

7546659-what-recedes-and-what-remains-when-markets-go-24-7-evidence-from-bitcoin-and-eth

SUMMARY: The study examines the effects of market closures on the Bitcoin and Ether futures markets, specifically focusing on the impact of extended trading hours. The research uses CME Bitcoin and Ether futures contracts, which did not trade over weekends while spot markets remained open, and CME's transition to continuous trading in May 2026. The study analyzes how the closure affects trading and pricing, and what remains after the closure is removed.

METHOD: The study uses CME Bitcoin and Ether futures data, which were traded continuously from May 29, 2026, and the impact of the weekend closure is analyzed. The analysis includes aligning contract-level one-minute futures trades with spot prices in the same minute, adding trade-by-trade quotes, aggressor sides, and top-of-book updates at every reopening. The study examines five key questions: whether the closed market takes up the price formed elsewhere, whether trading concentrates at the reopening, whether the reopening minute is more variable than the spot minute, and whether the variation leaves a lasting price component.

KEY FINDINGS:

- The closed market takes up about 94% of the weekend spot move.
- The futures price moves one-for-one with spot within a minute.
- The pre-close basis carries through the closure.
- The closure produces a burst at the reopen, with first-minute volume being four times the per-minute average over the following hour.
- The futures-minus-spot price change moves together during the first seconds.
- Order imbalance measured over those seconds does not predict the remainder of the minute or the following hour.
- The first-trade deviation largely reverses within five minutes.
- Liquidity suppliers earn no larger realized spreads after weekends.
- A contrarian strategy earns no statistically significant net profit after costs.
- After the transition, the futures-specific excess variation fell sharply in both contracts and was no longer detected in post-rebuild midquotes.
- The trading clock remains intact, with the 17:00 CT minute on Sunday still carrying 5.8 times the per-minute average volume of the surrounding hour.

IMPLICATION FOR TRADING: The findings suggest that extended trading hours can concentrate trading demand around the reopening, but the variation is short-lived. The study indicates that removing the closure does not eliminate the trading clock, as traders continue to crowd into the same reopening minute. These insights can inform trading strategies and market microstructure analysis, particularly for tokenized securities and cryptocurrency markets.

What Recedes and What Remains When Markets Go 24/7: Evidence from Bitcoin and Ether Futures*

Runa Lee*

Sungkyunkwan University, Seoul, Korea

Abstract

When an exchange extends trading to 24/7, what recedes and what remains? We answer using CME Bitcoin and Ether futures, which did not trade over weekends while spot markets remained open, and CME's move to continuous trading in May 2026. Before the transition, the closed venue reopened onto a price already formed elsewhere: the first futures trade reflects about 94% of the weekend spot move, the futures price moves one-for-one with spot within a minute, and the pre-close basis carries through the closure.

What the closure produced was a burst at the reopen. First-minute volume is four times the per-minute average over the following hour, compared with 1.6 times after the daily one-hour break. Only after weekends does the futures price range exceed the contemporaneous spot range: by about 20 bp on transaction prices and, once the book is rebuilt, by about 8 bp in Bitcoin and 13 bp in Ether on midquotes sampled at fixed intervals so that the measure does not depend on the number of trades.

The burst leaves no persistent price component. Order imbalance and

*Working paper. This version: 1 October 2026. A companion working paper studies the out-of-sample forecasting of first-minute reopening risk with machine learning; the present paper studies what the closure does and what its removal changes. The two papers share the weekend sample but ask different questions. Comments are welcome. Declarations of interest: none. Data are from public or licensed sources (Databento/CME, Binance, Bloomberg); replication code is available from the author. Generative AI tools were used for language editing, code assistance, and checking the consistency of reported numbers; all analyses were specified, run, and verified by the author, who takes full responsibility for the content.

*Corresponding author.

Email address: `graceruna@skku.edu` (Runa Lee)

the futures-minus-spot price change move together during the first seconds, but imbalance measured over those seconds does not predict the remainder of the minute or the following hour; the first-trade deviation largely reverses within five minutes; liquidity suppliers earn no larger realized spreads after weekends; and a contrarian strategy earns no statistically significant net profit after costs. After the transition, the futures-specific excess variation fell sharply in both contracts and was no longer detected in post-rebuild midquotes.

What remained was the trading clock. With no closure left to reopen from, the 17:00 CT minute on Sunday still carried 5.8 times the per-minute average volume of the surrounding hour, compared with 11.3 times before the transition. This spike was 3.1 times as large as the corresponding spike in spot and showed no fading over the weeks observed. E-mini S&P 500, euro FX, and Treasury futures, which retained their weekend closures, reopen in the same minute with volume spikes of roughly six to seven times.

The closure produced the reopening variation; the shared trading clock produced the concentration. Removing the closure took the variation away, but traders still crowded into the same Sunday minute.

Keywords: market closure, trading hours, 24/7 trading, reopening gap, order concentration, trading clock, tokenized securities, Bitcoin, Ether, CME futures, market microstructure

JEL: G13, G14, G12

1. Introduction

Trading hours are being extended. CME moved its cryptocurrency futures to continuous trading in May 2026; US equity exchanges have announced plans for, or obtained approval to run, weekday sessions that cover nearly the whole day; and tokenized versions of listed shares already trade at all hours while the exchange that lists the shares is closed.¹ Each of these changes removes a closure: a period in which one venue is shut while the price

¹NYSE Arca announced a 22-hour weekday session in October 2024 and Nasdaq a 24-hour weekday session in March 2025, both subject to regulatory approval; the SEC approved the 24X National Exchange in November 2024 to operate 23 hours a day on weekdays.

of the asset it references goes on being formed elsewhere. What does such a closure do to prices and to trading, and what changes when it is removed? Three answers run through the literature. Information that arrives during the closure may go unpriced until the reopen, which then has to discover a new price [20]. A security that cannot be traded for a period may be worth less, by as much as the value of the option to trade [30]. And closures concentrate trading demand around the reopen [26, 1], where the accumulated orders meet the market at once [23]. In markets whose underlying closes too, the three answers operate together: a price change at the open mixes the incorporation of news with the arrival of orders, and evidence that closures generate reversals [18] leaves open how much of the opening move is information and how much is the crowding of trades.

We separate them with CME Bitcoin and Ether futures, which closed from Friday 16:00 CT to Sunday 17:00 CT while spot traded without interruption, and with the exchange’s move to continuous trading on 29 May 2026. During the closure the price of the underlying is public in the spot market, and hedging demand can be met in spot or in perpetual swaps. What the closure can still do is concentrate the orders of traders bound to the futures venue at the reopen. We align contract-level one-minute futures trades with spot in the same minute, add trade-by-trade quotes, aggressor sides, and top-of-book updates at every reopen, and ask five questions in turn: does the closed market take up the price formed elsewhere; does trading concentrate at the reopen; is the reopening minute more variable than the spot minute at the same time; does that variation leave a lasting price component, whether as a predictable move, a reversal, or a return to liquidity suppliers; and what changes when the closure is removed.

The answers are these. First, we find no economically large or persistent price distortion at the frequencies and horizons examined: the first futures trade reflects about 94% of the weekend spot move, the futures price moves one-for-one with it within a minute, about 89% of the Friday basis remains

at the first trade and 77 to 89% through the first hour, the reopening gap inherits the spot variance of the closure, and no price discount is detected in the basis before the close; the absorption is the same with Coinbase in place of Binance as the spot reference. Second, trading concentrates in the first clock minute after the reopen: it carries a median 6.3% of the following hour’s volume on Sundays against 2.6% on Wednesdays, a same-week difference of 2.8 percentage points ($t = 5.5$) that survives subtracting the spot share; per minute, the first minute trades four times the average of the next fifty-nine minutes after a weekend and 1.6 times after the daily break. Third, the futures minute at the reopen is wider than the spot minute at the same time by about 20 bp after weekends and not at all after the daily break, in both contracts. Because a range of transaction prices widens mechanically with the number of trades, we also measure the minute on midquotes sampled at fixed times, which give every window the same number of observations, in three fixed clock windows: the whole minute, the opening seconds in which the book is rebuilt, and the seconds after the rebuild. After the rebuild the futures-specific excess is about 8 bp in Bitcoin and 13 bp in Ether, smaller but present, and again only after the weekend; the opening seconds are as wide after the daily break as after the weekend in Bitcoin and wider after the weekend in Ether. Fourth, this variation leaves no lasting price component. Order imbalance and the futures-minus-spot move coincide within the first seconds after a weekend, and only after a weekend; the move is specific to the futures venue, since spot observed at one-second frequency barely moves over those seconds; but imbalance in the first five seconds does not predict the rest of the minute, and neither imbalance nor the first-minute move predicts the following hour. The deviation at the first trade largely reverses within five minutes, by less than the cost of trading on it. Realized spreads earned by liquidity suppliers on first-minute trades are not larger after weekends than after the daily break at five, thirty, or sixty minutes, and a contrarian strategy earns no significant profit after costs. Effective spreads in the first

minute are not detectably higher after weekends in either contract (10.1 against 9.5 bp in Bitcoin, 13.5 against 11.0 bp in Ether). Fifth, when CME moved to continuous trading, the futures-specific excess of the first minute over spot fell sharply, by 22 bp in Bitcoin and 28 bp in Ether in a triple difference against spot and against Wednesdays on transaction prices, and on post-rebuild sampled midquotes the pre-transition excess of 8 and 13 bp is gone after the transition, while trading at 17:00 CT on Sundays continued at about half its former concentration and showed no fading over the eighteen weeks observed.

The contribution is to separate what the closure did from what the trading clock does. The setting provides a rare, and now permanently closed, identification window: the underlying asset went on revealing its price while the derivative venue was shut, so the reopening move can be split into the information that arrived during the closure and the effect of the closure itself, and the same asset offers a short daily break beside the long weekend closure. The subsequent removal of the closure lets us tell what was tied to the market boundary from what was anchored to the trading clock. The two identifications differ in strength: the decomposition rests on eight years of weekly reopens, whereas the removal is a single exchange decision observed in two contracts over eighteen weeks, and we treat it accordingly. By the trading clock we mean the observed synchronization of trading times across participants and markets, here 17:00 CT on Sunday, the start of the Asian week and the weekly open of CME's other markets; the data show that this synchronization outlived the closure, not which of habit, time zone, or coordination with other markets sustains it. The first-minute excess variation was tied to the closure: it appears only after the long closure, not after the daily break, and it fell when the closure ended. The timing of trades was not: participants kept meeting at 17:00 CT on Sundays, the start of the Asian week, after the venue no longer closed. The reopening gap of a venue whose underlying keeps trading therefore separates into the move already made in

the open venue, a change in the cross-venue premium, and a burst of trading and variation that the closure concentrates at the reopen and that does not persist. We measure each part, show that the last appears after the weekend closure and not after the daily break, and use the end of the closure as quasi-natural-experimental evidence. The results extend two classic results to assets that keep trading elsewhere: the closed venue inherits the variance generated in the open venue [20], and no marketability discount is detected in the basis when the option to trade survives elsewhere [30]. They do not support, in this setting, the inventory-compensation channel in which suppliers of immediacy earn a premium at the reopen [23, 15]: the reopen is where trading and variation concentrate, not where a measurable price is paid for immediacy.

Four literatures meet here. The first asks what closures and openings do to prices when the whole market closes: return variance is lower over non-trading hours [20, 29], opening prices are noisier and more volatile than closing prices and depend on the opening mechanism [5, 6, 34], pre-opening quotes and orders carry price discovery before the first trade [12, 14, 32], returns around non-trading days show distinct autocorrelation [11], and the split of returns between night and day has been tied to who trades when [31, 25, 13]. In all of these the underlying is closed too, so the opening move mixes news with the arrival of orders. The second studies trading outside regular hours, where thin volume coexists with price discovery [8, 9, 27]; our setting is its mirror image, a venue that is closed while an active market for the same asset stays open. The third studies price discovery across venues that trade the same asset, cross-listed shares and depositary receipts [19, 21] and, for Bitcoin, spot against futures [10, 28, 4, 2, 3], with information-share methods [24, 22] that require both venues to trade at once; the closure removes that requirement and lets us observe the open venue's move directly. The fourth is the theory of when traders choose to trade, in which concentration at particular times is self-reinforcing [1, 33] and closures

push demand toward the boundary [26]; the move to continuous trading tests whether the boundary or the shared time sustains the concentration. On measurement, Barardehi and Bernhardt [7] show that volatility and price impact aggregated in calendar time are biased where trading is intense, which is why we measure the reopening minute on sampled quotes as well as on trades. Cong et al. [17] study the mirror image of our setting, tokenized shares that trade while the listing exchange is closed.

The closest prior work on these markets, Aleti and Mizrach [3], compares the microstructure of CME Bitcoin futures with the major spot exchanges in 2018–2019, documenting spreads, depth, price impact, and the lead of the futures venue in price discovery. We take the cross-venue structure they describe as given and study a different object: the boundary at which the futures venue closes and reopens while spot continues, and the removal of that boundary. Section 8 states what the results imply for other claims that trade on venues with different schedules, from tokenized shares to depositary receipts. A companion paper [16] uses the same Bitcoin weekends to ask a different question: whether the size of the first-minute reopening adjustment can be forecast before the open from the state of the spot market. It uses one-minute bars only, ends before the transition, and does not use the quote data, the Wednesday comparison, or Ether. The present paper asks what the closure does and what its removal changes.

2. What a Closure Can Do

Framework. Let p_t be the efficient log price, observed continuously in the open venue, $dp_t = \sigma dW_t$, and let the futures venue close over $[0, T]$. Before the close the futures price is $f_C = p_0 + c$, where c is the carry basis. A fraction θ of hedging and liquidity demand can be met in substitute venues (spot, perpetual swaps) during the closure; the rest is bound to the closed venue and meets the market at the reopen as a net order imbalance Q_T with mean zero and variance $\eta^2(1 - \theta)T$, independent of W . If liquidity suppliers

with inventory costs absorb the imbalance [23], the price h after the reopen is

$$f_{R+h} = p_{T+h} + c' + \kappa_h Q_T + \epsilon, \quad (1)$$

where c' is the carry basis at the reopen, $\kappa_h \geq 0$ is the part of the price impact of the imbalance that remains h after the reopen, and ϵ is bid–ask noise. The framework contains no private information; it organizes the questions rather than offering a new model. At execution ($h \rightarrow 0$) the orders concentrated by the closure move the transaction price as they cross the book, so $\kappa_0 > 0$ whenever the book is finite. If suppliers require compensation for inventory, part of the impact persists ($\kappa_h > 0$ at horizons of minutes), reverses later, and is earned as a realized spread; if supply is elastic, κ_h is near zero beyond the first seconds, and the reopen shows a burst of trading and of transaction-price variation without a lasting price component. The tests below distinguish the two.

P1 (price continuity). The first trade absorbs the move formed in the open venue one-for-one and the pre-close basis survives up to the carry roll-down; the reopening gap carries the variance of the open venue; no discount arises before the close.

P2 (order concentration). Trading at the reopen concentrates in the first minute, more so after the long weekend closure than after the daily one-hour break, and its volume rises with activity in the open venue during the closure.

P3 (venue-specific variation). After a long closure, the futures minute at the reopen is more variable than the spot minute at the same time; after a short break it is not.

P4 (no lasting price component). If $\kappa_h > 0$ at horizons of minutes, order imbalance should predict the price change over the following interval, the move should reverse, and suppliers should earn a larger realized spread after the long closure. If $\kappa_0 > 0$ but $\kappa_h \approx 0$, imbalance and price coincide as the orders execute and nothing appears afterwards.

P5 (removal of the closure). When the closure is removed, the venue-specific

variation at the old reopening time should shrink. Whether trade concentration remains at that time distinguishes the effect of the closure from that of the trading clock.

3. Data and Measurement

Futures. CME Bitcoin futures one-minute OHLCV bars for all 107 out-right contracts, December 2017 to September 2026, and CME Ether futures from their February 2021 listing (Databento, CME Globex MDP 3.0). Bars are stamped at the start of the minute and exist only when a trade occurs. For each closure we select, using pre-close information only, the contract with the largest volume in the four hours before the close among those that remain listed after the reopen, and use it at both ends. The pre-close price is the close of the last bar before the close and the reopening price is the open of the first bar at or after the reopen; both must lie within five minutes of the boundary.

Trades and quotes. For every Sunday and Wednesday from February 2018 (Bitcoin) and February 2021 (Ether) to September 2026 we obtain all trades from 16:00 to 19:00 CT with the best bid and offer immediately before each trade and the aggressor side (Databento TBBO), and every top-of-book update from 16:55 to 18:15 CT (Databento MBP-1). Within each window we use the contract chosen by the same pre-close rule as for the bars, the contract with the largest volume in the 12:00–16:00 CT session of the preceding weekday (Friday for Sundays, the same day for Wednesdays); it is also the contract with the most trades in the window in 98.4% of Bitcoin windows and 98.8% of Ether windows, and Appendix A shows every statistic that the choice affects under both rules; the only material difference is the Ether effective-spread premium, which is significant only under the most-traded rule. Order imbalance is buyer-initiated minus seller-initiated volume over their sum, $\text{OFI} \in [-1, 1]$; trades without an aggressor side, mostly the opening match, are excluded from both. The effective spread is $2q(P -$

$M_0)/M_0$ with M_0 the midquote before the trade and q the trade direction, the price impact at horizon h is $2q(M_h - M_0)/M_0$ with M_h the last valid midquote at or before $t + h$, and the realized spread is their difference; all are volume-weighted over trades with a valid two-sided quote, and missing values are never filled. The quoted spread is time-weighted over valid quotes. All windows are fixed on the clock, 17:00:00 to 17:00:59 CT for the first minute, for futures and spot alike; times are located in the America/Chicago time zone, so the boundaries follow daylight-saving changes rather than a fixed offset from UTC.

Spot. Binance BTCUSDT and ETHUSDT one-minute bars over the full sample, 30-minute bars for longer horizons, and one-second bars from 16:58 to 17:03 CT in every Sunday and Wednesday window, used wherever futures and spot are compared within the minute; Binance perpetual swaps (hourly bars and funding); Coinbase BTC-USD and ETH-USD one-minute bars around every closure boundary, as a second spot reference; Bitcoin open interest from Bloomberg.

Participants. Weekly positions by trader category from the CFTC Traders in Financial Futures report serve as background. In the standard Bitcoin contract the share of open interest held by reportable traders rose from about 80% in 2018 to 95–96%; asset managers went from 3–5% to 28–30% in 2022–2023 and dealers from 0–2% to 16–26%, while non-reportable positions fell from about 20% to 4–5%. These are position shares, not trading shares, and the categories are self-reported; we do not use them to identify who trades at the reopen.

After the transition. CME moved its cryptocurrency futures to continuous trading at 16:00 CT on Friday, 29 May 2026, with a weekly maintenance window on Saturday.² For the period after the transition we use

²CME Group, “24/7 Maintenance Window Schedule Extension,” CME Globex Notice, 24 August 2026: the standard window is Saturday 02:00–04:00 CT for CME crypto futures and options, temporarily extended to 02:00–06:00 CT on 29 August and 02:00–08:00 CT

contract-level one-minute bars, TBBO, and MBP-1 from Databento and, as a check, Bloomberg one-minute bars of the front-month contracts; the two agree exactly in open, high, low, and close in 86% of minutes. The evidence after the transition covers 17 to 18 Sundays, so we describe changes after the transition rather than estimate an effect.

Samples. The main weekend sample contains the 355 Bitcoin weekends from February 2018 to May 2026 in which both futures trades lie within five minutes of the boundaries and spot is available in the same minutes, and 252 Ether weekends from February 2021. A boundary definition with spot at exactly 16:00 and 17:00 CT gives 393 Bitcoin weekends. We also detect every market-wide closure in the one-minute data as a gap of at least 55 minutes, across all contracts, that ends with trading resuming at 17:00 CT: 1,976 Bitcoin events, of which 1,545 daily one-hour breaks, 386 weekends, 21 long weekends, and 24 other holiday closures. Sunday–Wednesday comparisons pair each Sunday with the Wednesday of the same week and use HAC standard errors; unpaired rank tests are reported as a supplement. Table 1 lists every sample used below with its defining condition and size.

Decomposition. With $b = \ln F - \ln S$, the reopening gap $g = \ln(F_R/F_C)$ decomposes exactly into the spot return during the closure $r = \ln(S_R/S_C)$ and the basis change

$$\Delta b = b_R - b_C = g - r. \quad (2)$$

We estimate $g = \beta_0 + \beta r + \varepsilon$ (absorption), $b_R = \alpha + \rho b_C + u$ (persistence of the pre-close basis), and $\Delta b = a + \gamma b_C + e$. The futures-minus-spot move over an interval is the change in b over that interval. A price h minutes after the reopen requires a futures trade in that minute; in the main weekend sample 284 of 355 weekends have one at five minutes and 203 at sixty. Carrying the last trade forward instead gives the supplementary estimates reported alongside. Standard errors are Newey–West.

on 19 September 2026.

Table 1: Sample construction (Bitcoin; Ether). Each row states the condition that defines the sample used in the analyses listed, and its size. Weekends run from February 2018 (Bitcoin) and February 2021 (Ether); windows are Sundays and Wednesdays at 17:00 CT.

Sample and condition	Used in	BTC	ETH
Market-wide closures detected in the bars (gap $\geq$ 55 min ending at 17:00 CT); of which weekends	Table 4	1,976; 386	–
Boundary weekends: spot at exactly 16:00 and 17:00 CT, futures trades within 5 min	robustness	393	–
Main weekend sample: both futures trades within 5 min of the boundary and spot in the same minutes	Tables 2–3	355	252
of which with a futures trade in the target minute at +5 min / +60 min	Figure 1, Table 11	284 / 203	– / 135
Clock-minute windows before the transition, Sundays / Wednesdays (pre-close contract rule)	Tables 5, 6, 12	429 / 432	272 / 275
with spot bar at 17:00 CT (Sundays)	Tables 6, 12	402	273
with valid quotes in at least 30 of the 60 seconds, Sundays / Wednesdays	Table 7	411 / 427	254 / 273
with a signed first-minute trade and a first-trade basis, Sundays / Wednesdays	Table 9	342 / 374	236 / 232
with a signed trade in the first five seconds, Sundays / Wednesdays	Section 6	272 / 165	–
Main-sample weekends with Coinbase spot in the same minutes	Section 4	346	–
Windows after the transition, Sundays / Wednesdays / Saturday maintenance reopens	Section 7	18 / 17 / 17	18 / 17 / 17

Why synchronization matters. The daily futures “close” in common data sources is the 15:00 CT settlement price, an hour before trading stops. Table 2 shows, on 381 weekends aligned as daily data would align them, how the estimates change as the two prices are brought to the same minute. Pairing the settlement price with later spot makes the Friday basis appear to vanish at the reopen ($\gamma = -0.72$) and makes the adjustment look large (54 bp) and predictable. Once spot is observed at the settlement time, γ is -0.11 and the adjustment 16 bp. The lesson is general for any closed venue: a settlement or reference price set before the last trade, paired with a later

Table 2: Effect of price alignment. The first three rows use 381 weekends with the alignments that daily data offer; F15 is the 15:00 CT settlement price and S the time at which spot is observed. The last row is the main sample of this paper.

Alignment	β	γ (R^2)	med. $ \Delta b $
F15, spot 30 min late	0.839	-0.718 (36%)	54 bp
F15, spot at 16:00	0.912	-0.551 (38%)	35 bp
F15, spot at 15:00	0.941	-0.106 (2%)	16 bp
This paper (355 weekends)	0.943	-0.110 (2%)	14 bp

Table 3: Weekend absorption at the first futures trade (same-minute spot). HAC t with four lags.

	Bitcoin	Ether
Weekends	355	252
g on r : slope (R^2)	0.943 (97.5%)	0.941 (98.1%)
Cumulative slope one minute after the first trade	1.005	1.010
b_R on b_C : slope	0.890	0.816
b_{60} on b_C : slope (weekends with a trade at 60 min)	0.891 (203)	0.989 (135)
Δb on b_C : slope (t)	-0.110 (-2.6)	-0.184 (-3.1)
$ \Delta b $ median/mean/p95 (bp)	14.4/25.9/71.1	18.3/31.0/88.1

price from the open venue, manufactures a reopening correction that is not there. All results here use intraday prices.

4. Price Continuity (P1)

Absorption and persistence. Table 3 reports the weekend regressions. In Bitcoin the reopening gap loads on the weekend spot return with a slope of 0.943 ($R^2 = 97.5\%$); for weekends with a move above 20 bp, the median share reflected in the first futures trade is 97.9%. The Friday basis persists with a slope of 0.890, and γ is -0.110. Ether gives the same picture: an absorption slope of 0.941, persistence of 0.816, and a median basis change of 18 bp.

The first hour. Figure 1 traces, for Bitcoin, the coefficient of the futures return from the Friday close to h minutes after the first Sunday trade on the weekend spot return. It rises from 0.943 at the first trade to 1.005 after

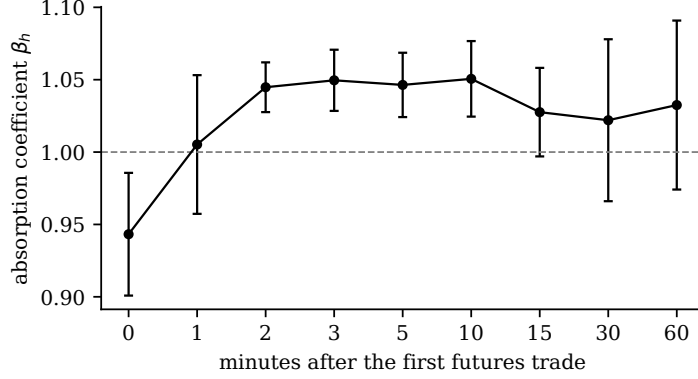


Figure 1: Cumulative absorption of the weekend spot move (Bitcoin): coefficient of the futures return from the Friday close to h minutes after the first Sunday trade on the weekend spot return, with 95% HAC intervals (355 weekends at the first trade; at later horizons, weekends with a trade in the target minute).

one minute and 1.046 after five, and stays between 1.02 and 1.05 through the hour; spot returns after the reopen do not load on the weekend move (coefficients below 0.015, $|t| \leq 1.2$). The persistence of the Friday basis is between 0.77 and 0.89 at one, two, five, ten, and sixty minutes after the reopen on weekends with a trade in the target minute (0.86 to 0.89 when the last trade is carried forward). The futures price therefore catches up with the weekend move within a minute while keeping the Friday basis; after five minutes the basis moves slightly in the direction of the weekend move, a change associated with the weekend change in the perpetual-futures premium and the expected carry roll-down.

A second spot reference. The results do not depend on the choice of Binance as the open venue. With Coinbase BTC-USD as the spot reference, on the 346 main-sample weekends with Coinbase prices in the same minutes, the absorption slope is 0.941 (0.942 with Binance on the same weekends) and the median basis change is 14.5 bp with either venue; the weekend returns of the two spot series have a correlation of 0.998. The persistence of the Friday basis is 0.79 with Coinbase against 0.89 with Binance ($\gamma = -0.21$, $t = -3.6$).

The gap comes from 2018–2019, when the price of Bitcoin in dollars and in tether differed by a large and persistent premium (a standard deviation of 75 bp on Fridays), which enters the Binance basis; since 2023 the premium is below 8 bp and the persistence is 1.02 with Coinbase and 0.93 with Binance. The excess range of Section 5 and its change at the transition are the same with either venue: a Sunday excess of 20.9 bp and a change of -22.4 bp in Bitcoin with Coinbase (20.8 and -22.3 with Binance), and 23.6 and -26.1 bp in Ether (24.0 and -27.5).

Variance is inherited. The ratio of the variance of the reopening gap to the variance of the spot return during the closure is 0.86 after daily breaks, 0.90 after weekends, and 0.92 after long weekends. The closed venue carries almost all of the variance generated in the open venue; the closure moves the variance to the reopen but does not remove it. In the classic evidence, variance is lower while markets are closed, which French and Roll attribute to the absence of trading [20]; here trading in the underlying continues and the closed venue inherits its variance.

No price discount detected before the close. If the weekend closure made futures non-marketable, futures should cheapen relative to spot as the close approaches, more so before a 49-hour closure than before a one-hour break. The basis change over the four hours before the close is -2.7 bp before weekends and -2.0 bp before daily breaks; the difference is -0.7 bp ($t = -0.6$), against a standard deviation of the weekend spot return of 324 bp. We detect no discount of the kind that a loss of marketability would produce [30], which is what one expects when the option to trade survives in another venue. This is a statement about the futures–spot basis, not about the cost of the closure to a trader bound to the futures venue, who may bear margin, mandate, or basis-risk costs that need not appear as a discount in the price.

At the frequencies and horizons examined, we therefore find no economically large or persistent price distortion from the closure. The unwinding of

Table 4: Closures by type (Bitcoin, boundary definition). First-minute range: log range of the first one-minute futures bar after the reopen. HAC standard errors.

	Daily	Holiday	Weekend	Long wknd
Events	1,545	24	386	21
Length, median (hours)	1	5	49	73
First-min. range, median/mean (bp)	7.7 / 16.6	12.1 / 24.8	27.8 / 40.1	27.5 / 38.8
First-min. volume, median	4	6	14	23
$ r $, median (bp)	26.6	98.7	121.4	71.3
g on r : slope	0.821	0.702	0.937	0.926
$\text{Var}(g) / \text{Var}(r)$	0.860	0.689	0.901	0.915

the Friday basis at the first trade is statistically significant but small, with a median basis change of 14 bp. The closure’s effect therefore lies in how trading arrives.

5. Trading and Variation Concentrate at the Reopen (P2, P3)

Closures by type. Table 4 and Figure 2 compare the first minute after each type of closure in Bitcoin. The median log range of the first one-minute bar is 7.7 bp after the daily one-hour break and 27.8 bp after weekends, and median first-minute volume rises from 4 to 14 contracts. Controlling for the absolute spot move, the weekend premium is 7.1 bp ($t = 3.0$). Within the reopen, variation sits in the first minute: the mean half-range of the futures bar at the first trade is 20.8 bp, against 8.0 bp one minute later, while spot in the same minutes has 8.8 and 8.0 bp (Figure 3). First-minute volume rises with the absolute weekend spot move ($t = 9.1$) and with weekend spot volume ($t = 5.5$; $R^2 = 33\%$), as orders bound to the futures venue meet the market at once. Long weekends do not show a larger first minute than weekends, so the evidence concerns the weekend against the daily break rather than a smooth function of closure length. Ether shows the same pattern: 33.7 bp and 14 contracts after weekends against 7.5 bp and 3 contracts after daily breaks.

Concentration on the clock. Bitcoin itself trades more at 17:00 CT

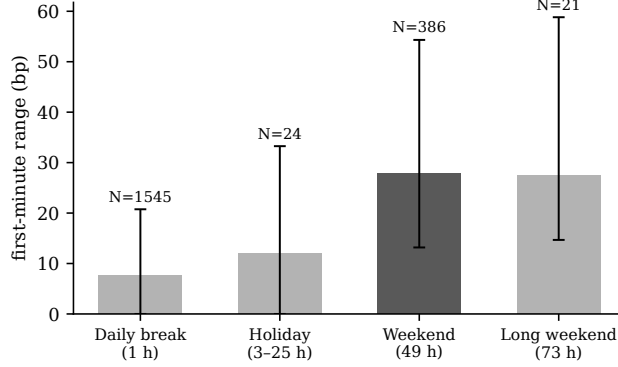


Figure 2: Median first-minute range after each type of closure (Bitcoin), with interquartile bars.

on Sunday than later in the evening, so the futures reopen must be compared with spot at the same time and with the same clock minute on a weekday. Table 5 measures the share of the hour 17:00–17:59 CT traded in its first clock minute. On Sundays before the transition the first minute carries a median 6.3% of the hour’s futures volume in Bitcoin, against 2.6% on Wednesdays and 1.7% if volume were spread evenly; the same-week Sunday-minus-Wednesday difference is 2.8 percentage points ($t = 5.5$), and 2.3 points ($t = 4.7$) after subtracting the spot share in the same minutes. In Ether the shares are 6.4% and 2.1% and the differences 3.5 ($t = 4.3$) and 3.0 points ($t = 3.7$). Per minute, the first minute after a weekend trades a median 14 contracts against 3.4 per minute over the next fifty-nine, a ratio of 4.0; after the daily break the ratio is 1.6. The reopen is a small part of the trading day: the first minute carries 0.4% and the first hour 4% of the volume of the Monday trade date, whose US daytime hours carry about half, and the first trade on 58% of Sundays is the opening match executed within 100 milliseconds of 17:00:00. The concentration is real, but 92 to 94% of the hour’s volume arrives after the first minute; volume shares cannot say whether the same traders chose to wait.

Excess variation over spot. Table 6 compares the futures minute at

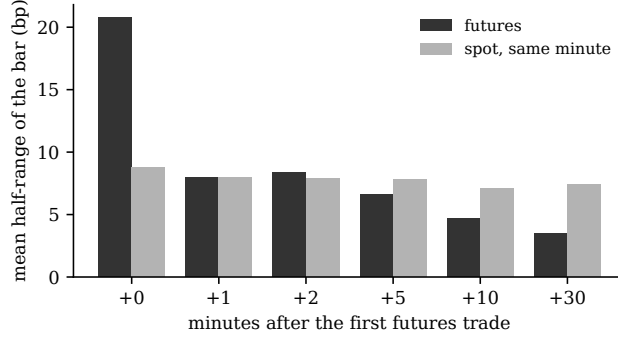


Figure 3: Mean half-range of the one-minute bar starting m minutes after the first Sunday futures trade, futures and spot in the same minute (Bitcoin, 355 weekends; futures bars exist only in minutes with a trade).

Table 5: Trading concentration in the first clock minute, 17:00:00–17:00:59 CT, as a share of the hour 17:00–17:59 (percent; even spreading gives 1.67). Windows (Sunday / Wednesday) with a trade in the hour; windows without a first-minute trade count as zero. Medians. Difference: Sunday minus the Wednesday of the same week, HAC t in parentheses; net of spot: the same difference after subtracting the spot share in the same minutes. Before the transition.

	Windows	Sunday	Wednesday	Difference (t)	Net of spot (t)
Bitcoin futures	429 / 432	6.3	2.6	+2.77 (5.5)	+2.26 (4.7)
Bitcoin spot		2.9	2.4		
Ether futures	272 / 275	6.4	2.1	+3.55 (4.3)	+3.01 (3.7)

17:00 CT with the spot minute at the same time. Before the transition, the futures minute at the Sunday reopen spans a median of 27.8 bp against 14.0 bp in spot, an excess of 12.9 bp over 402 weekends ($p < 0.001$); in Ether the excess is 11.5 bp (273 weekends). Regressing the futures-minus-spot range on a Sunday indicator, with Sundays and Wednesdays of the same week clustered, the Sunday excess is 20.8 bp in Bitcoin ($t = 9.0$) and 24.0 bp in Ether ($t = 5.7$), while at 18:00, 19:00, and 20:00 CT the Sunday–Wednesday difference is 0.6 to 1.7 bp. Wednesday stands for every weekday: the excess at 17:00 CT after the daily break is -3.5 to -5.1 bp at the median on Mondays through Thursdays in Bitcoin and -6.8 to -8.5 bp in Ether, none differing from Wednesday ($|t| \leq 1.4$), against $+12.0$ and $+11.7$ bp on Sundays. The

first-minute variation at the reopen is therefore specific to the futures venue and to the weekend closure.

The excess on sampled midquotes. A range of transaction prices widens with the number of trades: a minute with thirty trades reveals more of the path than a minute with three, and each trade crosses the spread. Since the weekend reopen has four times the trades of the Wednesday reopen, part of the excess in Table 6 could be observation rather than variation [7]. Table 7 therefore measures the same minute on the midquote sampled at fixed times, so that every window has the same number of observations whatever its trade count, over three fixed clock windows: the whole minute (17:00:00 to 17:00:59, sampled every second), the opening seconds in which the book is rebuilt (17:00:00 to 17:00:04, sampled every tenth of a second), and the seconds after the rebuild (17:00:05 to 17:00:59, every second). The split matters because the opening seconds are where the book is rebuilt after any closure (Table 8) and where the imbalance of the first trades and the price move coincide (Section 6). In Bitcoin the opening seconds are as wide after the daily break as after the weekend (19.3 against 11.0 bp at the median, but a same-week difference of 3.1 bp with $t = 0.7$): the rebuilt book, not the weekend, produces them. The seconds after the rebuild carry a weekend-specific excess of 10.5 bp ($t = 4.8$), or 7.9 bp net of the spot minute ($t = 3.8$); the whole minute mixes the two and shows a smaller, insignificant excess (6.4 bp, $t = 1.3$) because the opening seconds add noise on both days. In Ether both components are wider after weekends: 18.7 bp ($t = 3.5$) in the opening seconds and 19.6 bp ($t = 4.6$) afterwards, 13.0 bp net of spot ($t = 3.3$). Keeping only seconds in which the spread is at most 25 bp gives the same picture (6.3 and 6.6 bp net of spot, $t = 4.7$ and 6.2). The realized volatility of the sampled midquote after the rebuild gives 7.2 bp net of spot in Bitcoin ($t = 3.5$) and 5.6 bp in Ether ($t = 1.3$): the range result is common to both contracts, and the realized-volatility evidence is stronger in Bitcoin. Controlling for the logarithms of the trade count and of the quote-update

count leaves the transaction-price excess and its change at the transition (Section 7) in place. The transaction-price range therefore overstates the closure’s variation by a factor of two to three, because it counts the bid–ask bounce of many trades, but a futures-specific excess of about 8 to 13 bp is present in the quotes themselves once the book is rebuilt.

Spreads. Whether the reopen also costs more per trade is a separate question. On the clock minute, the volume-weighted effective spread of first-minute trades has a median of 10.1 bp on Sundays and 9.5 bp on Wednesdays in Bitcoin, a same-week difference of 1.2 bp ($p = 0.17$); in Ether it is 13.5 against 11.0 bp, a difference of 2.0 bp ($p = 0.15$). The Ether difference is 4.1 bp ($p = 0.008$) when the contract in each window is the one with the most trades in that window, a rule that conditions on the outcome, and we report the pre-close rule. The time-weighted quoted spread over the first minute is likewise no wider on Sundays in Bitcoin (13.7 against 13.4 bp at the median; same-week difference 1.4 bp, $t = 0.7$) and not significantly wider in Ether (9.8 bp, $t = 1.3$); displayed depth at the touch is three to four contracts on either day. Waiting sixty seconds lowers the quoted spread by about 5 bp in Bitcoin, and by the same amount on Wednesdays as on Sundays, so the saving belongs to any reopen rather than to the weekend. We find no robust evidence of a weekend premium in either contract’s spreads; the venue-specific excess range of 12 to 20 bp is in any case much larger than these spread differences; the sampled-midquote measure above shows that about half of it is price movement within the minute and the rest the bounce of many trades across the spread.

The book is rebuilt within seconds. Table 8 follows the top of the book through the first minutes after 17:00:00 CT. At the opening quote the median spread is 30 bp in Bitcoin on both Sundays and Wednesdays; it is 22 bp one second later, 14 bp after ten seconds, 11 bp after a minute, and reaches its 17:05–17:09 level of 9 to 11 bp within five minutes. Displayed depth at the touch is 3 contracts from the first second onward on either day.

Table 6: The first minute at the Sunday reopen: futures against spot, and spreads. Range: median log range (bp) of the one-minute bar starting at 17:00 CT (futures without a trade count as zero); excess: futures minus spot, median across windows, with the Wilcoxon p -value. ES: effective spread of trades in the clock minute 17:00:00–17:00:59, volume-weighted over trades with a valid quote, median across windows (bp); Sunday and Wednesday before the transition, with the same-week paired difference and its HAC p -value.

	N	Futures	Spot	Excess	p	ES Sun.	ES Wed.	Diff. (p)
BTC	402	27.8	14.0	+12.9	< 0.001	10.1	9.5	+1.23 (0.168)
ETH	273	30.7	19.5	+11.5	< 0.001	13.5	11.0	+2.01 (0.152)

The time until the spread first falls within 1.5 times its 17:05–17:09 level has a median of 2.7 seconds on Sundays and 2.1 on Wednesdays, and the same-week difference in means is 6.6 seconds ($t = 2.4$); depth is back to its later level within a second on either day. The first minute after a weekend carries 50% more quote updates (238 against 150 at the median; difference 209, $t = 4.8$). Ether shows the same path, with the spread within 1.5 times its later level after a median of 5 seconds on either day and a same-week difference of 6.4 seconds ($t = 2.1$). The reopen after a weekend is therefore not a period of thin quotes: the book is rebuilt within seconds, a few seconds more slowly than after the daily break, and the wide spreads that raise first-minute trading costs belong to the opening seconds, where the imbalance of the first trades and the price move coincide. After the transition there is no open to recover from, and the spread at 17:00 CT is at its ordinary level of 7 to 9 bp throughout.

6. Does the Variation Leave a Price Component? (P4)

Order imbalance and the opening move coincide within seconds.

Table 9 regresses the first-minute futures-minus-spot move on first-minute order imbalance. After the weekend, a buy imbalance is associated with a futures price higher relative to spot by 6.4 bp per unit of imbalance in Bitcoin ($t = 3.1$) and 8.2 bp in Ether ($t = 2.0$); after the Wednesday break the slope is -2.0 and -2.1 bp, and the difference is 8.4 bp ($t = 3.7$) and

Table 7: The first minute on sampled midquotes, three fixed clock windows. Midquote of the last valid top-of-book quote at each sampling time; whole minute and post-rebuild window sampled every second, opening seconds every 0.1 s; range: $10^4 \ln(\max / \min)$; RV: 10^4 times the square root of the sum of squared one-second log changes. Medians across windows before the transition; same-week Sunday-minus-Wednesday differences in means with HAC t (four lags), before and after the transition; net of spot: the same difference after subtracting the log range of the Binance one-minute bar at 17:00 CT; change: triple difference (Sunday $\times$ after) of the net-of-spot measure, standard errors clustered by week. For the opening seconds spot cannot be subtracted and the change is of the raw measure ($\dagger$). Windows with valid quotes in at least half of the sampling times.

		Sun.	Wed.	S–W before	S–W after	Net of spot	Change
Bitcoin	0–59 s	27.8	18.0	+6.4 (1.3)	+10.0 (3.9)	+3.8 (0.8)	–1.1 (–0.2)
	0–4 s (rebuild)	19.3	11.0	+3.1 (0.7)	+7.8 (2.8)	–	+5.5 (1.0) [†]
	5–59 s	18.2	11.6	+10.5 (4.8)	+5.5 (5.5)	+7.9 (3.8)	–10.4 (–3.7)
	RV, 5–59 s	14.3	9.1	+9.8 (5.0)	+3.3 (3.6)	+7.2 (3.5)	–11.9 (–4.5)
	Trade-price range	27.1	5.3	+25.0 (9.5)	+6.3 (1.3)	+22.4 (9.4)	–23.5 (–7.0)
Ether	0–59 s	44.3	21.7	+30.5 (5.2)	+11.4 (2.6)	+23.8 (4.2)	–21.5 (–3.6)
	0–4 s (rebuild)	28.1	14.1	+18.7 (3.5)	+10.2 (2.3)	–	–8.2 (–1.3) [†]
	5–59 s	26.1	15.0	+19.6 (4.6)	+5.2 (1.9)	+13.0 (3.3)	–17.4 (–3.5)
	RV, 5–59 s	22.1	11.4	+12.2 (2.6)	+4.9 (3.0)	+5.6 (1.3)	–9.9 (–1.7)
	Trade-price range	32.2	1.3	+32.9 (6.7)	+8.6 (1.5)	+26.3 (5.6)	–30.3 (–5.9)

10.3 bp ($t = 2.4$). Imbalance itself is not larger after the weekend (standard deviation 0.53 against 0.68 in Bitcoin). The association is contemporaneous, and non-overlapping intervals show where it lives. Using top-of-book updates, imbalance in the first five seconds after 17:00:00 and the midquote change over those same five seconds move together after weekends (10.9 bp per unit, $t = 5.3$; 5.4 bp, $t = 0.7$, on Wednesdays). The move is specific to the futures venue: spot observed at one-second frequency over the same five seconds has a standard deviation of 5.5 bp against 31.0 bp for the futures midquote and moves only weakly with the CME imbalance (1.0 bp per unit, $t = 2.6$), and subtracting it leaves the slope at 9.9 bp ($t = 4.9$). The same imbalance does not predict the midquote change from five to sixty seconds (1.1 bp, $t = 0.5$; –1.5 bp, $t = -1.0$, net of one-second spot) nor the spot-adjusted change from one to sixty minutes (2.5 bp, $t = 1.1$), and the first-minute spot-adjusted move does not predict the following hour either (slope –0.01, $t = -0.1$). Ether gives the same picture: 16.4 bp within five

Table 8: The top of the book after 17:00:00 CT (Bitcoin). Spread: quoted spread (bp, round trip) of the last valid quote at or before s seconds after 17:00:00, median across windows; base: time-weighted level over 17:05–17:09. Recovery: seconds until the spread first falls within 1.5 times its base level (median / mean); depth at the touch is back to its base level within a second on either day. Updates: top-of-book updates in the first minute, median. Same-week difference: Sunday minus the Wednesday of the same week, mean with HAC t , before the transition.

	0 s	1 s	5 s	10 s	60 s	Base	Recovery (s)	Updates
Sunday, before	30.5	21.7	17.6	13.7	10.7	8.9	2.7 / 18.8	238
Wednesday, before	31.0	20.4	15.2	13.3	11.5	10.6	2.0 / 12.3	150
Sun. – Wed. (t)							+6.59 (2.4)	+209 (4.8)
Sunday, after	–	8.9	8.5	7.4	7.2	5.0	0.1 / 1.3	1,258

seconds ($t = 4.3$), 13.6 bp net of one-second spot ($t = 3.7$), with spot moving 2.8 bp per unit ($t = 5.6$), and 1.8 bp afterwards ($t = 0.4$). Orders that arrive at the reopen move the transaction price as they are executed, and the effect is over within seconds.

The first-trade deviation reverses within five minutes. We regress the basis change from the Friday close to h minutes after the reopen on the basis change at the first trade; a coefficient of one means the first-trade change stays and zero that it is gone. On all 355 weekends the coefficient is 0.60 one minute after the reopen (SE 0.16) and 0.10 after five minutes (SE 0.07). On weekends with a futures trade in the target minute it is 0.07 at five minutes ($t = 1.1$, 284 weekends) and -0.00 at sixty ($t = -0.1$, 203 weekends). Both sides share the Friday basis, whose measurement noise biases the coefficient toward persistence. A version with no shared price, which regresses the basis change from the end of the first minute to h minutes on the first-trade change, gives -0.52 at five minutes ($t = -2.7$) and -0.70 at sixty ($t = -4.4$). Large first trades reverse most: excluding first-trade changes above 100 bp leaves 0.38 at five minutes and 0.22 at sixty ($t = 3.0$), so between 60 and 90% of the first-trade change is gone within five minutes and 80 to 100% within the hour. In Ether the share that remains after an hour is 0.08 (SE 0.08, 127 weekends), and the basis does not move further with the first-trade change

Table 9: Order imbalance and the first-minute move at the reopen. Slope of the first-minute futures-minus-spot move (bp) and of the change from one to sixty minutes (bp) on first-minute order imbalance ($\text{OFI} \in [-1, 1]$). Before the transition; weekends and Wednesdays with a first-trade basis change of at most 100 bp. The one-to-sixty-minute rows use reopens with a futures trade in the sixtieth minute. HAC t in parentheses; N: number of reopens. The last column is the interaction with a Sunday indicator in the pooled regression.

		Sunday	Wednesday	Difference
Bitcoin	First-minute move	6.39 (3.1)	-2.03 (-2.2)	8.43 (3.7)
	N	342	374	
	Change, 1-60 min	-7.67 (-2.7)	-1.20 (-0.6)	-6.47 (-1.9)
	N	195	171	
Ether	First-minute move	8.20 (2.0)	-2.07 (-1.4)	10.28 (2.4)
	N	236	232	
	Change, 1-60 min	0.50 (0.2)	-0.40 (-0.2)	0.90 (0.3)
	N	127	104	

after the first minute (-0.02 , $t = -0.4$). First-minute imbalance is followed by a reversal over the next hour in Bitcoin (-7.7 bp per unit, $t = -2.7$; Table 9) and not in Ether. The first-trade deviation is therefore temporary; whether its reversal can be traded on is the next question.

Liquidity suppliers earn no larger realized spread after weekends. If the reopen paid suppliers for bearing inventory, the realized spread on first-minute trades, the effective spread less the price impact at horizon h , should be larger after weekends than after the daily break. Table 10 reports the same-week Sunday-minus-Wednesday difference at five, thirty, and sixty minutes, with and without subtracting the spot return over the same interval. None is positive: in Bitcoin the raw difference is -3.2 bp at five minutes ($t = -1.1$), -12.0 at thirty ($t = -1.8$), and -17.7 at sixty ($t = -2.1$), and -2.8 , -4.0 , and -3.2 bp after the spot adjustment ($|t| \leq 1.5$); in Ether the differences are -3.7 , -16.1 , and -20.7 bp raw and -0.5 , -4.0 , and -4.4 bp spot-adjusted ($|t| \leq 1.2$). Restricting to quotes updated within the last five minutes or sixty seconds, or to trades with valid midquotes at all four horizons, changes nothing. The spot-adjusted price impact of first-minute trades

Table 10: Realized spreads of first-minute trades at horizons of 5, 30, and 60 minutes: same-week Sunday-minus-Wednesday difference (bp), HAC t in parentheses. Trades in 17:00:00–17:00:59 CT with an aggressor side and a valid quote; M_h is the last valid midquote at or before $t + h$ from the top-of-book updates. Spot-adjusted: the price impact is net of the spot return over the same interval (one-minute opens). Before the transition; 274 paired weeks in Bitcoin and 155 in Ether.

Horizon	Bitcoin		Ether	
	Raw	Spot-adjusted	Raw	Spot-adjusted
5 min	−3.20 (−1.1)	−2.80 (−1.0)	−3.69 (−0.7)	−0.53 (−0.1)
30 min	−12.02 (−1.8)	−3.95 (−1.5)	−16.12 (−1.2)	−3.97 (−0.8)
60 min	−17.71 (−2.1)	−3.15 (−1.2)	−20.70 (−1.2)	−4.43 (−0.9)

is, if anything, slightly larger after weekends (4 to 5 bp, $t \leq 1.8$), which is the opposite of a supplier premium. We find no evidence that liquidity supply at the weekend reopen is compensated more than at the daily reopen.

No profit after costs. If the first-trade deviation were a mispricing, a trader could bet on it. We take a basis position against the first-trade basis change one minute after the reopen and close it an hour later, on the 203 weekends with a futures trade at the exit, paying the effective spread measured in the TBBO data on each leg (a median round trip of 6.9 bp) plus exchange fees (Table 11). The gross return is 9.9 bp per weekend ($t = 2.8$); after futures costs it is 2.0 bp ($t = 0.6$), and it turns negative with a fee on the spot leg. Trading only on the largest third of first-trade changes raises the gross return to 24.7 bp; the net return is 15.3 bp ($t = 1.7$) before and 11.3 bp ($t = 1.3$) after a spot fee of 2 bp per side, on 68 weekends in eight years. A strategy based on order imbalance loses money after costs. No net return is significant at the 5% level.

Interpretation. The reopening price takes up the move formed in spot within a minute. What the closure adds is a burst of trades and of transaction-price variation in the first minute, whose direction coincides with the order imbalance of the first seconds and which leaves nothing lasting behind: no predictable continuation, a first-trade deviation that reverses within

Table 11: A contrarian strategy at the reopen (Bitcoin, 203 weekends with a futures trade sixty minutes after the reopen). Enter a basis position against the signal one minute after the reopen, exit sixty minutes after. Futures costs: effective spread on entry (first five minutes) and exit (30–60 minutes) measured in the TBBO data of each weekend, plus exchange fees. Mean return per traded weekend (bp), HAC t . Net (a): after futures costs; Net (b): also after a spot fee of 2 bp per side. Win: share of weekends with a positive gross return.

Signal	N	Gross	Net (a)	Net (b)	Win
First-trade change, all	203	9.89 (2.8)	1.99 (0.6)	−2.01 (−0.6)	0.60
First-trade change, top third	68	24.67 (2.6)	15.30 (1.7)	11.30 (1.3)	0.68
Order imbalance, all	188	2.63 (1.1)	−5.30 (−2.2)	−9.30 (−3.8)	0.57

minutes by less than the cost of trading on it, and no larger realized spread for those who supplied the liquidity. In terms of the framework, $\kappa_0 > 0$: imbalance and price move together as the orders execute, at about 11 bp per unit of imbalance over the first five seconds. But κ_h is close to zero at every horizon beyond those seconds; the orders concentrated by the closure are absorbed without a measurable price for immediacy. The transaction-price variation of the first minute is the footprint of trades crossing a book that is being rebuilt, not a price component.

7. Removing the Closure (P5)

The move to continuous trading on 29 May 2026 removes the closure by rule and leaves everything else in place. If the first-minute excess came from the closure, the part specific to futures should shrink; activity that Bitcoin shows at that hour for other reasons should remain, and it should appear in spot as well. Whether futures trading itself remains concentrated at 17:00 CT then tells the closure from the clock.

The futures-specific excess fell sharply. Table 12 compares the futures minute at 17:00 CT with the spot minute at the same time before and after the transition. After it, the Bitcoin futures minute at 17:00 CT on Sundays spans 8.5 bp against 15.9 bp in spot, and its excess over spot

is the same on Sundays as on Wednesdays ($p = 0.44$); the change in the Sunday excess from before to after is significant ($p < 0.001$), and Ether shows the same change ($p < 0.001$). In a triple difference, futures minus spot, Sunday minus the Wednesday of the same week, after minus before, the Sunday excess falls by 22.3 bp in Bitcoin ($t = -6.5$, clustered by week) and 27.5 bp in Ether ($t = -5.5$), from a pre-transition Sunday excess of 20.8 and 24.0 bp. The same regression at 18:00, 19:00, and 20:00 CT gives changes of 0.6 to 1.8 bp in Bitcoin; in Ether the 18:00 change is -5.8 bp ($t = -2.7$) and the later hours are near zero. Restricting the pre-transition period to the last 52 weeks gives -16.9 and -22.4 bp. Because the excess varies over the years, we also place the estimate in the distribution of placebo transitions, each eighteen weeks long and dated every four weeks within the pre-transition period: the true change is below 95% of the 91 placebo changes in Bitcoin (two-sided $p = 0.065$, one-sided 0.011) and below 89% of the 52 in Ether (0.170, 0.113). Figure 4 shows the two distributions with the actual change, and Figure 5 shows the weekly series of the Sunday excess over the year before and the months after: it is positive with no trend before the announcement, somewhat lower between announcement and transition, and near zero from the first week of continuous trading on. On the sampled midquotes of Table 7, which do not depend on the number of trades, the pre-transition futures-specific Sunday excess after the rebuild, 7.9 bp in Bitcoin and 13.0 bp in Ether, is gone after the transition: the post-transition same-week difference net of spot is -3.0 and -6.7 bp, and the triple difference is -10.4 bp ($t = -3.7$) and -17.4 bp ($t = -3.5$). The opening seconds behave differently: in Bitcoin they were never weekend-specific and do not change ($+5.5$ bp, $t = 1.0$), and in Ether their weekend excess falls but not significantly (-8.2 bp, $t = -1.3$). In raw terms the Sunday minute stays more variable than the Wednesday minute after the transition ($+5.5$ bp after the rebuild in Bitcoin, $t = 5.5$; $+5.2$ in Ether), and so does the spot minute at the same time; that is the trading clock, not the closure. The disappear-

ance of the futures-specific excess is therefore not an artifact of fewer trades in the minute. Pooling the two contracts, with contract-specific levels and a common change and with standard errors clustered by calendar week so that the two contracts share a cluster, gives -24.9 bp ($t = -7.6$) on transaction prices and -14.2 bp ($t = -4.4$) on post-rebuild midquotes; against the placebo distribution of pooled changes the two-sided p -values are 0.057 and 0.094 (one-sided 0.019 for the midquote measure), and 0.057 and 0.062 when every eligible week is tried as a placebo start. The change is not a feature of the first weeks: estimated on the first four, eight, thirteen, and eighteen weeks after the transition, the pooled change is -30.1 , -25.9 , -24.5 , and -24.9 bp on transaction prices and -11.7 , -13.8 , -15.2 , and -14.2 bp on midquotes (Figure 6). Adding the absolute spot return over the closure and the log of spot volume in the 17:00 minute as controls leaves the change at -17.8 bp in Bitcoin ($t = -4.5$) and -20.4 bp in Ether ($t = -3.9$). Replacing spot by the Binance perpetual swap, a derivative that trades around the clock, as the open venue gives the same picture on the 677 windows since 2020: a pre-transition Sunday excess of 21.1 bp ($t = 8.7$), a change of -24.3 bp ($t = -6.3$), and no change at 18:00 CT, while the perpetual’s own minute differs from spot’s by less than 1 bp on either day. The change did not begin before the rule changed: between CME’s announcement on 19 February 2026 and the transition, the Sunday excess was 12.6 bp in Bitcoin ($t = 2.1$) and 7.7 bp in Ether ($t = 0.9$, 27 windows), against 16.2 and 23.6 bp in the year before the announcement and -1.5 and -3.5 bp after the transition. With eighteen weeks after a single, exchange-decided change that affected both contracts on the same day, we describe the excess as having fallen sharply rather than as removed, and we treat the two contracts as one event observed twice rather than as independent replications.

Order flow and price after the transition. In the pooled regression of Sunday reopens before and after the transition, the interaction of first-minute imbalance with the post-transition period is -7.1 bp in Bitcoin ($t = -2.4$)

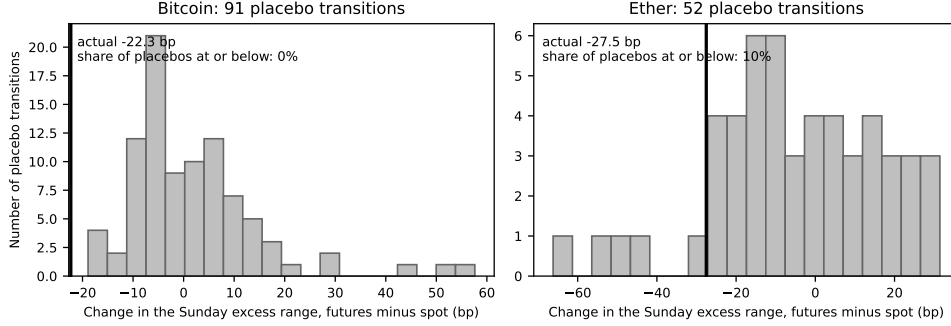


Figure 4: Placebo transitions. Each histogram collects the triple-difference change in the Sunday excess range (futures minus spot, Sunday minus the Wednesday of the same week) for eighteen-week windows dated every four weeks within the pre-transition period; the vertical line is the actual change at the May 2026 transition. Bitcoin: 91 placebos; Ether: 52.

Table 12: The minute at 17:00 CT before and after the move to continuous trading. Median log range (bp) of the one-minute bar starting at 17:00 CT (futures without a trade count as zero); excess: futures minus spot, median across windows, with the Wilcoxon p -value that it is zero.

		Windows	Futures	Spot	Excess	p
Bitcoin	Sunday, before	402	27.8	14.0	+12.9	< 0.001
	Sunday, last year before	49	34.0	15.1	+12.5	< 0.001
	Sunday, after	18	8.5	15.9	-5.5	0.003
	Wednesday, after	17	0.0	7.9	-4.7	0.023
Ether	Sunday, before	273	30.7	19.5	+11.5	< 0.001
	Sunday, after	18	12.7	23.2	-10.0	< 0.001

and -11.5 bp in Ether ($t = -2.3$), and the post-transition slope is about zero. At five seconds only eleven post-transition Sundays have trades in the window, too few for a test. On them the raw slope of the futures midquote on imbalance is unchanged in Bitcoin ($t = 0.2$ on the interaction) and lower in Ether (-19.1 bp, $t = -2.6$), but the futures midquote now moves with one-second spot (correlation 1.00 in Bitcoin, 0.99 in Ether), and net of spot the slope is 0.2 bp ($t = 0.6$) and -1.8 bp ($t = -1.3$), against 9.9 and 13.6 bp before. This is in line with the disappearance of the futures-specific move and is not separate evidence for it.

The trading clock remained. Participants kept meeting at 17:00 CT on Sundays. After the transition the 17:00 minute still trades 5.8 times the average of the surrounding sixty minutes in Bitcoin (median 4.3; 11.3 and 9.2 in the last year before the transition; 3.5 and 2.4 on Wednesdays after it), and 3.1 times more than spot’s own 17:00 spike ($t = 2.4$); in Ether the ratios are 5.5 and 1.5 ($t = 2.4$). These ratios use the surrounding hour, which includes the thin Sunday afternoon; against the following half hour alone, the 17:00 minute trades 2.2 times the per-minute average in Bitcoin futures after the transition (4.5 before) and 1.8 times in spot. Over the eighteen weeks there is no trend toward fading (slope on week number $t = 0.4$ in Bitcoin, -0.5 in Ether). The clock is shared with the rest of the exchange (Table 13): over the same sixteen months, the CME markets that kept their weekend closure open at 17:00 CT on Sunday with a first minute that trades 5.9 (E-mini S&P 500), 6.0 (euro FX), and 7.3 (ten-year Treasury) times the following half hour’s per-minute average, and 4.7 to 5.1 times after their daily one-hour break on Wednesdays, with no change at the Bitcoin transition date. Bitcoin futures, which no longer close, still show a reduced version of the same Sunday spike. Across the days of the week after the transition, the 17:00 minute on Sunday still carries a larger share of the hour than on Monday through Thursday (3.2 percentage points more in Bitcoin, $t = 1.9$; 3.6 in Ether, $t = 2.7$), while its excess range over spot no longer differs from any weekday (0.1 bp against Monday–Thursday in Bitcoin, $t = 0.1$; -3.1 bp in Ether, $t = -1.4$). The first-minute share of the hour’s volume fell in the median from 6.3% to 2.7%, but its same-week difference from Wednesday did not change detectably (-0.8 points, $p = 0.54$; net of spot -1.3 , $p = 0.27$), so we can say that the concentration continued at roughly half its former level and not that it fell. The new closure did not attract it (Table 14): at the end of the Saturday maintenance window no Bitcoin trade occurs in the first minute on any of 17 Saturdays, and Ether trades in two; the median wait to the first trade is over two hours, and the first hour after the window carries a

median of zero contracts against 337 and 233 contracts in the hour after 17:00 CT on the Sunday of the same week.³ Two further features of the old schedule survived: spot is busier at 17:00 CT, more so on Sundays ($p = 0.028$ after the transition), before and after; and venue-bound participants kept their weekday hours, with no Bitcoin futures trade between 12:00 and 16:00 CT on 17 of 18 Sundays after the transition, and none in Ether, although the venue was open.

Why the minute survives. Three explanations fit the evidence, and the data cannot rank them. First, 17:00 CT on Sunday is not a Bitcoin time: it is the weekly open of the E-mini S&P 500, euro FX, and Treasury futures, whose first minute trades 6 to 7 times the following half hour (Table 13), and it is Monday morning in Asia. Participants and systems that trade several CME markets start their week at that minute whether or not Bitcoin futures were open before it. Second, eight years of weekend closures fixed the routines around it: the point at which weekend hedges are adjusted, the schedules of trading algorithms, and the hours of trading desks were all set to the reopen, and a rule change does not reset them in a few months; that the concentration shows no fading over the weeks observed is consistent with this. Third, a closure does not by itself bring trades to its end: the Saturday maintenance window, a new closure of two hours, ends without a Bitcoin trade in its first minute on any of 17 Saturdays (Table 14). The comparison is a weak one. Saturday is the thinnest day of the week with or without a closure, with a median of 89 contracts over the whole day against about 8,800 on a weekday. Our one-minute bars also contain no trade between 19:00 CT on Friday and the start of the window in any week, although the exchange lists the window as the only scheduled interruption, and we cannot tell a market without trades from a gap in the feed; the table uses only

³The feed shows no trade between Friday 19:00 CT and the start of the maintenance window on any of these weekends, in either contract, which we could not verify against another source. The result at the end of the window does not depend on it.

Table 13: The 17:00 CT minute across CME markets and in spot. Spike: volume in the 17:00 minute over the per-minute average of 17:01–17:30, median across weeks; share: the 17:00 minute’s share of 17:00–17:59 volume (%), median. Sundays and Wednesdays from 25 May 2025 to 27 September 2026, split at the Bitcoin transition (29 May 2026); the E-mini S&P 500, euro FX, and ten-year Treasury futures kept their weekend closure and daily break throughout.

	Sun., before	Wed., before	Sun., after	Wed., after
E-mini S&P 500	5.9 / 12.2	4.7 / 8.5	5.4 / 11.3	4.2 / 8.1
Euro FX	6.0 / 11.7	5.1 / 8.5	7.2 / 13.7	6.3 / 14.0
Ten-year Treasury	7.3 / 15.1	4.7 / 6.5	8.2 / 17.0	9.1 / 13.8
Bitcoin futures	4.5 / 9.5	2.4 / 3.8	2.2 / 3.1	1.3 / 2.8
Ether futures	3.2 / 6.0	1.2 / 2.3	2.5 / 3.9	0.9 / 1.8
Bitcoin spot (Binance)	1.8 / 3.4	1.3 / 2.3	1.8 / 3.6	1.2 / 2.2

Table 14: The Saturday maintenance reopen after the transition. Seventeen Saturdays from 6 June to 26 September 2026; the window ends at 04:00 CT (06:00 on 29 August, 08:00 on 19 September). Volume in contracts across all expiries; the Sunday columns refer to 17:00 CT on the Sunday of the same week.

	Bitcoin		Ether	
	Sat. reopen	Sun. 17:00	Sat. reopen	Sun. 17:00
Weeks with a trade in the first minute	0 / 17	15 / 17	2 / 17	17 / 17
Weeks with a trade in the first hour	4 / 17	17 / 17	4 / 17	17 / 17
First-hour volume, median (mean)	0 (0.6)	337 (349)	0 (1.8)	233 (300)
Minutes to first trade, median (range)	136 (1–344)	–	151 (0–655)	–

the minutes after the window. With these limits, the Saturday evidence is in line with a closure producing a burst at its end only where the trading clock already brings participants to that time. The evidence does not tell coordination with other markets from habit or from the time zone; what it tells is that whichever of these sets the time, the closure did not.

Weekday concentration and participants. Over the sample, Bitcoin trading concentrated in weekdays and US hours: the weekend share of spot volume fell from 24% in 2018–2019 to 16–17% in 2023–2026, and the US-hours share rose from 23% to 32–34%, gradually rather than at a single date. As trading concentrated, the first minute after the weekend became rougher relative to the daily break (by 1.3 bp per percentage point of weekend share,

$t = -2.3$), but the spot minute at the same time did too, and the futures excess over spot did not change ($t = -0.3$). The composition of position holders changed most in 2022, when asset managers and dealers replaced non-reportable and other traders; their shares are not related to the reopening concentration or to first-minute spreads once a time trend or year effects are included. The weekly rhythm of Bitcoin grew stronger and its participants changed; the part specific to the closed venue stayed at about 12–13 bp until the closure ended.

8. External Validity, Implications, and Conclusion

The same pattern in Ether. Ether futures, a separate contract with its own participants but the same exchange, the same schedule, and the same transition day, show each step: absorption of 0.941 at the first trade and full absorption within a minute; a persistent pre-close basis; first-minute concentration of 6.4% against 2.1%; a futures minute 11.5 bp wider than spot at the Sunday reopen (24 bp in the regression); a within-seconds association of imbalance and price after weekends only; no prediction of later moves and no larger realized spread; a first-trade deviation largely gone within the minute; and a sharp fall of the futures excess after the transition with continued trading at 17:00 CT. Ether’s first-minute effective spread is higher after weekends only when the contract is chosen by the trades within the window; under the pre-close rule the difference is 2.0 bp ($p = 0.15$). Table 15 summarizes the tests.

Tokenized securities and other asynchronously traded claims. Many claims trade on venues with different schedules: tokenized shares trade around the clock while the listing exchange closes, depositary receipts and cross-listed shares trade while the home market is shut, and foreign-index funds trade while their constituent markets are closed. The measurements of this paper carry over to them, and the results suggest what to expect, as conjectures to be tested market by market. When the open venue is liquid,

the first trade of the closed venue should absorb most of its move; a low absorption coefficient would indicate that the open venue does not lead, as may be the case for thinly traded security tokens today. The cross-venue premium should persist across the reopen. The closed venue’s first minute should be busier and more variable than the open venue’s, and whether that variation leaves a lasting price component depends on the elasticity of liquidity supply. And extending trading hours should remove the venue-specific variation at the old boundary without, by itself, moving the times at which participants trade.

Implications. Extending the hours of a venue whose underlying already trades continuously should not be expected to make its reopening price more accurate, since that price already takes up the spot move within a minute; the evidence does not speak to other dimensions of price efficiency or to welfare. What it removes is the burst of variation at the boundary, and in the first months of continuous CME trading that burst fell sharply. It does not change when people trade: the concentration at 17:00 CT on Sundays, set by the Asian week and by the schedules of the other markets that open then, continued. Exchanges that extend hours should expect the clock of their participants, not the old boundary, to shape where liquidity is thin.

Limitations. The change in trading hours is a single event, decided by the exchange, that affected both contracts on the same day, so the two replications are not independent, and the evidence after it covers 17 to 18 weekends; the placebo distribution of eighteen-week changes is wide, and the Ether estimate is not outside it. The effective spread, realized spread, and order imbalance come from trades and top-of-book quotes; we do not observe the full book or the identity, inventories, and profits of liquidity suppliers, and spot is observed at one-second frequency in the reopening windows and at one-minute frequency elsewhere, so the timing of the first futures trades relative to spot is resolved to a second, not to the trade. Prices at later horizons require a trade in the target minute, which restricts the sample to

the more actively traded weekends. Volume shares cannot say whether the same traders wait, and the CFTC categories are self-reported position shares. The main spot reference is Binance; Coinbase gives the same absorption and the same excess range, and a lower persistence of the basis in the early years; other venues and the CME CF reference rate are not examined. Expiry dates are the contracts' official last trading days, the last Friday of the contract month or the preceding business day when that Friday is a holiday, confirmed against the last trade of each of the 100 expired Bitcoin contracts in the data.

Conclusion

The weekend closure of CME Bitcoin and Ether futures no longer exists. While it did, it offered a window in which the underlying kept revealing its price while the derivative venue was shut, and its removal showed which features of the reopen belonged to the boundary. When a market closes while the asset it references keeps trading elsewhere, we find no economically large or persistent price distortion: the reopening takes up the price formed in the open venue, the pre-close basis largely persists, no discount is detected before the close, and the closed venue inherits the variance of the open one. The closure instead concentrates trades and price variation in the first minute after the reopen—in the futures venue rather than in spot, and after the weekend rather than after the daily break. The excess range is about 20 bp on transaction prices, of which 8 to 13 bp remains on midquotes sampled every second. That variation coincides with order imbalance in the first seconds but leaves nothing lasting behind: no predictable continuation, a first-trade deviation that reverses within minutes, no larger realized spread for liquidity suppliers, and no significant net profit for a contrarian. When the exchange removed the closure, futures-specific variation fell sharply in both contracts, and the pre-transition excess disappeared on post-rebuild sampled midquotes. Because both contracts were affected by the same policy change, this is one event observed in two contracts rather than two independent

experiments. Trading at the old reopening time nevertheless continued at about half its former concentration. The closure produced the reopening variation; the trading clock set the timing of trades.

Appendix A. Contract-selection rule

Table A.16 reports, for the trade-and-quote analyses, every statistic that the choice of contract within a window changes by more than rounding. The pre-close rule (the contract with the largest volume in the 12:00–16:00 CT session of the preceding weekday) is used throughout the paper; the within-window rule (the contract with the most trades in the window) was used in an earlier version and conditions on the outcome. The two rules pick the same contract in 98.4% of Bitcoin windows and 98.8% of Ether windows.

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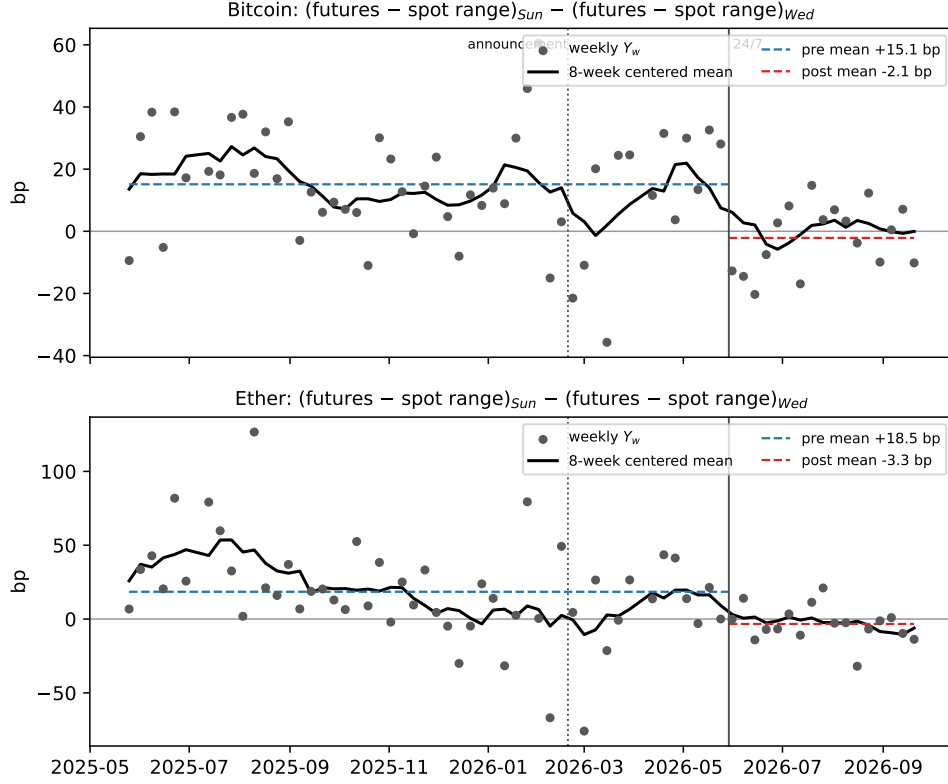


Figure 5: Weekly event-time series around the transition. Each point is $Y_w = (\text{futures range} - \text{spot range})_{\text{Sunday}} - (\text{futures range} - \text{spot range})_{\text{Wednesday}}$ for one week (log range of the 17:00 CT minute, bp, futures without a trade as zero); the line is an eight-week centered mean; dashed lines are the means over the 52 weeks before and the 17 weeks after the transition; the dotted vertical line is CME's announcement (19 February 2026) and the solid one the transition (29 May 2026).

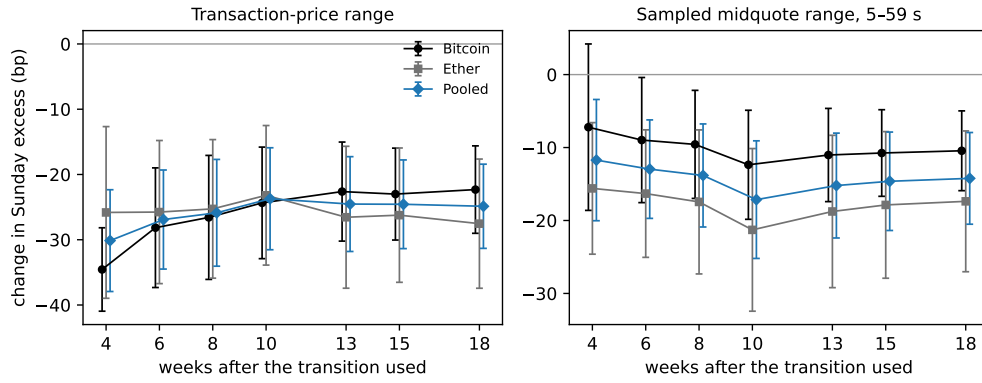


Figure 6: The change at the transition by the number of post-transition weeks used. Triple-difference change in the Sunday excess over spot (futures minus spot, Sunday minus the Wednesday of the same week, after minus before), estimated on the first k weeks after the transition, with 95% intervals from standard errors clustered by week. Left: one-minute transaction-price range. Right: range of the midquote sampled every second over 17:00:05–17:00:59 CT. The pooled estimate has contract-specific levels and a common change.

Table 15: Summary of the tests.

Question	Evidence (Bitcoin; Ether)	Reading
P1 price continuity	first trade absorbs 94% of the spot move; basis largely persists (0.89; 0.82; $\gamma = -0.11$, $t = -2.6$; 0.79 with Coinbase as spot); variance inherited; no price discount detected in the basis	holds; the 10% unwinding of the basis is significant but small
P2 order concentration	first clock minute 6.3% of the hour on Sundays against 2.6% on Wednesdays (6.4 against 2.1), net of spot; four times the per-minute average after weekends, 1.6 after daily breaks	holds
P3 venue-specific variation	futures minute exceeds spot's by 20.8 bp ($t = 9.0$) on transaction prices and by 7.9 bp ($t = 3.8$) on sampled midquotes after weekends, and by 0.6–1.7 bp at other hours; 24.0 and 13.0 bp	holds; transaction prices overstate it two- to threefold
P4 lasting price component	imbalance and price coincide within five seconds ($t = 5.3$; 4.3), net of one-second spot (4.9; 3.7), and not afterwards ($t \leq 0.5$); first-trade deviation largely reversed within five minutes; realized spreads not larger at 5–60 min; no profit after costs; spreads not detectably wider in either contract	immediate impact at execution, none persisting
P5 removal	futures excess falls by 22 bp ($t = -6.5$; placebo $p = 0.065$) and 28 bp ($t = -5.5$; 0.170), pooled 25 bp ($t = -7.6$; 0.057), the same with Coinbase as spot; one event observed in two contracts; on post-rebuild sampled midquotes the pre-transition excess of 8 and 13 bp is gone; trading at 17:00 CT continues at about half its former concentration, no fading over 18 weeks	fell sharply; a single event, 18 weeks, placebo p of 0.065 and 0.170

Table A.16: Statistics that depend on the contract-selection rule. Same-week Sunday-minus-Wednesday differences before the transition, HAC t or p in parentheses; the five-second slope is the coefficient of the midquote change on order imbalance over 17:00:00–17:00:04 on Sundays.

	Bitcoin		Ether	
	Within-window	Pre-close	Within-window	Pre-close
Effective spread, first minute (bp, p)	+1.13 (0.246)	+1.23 (0.168)	+4.05 (0.008)	+2.01 (0.152)
Quoted spread, first minute (bp, t)	+1.2 (0.6)	+1.4 (0.7)	+12.0 (1.3)	+9.8 (1.3)
Midquote on imbalance, first 5 s (bp, t)	10.9 (5.3)	10.9 (5.3)	18.0 (4.4)	16.4 (4.3)
Spread recovery time (s, t)	+5.9 (2.2)	+6.6 (2.4)	+6.3 (2.0)	+6.4 (2.1)