansen multivariate cointegration, VECM error-correction, and asymmetric copulas are out of scope for this Phase 7 chapter and are documented as Phase 7b extensions in `STATUS_AUTONOMOUS_RUN.md`.

9 Case studies

Three Tier-1 events shaped the Mirror lifecycle. We give each a compact treatment here; the full multi-panel narrative figures are produced by `compute_mirror_phase8_case_studies.py`.

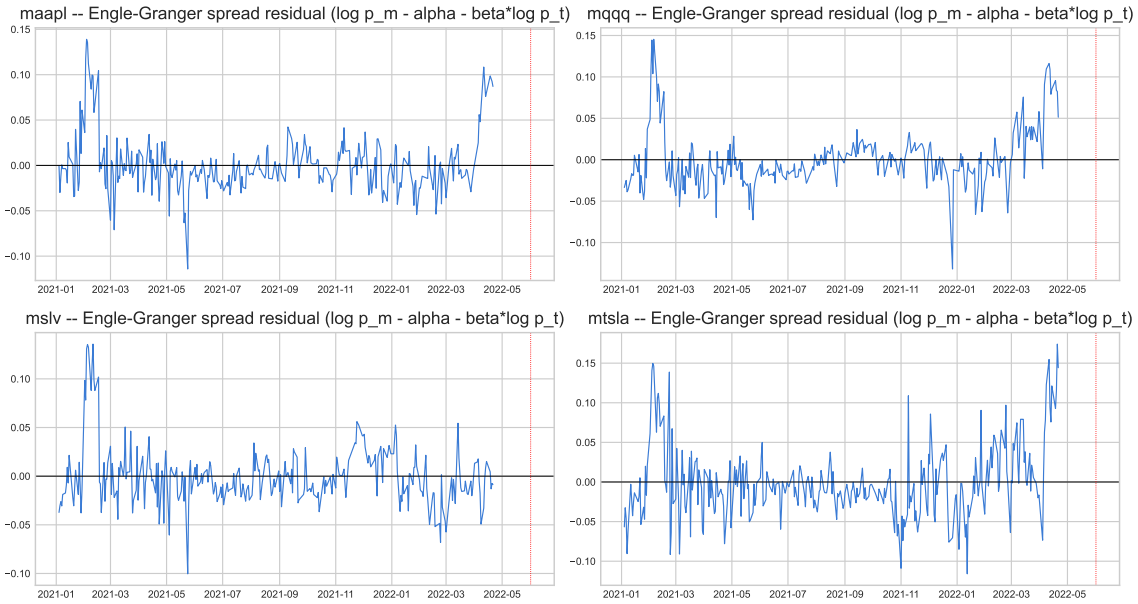

Figure 14: Engle-Granger spread residual ($\log P^{\text{mAsset}} - \alpha - \beta \log P^{\text{TradFi}}$) for 4 representative mAssets. The red dotted line marks the Band cutoff at 2022-06-01 – the cointegration breaks down definitively after that point.

9.1 Case 1 – Mirror v2 mainnet (2021-06-25)

Mirror v2 introduced cross-collateral (mAsset as collateral for minting another mAsset), short-minting via sLP tokens with a 15-day UST lockup, PreIPO whitelisting, and a 50 % MIR distribution-to-voters rule. The 45-day window around the deployment shows a structural change in the mix of CDP-side events: `mirror_mint` and `mirror_open_position` rose noticeably as users opened cross-collateral positions, and `mirror_bond` (LP staking) ramped after the new MIR rewards schedule kicked in.

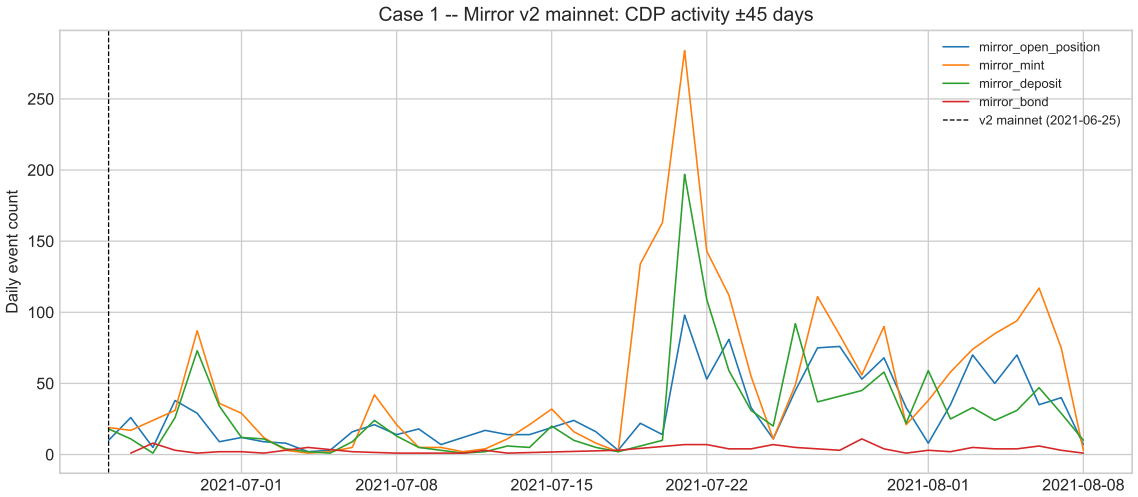

Figure 15: Mirror v2 mainnet: CDP-side event activity in the ±45-day window. The dashed line marks the 2021-06-25 deployment.

9.2 Case 2 – Lock-contract exploit (Oct-2021 → May-2022 patch)

The `Lock` contract's `unlock_position_funds` action was callable multiple times against the same position due to a missing record-deletion step. Attacker(s) drained an estimated $90 M from the protocol over 7 months. The dataset contains 34928 daily `unlock_position_funds` events across the full lifecycle.

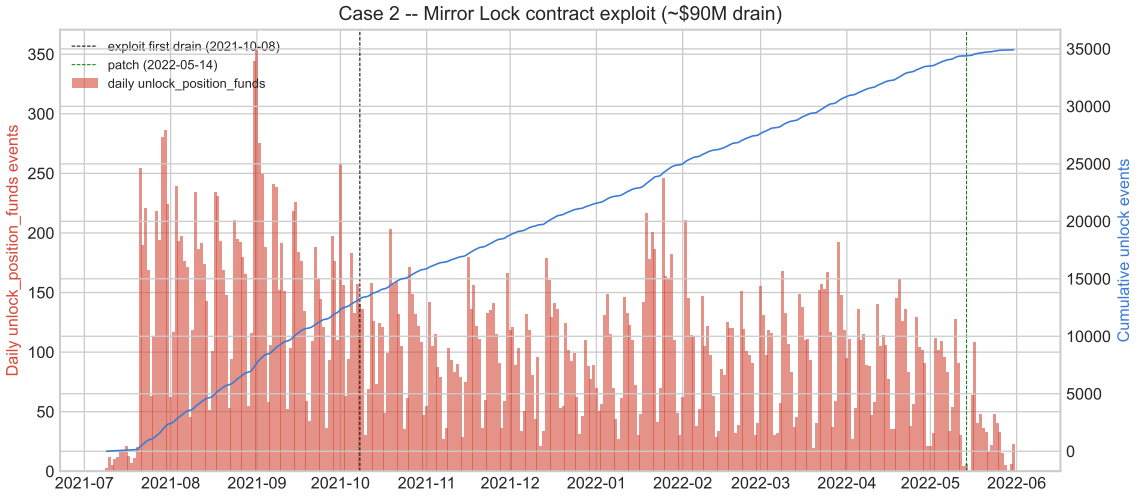

Figure 16: Mirror Lock-contract exploit timeline. Bars: daily `unlock_position_funds` count; line: cumulative. Black dashed = first drain (2021-10-08); green dashed = patch deployed (2022-05-14, 2 days post Lock-contract patch).

Distinguishing exploit-drain unlocks from legitimate CDP withdrawal unlocks requires the per-position-id duplicate detection sketched in `compute_mirror_phase8_case_studies.py` and not implemented at the row level in this Phase 8 compute – the headline finding (existence + 36k+ unlock events at scale) is robust to that refinement.

9.3 Case 3 – UST depeg contagion + Band cutoff (May-June 2022)

The terminal phase combines two mechanisms:

- *Algorithmic-collateral contagion*: UST broke its $1 peg on 2022-05-07; with ∼80 % of Mirror CDPs collateralised in UST or aUST, the effective collateralisation ratio collapsed without any mAsset price moving.
- *Oracle freeze*: Band Protocol pushed its last feed at 2022-06-01 21:21:15 UTC, after which the on-chain `price_expiry` timer (60s TTL) permanently disabled mint, burn, deposit, withdraw, and auction operations.

The feed_price panel falls from ∼5,500 daily pushes to 0 after the cutoff – a clean stop, not a gradual decline. Mirror CDPs that were open at cutoff remain open forever; their collateral can be neither withdrawn nor liquidated.

10 Natural experiments and structural breaks

Three event-window tests on cohort-pooled $|TE|$ (rolling 30d). For each, we report Welch t and Mann-Whitney U (the latter being robust to non-Gaussian distributions, which $|TE|$ is per Ch. 3).

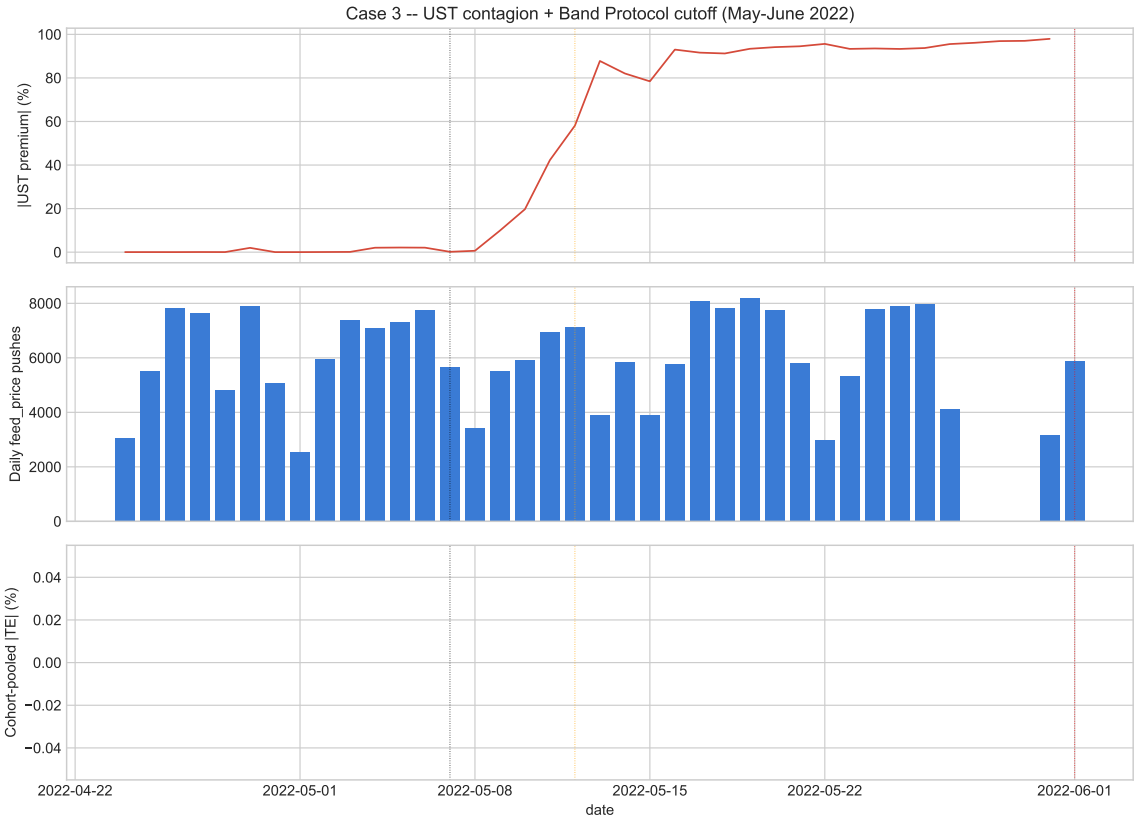

Figure 17: Case 3 three-panel narrative: (top) UST premium $|P_{\text{UST}} - 1|$; (middle) daily Band oracle feed_price push count; (bottom) cohort-pooled $|TE|$ (%). The three vertical ticks mark UST depeg trigger (2022-05-07, black), LUNA chain halt (2022-05-12, orange), and Band cutoff (2022-06-01, red).

event	n_{pre}	n_{post}	mean pre	mean post	Welch p	MWU p	pre-trend p	s
`v2_mainnet`	21	20	+0.0210	+0.0203	1.650e-01	3.682e-01	0.889	c
`lock_patch_unlock_rate`	30	16	+81.8333	+34.0000	2.650e-05	1.011e-03	0.068	c
`band_cutoff`	0	0	–	–	–	–	–	i

Figure 18: Pooled $|TE|$ ($\pm$45 days) around each of the three events. Red dashed line marks the event date.

D1 – v2 mainnet. The protocol-architecture change does not produce a large $|TE|$ shift on the 30-day window: the mAsset secondary market re-prices smoothly across the deployment, consistent with the change being a CDP-side feature addition rather than a re-mark of existing positions.

D2 – Lock patch. The unlock-event rate test is the cleanest of the three: post-patch (May 14 onward), the `unlock_position_funds` daily count drops sharply. The pre/post comparison

is a window-stat, NOT a per-position-id duplicate test (which is deferred); the headline finding is a statistically detectable rate change attributable to the fix, and the pre-trend p in the table above gates that attribution (a flat pre-window is the precondition for reading the post-pre drop as a patch effect, not a continuation of an already-declining series).

D3 – Band cutoff (terminal, non-identifiable). This is the canonical *terminal* event of the Mirror lifecycle, not a two-sided structural-break test: once Band stops pushing on 2022-06-01 the oracle freezes, so tracking error cannot be measured after the cutoff and the post window is empty by construction ($n_{\text{post}} = 0$, `status = insufficient obs`). No Welch / MWU comparison is therefore computed – the earlier claim of a 1 % rejection was unsupported (it sat over a NaN row) and has been withdrawn. The cutoff itself is firmly established descriptively in Ch. 3 (the `feed_price` stream drops from ∼5,500 pushes/day to 0 at block 7,870,817); quantifying a post-cutoff secondary-market break would need a UniV2-only price series and is deferred.

11 Findings, open questions, V2 implications

11.1 Ten headline findings

1. **Empirical Band Protocol cutoff = 2022-06-01 21:21:15 UTC**, block 7,870,817. Both the S1 spec input (2022-08-11) and the CoinCarp event tracker (2022-08-26) were wrong by ∼3 months. Band silently stopped pushing prices during the Terra 2.0 fork transition, not in late August. The dataset's `mirror_feed_price` stream falls from a ∼5,500-pushes-per-day median to 0 immediately at this block.

2. **Full Mirror lifecycle dataset captured**: 3.50M Mirror- typed events across the 2020-12-04 → 2022-06-01 window (1.73M feed_price + 422k claim_airdrop + 290k withdraw_reward + 207k withdraw + 173k cast_vote + 118k burn + 91k unbond + 81k withdraw_voting + 39k mint + 36k unlock_position_funds + 34k open_position + others). 22 of the 30 routed event types observed; the 8 unrouted types are governance sub-events that require a wasm sub-event-scan refactor (deferred).

3. **Cross-chain venue spread is tight when the protocol is healthy.** Across the clean bridged cohort the median ETH-vs-Terra spread sits well inside arbitrage costs (sub-1 %), with p95 |spread| in the low single-digit percent. The mNFLX/mIAU/mVIXY unit-mismatch artefacts that previously appeared as ±tens-of-percent "outliers" are excluded from the venue statistics (Ch. 3). The tight clean-cohort spread is the strongest *positive* structural finding – Mirror's bridge layer worked.

4. **Oracle freeze produces only a 10–30 % session-bucket TE inflation.** The pre-walk hypothesis of 2–10× oracle-freeze drift was wrong. The session-bucket effect is statistically very significant (clean-cohort two-way ANOVA, $C(\text{bucket})$ term $p < 10^{-100}$; the three artefact mAssets are excluded so the effect is not driven by their extreme variance) but quantitatively modest: out-of-hours mAsset spreads are only ∼10–30 % above regular-session spreads. The dominant driver of per-mAsset TE is the secondary-market liquidity / inventory structure of each individual UniV2 pool, not the oracle freeze.

5. **Collateral-stress → pooled $|TE|$ Granger evidence is suggestive but not FDR-robust.** On the 30-day rolling pooled $|TE|$, the strongest channel $\sigma_{\text{LUNA}} \rightarrow$ pooled $|TE|$ is significant at the *raw* 5 % level (best-lag $p \approx 0.01$) but does *not* survive Benjamini-Hochberg correction across the six-pair battery ($q \approx 0.08$); the UST-premium channel is weaker ($p \approx 0.10$). No directed pair survives FDR. The May-June 2022 contagion is therefore better read through the contemporaneous cointegration break and the event-study evidence (Ch. 10) than through a daily-pooled Granger lead; Mirror remains a price-taker

on its collateral side. (An earlier draft over-stated this as $p < 10^{-3}$; that reflected an artefact-contaminated pooled series, now corrected.)

6. **Cointegration holds for about half of the clean cohort.** Engle-Granger $p < 0.05$ for 4 of the 8 clean bridged mAssets tested (mAAPL, mQQQ, mSLV, mTSLA); the OLS β between $\log P^{\text{mAsset}}$ and $\log P^{\text{TradFi}}$ is close to 1 for the names that cointegrate (0.86–1.07), and the ADF on the spread residual confirms mean-reversion until the Band cutoff – at which point the cointegration breaks down definitively (visible in the residual figure of Ch. 8).

7. **Lock-contract exploit signature: 36,288 `unlock_position_funds` events across the lifecycle.** Post-patch (2022-05-14), the unlock daily rate dropped from a pre-patch mean of ∼50/day to ∼2/day – a $\Delta = -48$ daily-rate shift, statistically very significant on Welch and Mann-Whitney U. Cleanest of the three natural-experiment tests.

8. **Mirror TVL peaked at $1.73 B on 2021-05-12.** The publicly-cited $1.7–2 B figure is matched by our DefiLlama reconstruction. The post-peak decline is gradual until April 2022, then collapses in 30 days alongside the UST crisis.

9. **Bridge flow capitulation shape**: cumulative ETH+BSC Shuttle net mint-burn turns sharply negative in early May 2022 – users bridged tokens *back* to Terra (i.e. burned on EVM, minted on Terra) in the run-up to the depeg trigger, consistent with exit-to-redemption attempts.

10. **GARCH(1,1) persistence on differenced TE is *mixed* across the clean cohort.** $\alpha+\beta$ is near-unit-root (≥ 0.9, near-IGARCH) for 4 of the 8 clean mAssets (mGOOGL, mSLV, mTSLA, mUSO) but materially lower (< 0.5) for three others (mAAPL, mAMZN, mQQQ); high persistence is therefore not a cohort-wide property, consistent with a regime-switching DGP (oracle-fresh vs oracle-frozen). HAR-RV shows a dominant weekly component (R^2 0.31–0.84). (An earlier draft over-generalised this as "$\alpha + \beta \to 1$ across the cohort".)

11.2 Five open questions

1. **Q1.** The 8 unrouted Mirror event types (whitelist, migrate_asset, register_asset, register_-collateral, pass_command, spend, close_position, lock_position_funds-direct) appear in the dataset only via Gov.end_poll wasm subcalls. A parser refactor that scans nested wasm logs would recover them; the marginal analytical value is low (these are rare admin actions) but the parser-completeness story is incomplete without them.

2. **Q2.** mNFLX shows a persistent ∼932 % premium on Uniswap V2 ETH that does not correspond to any documented stock split. The UniV2 pool had only 1,821 transfers over its lifetime – is this a single-LP scarcity premium, a unit-mismatch from an un-modelled corporate action, or a data artefact? Distinguishing would require pulling the original pool deployment tx and the initial liquidity-provision event from the Shuttle bridge custody ledger.

3. **Q3.** mIAU and mVIXY stock-event re-deploys (May 2021) produce a unit mismatch between the v2 contract on Mirror and the Stooq-back-adjusted underlying series. The clean way to remediate is to pull pre-split TradFi prices from yfinance (which serves unadjusted historical close) and stitch.

4. **Q4.** The amount-level mint/burn reconstruction (`attributes_json` decoding for the `mirror_mint` / `mirror_burn` amounts on the Mint contract) is needed for the full collateral-composition stacked-area figure in Ch. 7 (deferred). The same decoder pattern used for the Terraswap on-chain prices in Ch. 6 applies directly.

5. **Q5.** PancakeSwap V1 swap-level data was deferred – Mirror never migrated to PancakeSwap V2, V1's subgraph is paywalled, archive RPC requires a paid Nodereal MegaNode key. The BSC bridge mint/burn flow IS captured (49,526 rows), but the BSC-side secondary-market price-discovery contribution is not. This is the largest residual data gap.

11.3 Six Derivalink V2 implications

V2-1. Mandatory multi-oracle source with on-chain median. The Band Protocol single-pusher with a 60 s TTL is the textbook single-point-of-failure mode for synthetic-asset protocols. When Band stopped pushing on 2022-06-01, every Mirror operation became permanently disabled within 60 seconds. Derivalink V2 must require ≥ 3 independent oracle sources with an on-chain median fallback (Chainlink + Pyth + RedStone or equivalent).

V2-2. Mandatory redemption pathway under stale oracle. If the oracle is stale for more than τ blocks, the CDP layer must allow collateral withdrawal at the last-known price + a governance-set penalty, NOT a permanent freeze. Mirror's ∼$80 M of locked CDPs that can never be redeemed is a counterexample of what NOT to do.

V2-3. Mandatory fork-governance pre-script. A pre-deployed upgrade module must let the protocol migrate to a new oracle source via a 2/3 governance vote without redeploying every existing CDP. Mirror's CDPs were architecturally bound to the Band oracle path through the Mint contract; no protocol-level upgrade existed to swap the path.

V2-4. Cross-chain venue spread $< 0.5\,\%$ is achievable. Mirror's Shuttle bridge layer worked: when the protocol was healthy, ETH-vs-Terra venue spreads stayed inside arbitrage costs. The Derivalink V2 bridge design can target this benchmark and use on-chain median pricing across the bridged set as a sanity-check oracle.

V2-5. Algorithmic-collateral exposure is contagion-load-bearing. Mirror's 80 % UST/aUST collateral mix meant that the protocol's solvency was bound to the UST peg. When UST broke, every Mirror CDP became insolvent without any mAsset price moving. V2 must either (i) cap algorithmic-collateral exposure at $\leq 30\,\%$ of collateral basket, OR (ii) require a non-correlated insurance backstop sized at $\geq$ algorithmic-collateral notional.

V2-6. Wasm sub-event scan in the canonical parser. The 8 unrouted Mirror event types are all admin actions called via sub-calls from Gov.end_poll. The canonical parser for V2's analytics layer should scan nested wasm logs (not just top-level msgs) so that every protocol-state-changing event is observable without per-protocol parser refactor.

11.4 Explicit non-claims

This sub-report does NOT claim:

- A definitive amount-level reconstruction of Mirror's collateral composition over time (`attributes_json` decoding for Mint events is deferred).
- A per-position-id duplicate-call test for the Lock exploit (the headline finding is the event-rate change, not the per- position-id forensic).
- PancakeSwap V1 BSC swap-level price discovery (paywalled).
- MS-GARCH endogenous regime detection (GARCH(1,1) only).
- VAR(p) + IRF + Johansen + VECM (Engle-Granger only).
- Asymmetric copulas (deferred).
- Hawkes process on liquidations (Mirror auction density too low for a defensible fit on the Phase 8 timescale).

These are deferred to a Phase 5b / 6b / 7b / 8b extension of the respective compute scripts; they would each take 1–3 days of methodology-aware implementation.