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The Weekend Vacuum: Structural Liquidity Mismatches in Spot Crypto ETFs

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1. Introduction

The approval of Spot Bitcoin ETFs in January 2024 marked a pivotal integration of the cryptocurrency market into the traditional financial system. These products present a structural paradox: unlike typical ETFs that enhance diversification or access, single-asset crypto ETFs mainly function as regulatory vehicles for institutional capital. Despite representing only approximately 6-7% of the total Bitcoin market capitalization as of late 2025, these vehicles exert disproportionate influence on price discovery due to the rigid concentration of their trading activity.

A structural mismatch emerges: Bitcoin trades 24/7, while its primary institutional vehicles operate only during U.S. equity hours (Mon–Fri, 9:30–4:00 EST). This discrepancy bifurcates the market into "Institutional Hours," characterized by deep liquidity and authorized participant activity, and "Native Hours" (weekends, nights and holidays), where price discovery relies entirely on crypto-native participants.

This paper investigates the market microstructure implications of this bifurcation, specifically testing the "Liquidity Vacuum" hypothesis. I posit that the cessation of institutional flows on weekends creates a fragile environment where prices drift inefficiently on low volume. This drift creates 'Gap Risk': the ETF must re-price instantly on Monday to catch up with shifts during the prior weekend.

Using high-frequency 5-minute data from January 2023 to November 2025, I document a significant structural regime shift. First, employing a Difference-in-Differences (DiD) framework, I find that the volatility gap between weekdays and weekends has widened significantly post-ETF. While weekday volatility surged due to institutional participation, weekend volatility failed to keep pace, deepening the relative liquidity vacuum.

Second, I identify a "Monday Morning Heartbeat" effect. In the post-ETF regime, Monday market opens exhibit a volatility spike approximately 40% higher than other weekdays—a phenomenon virtually non-existent in 2023. I additionally document a pre-market "anticipation phase" beginning around 8:00 AM EST, where native crypto traders appear to strategically position ahead of the expected liquidity shock at the U.S. market open. Finally, I demonstrate that this volatility is strongly correlated with the magnitude of weekend price drift, suggesting that Monday mornings have become a period of violent "catch-up" trading as institutional capital absorbs the variance accumulated during the weekend vacuum.

This structural segmentation not only delays price discovery but also reshapes it.

Because weekend price drift is driven largely by retail-dominated venues, the eventual re-entry of institutional flow does not simply correct the mispricing but often chases it. The interaction of rigid ETF trading windows and sentiment-driven weekend markets generates predictable bursts of volatility and short-term momentum at the Monday open.

2. Institutional Background and Theoretical Framework

This section outlines the institutional constraints that create the operating time mismatch, and the theoretical framework predicts its behavioral consequences.

2.1 Temporal Segmentation: Continuous vs. Discrete Trading

Bitcoin trades on a globally distributed network of exchanges that function continuously, facilitating 24/7 price discovery. In contrast, spot Bitcoin ETFs trade exclusively during U.S. equity market hours (Monday–Friday, 9:30 AM–4:00 PM EST). This creates a recurring "information blackout" for institutional capital every weekend, during which the underlying asset continues to trade and react to new information on native venues.

This structure is fundamentally different from traditional equity markets. When traditional stocks such as Apple (AAPL) stop trading on Friday, all global markets for Apple stock effectively stop. When a Bitcoin ETF stops trading, the underlying asset remains active. This creates a "Gap Risk" unique to crypto ETFs: the ETF price is static for about 64 hours (including the Friday night and Monday morning before 9:30 am EST) while the Net Asset Value (NAV) drifts, forcing a discrete "catch-up" event at the Monday open.

2.2 Theoretical Framework: The "Monday Effect"

Traditional finance literature has long documented "Day-of-the-Week" anomalies on Mondays (French, 1980), often attributing them to settlement cycles or bad news released on weekends. However, the crypto-ETF interaction suggests a different mechanism rooted in Market Segmentation Theory.

Consistent with the models of Admati and Pfleiderer (1988), which link volatility clustering to the concentration of informed and liquidity trading, we find that the ETF's trading schedule artificially forces this concentration into the Monday market open. The resulting volatility spike confirms that limiting institutional participation to specific windows concentrates variance rather than smoothing it.

Because institutional capital is sidelined on weekends, price movements during this period are driven by retail flow and "native" sentiment. I hypothesize that this segment is less efficient at pricing fundamental news. Rather than immediately correcting weekend drift, the resumption of institutional trading may initially amplify it. If weekend price action has positive signals, ETF participants might accumulate large buy demand waiting for the Monday open. This concentrated, mandatory buying pressure might keep the weekend trend further into the Monday session before any mean reversion occurs. This interplay predicts heightened volatility and short-term momentum continuation at the Monday open.

Thus, the Monday volatility spike is not solely a mechanical re-pricing event; it reflects the interaction between structural timing constraints and the behavioral dynamics of sentiment-driven weekend markets.

3. Data and Methodology

To empirically test the impact of ETF structural constraints on market microstructure, I construct a high-frequency dataset spanning the pre- and post-ETF launch periods.

3.1 Data Description

The primary analysis focuses on Bitcoin (BTC/USDT), representing the dominant asset in the crypto ETF ecosystem. I utilize 5-minute interval price and volume data sourced from Binance, the world's largest cryptocurrency exchange by volume. The sample period extends from January 1, 2023, to November 26, 2025, providing the window of approximately 12 months prior to and 22 months following the launch of spot Bitcoin ETFs in the United States on January 11, 2024. To validate the structural nature of the findings, I also include a supplementary dataset for Ethereum (ETH/USDT) covering the same period, treating its July 2024 ETF launch as a secondary robustness check.

The choice of a 5-minute sampling frequency is deliberate. While 1-minute data is available, it is often contaminated by microstructure noise such as bid-ask bounce and price discreteness, which can inflate realized volatility estimates (Andersen et al., 2001). Conversely, hourly data aggregates too much information, potentially smoothing out the precise "re-pricing shock" at the market open. The 5-minute interval offers an optimal balance, providing sufficient granularity to observe the immediate impact of the 9:30 AM open while allowing enough time for price formation to settle, ensuring a cleaner signal of realized variance.

A critical step in this analysis is the precise alignment of crypto-native trading activity with U.S. institutional market hours. Native crypto data is timestamped in Coordinated Universal Time (UTC). To accurately capture the interaction with U.S. equity markets, all timestamps were converted to U.S. Eastern Time (EST/EDT), accounting for Daylight Saving Time adjustments to prevent "ambiguous time" errors during clock shifts. Furthermore, I integrated the official NYSE trading calendar using the `pandas_market_calendars` library to filter out U.S. market holidays (e.g., Thanksgiving, Christmas) and early closures, classifying them as "Off-Hours" to prevent false positives in the analysis of institutional liquidity.

3.2 Variable Construction

The analysis relies on three primary measures of market activity:

- **Realized Volatility(RV_t):** Defined as the squared return over each 5-minute interval (r_t^2). In high-frequency finance, the sum of squared returns is a standard, unbiased estimator of variance (Andersen et al., 2003).
- **Amihud Illiquidity Ratio ($ILLIQ_t$):** To proxy for market fragility, I calculate the Amihud (2002) measure ($|r_t|/(P_t \times V_t)$). A higher ratio indicates that a smaller amount of capital is required to move the price, signifying a "thinner" market.

- **Market State Dummies:The sample is partitioned into three mutually exclusive states:**
  - `ETF_Open`: Monday through Friday, 9:30 AM to 4:00 PM EST, excluding holidays.
  - Weekend: Saturday 12:00 AM to Sunday 11:59 PM EST.
  - Off-Hours: Weeknights and holidays.

3.3 Econometric Model

To formally test the "Liquidity Vacuum" hypothesis, I employ a Difference-in-Differences (DiD) regression framework applied separately to Bitcoin and Ethereum. The model estimates the change in the volatility gap between weekdays and weekends following the respective ETF launch dates:

$$Vol_t = \beta_0 + \beta_1 \text{Post}_t + \beta_2 \text{Weekend}_t + \beta_3 (\text{Post}_t \times \text{Weekend}_t) + \gamma X_t + \epsilon_t$$

Treatment Definitions:

- **For Bitcoin:** $\text{Post}_t = 1$ for dates after January 11, 2024.
- **For Ethereum:** $\text{Post}_t = 1$ for dates after July 23, 2024.

The coefficient of interest is β_3. A negative and significant β_3 indicates that relative to the general increase in market volatility (β_1), weekend volatility failed to keep pace, widening the liquidity gap. To ensure robustness against volatility clustering, I estimate a second specification ("Martingale Control") that includes a lagged volatility term (Vol_{t-1}).

4. Empirical Results

This section presents the empirical evidence supporting the "Liquidity Vacuum" and "Monday Reversion" hypotheses. The analysis proceeds in four stages: establishing the structural widening of the liquidity gap, identifying the intraday timing of the re-pricing shock, examining the directional relationship between weekend drift and Monday price action, and finally, analyzing the temporal evolution of this inefficiency.

4.1 The Widening Liquidity Gap

To test the existence of a "Liquidity Vacuum," I first compare realized volatility across three market states: `ETF_Open` (institutional hours) and Weekend (native hours). Figure 1 visualizes the mean 5-minute realized volatility for the Pre-ETF and Post-ETF periods.

Consistent with the hypothesis, the data reveals a significant structural divergence. In the pre-ETF period (Orange bars), weekend volatility was naturally lower than weekday volatility, reflecting standard crypto market cycles. However, in the post-ETF period (Blue bars), this gap widened dramatically. While weekday volatility surged, driven by the injection of institutional volume during NYSE hours; weekend volatility failed to keep pace.

To confirm that this is a liquidity issue and not just price variance, I examined market fragility using the Amihud Illiquidity Ratio (Figure 2).

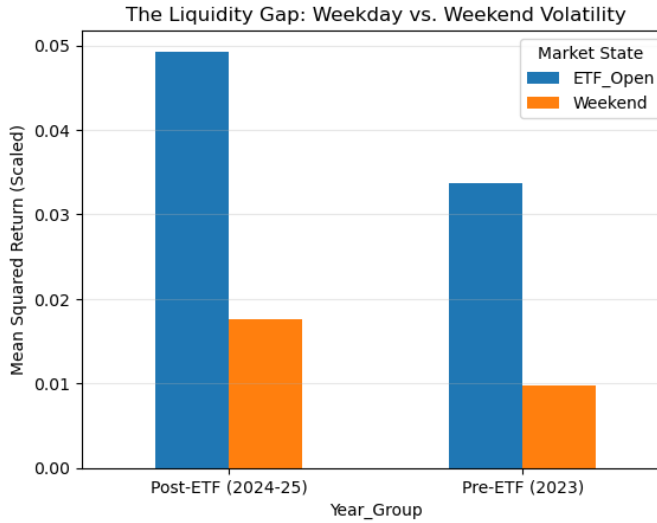
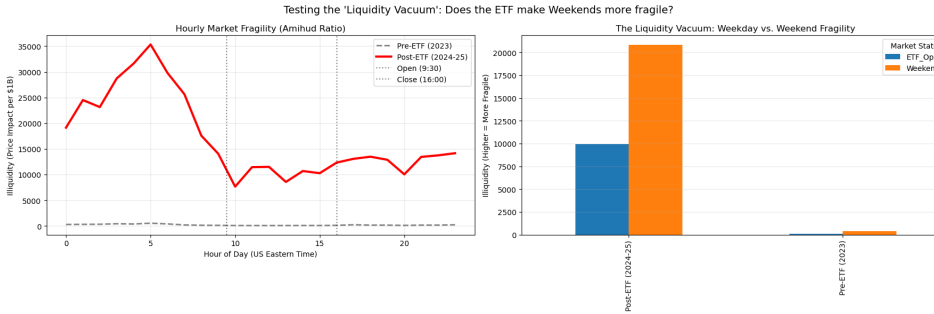


Figure 1. The Liquidity Gap Bar Chart



*Note:The sharp increase in absolute illiquidity levels from 2023 to 2024 is an artifact of Binance ending its zero-fee trading promotion, which significantly reduced reported volumes (the denominator). Analysis should focus on the relative difference between weekday and weekend fragility within each period, rather than comparing absolute values across years.

Figure 2. Amihud Fragility Chart

The left panel of Figure 2 reveals a distinct shaped fragility profile during the post-ETF period (Red Line). Fragility drops significantly during U.S. market hours (9:30 AM – 4:00 PM), confirming that ETF activity acts as a "liquidity subsidy." Crucially, as soon as the market closes at 4:00 PM, fragility spikes back up, leaving the weekend market structurally thinner and more susceptible to price impact.

While Figure 2 provides a visual illustration of the fragility profile, formal statistical testing is necessary to confirm that the observed pattern represents a significant structural change rather than random variation. Table 1 presents the results of a Difference-in-Differences (DiD) regression, which quantitatively validates this liquidity effect. In Model 1, the coefficient on the Interaction term (`Post_ETF` × Weekend)

is negative and statistically significant ($\beta_3 = -0.418, t = -4.63$), indicating that relative to the general increase in market activity, weekends became structurally "quieter." To ensure this result is not driven by simple volatility clustering, Model 2 presents the robustness check including a lagged volatility term. Even after controlling for the strong persistence of variance (`Lagged_Vol` $t = 116.8$), the structural break remains significant. The interaction term retains its negative sign ($\beta_3 = -0.331, t = -3.75$), proving that the widening gap is a fundamental market structure shift rather than a transient momentum effect.

Table 1. Difference-in-Differences Regression Results

Model 1: Basic DiD	Coef.	Std. Err.	t	P>|t|
Intercept	1.9872	0.039	51.19	0.000
Dummy_Post	1.1973	0.048	24.80	0.000
Dummy_Weekend	-1.0068	0.073	-13.87	0.000
Interaction	-0.4181	0.090	-4.63	0.000

Model 2: DiD + Lagged Vol	Coef.	Std. Err.	t	P>|t|
Intercept	1.5760	0.038	41.32	0.000
Dummy_Post	0.9495	0.047	20.08	0.000
Dummy_Weekend	-0.7983	0.071	-11.24	0.000
Interaction	-0.3311	0.088	-3.75	0.000
Lagged_Vol	0.2069	0.002	116.87	0.000

Notes: Interaction term tests the DiD effect. Model 2 controls for autocorrelation via lagged volatility.

4.2 The Monday Morning "Heartbeat"

If the weekend vacuum allows for inefficient price drift, the resumption of institutional trading should trigger a violent re-pricing event. Figure 3 plots the average intraday volatility profile for Bitcoin, aggregated by hour of the day (EST).

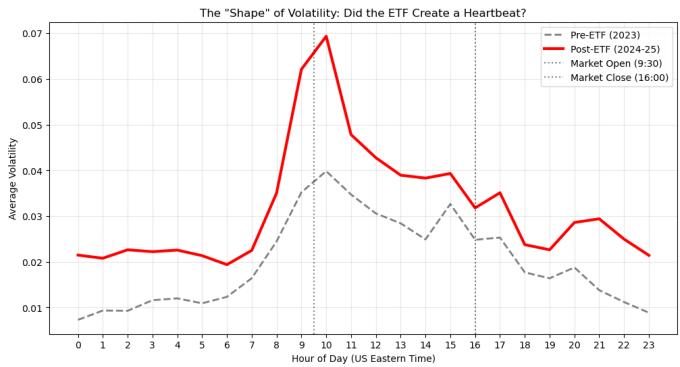


Figure 3. Intraday Volatility/Heartbeat

The contrast is striking. The 2023 profile (Grey line) shows a smoother curve typical of a continuously traded asset. In contrast, the 2024 - 2025 profile (Red line) exhibits a massive, artificial spike at exactly around 09:30 AM EST. This "Heartbeat" represents a volatility premium of approximately 40% over standard weekday trading hours. Crucially, this spike dissipates by 11:00 AM, suggesting it is a discrete "catch-up" event where the market processes the market-off information in the first 90 minutes of the trading day.

In addition to the sharp 9:30 AM jump, Figure 3 also reveals a pronounced volatility buildup beginning around 8:00 AM. This pre-market ramp is notable: even before U.S. equity trading officially begins, native crypto traders appear to “position ahead” of the expected liquidity shock. In microstructure terms, this resembles strategic predation—order flow accelerates and the market becomes increasingly jittery as traders attempt to anticipate AP-driven rebalancing at the open. The hour before 9:30 AM thus functions as a staging period where liquidity thins and informed traders effectively “hunt” for the upcoming move.

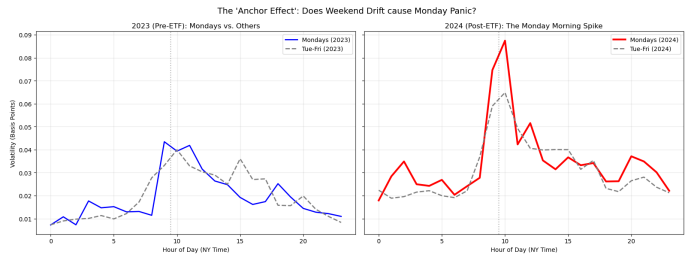


Figure 4. Monday’s Heartbeat

Figure 4 isolates the volatility of Monday morning compared to Tuesday–Friday. Pre-ETF, the Monday profile closely mirrors the rest of the week, indicating no special morning effect. Post-ETF, however, Monday exhibits substantially higher volatility than the other weekdays, confirming that the majority of the morning “Heartbeat” now occurs on Mondays, consistent with the hypothesis that institutional flows concentrate at the start of the trading week.

4.3 The Momentum "Chase"

Is this volatility spike a correction or a chase? Figure 5 tests the relationship between the magnitude of weekend price drift and the intensity of the Monday morning panic.

The scatter plot reveals a strong positive convexity in the post-ETF period (Red trendline). Unlike 2023 (Blue trendline), where weekend drift had little impact on Monday open volatility, the 2024 market shows a "Rubber Band" effect: the further prices drift over the weekend, the more violent the trading activity at the Monday open.

To understand the direction of this volatility, Figure 6 plots the conditional price path of Bitcoin on Monday mornings, segmented by whether the preceding weekend return was positive (Green) or negative (Red).

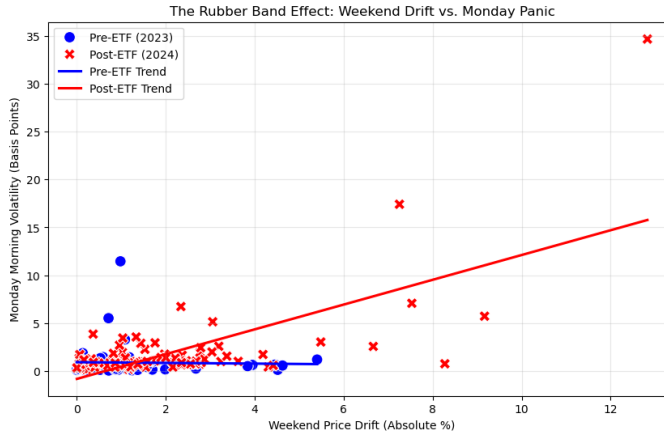


Figure 5. Scatter Plot Drift vs. Panic

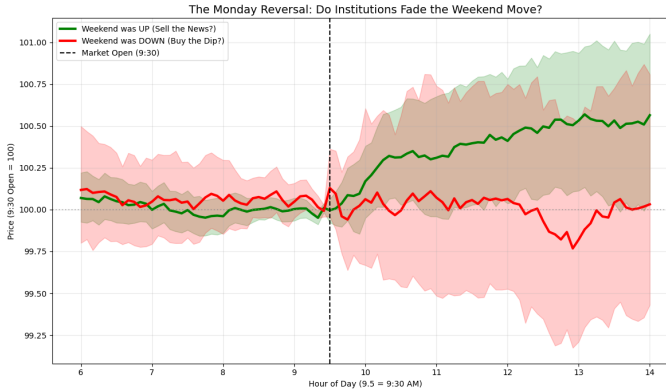


Figure 6. Price Path Reversion/Chase

The results reveal a clear "Momentum Continuation" pattern. On Mondays following a positive weekend (Green line), prices do not immediately revert; instead, they surge upwards at the 9:30 AM open, continuing the weekend trend until approximately 12:30 PM. Similarly, negative weekends (Red line) are followed by continued selling pressure at the open. This suggests that ETF-driven capital initially chases the retail sentiment accumulated over the weekend, amplifying the move before stabilizing in the afternoon.

4.4 Temporal Evolution and Persistence

Finally, to test whether the market is adapting to this inefficiency, I conducted a rolling sensitivity analysis (Alpha Decay). Figure 7 tracks the sensitivity of Monday volatility to weekend drift over time.

Contrary to the Adaptive Markets Hypothesis, we do not find consistent evidence

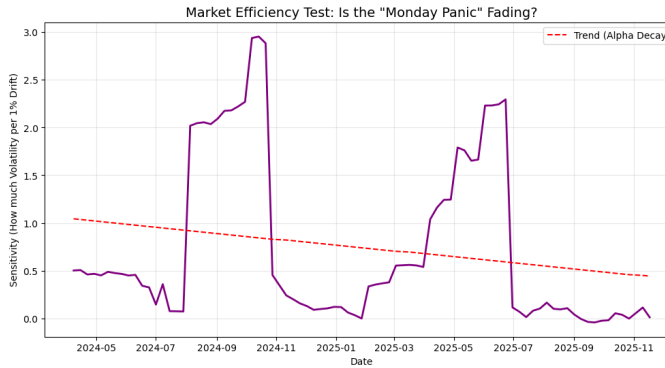


Figure 7. Alpha Decay/Sensitivity

of alpha decay in the *early* post-ETF period. The sensitivity remains highly variable and persistent throughout 2024, suggesting that the "Monday Reversion" is not a simple arbitrage opportunity that can be easily competed away. However, a noticeable dip in sensitivity appears in mid-2025, a structural shift discussed further in Section 5.

4.5 Robustness Check: The Ethereum Case

To determine whether these structural anomalies are unique to Bitcoin or a general feature of spot crypto ETFs, I replicate the same analysis on Ethereum surrounding its July 2024 ETF launch shown in figures and tables in the Appendix. The overall signals of Ethereum are less prominent than Bitcoin but still directionally same. The result likely reflects a weaker anchor phenomenon: unlike Bitcoin, where the ETF is the superior institutional vehicle, the Ethereum ETF lacks staking rewards, potentially reducing its dominance over price discovery relative to the native on-chain market. Nonetheless, the presence of the Monday spike across both assets strongly suggests that the "Liquidity Vacuum" is an inherent byproduct of the ETF vehicle's trading schedule, rather than an idiosyncrasy of Bitcoin itself.

5. Discussion

The empirical results establish two clear phenomena: a structural "Liquidity Vacuum" on weekends and a predictable "Reversion Shock" at the Monday open. This section interprets these findings through the lens of market microstructure, specifically examining the mechanical constraints of ETF creation and the limits to arbitrage that allowed these inefficiencies to persist.

5.1 The Mechanism of Inefficiency: Cash Creation as a Volatility Amplifier

The magnitude of the Monday volatility spike ($\beta_3 = -0.418$) suggests that institutional flows at the open are not merely "informed trading" but "forced execution." Under the "Cash Creation" model that dominated the sample period (January 2024 – July 2025), Authorized Participants (APs) were structurally unable to use Bitcoin inventory to settle net demand. Instead, weekend retail demand accumulation translated into

a mandatory cash liability for the ETF issuer at the Monday open. To minimize tracking error, the issuer's trading agents were compelled to execute spot purchases immediately upon market open, regardless of price impact. This converted "private sentiment" (weekend buying interest) into "toxic order flow" (predictable, price-insensitive buying), amplifying the very momentum that retail traders initiated over the weekend. The "Heartbeat" observed in Figure 3 is therefore not a reflection of new information entering the market, but the footprint of this mechanical rebalancing.

5.2 Limits to Arbitrage and Gap Risk

These limits allow retail-driven weekend drift, as a behavioral phenomenon, to interact with structural constraints, producing persistent and predictable Monday dislocations. Standard asset pricing theory suggests that predictable price patterns, such as the correlation between weekend drift and Monday returns, should be arbitraged away. The persistence of this anomaly for over 18 months indicates significant "Limits to Arbitrage" (Shleifer & Vishny, 1997).

To exploit the Monday reversal, an arbitrageur would need to accumulate Bitcoin over the weekend in anticipation of Monday's flow. However, this exposes the trader to significant "Gap Risk"—the risk that idiosyncratic news could crash the asset price while the ETF vehicle is closed and untradeable. For regulated market makers with strict Value-at-Risk constraints, the cost of holding unhedged weekend inventory acts as a barrier to entry. Consequently, the liquidity vacuum is not filled by arbitrageurs, allowing price drift to persist until the "adults return" on Monday.

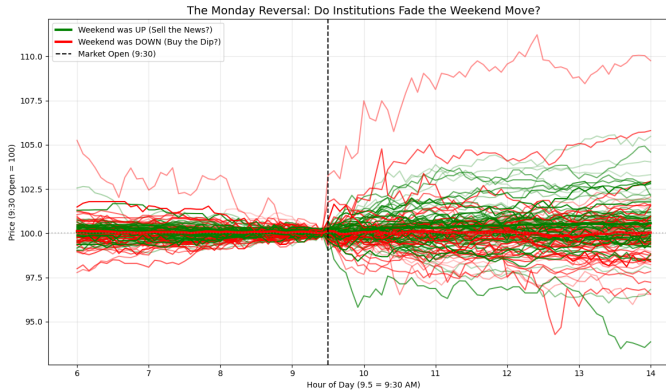
5.3 The Structural Fix: Evidence from the "In-Kind" Shift

The most compelling evidence that market structure drives this volatility comes from the regime shift observed in late 2025. As illustrated in the time-varying sensitivity analysis (Figure 7), the "Monday Panic" coefficient begins to decay notably following the SEC's approval of In-Kind creation in July 2025.

Visual analysis of individual Monday price paths further confirms this mechanism. In the early post-ETF period (Light Green lines in Figure 8), Monday opens following positive weekends exhibited strong momentum continuation, consistent with the "forced buying" of the Cash Create model. In contrast, the post-July 2025 period (Dark Green lines) shows significantly flatter trajectories. This suggests that APs began utilizing inventory transfer to buffer weekend demand shocks, effectively absorbing the "free money" internally rather than externalizing it as spot market volatility. The "Liquidity Vacuum" was not filled by more trading, but by better plumbing.

6. Conclusion

The approval of spot Bitcoin ETFs was heralded as a milestone for market maturity, yet this study reveals that the integration of a 24/7 digital asset into a 9-5 traditional financial wrapper initially introduced significant structural friction. By analyzing high-frequency data from 2023 through 2025, I document the emergence of a "Liquidity Vacuum" on weekends, characterized by a widening volatility gap between institutional and non-institutional trading hours. A notable implication of these results is the emergence of an "anticipation phase" in the hour preceding the U.S. open.



**Note:*the thick green line and red line are the averages identical as those in Figure 5. They look different due to the y-axis scale difference.

Figure 8. In-kind ETF approval

The consistent volatility buildup from 8:00–9:30 AM suggests that traders strategically cluster around predictable ETF-driven liquidity injections. Importantly, the inefficiency documented here does not arise from structure alone, but from the interaction between ETF plumbing constraints and the behavioral dynamics that dominate weekend crypto trading.

The findings challenge the notion that ETFs serve purely as stabilizing agents. Instead, the structural constraints of the Cash Creation model (dominant until mid-2025) concentrated liquidity demands into the Monday market open, creating a predictable and violent "Momentum Shock." Behavioral analysis of price paths indicates that weekend price drift is not efficiently absorbed; rather, it is "chased" by institutional capital, amplifying retail momentum in a volatile burst of activity at 9:30 AM EST. This phenomenon persists in Ethereum, suggesting that it is a feature of the crypto ETF vehicle itself rather than a specific asset.

These results illustrate how structural barriers can create persistent inefficiencies. The "Monday Panic" was not irrational; it contained a rational response by Authorized Participants forced to execute spot trades in a constrained window. The subsequent decay of this anomaly following the approval of In-Kind creation in July 2025 confirms that market efficiency is endogenous to market design. By buffering demand shocks, the In-Kind mechanism gradually narrows the vacuum, turning a mechanically amplified market response into a more manageable effect. It remains unclear whether the short-term momentum from weekend retail sentiment persists. Although APs mitigate many structural anomalies, some behavioral effects, such as FOMO-driven or retail herd trading, may linger.

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Appendix 1. Data and Code Availability

All datasets and code used in this paper are available for reproducibility. To access the files, please visit my GitHub repository:

- **Repository:** https://github.com/WRTeng/CryptoETF_Analysis
- **Data folder:** Contains processed BTC and ETH high-frequency data used in the analysis.
- **Code folder:** Includes Python scripts for data cleaning, computation of realized volatility and Amihud illiquidity ratio, and replication of all regression tables and figures.
- **README.md:** Provides an overview of the repository, explains the purpose of each notebook (main.ipynb for BTC, main copy.ipynb for ETH), and gives instructions for reproducing all figures, tables, and analyses.

Appendix 2. Ethereum comparative analysis

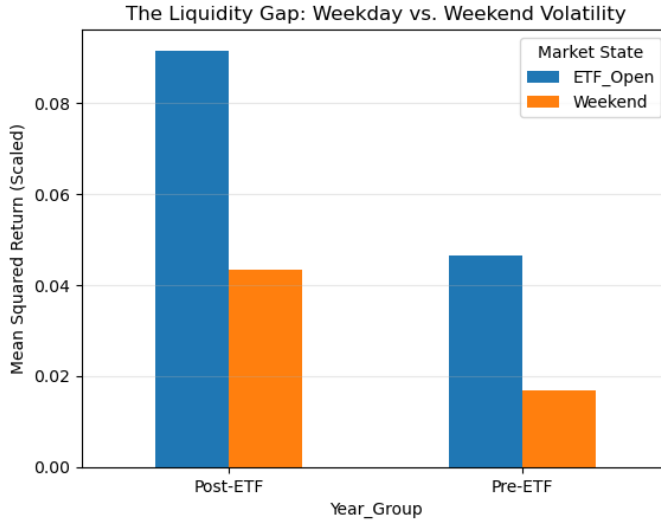

Figure 9. The Liquidity Gap Bar Chart

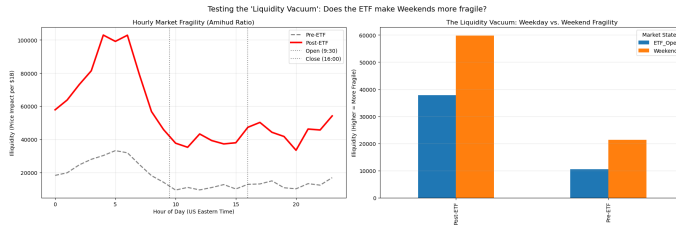

Figure 10. Amihud Fragility Chart

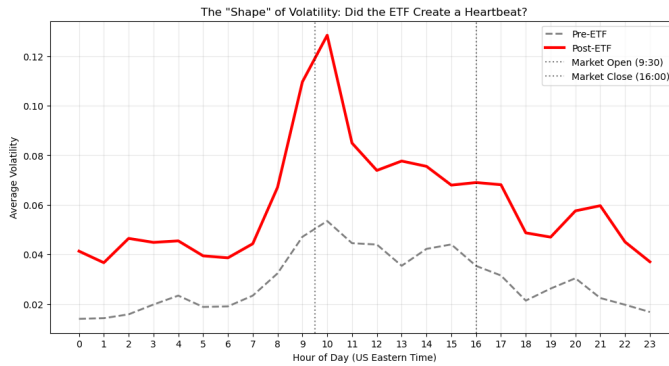

Figure 11. Intraday Volatility/Heartbeat

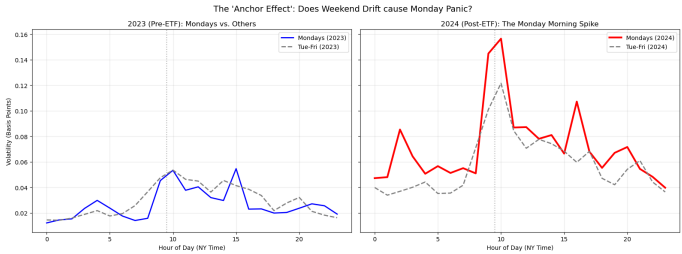

Figure 12. Monday vs. Tue-Fri

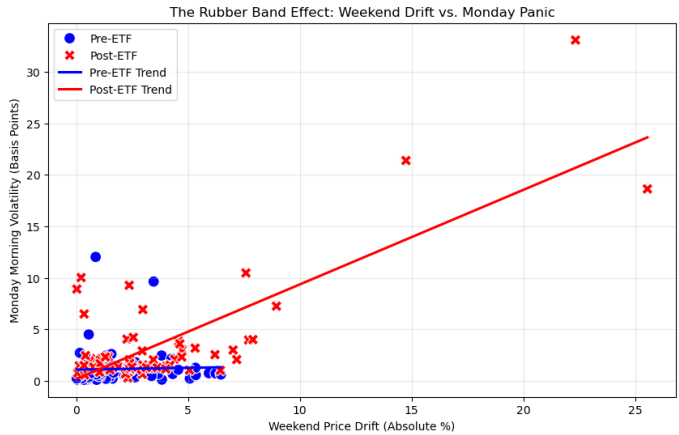

Figure 13. Scatter Plot Drift vs. Panic

Table 2. Difference-in-Differences Regression Results (ETH)

Model 1: Basic DiD	Coef.	Std. Err.	t	P>|t|
Intercept	2.8945	0.076	38.27	0.000
Dummy_Post	3.1633	0.111	28.55	0.000
Dummy_Weekend	-1.2246	0.141	-8.67	0.000
Interaction	-0.4933	0.207	-2.38	0.017

Model 2: DiD + Lagged Vol	Coef.	Std. Err.	t	P>|t|
Intercept	1.9458	0.072	27.16	0.000
Dummy_Post	2.1267	0.105	20.29	0.000
Dummy_Weekend	-0.8226	0.133	-6.16	0.000
Interaction	-0.3314	0.196	-1.69	0.091
Lagged_Vol	0.3277	0.002	191.96	0.000

Notes: Interaction term tests the DiD effect. Model 2 controls for autocorrelation via lagged volatility.