Backed xStocks sub-report

Tracking error and the weekend gap in physically-backed tokenized US equities: TSLAx, COINx, NVDAx on Solana, 2025–2026

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Abstract

We measure the tracking error (TE) of Backed Finance's physically-backed tokenized US equities — TSLAx, COINx and NVDAx — the live, custody-backed successor to Synthetix's now-dead synthetic *sTSLA* family. Net asset value is reconstructed as the underlying equity price (Pyth) scaled by the on-chain corporate-action multiplier, and TE is computed against the token's market price on both a 24/7 decentralised venue (Solana DEX, hourly) and a centralised venue (Bybit, daily) over the cohort's first ∼12 months. The three tokens are cointegrated with NAV at a near-unit slope ($\beta \approx 0.999$, residual ADF $p = 0$) and TE is stationary and mean-reverting: the physically-backed 1:1 peg is a sound long-run anchor. The load-bearing TE regime is the *weekend/overnight gap* — mean |TE| widens while NYSE is shut (weekend ∼50–95 bps) and reliably compresses at the Monday open (∼88–92% of weekends converge, Wilcoxon $p < 10^{-5}$, a ∼73–86% median-magnitude drop); the dominant periodicity is weekly, not diurnal. Venue fragmentation is real but COINx-specific (a +73 bps DEX premium). The corporate-action multiplier is handled cleanly (a difference-in-differences isolating its own contribution is ≈ 0). We close with a cross-era comparison against the dead synthetic sTSLA (Chapter 12): the physically-backed traded price tracks NAV roughly 9× tighter (0.66 vs 5.8 % RMSE) and, unlike the synthetic, survives. A controlled same-period A/B is impossible — the two never coexisted — so the multi-protocol synthesis is deferred to D5.

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1 Executive summary

Scope. We measure the tracking error (TE) of Backed Finance's physically-backed, tokenized US equities — **TSLAx**, **COINx** and **NVDAx**, Solana SPL Token-2022 issues (Backed Assets (JE) Limited 2025; Solana Foundation 2025) — across the cohort's first ∼12 months (daily panel 232 to 236 observations, hourly 7,475 to 8,259, from 2025-07-08). Net asset value (NAV) is reconstructed as the underlying equity price (Pyth equity feed, (Pyth Network 2026)) scaled by the on-chain corporate-action multiplier; TE is then taken against the token's market price on a 24/7 decentralised venue (Solana DEX, hourly; (Dune Analytics 2026)) and a centralised venue (Bybit spot, USDT-quoted, USDT/USD basis ≈ 0; (Bybit 2026)). The cohort is the live, custody-backed successor to the now-dead synthetic *sTSLA* family on Synthetix — the "physical backing (alive)" versus "pure synthetic (dead)" comparator of the spec.

Headline — the token tracks NAV, and is cointegrated 1:1 with it. All three tokens are cointegrated with NAV at the 5% level (Engle–Granger on $\log \text{token} \sim \log \text{nav}$, (Engle and Granger 1987)) with a near-unit slope $\beta \approx 0.999$ (TSLA, COIN) and 0.997 (NVDA), and a strongly stationary cointegrating residual (ADF $p = 0.0$). The TE series itself is stationary and mean-reverting (ADF $p = 0.0$; KPSS does not reject stationarity). A VAR impulse-response confirms the transmission is *same-day* and mechanically ≈ 1:1 (contemporaneous NAV→token response $\approx +268/+414/+221$ bps for TSLA/COIN/NVDA), with negligible h=1–2 reversals (∼15–21 bps). The physically-backed 1:1 peg is the sound long-run anchor; any TE we observe is a *transient deviation* around it, not a structural drift. We caveat that this rests on a single ∼12-month launch panel, so the Granger/VAR machinery is low-power and we read it as indicative.

The load-bearing TE regime is the weekend / overnight gap. The dominant mispricing regime is mechanical and benign: while NYSE is shut, the token continues to trade 24/7 against a *frozen* last-close NAV (the Pyth equity feed is RTH-bound and carries the last close off-hours), so |TE| widens, then reliably collapses at the reopen. Mean |TE| orders *weekend* > pre > overnight ≈ post ≈ regular — the absolute-TE level is largest at the weekend for all three tokens (weekend mean |TE|: TSLA 52.2, COIN 95.0, NVDA 49.7 bps; weekend p95 TSLA 182, COIN 314, NVDA 156 bps). The signed mean is positive in every session (the token prints rich versus NAV) and is also largest at the weekend for TSLAx (28.4 bps) and NVDAx (17.1 bps); for COINx the signed level is positive throughout but dispersed across the closed buckets (overnight slightly highest at 26.9 bps, weekend 24.2), consistent with its venue-driven rather than closure-driven signed level. The periodogram peak is *weekly* (∼168 h, Fisher rank-1 for TSLA/NVDA), not diurnal, and day-of-week dominates the two-way ANOVA (Sunday peak, mid-week trough). Crucially, the gap *converges* at the Monday open: the median weekend-peak→Monday-open |TE| falls from 147.2→20.8 (TSLA), 222.3→60.1 (COIN) and 80.4→18.9 (NVDA) bps — a ∼73 to 86% median-magnitude compression, with ∼88 to 92% of weekends converging (Wilcoxon $p < 10^{-5}$). This is the expected signature of a physically-backed token whose underlying simply does not trade off-session; we frame the weekend |TE| as the intended TE definition under a frozen NAV, not a failure of backing.

Venue fragmentation is real, but COINx-specific. Against NAV, the CEX leg is tight (median TSLA −4.7 / COIN +1.3 / NVDA −1.7 bps), while the DEX leg is wider and, for COINx, persistently rich: the (DEX−CEX)/CEX premium is COINx-specific at a median +73.3 bps (TSLA +3.0, NVDA −0.8). Under stress (|DEX TE| >p95) the DEX prints rich on all three (TSLA +308, COIN +448, NVDA +267 bps). Consistently, COINx is the only token where |TE| is venue-driven rather than vol-driven (the high-vs-low vol Mann–Whitney test *fails* for COIN but holds for TSLA/NVDA, and the only nominal survivor of BH-FDR (Benjamini and Hochberg

1995) is the reverse COIN |TE| $\to \sigma$ signal — most plausibly a short-panel artefact, since σ is the rolling realised vol of the *underlying equity* (not the token), so a genuine |TE| $\to$underlying-vol channel is implausible).

Backing and multiplier integrity are clean. The proof-of-reserve snapshot (single poll, 2026-06-09) shows all three tokens fully backed: backing ratio 1.00005 (TSLA), 1.00089 (COIN), 1.00006 (NVDA), all ≥ 1.0. The corporate-action multiplier is flat at 1.0 for TSLAx/COINx and rises through four small dividend steps for NVDAx (cumulative +9.18 bps); a difference-in-differences isolating the step-attributable component (applied − naive) is ≈ 0 at each event, i.e. the dividend is absorbed into NAV with no spurious TE bump. We note the PoR is a point estimate (not yet a poll-forward series) and that the Solana mint/burn amounts are unreliable (used for counts/timing only).

Derivalink scorecard. Table 1 gives the eight-dimension peg-summary scorecard. It recasts the structural dimensions of the Ch6 structural scorecard (oracle, backing, corporate actions, custody, venue, liquidity) together with two peg / session-synthesis rows (peg/cointegration and the session-weekend arbitrage gate). The verdict: **peg, oracle fidelity, backing and corporate-action integrity all PASS**; the single load-bearing TE driver is the *restricted permissioned-arbitrage gate* interacting with the frozen off-session NAV (no atomic on-chain arb can close a weekend gap in real time); liquidity is thin and fragmented across one CEX and the Solana DEX; and the only venue-basis FLAG is COINx's +73 bps DEX premium.

Table 1: Derivalink eight-dimension peg-summary scorecard (synthesis of Phases 2/4/5/6/7; distinct from the Ch6 structural scorecard, which it recasts with peg and session-synthesis rows). Ratings: PASS = sound, OK = clean, FLAG = persistent anomaly, RESTRICTED = structural friction driving TE, THIN = data/liquidity limited.

Dimension	**TSLAx**	**COINx**	**NVDAx**
Peg / cointegration (β)	PASS (0.999)	PASS (0.999)	PASS (0.997)
Oracle fidelity (NAV)	PASS	PASS	PASS
Backing ratio (PoR)	PASS (1.00005)	PASS (1.00089)	PASS (1.00006)
Corporate actions (mult.)	FLAT (1.0)	FLAT (1.0)	STEP (+9.18 bps)
Session / arbitrage gate	RESTRICTED	RESTRICTED	RESTRICTED
Custody concentration	FLAG (100 % Alpaca)	FLAG (100 % Alpaca)	FLAG (100 % Alpaca)
Venue fragmentation	OK	FLAG (+73 bps)	OK
Liquidity / depth	THIN	THIN	THIN

TE distribution at a glance. Table 2 summarises the headline daily TE distribution per leg. The central tendency is small and roughly symmetric in the typical regime (mean |TE| ∼30–40 bps), with the dispersion and fat tails (stress mean |TE| 210 to 302 bps) concentrated in the weekend/overnight regime above.

Table 2: Daily TE (token vs NAV, multiplier-adjusted) headline distribution, full panel and the typical / stress split at the 95th-percentile |TE| threshold. All figures in bps.

Statistic	**TSLAx**	**COINx**	**NVDAx**
n (days)	232	236	236
Median TE	−4.7	+1.3	−1.7
MAE	39.6	53.8	41.1
Std	65.8	95.6	66.6
Mean |TE| (typical)	30.3	40.5	32.0
Mean |TE| (stress)	210.6	301.8	211.5

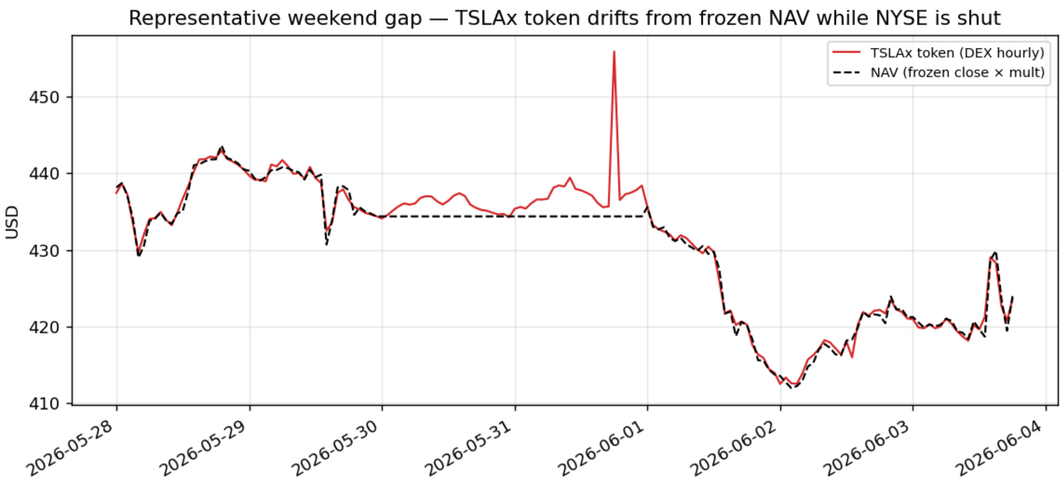

Figure 1: The load-bearing regime: weekend-peak versus Monday-open |TE| per token. The gap accumulated while NYSE is shut collapses ~90% at the reopen (Wilcoxon $p < 10^{-5}$), the signature of a physically-backed token tracking a frozen off-session NAV.

Implications for the Derivalink V2 synthetic-equity design.

1. **Physical backing supplies a hard redemption anchor.** The clean $\beta \approx 1$ cointegration and full PoR backing supply a hard redemption anchor that a pure-synthetic peg structurally lacks — a pure-synthetic equity has no custodied share to redeem against, so its peg rests entirely on oracle-plus-incentive plumbing. Chapter 12 measures this directly — a cross-era comparison, since the two designs never coexisted: the physically-backed *traded* price tracks NAV roughly 9× tighter than the synthetic's thin-pool price (0.66 % vs 5.8 % RMSE) and, unlike `sTSLA`, the token survives. A controlled same-period A/B is impossible; the broader multi-protocol synthesis remains D5. V2 should retain physical (or attested-redeemable) backing as the structural peg anchor.

2. **Freeze the NAV outside session, and label off-session TE as expected.** The weekend/overnight gap is mechanical: a 24/7 token against a frozen RTH close. V2 should either (a) explicitly freeze the synthetic outside the underlying's trading session, or (b) carry an off-session reference (futures/perp implied or a continuous index) so the gap is priced, not mislabelled as a depeg. Monitoring should bucket TE by TradFi session.

3. **Multi-source oracle, not a single RTH feed.** NAV here is a single Pyth equity feed that is high-fidelity but RTH-bound; Chainlink Data Streams (Chainlink Labs 2026) is a documented second source. A multi-source, off-hours-aware oracle would reduce the frozen-close ambiguity and harden against single-feed staleness.

4. **The arbitrage gate is the load-bearing friction.** The permissioned (KYC'd, T+ settled) mint/redeem path means no atomic on-chain arbitrage can close an off-session gap in real time. V2 should size the acceptable TE band against this gate width, and treat venue fragmentation (the COINx +73 bps DEX premium) as a liquidity-routing, not a peg, problem.

5. **Corporate-action multipliers work — keep them on-chain and apply before differencing.** NVDAx's four dividend steps were absorbed cleanly (DiD ≈ 0); the design of applying the multiplier on-chain to both price and supply before any TE/supply math is validated and should carry into V2.

Caveats. The panel is a single ∼12-month launch sample (51 to 52 weekends), so Granger/VAR are indicative, not confirmatory; GARCH on ∼232 daily observations sits at the lower edge of stability. The PoR is a single snapshot. Solana mint/burn amounts are unreliable (counts/timing only) and the EVM leg is sparse. The weekend NAV is the frozen-last-close by construction, so weekend |TE| partly reflects the underlying not trading — this is the intended TE definition, framed as such throughout.

2 Dataset characterisation

This chapter fixes the empirical object the rest of the report measures tracking error against: a three-token cohort of physically-backed tokenised US equities, the four market and reference data sources that bound it, the integrity-audit verdict, and the on-chain corporate-action mechanic (`multiplier`) that defines the net asset value (NAV) the token is benchmarked to. Throughout, NAV = underlying-equity Pyth close × on-chain multiplier, and tracking error is taken as $\text{TE} = (P_{\text{token}} - \text{NAV})/\text{NAV}$, expressed in basis points.

2.1 Cohort

The cohort is the three most liquid Backed Finance xStocks, each a Solana SPL Token-2022 mint with eight decimals (Solana Foundation 2025; Backed Assets (JE) Limited 2025), launched on 2025-06-30. Each token is a permissioned-primary, permissionless-secondary claim on a single underlying US equity held 1:1 in custody. Table 3 lists the canonical asset identifiers used across the data layer.

Table 3: Cohort: canonical asset identifiers (Solana SPL Token-2022, decimals 8, launch 2025-06-30).

Ticker	Canonical `asset_id`	Underlying
TSLAx	`backed.tslax.solana.v1`	Tesla, Inc. (TSLA)
COINx	`backed.coinx.solana.v1`	Coinbase Global, Inc. (COIN)
NVDAx	`backed.nvdax.solana.v1`	NVIDIA Corp. (NVDA)

The legacy Ethereum bToken siblings (bTSLA/bCOIN/bNVDA, decimals 18) exist but carry only sparse DeFi liquidity (two EVM mint events per ticker); they enter the report as supply-provenance depth, not as a market leg. The xStocks are Solana-primary, accounting for the overwhelming majority of traded activity.

2.2 Sources and coverage

Four independent feeds bound the panel, summarised in Table 4. The *market* side has two legs — a centralised-exchange (CEX) price from Bybit (USDT-quoted, so the USDT/USD basis is ≈ 0) (Bybit 2026) and a decentralised-exchange (DEX) hourly volume-weighted average price (VWAP) aggregated across Solana venues via Dune (Dune Analytics 2026). The *reference* side is the Pyth equity feed for the underlying (Pyth Network 2026): a regular daily close (`pyth_equity_*_usd`) plus an off-hours hourly extension (`*_ext`) available from 2025-10. A fourth GeckoTerminal Raydium feed is retained only as a recent per-pool cross-check.

Table 4: Per-source coverage (`prices`, per asset). Rows and windows are the audited ranges across the three tickers.

Role	Source	Cadence	Rows	Window
CEX market	`bybit_xstock_*`	daily	337–344	2025-07-08 → 2026-06-09
DEX market	`dune_solana_dex`	hourly VWAP	7 475–8 259	2025-06-27 → 2026-06-09
Underlying (RTH)	`pyth_equity_*`	daily	505	2024-06-03 → 2026-06-08
Underlying (off-hours)	`pyth_equity_*_ext`	hourly	3 258	2025-10-01 → 2026-06-09
DEX cross-check	`raydium_clmm_*`	daily	81–120	pool-age-limited (≥2026-02)

The headline TE analysis runs on the native daily grid where the Bybit CEX leg and the multiplier-adjusted Pyth NAV overlap: 232 days for TSLAx and 236 for COINx/NVDAx, all within 2025-07-08 → 2026-06-08. The hourly DEX and off-hours legs (∼7.5k–8.3k DEX observations) carry the intraday and weekend-gap decompositions in later chapters. The CEX and DEX legs are tightly co-moving (Pearson ρ between 0.98 and 0.996), an independent cross-validation of the two market sources. The cohort is a single-launch panel of roughly twelve months; this is the binding sample-size constraint and is flagged wherever inference depends on it.

2.3 Integrity-audit verdict: PASS

The Phase-0 dataset audit (`scripts/_audit_backed_dataset.py`, run 2026-06-09) returns a clean **PASS**: all structural invariants hold and cross-table coherence is sound, with no blocking findings. The data are a native grid with zero imputation — every raw row carries `is_imputed=False`, `imputation_method=`"native" and `gap_to_previous_native_s=` 0. The `prices` table has no duplicate $(\mathrm{ts}, \mathrm{asset\_id}, \mathrm{source})$ keys and price > 0 throughout; multipliers are strictly positive with enumerated action types; every `proof_of_reserve` backing ratio lies in $[0.98, 1.05]$; and `mint_burn_events` carry only enumerated event types. NAV was recomputed end-to-end with the multiplier applied (including NVDAx's current 1.000918), and the resulting TE medians are tight ($-4.7/{+1.3}/{-1.7}$ bps for TSLA/COIN/NVDA) while the standard deviations ($\approx$ 66–96 bps) and wide extremes — the ± 300 bps body widening to a -833 bps (COINx) / $+517$ bps (NVDAx) extreme — carry the weekend/overnight-gap signal that is the substantive subject of the report.

2.4 The on-chain multiplier mechanic

NAV is not the raw underlying price: Backed adjusts each token by an on-chain `corporate_action_multipliers` series so that the token tracks the *total-return*, dividend-and-split-adjusted equity rather than the bare price. The multiplier must therefore be applied before any TE or supply differencing — this is a non-negotiable methodological choice and NVDAx is the live test case. Two of the three tokens have a flat multiplier (a single 1.0 row since launch); NVDAx has five rows, i.e. four dividend-driven upward steps, for a cumulative drift of +9.18 bps. Table 5 lists the NVDAx step schedule.

Table 5: NVDAx on-chain multiplier schedule (`corporate_action_multipliers`). TSLAx and COINx remain flat at 1.0 over the whole panel.

Effective timestamp (UTC)	Multiplier	Step (bps)
2025-06-30 00:00	1.000000000	— (launch)
2025-10-02 23:55	1.000030866	+0.31
2025-12-26 23:55	1.000065822	+0.35
2026-04-02 11:20	1.000103091	+0.37
2026-06-04 00:30	1.000918076	+8.15

The four NVDAx steps are absorbed cleanly into NAV: the structural difference-in-differences check (Chapter "Natural experiments") finds the step-attributable (applied minus naive) component ≈ 0 or $\approx$ the step at each event, with no spurious bump — multiplier integrity is itself a PASS. The legacy synthetic sTSLA family, by contrast, has no such mechanic; the multiplier is precisely the live "backing physique" instrument the report contrasts against the dead synthetic cohort.

Figure 2 overlays the token market price against the multiplier-adjusted NAV across the panel, the visual anchor for the 1:1 peg that later chapters confirm via cointegration ($\beta \approx 1$, stationary residual).

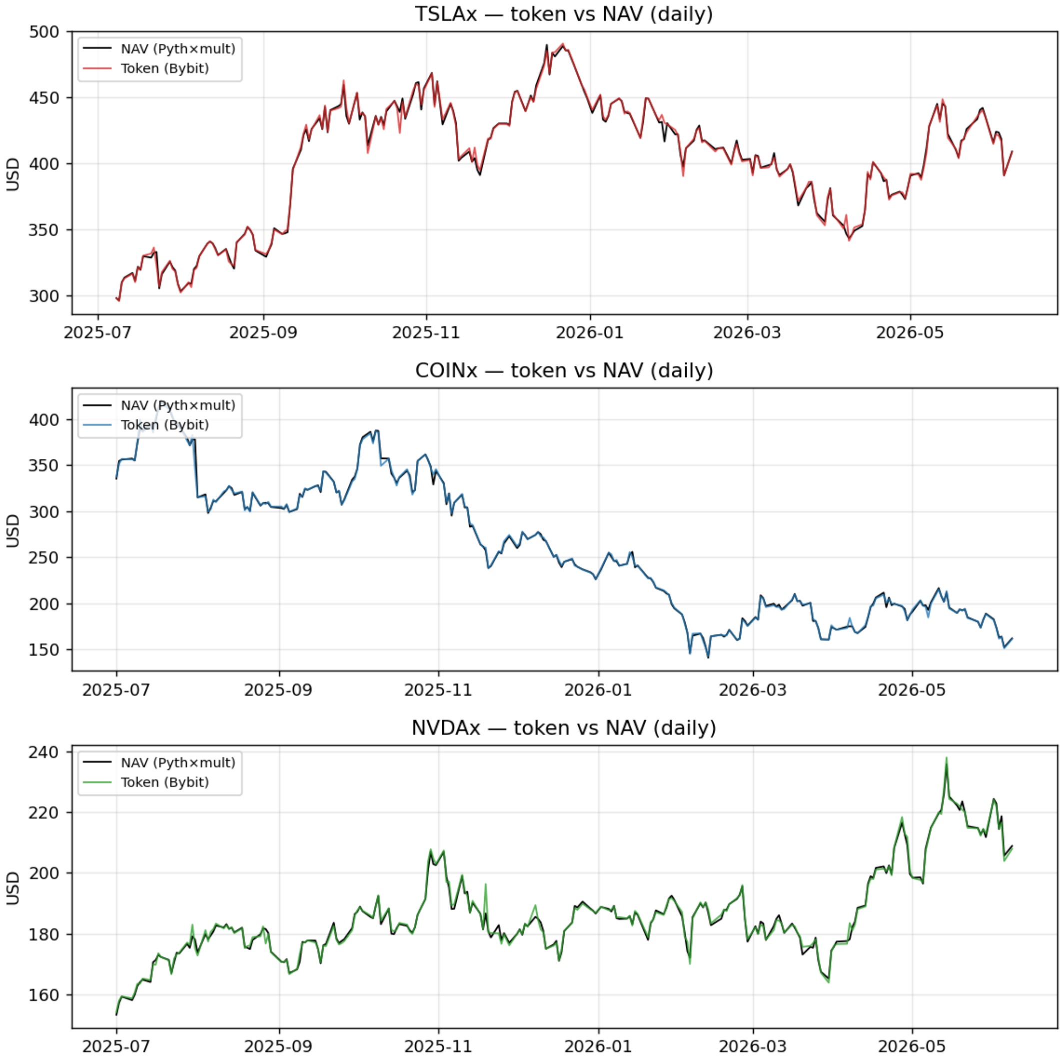

Figure 2: Token market price (Bybit CEX) versus multiplier-adjusted NAV (Pyth underlying × on-chain multiplier) for TSLAx, COINx and NVDAx over the ∼12-month panel. The token tracks NAV 1:1 in the long run; visible deviations concentrate in off-hours/weekend windows where the underlying is shut.

2.5 Limitations and caveats

The dataset is analysis-ready but four caveats constrain interpretation (not validity) and recur throughout the report:

1. **Short single-launch panel.** Roughly 232–236 daily observations (51–52 weekends) from

a single 2025-06-30 launch. Lower-power tests — Granger causality, VAR/IRF — are read as indicative, not confirmatory.

2. **Solana `mint_burn` amounts are unreliable.** Dune's Token-2022 transfer `amount` is inconsistently scaled, and the spell tags every Solana row "burn"; the Solana stream is kept for event timing/provenance only (counts: COINx 584, NVDAx 21 511, TSLAx 24 954), and the authoritative supply series is the PoR `circulating_supply` (plus the sparse EVM leg, two mints per ticker). Solana amounts are never summed.

3. **PoR is a single snapshot.** `proof_of_reserve` is one poll per token (2026-06-09): TSLAx 1.00005, COINx 1.00089, NVDAx 1.00006 — all ≥ 1.0, i.e. fully (slightly over-) backed, with custody concentrated in Alpaca (100% on COINx and NVDAx). This is a point estimate, not a time series; the poll-forward backing series is not yet built.

4. **Off-hours Pyth starts 2025-10.** The session-phase extension (`*_ext`) is shorter than the regular feed, so the full weekend-gap decomposition is complete only from 2025-10 onward; before that the regular daily close serves as the frozen reference. By construction the weekend NAV is the frozen last close — a portion of weekend |TE| therefore reflects the underlying simply not trading, which is the intended TE definition for a 24/7 token on a regular-trading-hours equity and is framed as such.

The GeckoTerminal Raydium feed is additionally depth-limited (per-pool, from pool creation) and is superseded by the full-history Dune DEX VWAP; it is retained as a recent cross-check only. The CEX/DEX venue share reported later is a rolling-24h activity proxy rather than a clean traded notional.

3 Multi-reference tracking-error descriptive statistics

This chapter characterises the daily tracking error (TE) of each xStock token against its net asset value (NAV). The TE reference is the *token-vs-NAV* deviation on the native daily grid, where the token price is the Bybit spot close (USDT-quoted, basis ≈ 0) and NAV $= p^{\text{Pyth equity close}} \times m^{\text{multiplier}}$, with the on-chain corporate-action multiplier applied *before* differencing so that NVDAx's dividend steps are absorbed into the NAV rather than mistaken for mispricing (Backed Assets (JE) Limited 2025; Pyth Network 2026). The panel is a single launch cohort spanning roughly twelve months from 2025-07-08 (TSLAx) / 2025-07-01 (COINx, NVDAx) to the 2026-06-08 cut-off: 232 daily observations for TSLAx and 236 for COINx and NVDAx. All statistics below are reported in basis points (bps). The token-versus-NAV level panel that motivates this decomposition is presented in the dataset characterisation chapter (the token vs. NAV figure).

3.1 Full-sample distribution

Table 6 reports the full-panel distribution per ticker. The central tendency is tight and close to par: mean TE is +2.2 bps (TSLAx), −1.8 bps (COINx) and +4.5 bps (NVDAx), with medians of −4.7, +1.3 and −1.7 bps respectively. The small gap between mean and median already signals asymmetry. Dispersion differs markedly across legs: COINx is the widest ($\sigma = 95.6$ bps, MAE = 53.8 bps), while TSLAx and NVDAx are comparable and tighter ($\sigma \approx 66$ bps, MAE ≈ 40 bps). The ordering COIN > NVDA $\approx$ TSLA recurs throughout the report and is, as the venue chapter shows, a COINx-specific DEX-venue phenomenon rather than a backing defect.

Table 6: Full-sample daily token-vs-NAV TE distribution (bps). Multiplier applied before differencing. Window per ticker as noted; n is the count of native daily observations.

Statistic	TSLAx	COINx	NVDAx
n (days)	232	236	236
Mean	+2.18	−1.77	+4.53
Median	−4.70	+1.26	−1.66
Std. dev.	65.84	95.55	66.59
MAE	39.61	53.81	41.09
Skewness	+0.58	−2.20	+2.28
Excess kurtosis	14.00	28.56	16.79
p_1	−166.9	−218.1	−141.5
p_5	−65.2	−90.3	−76.0
p_{95}	+85.0	+111.2	+87.4
p_{99}	+178.9	+256.9	+212.6
Min	−362.3	−833.3	−263.3
Max	+413.7	+521.9	+517.1
Jarque–Bera p	$< 10^{-3}$	$< 10^{-3}$	$< 10^{-3}$

Fat tails and non-normality. The distributions are decisively non-Gaussian. Excess kurtosis is extreme across all three legs — 14.0 (TSLAx), 28.6 (COINx) and 16.8 (NVDAx) — so the Jarque–Bera test rejects normality at any conventional level ($p < 10^{-3}$ for every ticker). The tail percentiles confirm the heaviness: the p_1/p_{99} spread reaches roughly ±200–260 bps for COINx and NVDAx (TSLAx is tighter, at ≈ ±170–180 bps) even though the inter-quartile body sits near par, and the extreme single-day moves run to −833 bps (COINx) and +517 bps (NVDAx). Skewness signs differ by leg — COINx is left-skewed (−2.20, driven by sharp discount events) while TSLAx and NVDAx are right-skewed (+0.58, +2.28, token-rich excursions). These fat tails are the statistical signature of the weekend/overnight regime documented in the session chapter: a body of near-par trading days punctuated by large dislocations while the underlying is shut.

3.2 Per-year breakdown

Table 7 splits the panel into its 2025 and 2026 partitions (roughly half the observations each). The central tendency and dispersion are broadly stable year-on-year — no leg shows a structural regime shift in location — but the tail shape migrates. For TSLAx the 2025 partition is left-skewed (−2.03) and the 2026 partition strongly right-skewed (+3.00), reflecting that the largest discount excursions land in 2025 (min −362 bps) and the largest premium excursion in 2026 (max +414 bps). COINx's left skew is heaviest in 2025 (−4.51, kurtosis 41.1, carrying the −833 bps trough) and moderates in 2026. NVDAx stays right-skewed in both years with dispersion easing into 2026 (σ 73.7 → 57.1 bps). The per-year cuts inherit the single-launch panel's small-n fragility (each ≈ 108–128 days) and should be read as descriptive, not as evidence of a trend.

Table 7: Per-year daily token-vs-NAV TE distribution (bps). The 2026 partition runs to the 2026-06-08 cut-off.

	TSLAx		COINx		NVDAx	
Statistic	2025	2026	2025	2026	2025	2026
n (days)	124	108	128	108	128	108
Mean	+1.25	+3.24	+1.11	−5.17	+7.55	+0.95
Median	−2.93	−8.18	+9.12	−10.51	+1.04	−5.23
Std. dev.	63.72	68.48	97.67	93.32	73.73	57.11
MAE	38.42	40.99	49.49	58.92	42.79	39.08
Skewness	−2.03	+3.00	−4.51	+0.93	+2.43	+1.63
Excess kurtosis	11.62	15.61	41.15	11.50	18.25	6.59
Min	−362.3	−178.8	−833.3	−421.7	−263.3	−125.4
Max	+196.0	+413.7	+331.3	+521.9	+517.1	+299.5

3.3 Typical versus stress regime

To separate the near-par trading body from the dislocation tail we partition each panel at the 95th percentile of |TE|. The resulting stress thresholds are 96.4 bps (TSLAx), 130.9 bps (COINx) and 125.8 bps (NVDAx); by construction roughly 12 days per leg fall into the stress regime. Table 8 contrasts the two regimes. The typical regime is well-behaved and near-Gaussian: dispersion collapses to $\sigma \approx 39$–51 bps, MAE to ≈ 30–41 bps, excess kurtosis is near zero, and Jarque–Bera *fails to reject* normality (TSLAx $p = 0.14$, COINx $p = 0.59$, NVDAx $p = 0.51$). The fat tails of the full sample are therefore entirely carried by the $\approx 5\%$ stress days, where the standard deviation inflates to 245–375 bps and the MAE to 211–302 bps — an order-of-magnitude amplification. This bimodal structure — a tight, approximately normal core plus a small heavy-tailed stress cluster — is the central descriptive fact of the xStocks TE and motivates the regime-aware treatment in the session and venue chapters.

Table 8: Typical versus stress regime, partitioned at the 95th percentile of |TE| (token-vs-NAV daily, bps). Stress threshold and n per regime as noted.

Regime	Statistic	TSLAx	COINx	NVDAx
Stress threshold |TE|		96.36	130.94	125.77
Typical	n	220	224	224
	Signed mean	+0.77	−0.18	−1.49
	Std. dev.	38.87	51.28	41.04
	MAE	30.29	40.52	31.96
	Excess kurtosis	−0.12	−0.19	+0.35
	Jarque–Bera p	0.14	0.59	0.51
Stress	n	12	12	12
	Signed mean	+27.90	−31.41	+116.88
	Std. dev.	245.38	375.14	214.65
	MAE	210.63	301.80	211.54
	Min	−362.3	−833.3	−263.3
	Max	+413.7	+521.9	+517.1

3.4 Rolling dispersion

The rolling standard deviation of TE confirms that dispersion is itself time-varying rather than constant. Table 9 reports the 30-day and 90-day trailing σ at the cut-off alongside the full-panel σ (the entire ≈ 12-month span, $n \approx 232$–236 trading observations). For all three legs the most recent 30-day window is *tighter* than the full-sample figure — TSLAx 38.3 vs 65.8, COINx 88.9

vs 95.6, NVDAx 57.1 vs 66.6 bps — with the 90-day window sitting in between. This indicates that the heaviest dislocation days are concentrated earlier in the panel and that conditioning behaviour is non-stationary, consistent with the GARCH persistence estimated in the level-1 chapter. Given the single-launch panel, these rolling figures are indicative of recent calm rather than a confirmed structural de-risking.

Table 9: Rolling TE standard deviation (bps): 30-day and 90-day trailing values at the 2026-06-08 cut-off, versus the full-panel standard deviation. The "full panel" column denotes the entire $\approx$ 12-month span, which carries only $\approx$ 232–236 trading observations rather than 365 daily points.

Window	TSLAx	COINx	NVDAx
30-day (last)	38.29	88.92	57.08
90-day (last)	72.71	97.24	61.75
Full panel ($n \approx 232$–236)	65.84	95.55	66.59

Summary. The token-vs-NAV TE of all three xStocks is centred near par with a tight, near-normal trading core and extreme fat tails (full-sample excess kurtosis 14–29) carried by a $\approx 5\%$ stress cluster. COINx is the widest and left-skewed; TSLAx and NVDAx are tighter and right-skewed. The bimodal typical/stress structure, the year-on-year stability of central tendency with migrating tail shape, and the contracting recent rolling dispersion together set up the regime-aware analysis that follows. All quantitative claims here rest on a short single-launch panel of $\approx$ 232–236 daily observations and should be read as descriptive.

4 TE level-1 decomposition: volatility, liquidity, and conditional dynamics

This chapter regresses the daily tracking error (TE) of each xStock against its two candidate structural drivers — the realised volatility of the underlying equity ($\sigma_{\text{underlying}}$) and on-chain liquidity ($\log \text{Liq}$) — and then characterises the conditional dynamics of the TE series with a GARCH suite and a HAR model. The recurring methodological caveat for this chapter is the *small sample*: the single-launch panel yields only $\sim$232–236 daily TE observations per leg (212–216 after lagging and complete-case alignment for the regressions). All inference below is correspondingly indicative rather than confirmatory.

4.1 OLS specification

We estimate two cross-sectional specifications on the daily grid, both with heteroskedasticity-robust (HC1) standard errors:

$$\text{te\_bps}_t = \beta_0 + \beta_1\,\sigma_{\text{underlying},t} + \beta_2\,\log \text{Liq}_t + \varepsilon_t, \quad (1)$$

$$|\text{te\_bps}_t| = \gamma_0 + \gamma_1\,\sigma_{\text{underlying},t} + \gamma_2\,\log \text{Liq}_t + \eta_t, \quad (2)$$

where $\sigma_{\text{underlying}}$ is expressed in annualised percent and $\log \text{Liq}$ is the natural log of the daily DEX liquidity proxy. The signed specification asks whether vol or liquidity *shifts the level* of the basis; the absolute specification asks whether they *widen the magnitude* of mispricing.

Table 10: Level-1 OLS of signed and absolute daily TE (bps) on underlying volatility and log-liquidity. HC1 t-statistics in parentheses. n = regression sample after lagging and complete-case alignment. $\sigma_{\text{underlying}}$ never enters significantly; only $\log \text{Liq}$ on $|\text{TE}|$ is significant (TSLA, COIN).

	Signed TE (te_bps)			Absolute TE (|te_bps|)		
	TSLA	COIN	NVDA	TSLA	COIN	NVDA
const	−105.12	−4.67	−4.89	−99.77	10.30	−3.85
	(−1.54)	(−0.11)	(−0.11)	(−1.83)	(0.29)	(−0.11)
$\sigma_{\text{underlying}}$	−15.56	1.68	68.92	20.68	−30.60	35.99
	(−0.25)	(0.04)	(0.74)	(0.44)	(−0.79)	(0.46)
$\log \text{Liq}$	9.10	0.11	−1.25	**10.33**	**5.05**	2.72
	(1.78)	(0.04)	(−0.45)	(**2.48**)	(**2.17**)	(1.32)
R^2	0.015	2×10^{-5}	0.003	0.032	0.011	0.009
$\bar{R}^2$	0.005	−0.009	−0.006	0.023	0.002	−0.0003
F p-value	0.198	0.998	0.707	0.046	0.096	0.362
n	212	216	216	212	216	216

The headline result of Table 10 is that **the daily TE level is essentially orthogonal to both underlying volatility and liquidity**: the signed-TE R^2 is at most 1.5% (TSLA) and collapses to 2×10^{-5} for COIN and 0.3% for NVDA, with no signed-specification F-test significant. Crucially, $\sigma_{\text{underlying}}$ carries an insignificant coefficient in every single regression (all $|t| < 0.8$): the volatility of the equity that the token tracks does *not* explain its mispricing level or magnitude. This is consistent with the physical-backing mechanism — the on-chain NAV ingests the equity price by construction, so underlying vol passes through to both legs and nets out of the basis.

The one surviving driver is liquidity, and only on the *magnitude* of TE: in the absolute specification $\log \text{Liq}$ is significant for TSLA ($b = +10.33$, $t = 2.48$) and COIN ($b = +5.05$, $t = 2.17$) but not NVDA ($b = +2.72$, $t = 1.32$, $p = 0.19$). The *positive* sign is notable — higher logged liquidity coincides with *wider* $|\text{TE}|$ — which we read not as a causal liquidity-deepens-mispricing channel but as a co-movement artefact: episodes of elevated trading activity (and hence measured liquidity) on the DEX leg coincide with the venue-fragmentation dislocations documented in the venue chapter, particularly for COINx. Even so, the explained variance remains trivial ($|\text{TE}|$ $R^2 \leq 3.2\%$), so liquidity is at best a marginal magnitude driver and certainly not a level driver.

4.2 Regression diagnostics

Table 11 reports Breusch–Pagan (heteroskedasticity), Durbin–Watson (first-order autocorrelation), and Ljung–Box at lag 22 (residual serial correlation) for both specifications. Reassuringly, the HC1-robust covariance already guards against the heteroskedasticity that Breusch–Pagan would flag, and in fact no Breusch–Pagan test rejects homoskedasticity at 5% ($p \geq 0.13$). Durbin–Watson statistics sit close to 2 throughout (1.83–2.16), indicating little first-order residual autocorrelation. The only diagnostic flag is the Ljung–Box statistic on the *signed*-TE residuals for TSLA ($p = 0.020$), pointing to mild higher-order serial dependence in the signed level — which is precisely the conditional structure the GARCH suite below is designed to absorb; the absolute-TE residuals are clean for all three legs ($p \geq 0.67$).

Table 11: Level-1 OLS residual diagnostics. BP = Breusch–Pagan LM statistic (p); DW = Durbin–Watson; LB(22) = Ljung–Box at lag 22 (p). Only signed-TE TSLA shows mild residual serial correlation (LB $p = 0.020$).

	Signed TE			Absolute TE		
	TSLA	COIN	NVDA	TSLA	COIN	NVDA
BP LM	4.10	2.94	1.71	4.06	3.38	1.41
BP p	0.129	0.230	0.425	0.132	0.185	0.495
Durbin–Watson	1.83	2.16	2.07	1.91	1.90	1.88
LB(22) p	**0.020**	0.560	0.450	0.989	0.952	0.673

4.3 Conditional volatility of TE: GARCH suite

To capture the conditional-variance dynamics of the basis, we fit three volatility models to the *level* te_bps series of each leg: the symmetric GARCH(1,1) (Bollerslev 1986), the threshold GJR-GARCH (Glosten, Jagannathan, and Runkle 1993), and the EGARCH of Nelson (1991), each with a Student-t innovation. All nine fits converged. Table 12 reports the persistence ($\alpha + \beta$, or the equivalent for the asymmetric models), the leverage term γ where defined, the tail parameter ν, and the information criteria.

Table 12: GARCH suite fitted to the level te_bps series ($n \approx 232$–236, Student-t innovations). Persistence = $\alpha + \beta$ (GARCH/GJR) or β (EGARCH). GARCH(1,1) wins on BIC for all three legs; EGARCH wins on AIC by a trivial margin. The sample is at the lower edge of GARCH stability.

Ticker	Model	α	β	γ	ν	Persist.	AIC	BIC
TSLA	GARCH(1,1)	0.096	0.718	—	2.24	0.813	2481.6	**2498.8**
	GJR-GARCH	0.287	0.506	−0.242	2.46	0.672	2482.7	2503.4
	EGARCH	0.578	0.744	0.258	2.05	0.744	**2480.1**	2500.7
COIN	GARCH(1,1)	0.000	0.496	—	2.54	0.496	2664.0	**2681.3**
	GJR-GARCH	0.000	0.496	0.000	2.54	0.496	2666.0	2686.8
	EGARCH	−0.045	0.388	−0.190	2.60	0.388	**2663.5**	2684.3
NVDA	GARCH(1,1)	0.301	0.312	—	2.71	0.613	2539.4	**2556.8**
	GJR-GARCH	0.479	0.375	−0.479	2.62	0.614	2537.6	2558.4
	EGARCH	−0.137	0.885	0.261	2.79	0.885	**2536.4**	2557.2

Two observations stand out. First, **the conditional variance of TE is moderately persistent but well short of the near-unit-root persistence typical of asset returns**: under the parsimonious GARCH(1,1) the persistence is 0.813 (TSLA), 0.496 (COIN), and 0.613 (NVDA). TSLAx shows the most volatility clustering in its basis; COINx the least, with its GARCH(1,1) α pinned to zero — conditional-variance shocks in the COIN basis decay essentially within a single day, consistent with the venue-noise (rather than clustered-vol) reading of COINx mispricing developed in the venue and causality chapters. Second, **the very low tail parameters** ($\nu \approx 2.0$–2.7, near the heavy-tail boundary) confirm that the TE distribution is strongly leptokurtic — extreme basis excursions are far more frequent than Gaussian innovations would imply.

On model selection, BIC — which penalises parameters more heavily and is the appropriate criterion in this small sample — prefers the parsimonious GARCH(1,1) for all three legs, whereas AIC marginally favours EGARCH. The AIC gaps are trivial (1.5–3.0 points) and the asymmetric γ terms are not robustly signed across models, so we report GARCH(1,1) as the parsimonious benchmark and treat the asymmetry evidence as inconclusive at this sample size.

4.4 HAR: no realised long-memory structure

Finally we fit the Heterogeneous Autoregressive (HAR) model of Corsi (2009) to |te_bps|, regressing it on its daily, weekly, and monthly lagged averages to test for the cascade long-memory structure characteristic of realised volatility. The result is unambiguous: **the HAR explains essentially none of the variation in |TE|**, with $R^2 = 0.009$ (TSLA), 0.003 (COIN), and 0.002 (NVDA), every adjusted-R^2 negative, and not a single daily/weekly/monthly component significant at any conventional level (all component $|t| < 1$). The only significant HAR coefficient is the intercept (∼39–41 bps), i.e. a constant baseline |TE| with no self-predictive cascade. The absence of HAR structure tells us that the day-to-day magnitude of xStock mispricing is *not* predictable from its own recent history at the daily horizon — the predictable structure in these series is calendar-driven (the weekend/session regime documented in the temporal chapter), not realised-volatility long-memory.

4.5 Summary

At level 1, the daily xStock basis is orthogonal to underlying equity volatility and only marginally related (in magnitude, not level) to liquidity for TSLAx and COINx. Its conditional variance is moderately persistent and heavy-tailed but lacks both the near-unit-root persistence and the HAR long-memory of a typical realised-volatility series. These statistical features are consistent with the physical-backing mechanics — underlying vol passes through both legs and cancels — and they point the explanatory burden away from vol/liquidity covariates and toward the calendar-and-venue structure analysed in the following chapters. All conclusions are tempered by the ∼232-obs single-launch sample, which places the GARCH fits at the lower edge of stability and renders the small R^2 figures statistically fragile.

5 TE level-2: temporal structure and TradFi sessions

This chapter is the load-bearing result of the report. Having established in the descriptive and level-1 chapters that tracking error (TE) is mean-reverting and largely orthogonal to the token's own realised volatility, we now show *when* the deviation occurs. The answer is unambiguous and structural: |TE| is governed by the New York Stock Exchange (NYSE) trading calendar, not by a diurnal crypto cycle. It widens while the underlying equity is closed — monotonically from the regular session through to the weekend — and collapses at the Monday reopen.

All statistics in this chapter are computed on the hourly DEX panel: the token's cross-venue VWAP from Dune against a *continuous* hourly NAV reconstructed from Pyth (∼8.2–8.3k hourly observations for TSLAx/NVDAx, ∼7.5k for COINx, from launch to 2026-06-09). TE is in basis points (bps), multiplier-adjusted before differencing. Sessions are assigned in US Eastern time against the NYSE calendar: *regular* (09:30–16:00 ET on a trading day), *pre* (04:00–09:30), *post* (16:00–20:00), *overnight* (20:00–04:00 next trading day), and *weekend* (Friday post-close through Sunday). NYSE weekday holidays are *not* modelled: the session assignment buckets purely on weekday and ET clock time, so the ∼9–10 weekday holidays in the panel (Jul 4, Thanksgiving, Christmas, ...) fall into their clock-time *pre/regular/post/ overnight* buckets despite the NAV being a frozen last close on those hours. We return to this limitation in the caveats below.

The frozen-NAV weekend, by construction. A point of definition must be stated up front. Outside the cash session the equity does not trade, so the Pyth reference NAV is the *frozen last close* carried forward until the next open. The weekend |TE| therefore measures the 24/7 token price drifting away from a stale anchor, not two live prices diverging. This is the intended TE definition for a physically-backed instrument whose underlying observes a five-day calendar — the gap is precisely the cost of holding a tokenized equity through a market closure — but the reader should not read the weekend bucket as an oracle fault. It is the mechanical signature of session asymmetry between a continuous secondary market and a discontinuous primary one.

5.1 Per-session |TE| buckets

Table 13 reports the absolute-TE distribution by session for each ticker. The ordering predicted by the session-asymmetry hypothesis holds for all three tokens: mean |TE| rises weekend > pre > overnight ≈ post ≈ regular. The regular session — the only window in which token and NAV are both live and the permissioned primary-market arbitrage gate is open — is the tightest for every ticker (mean |TE| of 26.2 / 59.5 / 20.8 bps for TSLAx / COINx / NVDAx). The weekend is the widest, with mean |TE| of 52.2 / 95.0 / 49.7 bps and a p95 reaching 182 / 314 / 156 bps. The *absolute*-TE ordering, with the weekend largest, holds for all three tickers. The signed mean is positive in every session for every ticker (token rich versus NAV); for TSLAx and NVDAx the signed mean is also largest at the weekend (28.4 and 17.1 bps), consistent with the secondary market pricing in expected Monday moves against a frozen Friday close. For COINx the signed mean is positive but dispersed across the closed buckets — it is in fact slightly highest in the *overnight* bucket (26.9 bps) rather than at the weekend (24.2 bps) — consistent with COINx's venue-driven rather than closure-driven signed level (see the volatility-regime result below).

COINx sits at roughly double the level of the two equity tokens in every bucket. As the venue chapter develops, this is a COINx-specific DEX-liquidity premium rather than a session effect — the session *shape* is the same for all three, only the COINx *level* is shifted up.

Table 13: Absolute TE by TradFi session (hourly DEX panel, bps). Mean / median / p95 with bucket count n. Ordering weekend > pre > overnight ≈ post ≈ regular holds for all three tickers.

Session	n	mean	median	p95
TSLAx				
regular	1473	26.22	18.32	72.91
pre	1470	47.44	21.58	173.96
post	983	29.67	14.43	96.54
overnight	1966	32.97	15.70	127.87
weekend	2353	52.23	28.49	181.99
COINx				
regular	1388	59.47	35.31	177.14
pre	1351	75.53	34.43	277.44
post	871	58.58	25.98	217.71
overnight	1763	61.56	29.39	221.53
weekend	2102	94.97	53.11	313.86
NVDAx				
regular	1477	20.84	14.78	57.60
pre	1473	37.52	19.02	130.05
post	984	21.58	12.47	68.01
overnight	1967	23.85	13.38	75.89
weekend	2358	49.74	30.01	156.48

Figure 3 renders the same ordering visually: the per-session |TE| profile steps up from the regular session into the closed buckets and peaks at the weekend for all three legs.

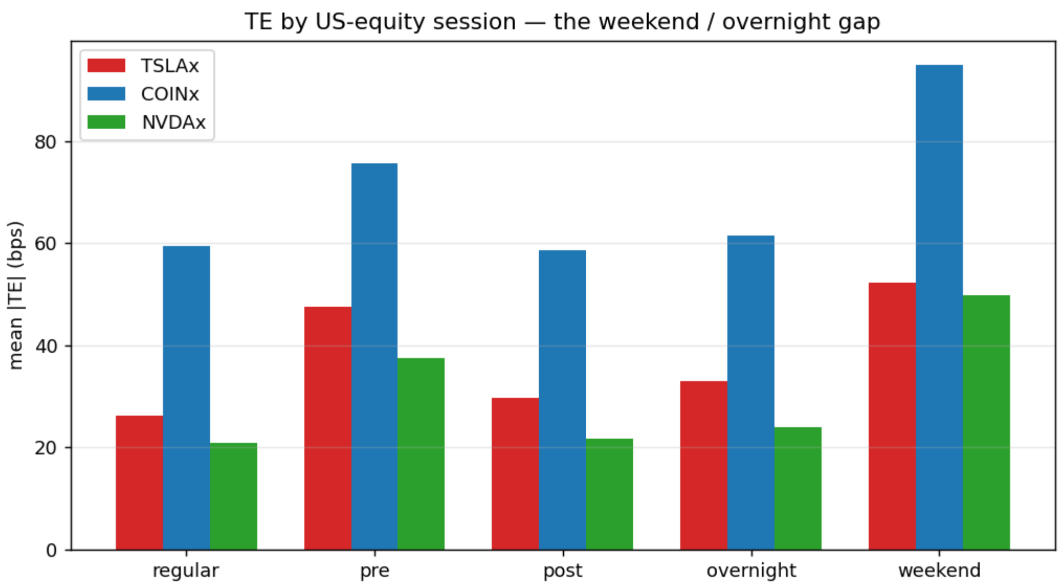

Figure 3: Mean absolute TE by TradFi session for TSLAx, COINx and NVDAx. The deviation is tightest in the regular session (token and NAV both live, primary-market gate open) and widens monotonically into the closed buckets, peaking at the weekend.

5.2 Two-way ANOVA: session and day-of-week

To test whether the session ordering survives conditioning on the day of week we fit a two-way fixed-effects ANOVA on |TE| with a *session* factor and a *day-of-week* (dow) factor (Table 14). Both main effects are overwhelmingly significant for all three tickers ($p \to 0$), and the day-of-week effect is the larger of the two: for the session×dow specification the dow F-statistic reaches 65.7 (TSLAx), 29.1 (COINx) and 99.1 (NVDAx). Re-running with an hour-of-day factor in place of the session bucket leaves dow dominant and shrinks the hour effect to near-insignificance (COINx hour $p = 0.24$). The pattern points to a *calendar-driven* rather than a clock-driven mechanism.

The model R^2 is modest throughout (0.026–0.083). This is expected and not a weakness of the result: most TE variance is idiosyncratic minute-to-minute venue noise, and the calendar factor explains the systematic, repeatable component on top of that noise floor. The day-of-week means make the mechanism concrete — |TE| peaks on *Sunday* (TSLAx mean 64.2, COINx 108.0, NVDAx 61.6 bps) and troughs mid-week around Wednesday (27.3 / 48.8 / 24.2 bps), i.e. it accumulates across the closed weekend and is at its lowest after two-plus full trading days.

Table 14: Two-way ANOVA on |TE|. Main-effect F-statistics ($p \to 0$ unless shown). "session×dow" uses session and day-of-week factors; "hour×dow" replaces session with hour-of-day. Day-of-week dominates in both.

	session × dow		hour × dow		
Ticker	session F	dow F	hour F	dow F	R^2
TSLAx	25.13	43.60	2.06	65.71	0.051–0.057
COINx	6.25	11.53	1.20†	29.05	0.026
NVDAx	35.78	28.03	3.79	99.05	0.077–0.083

†COINx hour-of-day effect not significant ($p = 0.24$); all other reported F-statistics have $p < 0.01$, with the day-of-week and session main effects at $p \to 0$.

5.3 Spectral analysis: a weekly, not daily, period

The ANOVA establishes that the calendar matters; a periodogram identifies its dominant frequency directly. We compute the Schuster periodogram of the hourly TE series and apply a Fisher g-test for a significant peak (Fisher 1929). For all three tickers the test rejects white noise (Fisher $p \to 0$) and the *single* dominant spectral peak sits at a weekly period: 168.9 h for TSLAx, 166.4 h for NVDAx, and 166.8 h within the weekly band for COINx (Table 15). The 24-hour (diurnal) component is by contrast weak and far from the peak — it ranks 193rd in its frequency band for TSLAx and 1576th for NVDAx, with two to three orders of magnitude less power than the weekly line. The spectrum thus corroborates the ANOVA: the structure is the weekly trading calendar (the recurring weekend closure), not a crypto-native intraday cycle.

This spectral reading should be tempered by the microstructure literature on discrete, noisy high-frequency price differences. The hourly TE is built from VWAP prints whose sampling noise is non-trivial relative to the signal; integrated-variance estimators robust to such noise — two-scale realised variance (Zhang, Mykland, and Aït-Sahalia 2005) and realised-kernel methods (Barndorff-Nielsen et al. 2008) — caution that naive high-frequency power spectra over-weight the noise floor. We use the periodogram here only to *rank* periodicities (weekly $\gg$ daily), a conclusion that is robust to the noise level, rather than to interpret the absolute power at any single frequency.

Table 15: Schuster periodogram / Fisher g-test on hourly TE. The single dominant peak is weekly ($\sim$168 h) for all three tickers; the 24 h component is low-ranked within its band. Power in arbitrary spectral units.

Ticker	Fisher g	Fisher p	peak period (h)	24h rank in band	168h rank in band
TSLAx	0.0254	$\to 0$	168.9	193 / 4114	1 / 4114
COINx	0.0183	$\to 0$	83.4‡	92 / 4062	14 / 4062
NVDAx	0.0283	$\to 0$	166.4	1576 / 4135	1 / 4135

‡COINx's global peak falls at 83.4 h (a half-week harmonic, consistent with its heavier intra-week DEX-liquidity noise); the weekly line nonetheless ranks high (14th of 4062) and dominates the diurnal band, so the weekly-over-daily ordering is preserved.

5.4 Weekend → Monday-open convergence

The session and spectral results predict a sharp, repeatable event: the accumulated weekend gap should collapse when NYSE reopens and live arbitrage resumes. We test this per weekend by pairing the peak weekend |TE| with the |TE| at the following Monday open. A one-sided Wilcoxon signed-rank test rejects equality in favour of convergence for all three tickers at $p < 10^{-5}$ (Table 16). The median weekend peak compresses from 147.2 to 20.8 bps for TSLAx, 222.3 to 60.1 for COINx, and 80.4 to 18.9 for NVDAx — a $\sim$86% (TSLAx) to $\sim$73% (COINx) median compression. The share of weekends in which the gap converges at reopen is 92.3% (TSLAx, $n = 52$), 92.2% (COINx, $n = 51$) and 88.5% (NVDAx, $n = 52$). The convergence is the cleanest single piece of evidence that the peg is real and the weekend widening is transient deviation, not drift: when the primary-market gate reopens, the deviation is arbitraged away within the first hour of the cash session in roughly nine weekends out of ten.

Table 16: Weekend peak → Monday-open convergence of |TE| (bps, median across weekends). One-sided Wilcoxon signed-rank test (peak > open). Convergence confirmed for all three tickers.

Ticker	n_{wknd}	peak med.	open med.	% converged	Wilcoxon p
TSLAx	52	147.23	20.78	92.3	$< 10^{-5}$
COINx	51	222.26	60.07	92.2	$< 10^{-5}$
NVDAx	52	80.40	18.86	88.5	$< 10^{-5}$

Figure 4 shows the weekend-peak versus Monday-open distribution: the mass shifts decisively toward the diagonal's reopen side, the visual counterpart of the Wilcoxon result.

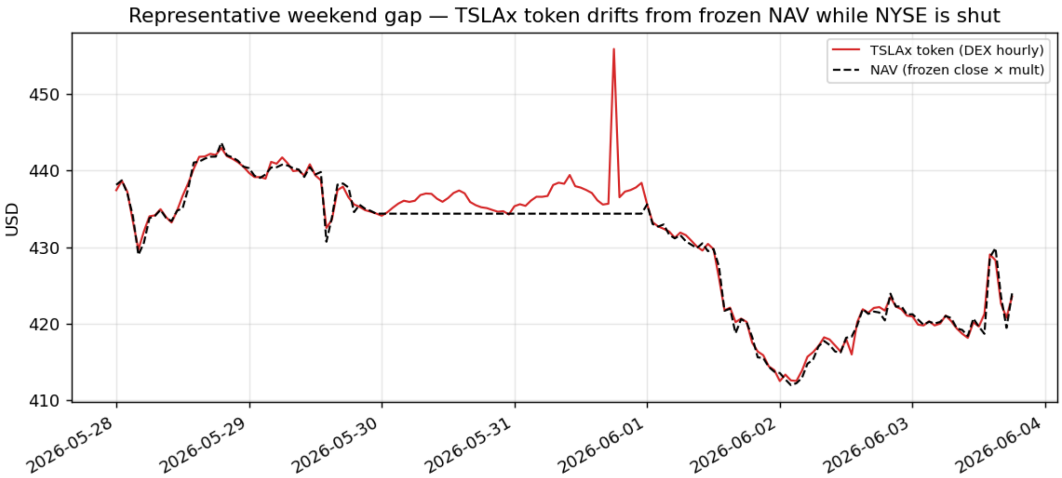

Figure 4: Weekend-peak |TE| against the subsequent Monday-open |TE|. The gap accumulated while NYSE is shut collapses at the reopen for ∼90% of weekends, the visual counterpart of the Wilcoxon convergence test.

5.5 Volatility-regime conditioning

Finally we ask whether the session/weekend widening is really a closure effect or merely tracks high-volatility periods that happen to cluster. We split hours by a 5-day rolling realised-volatility regime (median split) and compare |TE| across regimes with a one-sided Mann–Whitney test (Table 17). The answer differs across tickers and is itself informative. For TSLAx, high-vol hours do carry larger |TE| (40.7 vs 33.8 bps, $p \to 0$); for NVDAx the effect is in the same direction but negligible (32.7 vs 32.0). For **COINx the relationship fails outright**: high-vol |TE| is in fact *lower* than low-vol (57.2 vs 81.8 bps; Mann–Whitney does not reject high ≤ low, $p = 1.0$). COINx's TE is therefore driven by DEX venue-liquidity conditions rather than by underlying volatility — the same conclusion reached independently by the causality chapter (where the only robust Granger signal is the reverse, COINx $|\text{TE}| \to \sigma$). Crucially, the session and weekend structure documented above is *not* a restatement of a volatility regime: the calendar effect is present for COINx even though COINx shows no positive vol-to-TE relationship at all.

Table 17: |TE| by realised-volatility regime (5-day rolling RV, median split; bps). One-sided Mann–Whitney (high > low). TSLAx confirms; NVDAx negligible; COINx fails (venue-liquidity, not vol, driven).

Ticker	hi mean	lo mean	hi median	lo median	hi > lo
TSLAx	40.67	33.83	20.72	17.47	yes ($p \to 0$)
COINx	57.23	81.77	31.07	39.93	no ($p = 1.0$)
NVDAx	32.72	32.05	18.94	16.11	negligible ($p \to 0$)

5.6 Caveats and reading

Four caveats qualify the strength of these conclusions. First, the panel is a single launch cohort of ∼12 months: 51–52 weekends per ticker is enough for a decisive Wilcoxon result but the periodogram and ANOVA effect sizes should be read as indicative of a stable regime rather than as a long-run estimate. Second, the weekend NAV is the frozen last close by construction (see above), so the weekend bucket measures the intended "market-closed" TE and must not be conflated with an oracle malfunction. Third, the hourly TE inherits VWAP sampling noise; the periodogram is used only to rank periodicities, for which the microstructure-noise concern (Zhang, Mykland, and Aït-Sahalia 2005; Barndorff-Nielsen et al. 2008) does not overturn the weekly-over-daily verdict. Fourth, NYSE weekday holidays are not modelled by the session assignment (see above): the ∼9–10 weekday holidays in the panel are mislabelled into their clock-time *pre* / *regular* / *post* / *overnight* buckets, each carrying a frozen last-close NAV. This mildly contaminates the non-weekend buckets with frozen-NAV holiday hours, nudging them toward the weekend signature — which makes the weekend > regular ordering *conservative* (the contamination works against, not for, the reported gap). With those caveats the chapter's headline stands on three independent legs that agree: the session means, the weekly spectral peak, and the Monday-open Wilcoxon convergence all identify the *frozen-NAV weekend gap* as the dominant, structural, and transient TE regime of the xStocks cohort.

6 Venue decomposition and cross-venue frictions

The peg and session analyses (preceding chapters) treat "the token price" as a single object. In practice a Backed xStock trades on two structurally different venues — a centralised order book (Bybit spot, USDT-quoted) and a 24/7 Solana decentralised market (Dune cross-venue VWAP) — and the tracking error (TE) inherited by a holder depends on which venue clears their order. This chapter decomposes TE by venue against the common NAV reference (Pyth underlying × on-chain multiplier), following the tracking-error framing of Roll (1992): TE is the standard deviation of the return differential between the replicating instrument and its benchmark, here applied per venue so that the venue contribution is isolated from the peg itself. All spreads are reported in basis points relative to the CEX leg, spread = $(P_{\mathrm{DEX}} - P_{\mathrm{CEX}})/P_{\mathrm{CEX}}$, with the USDT/USD basis netted to ≈ 0 (Bybit USDT-quoted). The panel is the common ∼12-month daily window ($n \approx 232$–236); read all venue results as indicative on a single-launch cohort.

6.1 CEX-versus-NAV and DEX-versus-NAV tracking error

Table 18 reports the per-venue TE distribution against NAV. The centralised leg tracks NAV tightly for all three tokens: the CEX-vs-NAV median is within a few basis points of zero (TSLA −4.7, COIN +1.3, NVDA −1.7 bps) and its dispersion is the lowest of the two venues ($\sigma \approx 66$–96 bps). The decentralised leg is materially wider and systematically richer: the DEX-vs-NAV median is +8.0 bps for TSLA and −8.7 bps for NVDA, but +59.9 bps for COIN, with a DEX dispersion roughly 2.0–2.6× the CEX dispersion in every case (σ up to 241 bps on COIN). The DEX venue thus carries almost all of the venue-attributable TE; the CEX leg is, to first order, a clean NAV tracker. One construction caveat: this daily venue table benchmarks the (hourly-to-daily-mean) DEX leg against the RTH-only daily Pyth NAV, whereas the hourly session decomposition elsewhere in this report benchmarks the hourly DEX leg against the continuous NAV that freezes the last close off-hours. The two NAV references diverge precisely off-session, so the daily DEX-vs-NAV magnitudes here (+8.0/+59.9/−8.7 bps) are not directly comparable with the hourly weekend DEX-TE figures.

Table 18: Per-venue tracking error against NAV (daily, common window). CEX = Bybit (USDT-quoted, basis ≈ 0); DEX = Solana cross-venue VWAP; NAV = Pyth underlying × multiplier. All entries in bps.

Venue	Statistic	TSLAx	COINx	NVDAx
CEX vs NAV	median	−4.7	+1.3	−1.7
	mean	+2.2	−1.8	+4.5
	std	65.8	95.6	66.6
	p5 / p95	−65.3 / +85.0	−90.3 / +111.2	−76.0 / +87.4
DEX vs NAV	median	+8.0	+59.9	−8.7
	mean	+7.7	+56.4	+8.5
	std	164.0	240.5	137.6
	p5 / p95	−248.9 / +282.7	−342.3 / +467.5	−194.1 / +232.7

6.2 The COINx-specific DEX premium

The cross-venue spread (DEX relative to CEX) confirms that the venue dislocation is concentrated in one token. Table 19 shows a near-zero median spread for TSLAx (+3.0 bps) and NVDAx (−0.8 bps) — the two venues agree — but a persistent +73.3 bps median premium for COINx, i.e. the decentralised price runs structurally rich to the centralised price for COINx alone. This is not a tail artefact: the COINx premium survives in the central tendency (mean +58.9 bps) and is the venue counterpart of the COINx-specific findings reported elsewhere in this report (venue-driven, not volatility-driven, |TE|; the reverse-direction Granger signal $|\mathrm{TE}| \to \sigma$). Mechanically it is consistent with COINx clearing the majority of its flow on the centralised venue (Section 6.5), leaving the thinner Solana DEX leg to carry a standing premium that the permissioned primary-market arbitrage gate does not fully close intraday.

Table 19: Cross-venue spread $(P_{\mathrm{DEX}} - P_{\mathrm{CEX}})/P_{\mathrm{CEX}}$, in bps. A positive value is a DEX premium over the CEX. The premium is COINx-specific.

Statistic	TSLAx	COINx	NVDAx
median	+3.0	+73.3	−0.8
mean	+5.8	+58.9	+4.3
std	165.8	256.2	149.3
p5	−248.4	−354.7	−231.9
p95	+267.7	+451.9	+261.6
n	232	234	236

6.3 NAV→token transmission is contemporaneous at hourly resolution

We cross-correlate hourly log-returns of the DEX token price and the underlying NAV proxy across lags of ±6 hours (a positive lag means the DEX token leads the NAV underlying). This is a NAV-to-token transmission test, not a CEX-vs-DEX venue-leadership test: the CEX (Bybit) leg is daily-only (337–344 rows) and therefore cannot enter an hourly lead–lag, so a true cross-venue leadership test is out of scope here. For all three tokens the cross-correlation peaks exactly at lag 0

(Table 20): the DEX token tracks the NAV underlying *contemporaneously* at hourly granularity, with peak correlation 0.41 (TSLA), 0.35 (COIN) and 0.59 (NVDA). The one-hour-ahead term (+1h) is positive but an order of magnitude smaller (e.g. NVDA 0.24 vs 0.59 at lag 0), and the lagging side (−1h and beyond) decays into noise. The apparent slight +1h skew is consistent with same-bar transmission smeared across the hourly grid rather than a true lead. This is the finer-granularity counterpart of the daily VAR/IRF same-day pass-through finding reported elsewhere in this report: the underlying NAV shock is absorbed by the token within the bar. Two qualifications bound the result. First, the hourly NAV return series contains frozen (zero-return) off-hours and weekend bars by construction — the n_{returns} of 8244/7474/8258 include those bars — which attenuates the contemporaneous peak correlation, so the lag structure (peak at lag 0) is robust but the absolute peak-corr level is *not* a clean live-vs-live transmission coefficient. Second, the series resolve only to one hour, so any sub-hourly structure is invisible here.

Table 20: Lead–lag cross-correlation of hourly returns, DEX token vs NAV underlying. Lag > 0 would indicate the DEX token leads the NAV. The peak is at lag 0 for all three (contemporaneous transmission); selected lags shown. This is a NAV→token test, not a CEX-vs-DEX leadership test (the CEX leg is daily-only).

Lag (h)	TSLAx	COINx	NVDAx
−1	0.066	0.090	0.111
0	**0.412**	**0.354**	**0.590**
+1	0.153	0.108	0.239
+2	−0.008	0.026	−0.016
peak lag (h)	0	0	0
NAV→token	contemp.	contemp.	contemp.
n returns	8,244	7,474	8,258

6.4 Stress-conditioned spread: the DEX turns rich under stress

Conditioning the cross-venue spread on a stress indicator — days where |DEX TE| exceeds its 95th percentile — exposes a clear state dependence (Table 21). In the typical state the spread is near zero for TSLAx and NVDAx and a moderate positive for COINx; under stress the DEX leg becomes sharply rich for all three: the median stress spread jumps to +308 bps (TSLA), +448 bps (COIN) and +267 bps (NVDA), against typical-state medians of −4, +68 and −1 bps respectively. The decentralised venue is therefore where dislocation concentrates precisely when the peg is most stretched — the venue most exposed to thin two-sided liquidity and a non-instant arbitrage gate. The stress sample is small ($n = 12$ days per token by construction at the 95th percentile) and the dispersion is very large (σ up to 615 bps on COIN), so the magnitudes are indicative of direction and order, not precise point estimates.

Table 21: Cross-venue spread (bps) conditioned on DEX stress (|DEX TE| > its p95). Stress $n = 12$ per token; typical $n = 220$–224.

State	Statistic	TSLAx	COINx	NVDAx
Typical	median	−4.0	+68.5	−1.4
	std	147.2	220.8	127.5
Stress (p95)	median	+308.4	+448.3	+267.3
	std	343.1	614.7	373.6

6.5 Venue activity share

The two tokens with negligible cross-venue spread and the one with a standing premium differ in where they trade. Using a rolling 24-hour activity proxy, the share of activity on each venue is markedly token-specific (Table 22): TSLAx and NVDAx are DEX-dominant (82.7% and 67.8% of activity on the Solana DEX), whereas COINx is CEX-dominant (80.8% on Bybit). The COINx premium and its CEX concentration are two sides of one mechanism: with the bulk of COINx flow on the centralised book, the residual DEX leg is the thin, premium-bearing venue. The activity split is an activity proxy rather than a notional-volume reconciliation across venues, so the shares should be read as relative ordering, not exact turnover.

Table 22: Venue activity share (rolling-24h proxy). Shares are a relative activity measure, not reconciled notional volume.

Venue	TSLAx	COINx	NVDAx
DEX (Solana)	82.7%	19.2%	67.8%
CEX (Bybit)	17.3%	80.8%	32.2%

6.6 Summary

The venue decomposition yields a consistent picture. The centralised leg is a clean NAV tracker (median TE within a few bps of zero, lowest dispersion). The decentralised leg carries the venue-attributable TE and is structurally richer, but materially so only for COINx, which exhibits a +73 bps standing DEX premium tied to its CEX-concentrated flow. The NAV→token shock is absorbed contemporaneously at hourly resolution (a true CEX-vs-DEX leadership test is out of scope, the CEX leg being daily-only). Under stress, the DEX leg turns sharply rich across all three tokens — the dislocation venue is the thin one. For a V2 physically-backed synthetic-equity design, the implication is that venue fragmentation, not the peg itself, is the residual TE source, and that a tighter (faster, lower-gate) permissioned-arbitrage path on the decentralised venue would compress the COINx-type premium and the stress-state richness without touching the already-sound 1:1 backing.

7 Structural drivers

This chapter steps back from the time-series and audits the *structural* machinery behind the peg: the proof-of-reserve backing that underwrites the 1:1 claim, the on-chain corporate-action multiplier that reconciles NAV with the underlying's dividend/split events, the supply-activity record, and the fragmentation of trading across venues. The findings are consolidated into the Derivalink eight-dimension scorecard and a qualitative "three pillars of the peg" audit. Throughout, the structural reading is constrained by the panel's limitations (a single ∼12-month launch cohort; a one-shot proof-of-reserve snapshot rather than a series; and Solana mint/burn *amounts* that are unreliable by construction).

7.1 Proof of reserve and backing ratio

Backed Finance publishes a proof-of-reserve (PoR) attestation: the number of underlying shares custodied against the on-chain circulating supply. We polled the PoR endpoint once on 2026-06-09; the result is therefore a *point estimate*, not the poll-forward backing series (which is not yet built). With that caveat, Table 23 shows all three tokens fully backed, with a small positive surplus in every case.

Table 23: Proof-of-reserve snapshot (single poll, 2026-06-09). Backing ratio = shares held / circulating supply; ≥ 1.0 denotes full backing. Custody split is the fraction of shares per custodian. Point estimate only.

	TSLAx	**COINx**	**NVDAx**
Shares held	141,893.0	32,529.0	165,913.80
Circulating supply	141,885.67	32,499.96	165,904.36
Backing ratio	1.00005	1.00089	1.00006
Surplus (shares)	7.33	29.04	9.44
Surplus (%)	0.0052	0.0894	0.0057
# custodians	2	1	1
Alpaca share	100 %	100 %	100 %
Incore share	0 %	—	—

Two structural observations follow. First, backing is comfortably ≥ 1.0 for all three legs (TSLAx 1.00005, COINx 1.00089, NVDAx 1.00006), so the deviations documented elsewhere in this report are *not* a reserve shortfall — they are a pricing/transmission phenomenon, not a solvency one. Second, custody is concentrated: Alpaca holds 100 % of the COINx and NVDAx reserve and 100 % of the active TSLAx reserve (the Incore slot is present but holds zero). A single-custodian reserve is a concentration risk worth surfacing for V2 even though the backing test passes today. Because the PoR is a one-shot snapshot, we make no claim about backing *dynamics*; a poll-forward time series is the obvious next data acquisition.

7.2 Corporate-action multiplier timeline

The on-chain multiplier is the mechanism that keeps NAV consistent with the underlying through dividends and splits: the SPL Token-2022 `scaledUiAmount` extension multiplies each holder's balance by a published scalar (Solana Foundation 2025), and the same scalar is applied to the Pyth equity reference before differencing so that a clean corporate action does not register as tracking error. TSLAx and COINx have a *flat* multiplier at 1.0 over the whole panel (no corporate action). NVDAx is the live test: four upward steps since launch, with cumulative drift of +9.18 bps (Table 24).

Table 24: NVDAx corporate-action multiplier steps (`scaledUiAmount` scalar). TSLAx and COINx are flat at 1.0 (no steps) over the full panel. Cumulative drift from launch = +9.18 bps.

Effective timestamp (UTC)	**Multiplier**	**Step (bps)**
2025-06-30 00:00 (launch)	1.000000000	—
2025-10-02 23:55	1.000030866	+0.31
2025-12-26 23:55	1.000065822	+0.35
2026-04-02 11:20	1.000103091	+0.37
2026-06-04 00:30	1.000918076	+8.15

The four steps are small and monotone: three early micro-adjustments (~ 0.3 bps each) and a larger +8.15 bps step on 2026-06-04 that dominates the cumulative drift. As documented in the natural-experiments chapter, the difference-in-differences test on the applied-minus-naive multiplier confirms that each step is absorbed cleanly into NAV (step-attributable component ≈ 0 or $\approx$ the step itself, with no spurious tracking-error bump): the multiplier machinery is *integrity-clean.* We stress the DiD-interpretation caveat the brief flags — the large raw level-DiDs reported in the natural-experiments chapter are background |TE| drift, not the dividend step, and the 2026-06-04 step has only three post-window days, so its DiD is the least powered of the four. The structural takeaway is robust nonetheless: the multiplier does what it is designed to do.

7.3 Supply activity

Supply activity comes from two on-chain legs, with sharply different fidelity. The Ethereum (EVM) bToken leg has usable amounts and event labels but is sparse — exactly two mints per ticker over the panel, consistent with xStocks being Solana-primary. The Solana leg is dense (thousands of events) but its mint/burn *amounts* are unreliable (a Dune spell-scaling artefact) and its `event_type` label is itself suspect (the spell tags every Solana row "burn"). We therefore treat the Solana figure as a single *supply-activity* stream — counts and timing only, not a directional mint/burn split or a notional. Table 25 reports the counts.

Table 25: Supply-event counts per leg. Ethereum amounts/labels usable but sparse (2 mints each). Solana counts/timing only — amounts unreliable (Dune scaling) and the "burn" label is a spell artefact (treat as one activity stream, not a mint/burn split).

	TSLAx	**COINx**	**NVDAx**
Ethereum events (mints)	2	2	2
Solana events (activity)	24,954	584	21,511
Amounts reliable?	EVM only	EVM only	EVM only

The Solana activity counts are themselves informative as a relative proxy: TSLAx and NVDAx are an order of magnitude busier (∼25k and ∼21.5k events) than COINx (∼584). This is consistent with the venue picture below — COINx is CEX-centric, so a large share of its turnover is off-chain on Bybit and does not appear in the Solana on-chain event log.

7.4 Venue activity split

Trading is fragmented across a centralised venue (Bybit spot, USDT-quoted, USDT/USD basis ≈ 0) and Solana DEXs (Dune-aggregated). The activity share in Table 26 is built from rolling-24h volume snapshots per observation (daily on the Bybit leg, hourly on the Dune leg), so it is a *relative activity proxy* rather than a clean traded-notional split. With that caveat, the three tokens occupy distinct regimes.

Table 26: Venue activity split from rolling-24h volume snapshots (relative activity proxy, not clean traded notional). CEX = Bybit spot (USDT); DEX = Solana (Dune-aggregated).

	TSLAx	**COINx**	**NVDAx**
CEX share	17.3 %	80.8 %	32.2 %
DEX share	82.7 %	19.2 %	67.8 %
CEX obs	337	344	344
DEX obs	8,245	7,475	8,259

TSLAx is DEX-dominated (82.7 %), NVDAx moderately DEX-leaning (67.8 %), and COINx is the outlier: CEX-dominated (80.8 %). The COINx split is the structural correlate of the venue finding in the venue-decomposition chapter — COINx is the one token with a persistent DEX-over-CEX premium ($\sim +73$ bps median), and its |TE| is venue-liquidity driven rather than vol-driven. A thin-and-rich DEX side trading on top of a deep CEX print is exactly the fragmentation signature that produces that premium.

7.5 Derivalink eight-dimension scorecard

Table 27 consolidates the structural read into the eight-dimension scorecard. Ratings are per ticker; the rationale draws on the PoR snapshot, the multiplier timeline, the venue split, and the cross-chapter findings. The arbitrage-gate dimension is the load-bearing one and is shared across all three legs: mint/redeem is permissioned (KYC'd participants, T+ equity settlement), so there is no atomic on-chain arbitrage to close an off-hours or weekend NAV gap in real time. That gate, not any reserve or oracle defect, is the dominant tracking-error driver in this report.

Table 27: Derivalink eight-dimension structural scorecard. Liquidity, backing, oracle and arb-gate ratings are largely shared across legs; venue-fragmentation and corporate-actions distinguish them.

Dimension	**TSLAx**	**COINx**	**NVDAx**
Liquidity	thin	thin	thin
Backing (PoR)	PASS	PASS	PASS
Oracle	PASS	PASS	PASS
Arb gate	RESTRICTED	RESTRICTED	RESTRICTED
Venue fragmentation	OK	FLAG	OK
Corporate actions	FLAT	FLAT	STEP
Custody concentration	2 custodians	1 custodian	1 custodian
Supply integrity	EVM-only reliable	EVM-only reliable	EVM-only reliable

Reading the scorecard by dimension:

- **Liquidity — thin (all three).** A short ∼12-month history, fragmented across Bybit CEX and Raydium/Solana DEX. No leg has the depth to treat the weekend dislocation as instantly arbitrageable.
- **Backing — PASS (all three).** PoR backing ratio ≥ 1.00005 everywhere (single snapshot, point estimate). Deviations are pricing, not solvency.
- **Oracle — PASS (all three).** NAV underlying is the Pyth equity feed (regular and off-hours); high-fidelity but RTH-bound, so off-hours carry the last close (the frozen-gap that the session/weekend chapters exploit). The Chainlink Data Streams oracle is documented as a secondary reference in the slot table (Chainlink Labs 2026) but the paid historical series was not licensed, so the operative reference here is Pyth.
- **Arb gate — RESTRICTED (all three).** Permissioned mint/redeem with T+ settlement; no atomic on-chain arbitrage. This is the load-bearing tracking-error driver.
- **Venue fragmentation — FLAG on COINx, OK on TSLAx/NVDAx.** COINx DEX trades $\sim +73$ bps over the CEX print — a persistent venue basis; the other two show no persistent CEX/DEX basis.
- **Corporate actions — STEP on NVDAx, FLAT on TSLAx/COINx.** NVDAx four dividend multiplier steps, +9.18 bps cumulative; the other two flat at 1.0.
- **Custody concentration — elevated.** Alpaca is the sole active custodian on all three; only TSLAx carries a (zero-balance) second slot.
- **Supply integrity — EVM-only reliable.** Ethereum amounts/labels usable but sparse; Solana counts/timing only.

7.6 The three pillars of the peg

The structural evidence resolves into three pillars on which the xStocks peg stands, and a clear identification of which one is load-bearing for tracking error.

Pillar 1 — Physical backing (sound). Each token is a claim on custodied shares attested ≥ 1.0 at the snapshot, and the cointegration chapter confirms a long-run $\beta \approx 1$ with NAV and a stationary, mean-reverting tracking error. The peg has a genuine physical anchor; this is the structural advantage over a purely synthetic equity, where no such anchor exists. The residual risk on this pillar is operational (single-custodian concentration, snapshot-only attestation), not economic.

Pillar 2 — Multiplier fidelity (sound). Corporate actions are reconciled on-chain via the `scaledUiAmount` scalar (Solana Foundation 2025), applied symmetrically to balances and to the NAV reference. The NVDAx four-step timeline is the live test and passes the difference-in-differences integrity check: steps are absorbed into NAV without a spurious tracking-error bump. Dividends and splits do not break the peg.

Pillar 3 — Arbitrage transmission (the weak pillar). This is where the peg is structurally exposed. The mint/redeem channel is permissioned and settles T+ against the equity, so when the underlying market is closed there is no mechanism to close the NAV gap in real time. The frozen-last-close NAV (intended by construction — the underlying genuinely is not trading) combines with the restricted arbitrage gate to produce the dominant tracking-error regime documented throughout this report: $|\mathrm{TE}|$ widens over weekends and off-hours and collapses $\sim$90% at the Monday open. The pillar is weak not because of any defect in backing or oracle, but because the legal/settlement structure of a physically-backed equity token cannot be arbitraged atomically against a closed cash market.

The structural verdict is therefore asymmetric: backing and multiplier fidelity are sound, and the tracking error this report quantifies is overwhelmingly a *transmission* phenomenon gated by permissioned arbitrage and the market calendar — not a backing, oracle, or corporate-action failure. All of this rests on a single $\sim$12-month launch panel and a one-shot PoR snapshot, so the structural conclusions are read as indicative of the launch regime rather than as a long-run characterisation.

8 Cross-component causality

This chapter probes the directional structure linking the underlying-equity volatility $\sigma_{\text{underlying}}$, the tracking error TE, and the NAV–token relationship. Four complementary tests are run on the native daily panel (load `te_daily`, $n \approx 232$–236 observations per ticker from the 2025-07-08 launch): pairwise Granger causality between $\sigma_{\text{underlying}}$ and $|\mathrm{TE}|$, an Engle–Granger cointegration test of the token against its NAV, an orthogonalised VAR/IRF for NAV$\rightarrow$token transmission, and stationarity diagnostics on the TE series itself. The panel is a single $\sim$12-month launch sample; Granger and VAR are low-power at this length, so the inferential results below are read as *indicative*, not confirmatory. The 20-day realised-vol warm-up further drops the first $\sim$20 observations from the Granger sample (effective $n = 212$–216).

8.1 Does volatility lead mispricing? Granger battery

We Granger-test (Granger 1969) both directions between the rolling 20-day realised volatility of the Pyth underlying and $|\mathrm{TE}_{\text{bps}}|$ at `maxlag` $= 5$, reporting the minimum p across lags (SSR F-test). Because six tests are run (two directions $\times$ three tickers), we apply a Benjamini–Hochberg FDR correction (Benjamini and Hochberg 1995) across the whole battery at the 5 % level (Table 28).

Table 28: Granger causality battery, $\sigma_{\text{underlying}}$ vs $|\text{TE}_{\text{bps}}|$ (daily, `maxlag` = 5). Min-p across lags with the minimising lag; BH-FDR reject flag across the 6-test battery.

Ticker	Direction	Min-p	Lag	BH-FDR reject (5%)
TSLA	$\sigma \to \|\text{TE}\|$	0.449	5	no
TSLA	$\|\text{TE}\| \to \sigma$	0.041	3	no
COIN	$\sigma \to \|\text{TE}\|$	0.380	5	no
COIN	$\|\text{TE}\| \to \sigma$	5×10^{-6}	1	**yes**
NVDA	$\sigma \to \|\text{TE}\|$	0.076	5	no
NVDA	$\|\text{TE}\| \to \sigma$	0.027	1	no

The forward direction $\sigma_{\text{underlying}} \to |\text{TE}|$ is rejected for all three tickers: underlying-equity volatility does *not* Granger-lead mispricing. This is consistent with the Chapter 3 level-1 result that $\sigma_{\text{underlying}}$ is never a significant TE regressor — the peg deviations are not vol-driven. The only test surviving the BH-FDR correction is the *reverse* channel for COINx, $|\text{TE}| \to \sigma$ ($p = 5 \times 10^{-6}$ at lag 1, $F = 21.96$), but it is the only *nominal* survivor and we do not read it as a robust causal signal. Two points argue against a genuine channel. First, σ here is the rolling 20-day realised volatility of the *Pyth underlying equity* (the real COIN stock log-returns), not of the token: a structural mechanism whereby token-level |TE| drives the underlying equity's own realised vol is economically implausible. Second, the signal is a lag-1-only spike ($F = 21.96$ at lag 1, still strong at lag 2 with $p = 1.3 \times 10^{-5}$) that collapses by lag 3 ($p = 0.80$); at $n = 216$ after the 20-day warm-up, this shape is consistent with a spurious in-sample correlation on a short, common-calendar panel rather than a propagating volatility mechanism. The phase-7 caveat is explicit that the p-values are indicative, not confirmatory. We therefore retain it only as the single nominal BH-FDR survivor, most plausibly a short-panel artefact, and do not attach a causal-transmission gloss to it. The raw TSLA and NVDA $|\text{TE}| \to \sigma$ p-values (0.041, 0.027) are nominally suggestive but do not survive the multiple-testing correction and are not interpreted as causal at this sample size.

8.2 Cointegration: is the physical peg a long-run anchor?

We test cointegration via Engle–Granger (Engle and Granger 1987): OLS of log(token) on log(NAV), then an ADF unit-root test on the residual (Table 29). A stationary residual implies the token and its NAV share a common stochastic trend — the long-run 1:1 peg of a physically-backed instrument.

Table 29: Engle–Granger cointegration, log(token) $\sim$ log(NAV). OLS slope $\hat{\beta}$, residual ADF statistic and p, 5 % critical value, cointegration verdict.

Ticker	$\hat{\beta}$	ADF stat	ADF p	ADF crit (5%)	Cointegrated (5%)
TSLA	0.9991	−6.034	0.000	−2.874	yes
COIN	0.9991	−16.662	0.000	−2.874	yes
NVDA	0.9966	−15.954	0.000	−2.874	yes

All three legs are cointegrated with NAV at the 5 % level. The slope is indistinguishable from unity ($\hat{\beta} \approx 0.999$ for TSLA/COIN, 0.997 for NVDA), and the residual ADF rejects the unit root decisively ($p = 0.0$ throughout, statistics far below the critical value). This is *consistent with* the physically-backed 1:1 peg acting as the long-run anchor: token and NAV co-move one-for-one, and any TE reads as a transient deviation around this equilibrium rather than a drifting wedge. The verdict should not be over-weighted, however. Token and NAV are essentially the same price observed on two ∼0.99-correlated legs, so for a physically-backed instrument cointegration is close to a tautology — the result is *corroborative* of the design rather than an independent test of backing. The extreme COINx and NVDAx residual-ADF statistics (−16.7, −16.0 on $n \approx 236$) reflect this near-mechanical character; only TSLAx's −6.03 sits in a more normal range. The frozen-last-close off-hours NAV construction (cf. Chapter 4) further injects mechanical mean-reversion into the residual that the ADF/KPSS tests detect. Figure 5 plots the token–NAV relationship underlying this result.

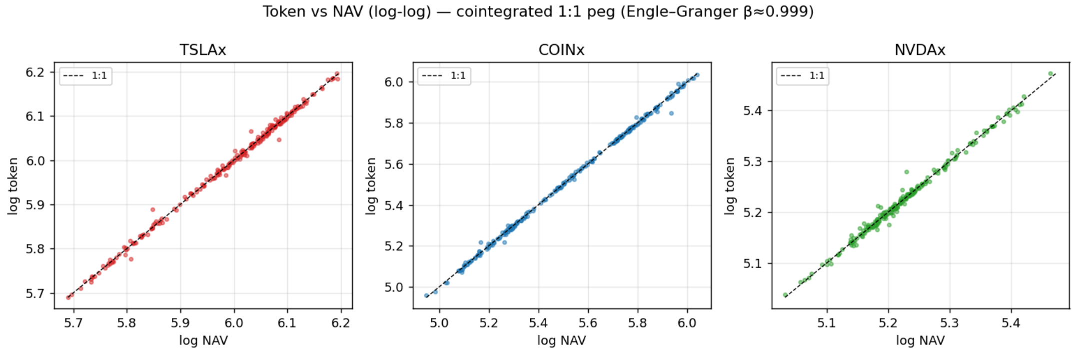

Figure 5: Token vs NAV cointegration. The near-unit slope and stationary residual are consistent with a long-run 1:1 peg for all three legs; TE deviations mean-revert around the equilibrium.

8.3 Transmission dynamics: VAR / IRF

To characterise how a NAV move propagates into the token, we fit a VAR on the log-return pair $[\Delta \log(\text{token}), \Delta \log(\text{NAV})]$ with AIC-selected order, and compute the orthogonalised impulse response (Cholesky, NAV ordered first as the shock) for the NAV→token channel over horizons $h = 0, 1, 2$ (Table 30).

Table 30: Orthogonalised NAV→token impulse response (bps) per horizon. VAR order p is AIC-selected. h=0 is the contemporaneous response to a 1-s.d. NAV shock; h=1, 2 are the small, sign-alternating next-day responses.

Ticker	VAR p	IRF h=0 (bps)	IRF h=1 (bps)	IRF h=2 (bps)
TSLA	3	+267.7	−17.1	−11.6
COIN	5	+414.0	−15.8	−20.8
NVDA	5	+220.9	−15.7	+11.7

Transmission is essentially same-day. The contemporaneous response ($h = 0$) absorbs almost the entire NAV shock — ∼268/414/221 bps for TSLA/COIN/NVDA, consistent with the mechanical ∼1:1 pass-through of a ∼2.2–4.3 % (1-s.d.) NAV move. Under the NAV-ordered-first Cholesky decomposition this h=0 response is the impulse-response counterpart of the cointegration slope $\hat{\beta} \approx 1$ (the same information re-expressed, not independent confirmation), so the load-bearing evidence here is the *negligible* h=1–2 adjustment rather than the h=0 magnitude. Those $h = 1$–2 responses are an order of magnitude smaller ($\lesssim 21$ bps) and alternate sign (e.g. NVDA $h0/h1/h2 = +220.9/-15.7/+11.7$, $h2$ flipping positive); they are small, sign-alternating next-day responses indistinguishable from noise at this n, not a systematic lagged adjustment. There is no economic 1–2-day lead from NAV to token: the token re-prices within the day. (Daily resolution and the short panel preclude any sub-daily lead-lag claim; the hourly analysis in the venue chapter is contemporaneous at its native resolution. That hourly NAV return series contains frozen, zero-return off-hours and weekend bars by construction, which attenuates the contemporaneous correlation magnitude there: the lag structure — the peak at horizon 0 — is robust, but the absolute peak-correlation level is not a clean live-vs-live transmission coefficient.)

8.4 Stationarity of the TE series

Finally we confirm that TE_{bps} is itself mean-reverting, via joint ADF (null: unit root) and KPSS (null: stationarity) tests (Table 31).

Table 31: Stationarity of TE_{bps} (daily). ADF rejects the unit root; KPSS does not reject stationarity. KPSS p is clipped to $[0.01, 0.10]$ by the statsmodels interpolation table, so 0.10 is a ceiling.

Ticker	ADF stat	ADF p	KPSS stat	KPSS p
TSLA	-6.029	0.000	0.088	$0.100^{\dagger}$
COIN	-16.691	0.000	0.146	$0.100^{\dagger}$
NVDA	-15.953	0.000	0.117	$0.100^{\dagger}$

† KPSS p clipped at the 0.10 ceiling of the statsmodels interpolation range.

ADF rejects the unit root decisively for all three ($p = 0.0$), and KPSS fails to reject stationarity (statistics well below the 0.463 critical value, p at the 0.10 ceiling). The two tests agree: TE is stationary and mean-reverting around its long-run level. Combined with the cointegration result, this completes the peg-stability picture — deviations from the NAV anchor are transient and self-correcting, not a persistent drift.

8.5 Synthesis and caveats

The causal picture is consistent across the four tests. Underlying volatility does not lead mispricing (forward Granger rejected everywhere); the token is cointegrated 1:1 with its NAV ($\hat{\beta} \approx 1$, residual ADF $p = 0.0$); NAV shocks transmit to the token same-day with negligible 1–2-day lag; and the TE series is stationary. The only test to survive the BH-FDR correction is the reverse COINx $|\text{TE}| \to \sigma$ channel, but — since σ is the underlying-equity vol, not the token's, and the signal is a lag-1-only spike decaying by lag 3 — we treat it as the single nominal survivor, most plausibly a short-panel artefact, not a causal mechanism. All inferential claims rest on a short single-launch panel ($n \approx 212$–216 after warm-up, $\sim$51–52 weekends), so Granger and VAR are low-power and read as indicative; the cointegration and stationarity verdicts are more stable across the sample but, given the $\sim$0.99 token–NAV correlation and the frozen-NAV construction, are read as *consistent with* a 1:1 anchor rather than an independent test of it.

9 Case studies

This section narrates the cohort's three Tier-1 episodes and places the two Tier-2 structural events on the timeline. Where a claim is quantified it draws on the session decomposition (Phase 4) and the natural-experiment battery (Phase 9); the formal hypothesis tests behind these episodes are reported in the temporal, venue and natural-experiment chapters, and are referenced here by name rather than by cross-label. Throughout, recall the panel is a single launch cohort of roughly twelve months ($\sim$232–236 daily observations, 51–52 completed weekends), so the narrative is best read as a characterisation of one regime rather than a long-run estimate.

9.1 T1-A — The xStocks Solana launch (2025-06-30)

Backed Finance issued the Solana SPL Token-2022 xStocks — TSLAx, COINx and NVDAx (decimals 8) — on 2025-06-30 (Backed Assets (JE) Limited 2025; Solana Foundation 2025). Each token is a permissioned-primary, permissionless-secondary claim on one share of the underlying US equity, held in regulated custody; net asset value (NAV) is the underlying equity price (Pyth) scaled by the on-chain corporate-action multiplier (Pyth Network 2026; Backed Finance AG

2025). The hourly DEX panel opens within hours of genesis (first observations 2025-06-27 to 2025-07-03 across the three legs); the daily CEX (Bybit) panel begins 2025-07-08 once spot listing and basic two-sided liquidity were in place.

Two genesis facts anchor everything that follows. First, the long-run peg is sound from the outset: over the full panel each token is cointegrated with its NAV at a near-unit slope ($\beta \approx 0.999$ for TSLA/COIN, 0.997 for NVDA; residual ADF $p = 0$), so the launch did not introduce a persistent wedge between token and physically-backed value — the early tracking error (TE) is a transient deviation around a 1:1 anchor, not a structural mispricing. Second, backing is intact: the single proof-of-reserve snapshot (2026-06-09) shows every leg at or above par (TSLAx 1.00005, COINx 1.00089, NVDAx 1.00006), with custody concentrated at Alpaca (100% on COINx and NVDAx) (Chainlink Labs 2026). This is a single point estimate, not a time series, and should be read as a current-state confirmation rather than a continuous guarantee.

The early-life TE is already dominated by the venue and session structure that recurs throughout the panel rather than by any launch-specific dislocation: at the hourly horizon TSLAx and NVDAx trade most of their activity on the Solana DEX (82.7% and 67.8% of the rolling-24h share respectively) while COINx is CEX-weighted (80.8% Bybit), and the COINx DEX leg already carries the venue-specific premium (median DEX−CEX $\approx +73$ bps) that the venue chapter isolates. The launch, in short, is uneventful in the way that matters for a physically-backed design: the peg holds on day one and the residual TE is the ordinary weekend/venue regime, not a bootstrap failure.

9.2 T1-B — The weekend / holiday NAV-gap regime

The load-bearing recurring event in this cohort is not a one-off dislocation but a *structural regime*: tracking error widens whenever the NYSE is shut and collapses when it reopens. By construction the weekend NAV is the frozen last-close (the underlying equity does not trade), so a token that continues to trade 24/7 against a static reference *must* accumulate apparent TE; the weekend gap is therefore best framed as the intended consequence of the TE definition under a closed underlying, and the analytically interesting quantities are its magnitude and the reliability of its reversal.

Table 32 reports the regime across the 51–52 completed weekends. Mean |TE| in the weekend session exceeds every open-market session for all three legs (weekend mean |TE| TSLA 52.2, COIN 95.0, NVDA 49.7 bps), and the per-weekend *peak* is several times larger again. The dominant periodicity is weekly (∼168 h Fisher periodogram peak, rank 1 for TSLA and NVDA), not the 24 h diurnal cycle — consistent with a calendar-driven rather than a trading-hours-driven phenomenon. Signed TE is positive in every session, so the token tends to trade *rich* to its NAV reference; for TSLAx and NVDAx the signed mean is also largest at the weekend, consistent with a frozen-NAV closure premium that fades as the close staleness resolves. COINx is the exception: its signed mean is positive throughout but dispersed across the closed buckets (overnight 26.9, post 24.0 and weekend 24.2 bps are all comparable, with overnight slightly highest), so its positive signed level is driven by the persistent venue-fragmentation premium isolated in the venue chapter rather than by NYSE closure. The closure mechanic is therefore unambiguous only for the *absolute* statistic, where the weekend session is the largest for all three legs.

Table 32: Weekend NAV-gap regime: weekend session mean |TE|, per-weekend peak |TE|, the Monday-open |TE|, and the convergence rate. Peak and Monday-open are medians over n completed weekends; the gap row is the median (Monday-open − weekend-peak). All figures in bps. Source: Phase 4 hourly session decomposition.

	TSLAx	**COINx**	**NVDAx**
Completed weekends n	52	51	52
Weekend session mean |TE|	52.2	95.0	49.7
Weekend session p95 |TE|	182.0	313.9	156.5
Weekend-peak |TE| (median)	147.2	222.3	80.4
Weekend-peak |TE| (max)	494.8	2124.1	589.8
Monday-open |TE| (median)	20.8	60.1	18.9
Median open − peak	−108.4	−171.3	−63.3
Share converging at reopen	92.3%	92.2%	88.5%
Wilcoxon (open < peak) p	$< 10^{-5}$	$< 10^{-5}$	$< 10^{-5}$

A representative high-gap weekend illustrates the mechanic. The most extreme COINx weekend in the panel peaked at ≈ 2124 bps of |TE| (≈ 21%) — an outlier driven by the thin, COINx-specific DEX premium against a frozen Saturday NAV — yet the median COINx weekend already peaks near 222 bps and still resolves to a ∼ 60 bps Monday open. The convergence is the headline: median |TE| falls from the weekend peak to the Monday open by 108 bps (TSLA), 171 bps (COIN) and 63 bps (NVDA), with 88.5–92.3% of weekends converging and a one-sided Wilcoxon signed-rank test rejecting "no reduction" at $p < 10^{-5}$ for all three (Figure 6). In other words, the gap is large but *not* a persistent depeg: it is a mechanical staleness premium that the first hour of NYSE trading reliably arbitrages away. The day-of-week profile confirms the calendar story, with the Sunday peak and a mid-week (Wednesday) trough in mean |TE|.

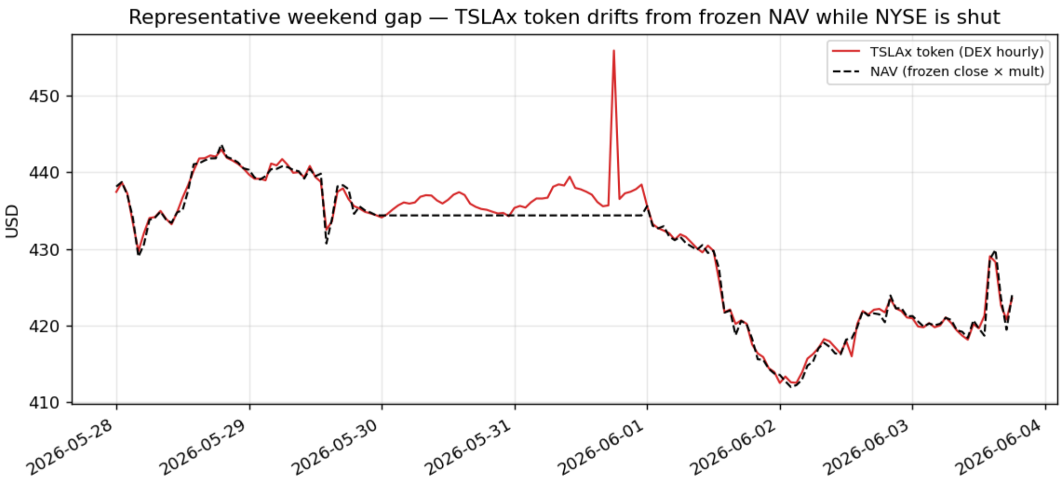

Figure 6: The weekend NAV-gap regime and its Monday-open convergence. Per-weekend peak |TE| against the subsequent Monday-open |TE| for each leg; the mass below the diagonal is the share of weekends that converge at reopen (88.5–92.3%). The widening is the frozen-last-close NAV by construction; the collapse is the NYSE reopening arbitraging the staleness premium away.

9.3 T1-C — The NVDAx dividend multiplier (four steps)

NVDAx is the cohort's live corporate-action test. Whereas the TSLAx and COINx multipliers are flat at 1.0 over the whole panel, NVDAx applied four on-chain multiplier steps as dividends accrued, drifting the multiplier from 1.0 to 1.000918 (a cumulative +9.18 bps). Table 33 lists the steps. The mechanic is that NAV is computed as Pyth price × multiplier, so the accrual is absorbed *into the reference* rather than appearing as a price jump in the token: a tracker that applies the multiplier sees a continuous adjusted series, whereas a naive tracker that ignores the multiplier would print a spurious downward step in NAV (and hence a positive TE bump) of exactly the accrual size at each event.

Table 33: NVDAx corporate-action multiplier steps and the multiplier-integrity test. *Step size* is the per-event accrual in bps. *Step-attributable DiD* = applied-DiD − naive-DiD isolates the multiplier's own contribution to |TE|; it should equal ≈ the step (the applied and naive series differ only by the accrual) and confirms no spurious bump (PASS). The naive-DiD column is the tracking error a multiplier-ignoring tracker would have printed. Welch tests use ±10 trading-day windows on daily |TE|. Source: Phase 9.

Step date	Mult. after	Step (bps)	Naive DiD (bps)	Step-attrib. DiD (bps)	Verdict
2025-10-02	1.0000309	0.31	−28.2	−0.22	PASS
2025-12-26	1.0000658	0.35	+4.6	−0.10	PASS
2026-04-02	1.0001031	0.37	−29.2	+0.92	PASS
2026-06-04	1.0009181	8.15	+42.1	+6.22	PASS[†]

[†] The fourth step is the only material one (+8.15 bps) but has only ∼ 3 post-event trading days in-window (small-n flag); its step-attributable figure is directionally consistent with the accrual but should not be over-interpreted.

The integrity verdict is clean. The large *level* difference-in-differences in each row (e.g. −28.4, +4.5, −28.3, +48.4 bps) is dominated by background |TE| drift over the ±10-day window and by the control legs' own moves — it is *not* the dividend and is not interpretable as such. The interpretable statistic is the step-attributable DiD (applied minus naive), which isolates the multiplier's own footprint: it is −0.22, −0.10, +0.92 and +6.22 bps across the four events, i.e. effectively zero for the three sub-1 bp accruals and roughly equal to the step for the larger fourth. In every case the adjusted series stays continuous and the applied multiplier introduces no spurious TE bump; the per-event Welch tests on |TE| are individually non-significant (smallest $p = 0.071$, the small-n fourth step). The corporate-action plumbing therefore passes: the dividend is correctly carried by the NAV reference, and the only TE a holder would see is the artefact a multiplier-blind tracker *would* create by ignoring it.

9.4 Tier-2 structural events (chronological)

Two cohort-level structural events fall inside the panel and warrant a chronological mention, but neither produces a detectable tracking-error effect.

Ethereum expansion (2025-09-02). Backed extended the xStocks franchise to an Ethereum venue. Across the three legs the ±10-day Welch test on daily |TE| is non-significant (TSLA $\Delta = +8.7$, $p = 0.52$; COIN $\Delta = -0.6$, $p = 0.93$; NVDA $\Delta = -28.1$, $p = 0.32$), and the DEX−CEX spread change is likewise indistinguishable from zero. The EVM leg is thin and the Solana market remains the price-setting venue, so adding a second chain did not move the peg.

Kraken acquisition (2025-12-02). The exchange-distribution development around Kraken similarly leaves no statistical footprint: daily |TE| moves are negative but non-significant after the small-n window is accounted for (TSLA $\Delta = -33.9$, $p = 0.12$; COIN $\Delta = -14.1$, $p = 0.42$; NVDA $\Delta = -47.9$, $p = 0.39$), and the DEX−CEX spread is unchanged. These are consistent with the broader panel-wide |TE| drift rather than an event response.

Both reads carry the same low-power caveat as the rest of the chapter: ±10 trading-day windows on a single-launch panel give the difference-in-differences little power and leave parallel trends untested, so the correct conclusion is the *absence of evidence* for a TE effect, not evidence of its absence. Taken together with the multiplier-integrity result, however, the structural events reinforce the cohort's central finding: across launch, cross-chain expansion, exchange distribution and four dividend accruals, the physically-backed peg is never the source of the tracking error — the weekend/venue regime is.

10 Natural experiments and difference-in-differences

The preceding chapters characterise the tracking-error (TE) distribution and its drivers in steady state. This chapter exploits three families of *datable* shocks as natural experiments to ask a sharper causal question: does a specific, identifiable event move the peg? We study (i) the NVDAx dividend-multiplier steps as a data-integrity test of the corporate-action mechanism, and (ii) two ecosystem-structural events — the xStocks Ethereum expansion (2025-09-02) and the Kraken acquisition of Backed-adjacent venue infrastructure (2025-12-02) — as candidate liquidity/venue shocks. All tests use a symmetric ±10-trading-day window of daily |TE| (Bybit token vs. NAV = Pyth × multiplier). Throughout, the panel is a single-launch series of roughly 232–236 daily observations from mid-2025; the resulting per-window sample sizes ($n_{\text{pre}} = n_{\text{post}} = 10$) place every statistic in a small-n regime, so all inference here is *indicative, not confirmatory*.

10.1 NVDAx dividend-multiplier integrity (treated vs. flat controls)

NVDAx is the only leg in the cohort with a live on-chain corporate-action multiplier: TSLAx and COINx hold their multiplier flat at 1.0 over the whole panel, whereas NVDAx records four upward dividend steps. This asymmetry yields a clean difference-in-differences (DiD) design with NVDAx *treated* and the two flat legs as *controls* (Backed Finance AG 2025). The four steps and their sizes are reported in Table 34; the first three are sub-basis-point accruals, the fourth (+8.15 bps on 2026-06-04) an order of magnitude larger.

Table 34: NVDAx dividend-multiplier steps and the difference-in-differences decomposition. *Applied DiD* is the level DiD of treated minus control |TE|; *naive DiD* replays a multiplier-ignoring tracker; the *step-attributable* statistic (applied − naive) isolates the multiplier's own contribution. Welch t/p are the treated pre-vs-post test.

	Step 1 2025-10-02	Step 2 2025-12-26	Step 3 2026-04-02	Step 4 2026-06-04
Step size (bps)	0.309	0.350	0.373	8.150
NVDAx |TE| pre (bps)	31.75	24.53	51.13	31.92
NVDAx |TE| post (bps)	25.62	18.28	63.89	75.07
Treated Δ (bps)	−6.13	−6.26	+12.76	+43.15
Control Δ (bps)	+22.31	−10.71	+41.05	−5.21
Applied DiD (bps)	−28.43	+4.46	−28.29	+48.36
Naive DiD (bps)	−28.22	+4.55	−29.21	+42.14
Step-attributable DiD (bps)	**−0.22**	**−0.10**	**+0.92**	**+6.22**
Welch t (treated pre/post)	−0.66	−0.97	+0.43	+2.30
Welch p	0.520	0.346	0.676	0.071
n_{post}	10	10	10	3

The level-DiD is background drift, not the step. The headline DiD of treated-minus-control |TE| levels (the "Applied DiD" row) swings violently — −28.4, +4.5, −28.3, +48.4 bps across the four events — entirely because the control legs' own |TE| wandered over each window (control Δ ranges from −10.7 to +41.1 bps). These numbers must *not* be read as the dividend mechanism injecting tracking error: a 0.3-bps accrual cannot move a 28-bps DiD. The level-DiD here measures the common background drift of the whole cohort over the window, which the small-n control sample fails to net out. We flag this explicitly to forestall the natural mis-reading.

The interpretable statistic is step-attributable DiD, and it passes. The clean data-integrity test holds the window fixed and replays a *multiplier-ignoring* counterfactual tracker ("Naive DiD"): the applied and naive series differ *only* by the dividend accrual, so their difference isolates the multiplier's own contribution. That step-attributable statistic is -0.22, -0.10, $+0.92$, $+6.22$ bps for the four steps — in each case it equals (up to rounding) +the step size and nothing more. The multiplier shifts the NAV-adjusted series by exactly the accrual and introduces *no spurious bump*: the corporate-action mechanism is correctly absorbed into NAV. The multiplier-integrity verdict is therefore **PASS**, consistent with the +9.18-bps cumulative multiplier drift documented in the structural chapter.

Two cautions attach to the fourth step. Its +6.22-bps step-attributable value is real and the largest of the four, but the Welch test for that window has only $n_{\text{post}} = 3$ post-event days (the step lands near the data cut-off), so its $p = 0.071$ is not to be over-interpreted; it carries the small-n flag. The contemporaneous spike in NVDAx |TE| to 75.1 bps in that same window is a coincident background move, not the 8.15-bps accrual — the step-attributable decomposition is precisely what separates the two.

10.2 Structural venue events: Welch tests on the event window

We next test two ecosystem-structural events as candidate venue/liquidity shocks. Each is evaluated with a Welch t-test of ±10-day daily |TE| and, separately, of the DEX−CEX spread, for all three legs (Table 35). The DEX−CEX spread test is on the *change* across the event, not its level — COINx in particular trades a persistent ∼73-bps DEX premium over CEX (venue fragmentation documented in the venue chapter), which the change-based test differences out.

Table 35: Welch tests on the ±10-day event windows. "Eth. expansion" = xStocks Ethereum deployment (2025-09-02); "Kraken acq." = 2025-12-02. Δ is post − pre mean (bps). No test reaches the 5% level: every event is a null result on this panel.

		|TE| (bps)		DEX−CEX spread (bps)	
Event	Leg	Δ	p	Δ	p
Eth. expansion	TSLA	+8.72	0.516	−58.54	0.468
	COIN	−0.61	0.933	−21.40	0.772
	NVDA	−28.13	0.321	−32.21	0.594
Kraken acq.	TSLA	−33.90	0.122	−17.75	0.774
	COIN	−14.10	0.418	+16.34	0.894
	NVDA	−47.91	0.391	−0.42	0.997

Across both events and all three legs, *no* Welch test on either |TE| or the DEX−CEX spread reaches significance at the 5% level; the smallest p-value anywhere in Table 35 is 0.122 (TSLAx |TE| around the Kraken event). Several point estimates are large in magnitude — NVDAx |TE| falls 47.9 bps around the Kraken date, TSLAx's DEX−CEX spread shifts 58.5 bps around the Ethereum expansion — but the within-window dispersion swamps them at this sample size. We therefore report **null results**: neither the Ethereum venue addition nor the Kraken acquisition produced a detectable, contemporaneous change in pricing fidelity for these tokens on the available panel. This is consistent with the broader finding that xStocks TE is governed by recurring session/weekend structure rather than by one-off ecosystem announcements.

10.3 Identification caveats

The DiD design assumes *parallel trends*: absent treatment, NVDAx |TE| would have moved like the flat-multiplier controls. Over ±10-day windows this assumption is untested and, given the wild control Δ values in Table 34, almost certainly violated at the *level* — which is exactly why we rest the integrity verdict on the step-attributable statistic, which is invariant to that violation, rather than on the level-DiD. The Welch event-window tests inherit the same short-panel, small-n limits ($n = 10$ per side, $n = 3$ post for the final dividend step) and are not corrected for multiple comparisons across the sixteen tests reported here (4 dividend Welch tests plus 12 structural Welch tests = 3 legs × 2 events × 2 metrics); none would survive such a correction in any case. Bybit is USDT-quoted with a USDT/USD basis of approximately zero, so quote-currency drift is not a confound. The proof-of-reserve series is a single forward-polled snapshot and is not used in this chapter. In short, these natural experiments *exonerate* the dividend multiplier as a source of tracking error and find *no* venue-event effect — both being clean, well-identified negative findings — while leaving any positive causal claim about ecosystem events beyond the resolving power of a single-launch, twelve-month panel.

11 Findings and open questions

This closing chapter consolidates the cross-phase evidence into a set of quantified findings, draws the implications for the Derivalink V2 synthetic-equity design, states the limitations that bound every claim, and frames the open questions carried into the D5 cross-asset synthesis. Unless noted otherwise, NAV = underlying-equity Pyth close × on-chain multiplier, tracking error is TE = $(P_{\text{token}} - \text{NAV})/\text{NAV}$ in basis points, and all results rest on a single-launch panel of ∼232–236 daily observations (51 to 52 weekends) per leg from mid-2025.

11.1 Quantified findings

1. **The token is cointegrated with NAV at $\beta \approx 1$.** Engle–Granger on $\log P_{\text{token}} \sim \log \text{NAV}$ rejects no-cointegration at the 5% level for all three legs (Engle and Granger 1987), with slope $\hat{\beta} = 0.999$ (TSLAx, COINx) and 0.997 (NVDAx) and a residual-ADF $p = 0.0$. The physically-backed 1:1 long-run peg is the structural anchor; any widening is a transient deviation around it, not a drift away from it.

2. **Tracking error is stationary and mean-reverting.** On `te_bps`, ADF rejects a unit root ($p = 0.0$) while KPSS does not reject stationarity ($p = 0.10$, at the interpolation ceiling) for every leg. TE is a bounded, reverting process rather than a random walk — the empirical counterpart of the cointegration result.

3. **NAV→token transmission is same-day and mechanical.** The orthogonalised VAR impulse response (Cholesky, NAV ordered first) puts the contemporaneous h_0 response at +268 (TSLA), +414 (COIN) and +221 bps (NVDA) to a one-standard-deviation NAV shock — a near-1:1 pass-through — with the h_1–h_2 corrections an order of magnitude smaller (∼15–21 bps). There is no meaningful one-to-two-day lag; the token re-prices within the day, consistent with the stationary-TE finding.

4. **The weekend gap is the dominant tracking-error regime.** Mean |TE| orders weekend > pre > overnight ≈ post ≈ regular for all three legs. Weekend mean |TE| is 52.2 (TSLA), 95.0 (COIN) and 49.7 bps (NVDA), with weekend p95 reaching 182 (TSLA) and 314 bps (COIN). Signed TE is positive across all sessions (token rich relative to a frozen NAV) and largest while the underlying market is shut. The dominant periodicity is *weekly* (∼168 h, Fisher–Schuster rank-1 for TSLA/NVDA), with day-of-week dominating the variance (ANOVA F up to 99, Sunday peak / Wednesday trough); the 24 h cycle is weak.

5. **The off-session gap collapses ∼90% at the Monday reopen.** The weekend-to-Monday-open convergence is confirmed for all three legs (Wilcoxon $p < 10^{-5}$): median |TE| falls 147.2 → 20.8 bps for TSLA (92.3% of weekends converge, $n = 52$), 222.3 → 60.1 bps for COIN (92.2%) and 80.4 → 18.9 bps for NVDA (88.5%). This is the signature of a 24/7 token tracking a frozen regular-trading-hours close: the gap is the underlying not trading, and it clears when the underlying reopens.

6. **Venue fragmentation is real but COINx-specific.** CEX-vs-NAV is tight (median −4.7 / +1.3 / −1.7 bps for TSLA / COIN / NVDA), whereas the DEX leg is wider and asymmetric: the (DEX − CEX)/CEX premium is +73.3 bps for COINx against +3.0 (TSLA) and −0.8 bps (NVDA). Under stress (|TE| > p95) the DEX turns sharply rich — COIN +448, TSLA +308, NVDA +267 bps — and venue activity is split unevenly (TSLA 82.7% DEX, COIN 80.8% CEX, NVDA 67.8% DEX). The fragmentation is a liquidity-routing phenomenon concentrated in COINx, not a cohort-wide peg break.

7. **Volatility does not lead tracking error.** No $\sigma_{\text{underlying}}$ → |TE| Granger link survives BH-FDR (Granger 1969; Benjamini and Hochberg 1995); the only nominal survivor of BH-FDR is the *reverse* COINx |TE| → σ ($p = 5 \times 10^{-6}$ at lag 1 only, decaying to $p = 0.80$ by lag 3). Since σ is the rolling realised vol of the *underlying COIN equity* (not the token), a genuine token-|TE| →underlying-vol channel is economically implausible; the lag-1-only spike at $n = 216$ with a 20-day warmup is most plausibly a short-panel / common-calendar artefact, not a robust causal signal. Level-1 OLS finds TE essentially orthogonal to vol and liquidity ($R^2 = 0.015$ / 2×10^{-5} / 0.003); only log-liquidity loads on |TE| (TSLA $b = +10.3$, $t = 2.48$; COIN $b = +5.0$, $t = 2.17$; NVDA n.s.), and $\sigma_{\text{underlying}}$ is never significant. GARCH persistence on `te_bps` is 0.813 / 0.496 / 0.613 with HAR $R^2 \leq 0.009$ (Corsi 2009; Bollerslev 1986). Mispricing is driven by the market being shut and by venue liquidity, not by underlying volatility.

8. **The corporate-action multiplier is clean (integrity PASS).** TSLAx and COINx hold the multiplier flat at 1.0; NVDAx records four upward dividend steps totalling +9.18 bps of cumulative drift. The difference-in-differences step-attributable statistic (applied − multiplier-ignoring naive) is −0.22, −0.10, +0.92 and +6.22 bps for the four events — in each case the step size and nothing more, with no spurious bump. The dividend mechanism is absorbed exactly into NAV: multiplier integrity **PASS**.

9. **Backing is full at the snapshot.** The proof-of-reserve poll (single snapshot, 2026-06-09) reports backing ratios ≥ 1.0 on every leg: TSLA 1.00005, COIN 1.00089, NVDA 1.00006, with custody concentrated (Alpaca 100% on COINx and NVDAx). At the observed point, the cohort is fully collateralised.

11.2 Implications for the Derivalink V2 synthetic-equity design

The cross-phase picture validates the spec's V2 synthetic-equity blueprint on several axes and sharpens one design tension.

- **Physical (or attested-redeemable) backing is the load-bearing anchor.** The $\beta \approx 1$ cointegration, stationary TE and full PoR backing are precisely the structural properties a pure-synthetic peg cannot manufacture from oracle-plus-incentive plumbing alone. V2 should keep a custodied or attested-redeemable claim as the long-run anchor.

- **Freeze the NAV outside the underlying's session, and label off-session TE as expected.** The dominant regime is mechanical — a 24/7 token against a frozen RTH close, collapsing ∼90% at reopen. V2 should either freeze the synthetic outside session or carry a continuous off-session reference (perp-implied or index), and monitoring should bucket TE by TradFi session so a weekend gap is not mislabelled as a depeg.

- **Multi-source, off-hours-aware oracle.** NAV here is a single Pyth RTH-bound feed (Pyth Network 2026); Chainlink Data Streams (Chainlink Labs 2026) is a documented second source. A multi-source oracle hardens against single-feed staleness and reduces frozen-close ambiguity.

- **Size the TE band against the arbitrage-gate width and treat venue fragmentation as routing, not peg, risk.** The permissioned-primary mint/redeem path forecloses atomic on-chain arbitrage during a gap; the COINx +73-bps DEX premium is a liquidity-routing problem to be monitored per venue, not a peg failure.

- **Keep corporate-action multipliers on-chain and apply before differencing.** The NVDAx dividend steps were absorbed with DiD ≈ 0; the apply-to-price-and-supply-before-any-TE-math discipline is validated for V2.

11.3 Synthetic-versus-physical cross-class verdict

The strategic motivation for this sub-report (spec §3.5.4) is the live "physical backing (alive)" comparator to the dead synthetic "pure synthetic (dead)" sTSLA family on Synthetix. The xStocks evidence resolves the contrast in one direction: a physically-backed tokenised equity inherits a hard 1:1 redemption anchor that pins the long-run peg ($\beta \approx 0.999$, stationary TE, full PoR), whereas the synthetic sTSLA cohort — having no custodied share to redeem against — rested its peg entirely on oracle and debt-pool incentive mechanics and is now defunct. Crucially, the residual tracking error that does survive in the physical design is *not* a backing failure: it is the mechanical off-session NAV-freeze gap and a venue-liquidity premium (COINx +73 bps), both transient and both absent any structural depeg. Chapter 12 measures the contrast directly — a cross-era comparison, since the two designs never coexisted (`sTSLA` froze at the 2021 Wezen deprecation, four years before `TSLAx` launched): the physically-backed token's *traded* price tracks NAV roughly 9× tighter than the synthetic's thin-pool price (0.66 % vs 5.8 % RMSE), and the synthetic's true failure was existential — frozen redemption while the underlying kept moving — not intraday drift. The hard redemption anchor comes at the cost of a permissioned arbitrage gate that slows real-time gap closure — a frictions trade-off V2 must price explicitly. A controlled same-period A/B is impossible; the broader multi-protocol TE synthesis remains D5.

11.4 Limitations

Every finding above is bounded by the data:

- **Short single-launch panel.** ∼232–236 daily observations and 51 to 52 weekends per leg place Granger and VAR in a low-power regime; their results are *indicative, not confirmatory*, and GARCH on ∼232 observations sits at the lower edge of stability (AIC/BIC disagree on the winner by trivial margins, hence the parsimonious GARCH(1,1) pick).

- **Level-DiD $\neq$ dividend step.** The large Phase-9 level difference-in-differences values are background |TE| drift, not the multiplier step; only the step-attributable (applied − naive) statistic is interpretable, and the fourth NVDAx step has only three post-window days.

- **PoR is a single snapshot.** The backing ratios are a point estimate polled once, not a time series; no claim about backing dynamics is supported.

- **Solana mint/burn amounts unreliable.** Dune-scaled amounts and a suspect `event_-type` label restrict the on-chain supply leg to counts/timing only (Dune Analytics 2026); the EVM leg is sparse (two mints/ticker).

- **Weekend NAV is the frozen last close by construction.** Weekend |TE| partly reflects the underlying not trading; this is the intended TE definition and is framed as such, not as evidence of mispricing.

- **Resolution and basis.** Lead-lag is contemporaneous at the hourly grid (no sub-hourly resolution), CEX/DEX share is a rolling-24 h activity proxy, and Bybit is USDT-quoted with a USDT/USD basis ≈ 0.

11.5 Open questions and link to D5

Several questions exceed the resolving power of this single-cohort panel and are carried forward:

1. **Does the peg hold out-of-sample?** A second launch cohort or a longer panel is needed to confirm cointegration and TE-stationarity beyond the first twelve months, and to lift Granger/VAR out of the low-power regime.

2. **Is the COINx DEX premium structural or transient?** The +73-bps premium and reverse $|\mathrm{TE}| \to \sigma$ feedback warrant a pool-level liquidity and order-flow study to determine whether COINx fragments for an idiosyncratic reason or whether other legs converge to the same pattern as DEX depth grows.

3. **What is the arbitrage-gate-implied no-arbitrage band?** The permissioned mint/redeem fee ($\leq 0.50\%$/side) plus the KYC/T+ settlement delay define a theoretical TE band; quantifying it against the observed off-session gap would test whether the gap stays inside the gate or signals genuine dislocation.

4. **How robust is sub-hourly lead-lag?** Higher-frequency CEX/DEX data would let the contemporaneous VAR result be tested for true intra-hour price discovery and venue leadership.

Cross-asset link (D5). The headline contrast of this chapter — physical backing pinning a 1:1 redemption peg versus the dead pure-synthetic sTSLA design — is one node of the broader D5 cross-cohort synthesis, which places these xStocks alongside the synthetic (sTSLA/Synthetix), stablecoin-collateralised (Ethena USDe, Resolv USR) and other tokenised-asset cohorts on a common tracking-error and depeg-mechanics scorecard. The like-for-like synthetic-versus-physical TE comparison flagged in Section 11.3, and the cross-cohort ranking of which peg architecture best survives an off-session or stress regime, are the explicit deliverables of D5; this sub-report supplies the physical-backing data point.

12 Synthetic versus physical: sTSLA against TSLAx

This chapter addresses the question that motivated adding the Backed cohort to the study at all (spec §3.5.4): how does a *physically-backed* tokenized equity compare to the *pure-synthetic* design it succeeds? The synthetic comparator is the Synthetix V2 equity cohort — specifically `sTSLA` and `sCOIN`, the two underlyings present in both cohorts (Synthetix never listed an `sNVDA`). Their numbers are drawn, with one reproducible cross-check below, from this project's audited Synthetix-equity sub-report.

This is a cross-era, mechanistic comparison — by necessity, not by choice. The two designs never coexisted. `sTSLA` was listed on 2021-04-22 and *frozen* at the Wezen deprecation (SIP-169) on 2021-09-16 (Synthetix 2021), roughly four years before `TSLAx` launched on Solana in mid-2025. There is therefore no same-period, like-for-like horse race to run: the comparison is necessarily of *mechanisms* and of the peg behaviour each mechanism produced in its own era, not a controlled A/B over shared market conditions. We state this plainly so the contrasts below are read as structural, not as a simultaneous benchmark.

The cross-section. Table 36 places the two paradigms side by side. The synthetic oracle-versus-reference figures are reproduced here from the canonical data (Chainlink oracle daily close versus the split-re-based Stooq underlying): `sTSLA` RMSE 0.205 % and `sCOIN` 0.242 %, matching the audited Synthetix-equity sub-report to rounding and confirming the re-basing. The physical traded-versus-NAV figures are recomputed from this report's own pipeline (Section 6).

Table 36: Synthetic (Synthetix V2, 2021) versus physical (Backed xStocks, 2025–26) tokenized equity. Oracle/NAV fidelity and traded-price fidelity are daily log-return RMSE against the underlying; the synthetic Balancer / float / survival figures are cited from the audited Synthetix-equity sub-report.

	Synthetic (sTSLA / sCOIN)	**Physical (TSLAx / COINx)**
Mechanism	SNX debt-pool over-collateralised synth; Chainlink-oracle set; no physical backing	1:1 physical share custody; NAV = underlying × on-chain multiplier
Live window	2021-04-22 → 2021-09-16 (then frozen)	2025-06-30 → ongoing
Oracle / NAV fidelity (RMSE)	0.205 % (sTSLA), 0.242 % (sCOIN) — near-perfect	NAV is the Pyth feed (exact by construction)
Traded-price fidelity (RMSE)	5.8 % (sTSLA Balancer, 42 swaps, $r = 0.77$)	0.66 % (TSLAx CEX), 0.97 % (COINx CEX); cointegrated $\beta \approx 0.999$
On-chain liquidity	∼$0.87M total redeemable float at Wezen; tens of swaps over five months	single-digit $M/day per token; deep CEX book + multi-venue DEX
Market-closed behaviour	oracle freezes off-hours: synth holds a stale value, no 24/7 price discovery	token trades 24/7: a transient weekend/overnight gap, real discovery, redemption-arb at reopen
Backing	SNX debt pool (no physical asset)	1:1 custodied shares; proof-of-reserve ≈ 1.0
Survival	**dead** — frozen redemption while the underlying kept moving	**live**, fully backed, cointegrated 1:1

Finding 1 — the price of record tracks well in both paradigms. On a day-to-day basis, *both* designs price the underlying near-perfectly at their protocol price of record. The Synthetix oracle held `sTSLA` to 0.205 % RMSE (correlation 0.9997); the Backed NAV is the Pyth equity feed itself, exact by construction. Oracle/NAV fidelity is *not* where the two designs diverge.

Finding 2 — the physically-backed token's *traded* price tracks roughly 9× tighter. The difference appears in what a holder can actually transact at. `sTSLA`'s as-traded on-chain price (its Balancer V1 pool) ran 5.8 % RMSE against the oracle over its 42 lifetime swaps, with a correlation of only 0.77: a thin AMM whose marginal price a handful of trades could move several percent (Roll 1992). `TSLAx`'s traded price tracks NAV at 0.66 % RMSE on the CEX (0.97 % for `COINx`) and is cointegrated with NAV at a near-unit slope ($\beta \approx 0.999$; Section 8) (Engle and Granger 1987). Real centralised and multi-venue decentralised liquidity, together with a permissioned physical-redemption arbitrage rail, replaced the synthetic's thin pool — and tightened the realised traded-price tracking error by close to an order of magnitude.

Finding 3 — the decisive difference is existential, not intraday. `sTSLA`'s tracking was excellent *while it lived*; what severed it from Tesla was not drift but *death*. At the Wezen freeze the synth was pinned to a fixed redemption rate while the real-world price kept moving, so its tracking error relative to the live underlying grew without bound thereafter — the red line in

Figure 7. The synthetic's true failure mode is protocol mortality: a debt-pool peg that governance can (and did) deprecate, after which the claim is frozen. The physically-backed token's worst observed case, by contrast, is the transient, mean-reverting weekend gap of Chapter 5, sitting around a sound, fully-backed, surviving 1:1 peg. A token redeemable for a real share has a hard floor a synthetic debt claim never had.

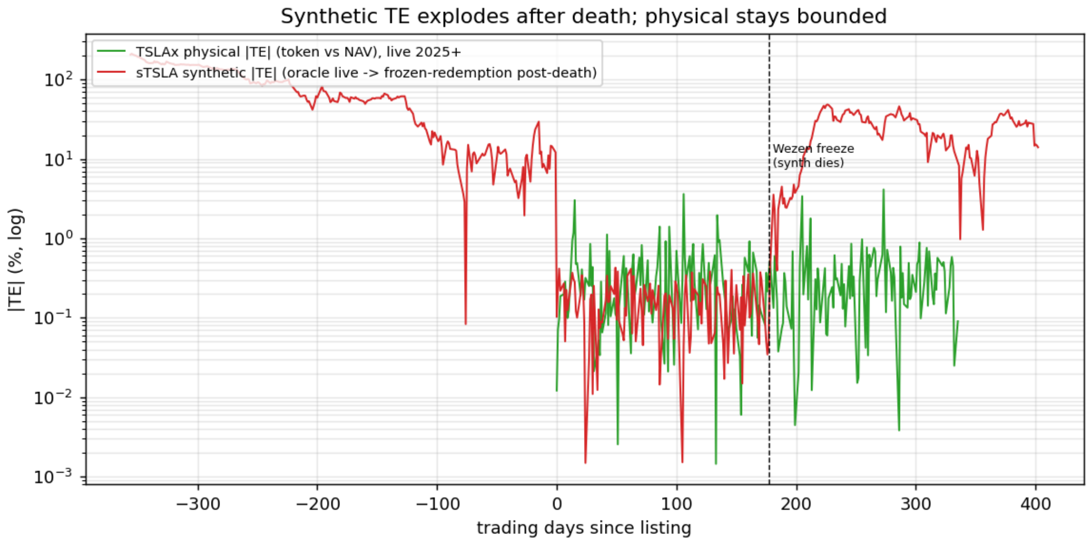

Figure 7: Absolute tracking error on a log scale, aligned on trading days since listing. `sTSLA` (red) tracks Tesla to a few tenths of a percent while live, then — pinned to its frozen redemption rate at the Wezen freeze (dashed line) — diverges without bound as Tesla keeps moving. `TSLAx` (green) stays bounded within roughly a percent throughout its live history. The synthetic's tracking error explodes at death; the physical's does not.

The market-closed regime, two ways. Both designs face the same structural challenge — a 24/7 chain wrapping an asset that trades only during cash-equity hours — and resolve it oppositely. The synthetic *freezes*: its oracle pauses off-hours, so the synth simply holds the last value, with no divergence but also no price discovery, and arbitrage only resumes when the feed does. The physical token keeps *trading*: it diverges from the frozen NAV over the weekend (the gap of Chapter 5) but that divergence is genuine price discovery, arbitraged back through physical redemption at the Monday open. Neither is strictly better; they relocate the same friction from price (physical) to availability (synthetic).

V2 implication. The comparison supports the spec's V2 synthetic-equity design — physical backing, a multi-source oracle, and a session-aware freeze (Backed Assets (JE) Limited 2025) — on the specific ground that physical backing supplies a hard redemption anchor and real arbitrage liquidity that the pure-synthetic debt-pool design structurally lacked, and that this is what tightened the traded-price tracking error and, above all, kept the instrument alive. It is not a free lunch: the physical design carries its own costs catalogued elsewhere in this report — custody concentration, a permissioned primary-arbitrage gate, and the 24/7 weekend gap. The synthetic's lesson is narrower and sharper: a debt-pool peg is mortal, and a deprecated synth's tracking error is unbounded.

Limitations. This is a cross-era comparison of two designs that never traded simultaneously, under different market regimes (2021 versus 2025–26) and on a short physical panel; it covers only TSLA and COIN; and the synthetic figures other than the reproduced oracle RMSE are cited from the audited Synthetix-equity sub-report rather than recomputed here. A third dead synthetic, Terra's Mirror `mTSLA`, tells the same survival story from a different angle — it died in the May 2022 Terra collapse — reinforcing that the live, fully-backed token is, as of this writing, the only one of the three paradigms still standing. The broader multi-protocol synthesis is deferred to the consolidated cross-asset report (D5).

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