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Extreme Perpetual Futures Funding and Subsequent Bitcoin Returns: Intraday Evidence from Binance

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Abstract:
Perpetual futures funding rates are central to cryptocurrency derivatives markets because they help anchor perpetual-contract prices to spot prices while simultaneously reflecting the state of the derivatives market. This study examines whether historically extreme Bitcoin perpetual-futures funding rates contain information about subsequent Bitcoin spot returns. Binance BTCUSDT perpetual funding observations from 10 September 2019 to 10 August 2026 are aligned with Binance BTCUSDT spot prices sampled at 15-minute frequency. Extreme funding is classified ex ante using the current funding rate's mid-rank percentile within the preceding 180-day distribution, with the lower and upper deciles defining extreme negative and extreme positive states. Bitcoin spot returns are measured over 15-minute, one-hour, four-hour, eight-hour and 24-hour post-settlement horizons. Parametric, non-parametric and directional tests are supplemented by heteroskedasticity and autocorrelation consistent regressions controlling for the four-hour price movement preceding settlement. The main result is concentrated in the negative tail: extreme negative funding is followed by an average 24-hour Bitcoin return of 0.506%, significant under t, Wilcoxon and directional-frequency tests and robust to false-discovery-rate adjustment. Extreme positive funding does not exhibit a comparable 24-hour effect. In categorical HAC regressions, extreme negative funding is associated with approximately 0.491 percentage points of additional 24-hour return after controlling for the pre-settlement return. Non-overlapping 24-hour subsamples retain positive and statistically significant mean returns after extreme negative funding. The evidence suggests that funding-rate information is nonlinear, asymmetric and horizon dependent rather than adequately represented by a simple linear relation between funding and future returns.

Keywords: Bitcoin, Perpetual Futures, Funding Rate, Cryptocurrency Derivatives, Intraday Returns, Market Positioning, Price Discovery

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1. Introduction

Perpetual futures have become one of the defining instruments of cryptocurrency derivatives markets. Unlike conventional futures contracts, they do not expire and therefore do not require periodic rollover. Their continued alignment with the underlying spot market instead depends on a recurring funding mechanism under which payments are transferred between long and short positions. The mechanism is economically important because it links the derivatives contract to the spot asset while allowing leveraged positions to remain open for an indefinite period. The theoretical roots of perpetual futures predate cryptocurrency markets [1], but digital-asset trading has provided the setting in which the contract has achieved its widest practical use [5, 6].

The funding rate is frequently interpreted by market participants as an indicator of derivatives-market positioning. Positive funding generally means that long positions pay short positions, while negative funding reverses the direction of payment. A large positive funding rate may therefore coincide with strong demand for leveraged long exposure, whereas unusually negative funding can occur when bearish positioning becomes particularly pronounced. Yet this interpretation does not imply that funding mechanically forecasts future spot returns. Funding is partly endogenous to the relation between perpetual and spot prices, and extreme funding can occur after large price movements have already taken place. The empirical question is therefore whether an extreme funding state contains incremental information about what happens next, rather than merely describing what has just occurred.

This question is relevant because cryptocurrency derivatives can play an important role in price discovery. Studies using regulated and unregulated Bitcoin futures have found meaningful information transmission between derivative and spot markets [2, 3, 4]. The structure of perpetual contracts provides an additional channel through which derivatives-market pressure can be observed at high frequency. De Blasis and Webb [5] document distinctive microstructure properties of Bitcoin perpetual futures, while Ackerer, Hugonnier and Jermann [6] show formally that periodic funding payments are fundamental to the no-arbitrage anchoring of perpetual futures to spot prices. These findings establish the economic importance of funding, but they do not by themselves determine whether unusually extreme funding states predict subsequent Bitcoin spot performance.

The present study asks whether historically extreme Bitcoin perpetual-futures funding states contain information about subsequent spot-market returns, and whether that information differs between unusually negative and unusually positive funding conditions. The question is deliberately predictive rather than causal: funding may summarize derivatives-market conditions that precede later spot adjustment without itself causing that adjustment.

The study uses Binance BTCUSDT perpetual funding settlements and 15-minute Binance BTCUSDT spot prices from September 2019 to August 2026. Funding observations are classified relative to their preceding historical distribution so that extreme states are identified using information available at the time of each settlement. Subsequent spot returns are examined across intraday and one-day horizons, with the preceding price movement controlled for in regression analysis.

The results indicate that the predictive content of funding is concentrated in the negative tail. Extreme negative funding is followed by significantly positive Bitcoin returns over the subsequent 24 hours, whereas extreme positive funding does not exhibit a comparable longer-horizon pattern. The negative-tail result remains evident after controlling for the pre-settlement price movement and in non-overlapping 24-hour return subsamples.

The study contributes a settlement-aligned, ex-ante examination of funding extremes and subsequent Bitcoin spot returns. It complements research on futures price discovery, arbitrage, contract design and market microstructure by focusing on whether unusual funding states contain incremental information about what happens after settlement, while distinguishing short intraday adjustment from the response observed over a full day.

2. Literature Review

2.1 Bitcoin Futures, Perpetual Contracts and Price Discovery

The economic logic of perpetual futures can be traced to Shiller's proposal for contracts designed to remain outstanding without a conventional maturity date [1]. In cryptocurrency markets, this structure allows leveraged directional exposure to be maintained without repeatedly rolling an expiring position. Ackerer et al. [6] provide a no-arbitrage treatment of perpetual-futures pricing in which the specification of recurring funding payments determines how closely the perpetual contract remains linked to its underlying spot asset. This theoretical perspective is important for empirical work because the funding rate should not be interpreted as a free-standing sentiment measure; it is part of the contract's price-linkage mechanism.

Evidence on where Bitcoin price information enters first is mixed, but it consistently points to a close informational connection between derivatives and spot trading. Baur and Dimpfl [2] find that the globally traded spot market leads the U.S. regulated futures contracts in their sample. In a different high-frequency setting, Akyildirim et al. [8] report a stronger price-discovery role for Bitcoin futures and identify the CBOE contract as the leading source of information relative to CME futures. Alexander et al. [3] find that BitMEX derivatives incorporate price information ahead of several major spot venues, while Aleti and Mizrach [4] document an important CME role in price discovery. These differing results reinforce the broader premise that derivatives-market conditions can contain information relevant to subsequent spot-market adjustment.

The perpetual-futures setting differs from dated futures because there is no fixed expiry at which convergence must occur. De Blasis and Webb [5] show that Bitcoin perpetual and quarterly futures display different trading-pattern and contract-design characteristics, with evidence that shocks can pass between the two contract types. Hattori and Ishida [7] find that futures-spot arbitrage opportunities are generally limited in normal conditions but become much larger during sharp Bitcoin market declines. Together, these findings motivate treating funding states as observable conditions within an interconnected derivatives-spot system rather than merely as a trading cost.

2.2 Funding Rates and Subsequent Price Adjustment

A positive funding rate usually corresponds to payments from long to short perpetual positions, whereas negative funding reverses the flow. Economically, an unusually large positive rate can be associated with strong demand for long exposure or a substantial perpetual premium, while a deeply negative rate can accompany heavy short positioning or a discount of the perpetual contract relative to spot. Either

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state could plausibly be followed by continuation if derivatives traders possess information that has not yet been fully incorporated into spot prices. Alternatively, an extreme rate could precede correction if leveraged positioning has become crowded or if the basis itself is temporarily dislocated.

The expected sign is therefore theoretically ambiguous. The price-discovery literature suggests that derivatives can lead spot prices [3], which is consistent with continuation. The arbitrage and contract-design literature, however, emphasizes mechanisms that pull derivative and spot prices back toward alignment [5]–[7], which can generate corrective dynamics when the basis or funding state becomes unusually large. Moreover, funding is endogenous to recent market conditions. A negative funding observation may be caused partly by a preceding price decline, so a subsequent rebound could reflect ordinary return reversal rather than independent information in the funding rate. This identification concern motivates controlling explicitly for the pre-settlement Bitcoin return.

Taken together, the literature shows that funding rates sit at the intersection of perpetual-contract pricing, arbitrage and derivatives-market positioning. It also implies that the relation between funding and later spot returns need not be linear or symmetric, because the same observed funding rate can reflect different combinations of basis pressure, positioning and recent price adjustment.

2.3 Research Gap and Hypotheses

Existing research is considerably richer on Bitcoin futures price discovery, arbitrage, contract design and market microstructure than on the direct mapping from ex-ante extreme funding states to subsequent BTC spot returns. The cited literature does not establish whether funding extremes identified at actual BTCUSDT settlement times contain information about later Binance spot returns, nor whether any such relation changes across intraday and one-day horizons. This narrower question therefore remains open within the literature reviewed here.

Extreme positive and extreme negative funding represent opposite tails of derivatives-market conditions and need not produce mirror-image spot responses. If heavily long and heavily short markets differ in the way positioning pressure, basis adjustment or subsequent normalization unfolds, the conditional return distributions following the two tails may also differ. This motivates both within-tail tests and a direct comparison of post-settlement returns following extreme negative and extreme positive funding states.

A further issue is whether funding contains information beyond recent spot-price behaviour. Funding conditions may partly reflect price movements that have already occurred before settlement; an apparent post-funding relationship could therefore be continuation or reversal of the preceding move rather than incremental information in the funding state itself. Controlling for the preceding four-hour Bitcoin return provides a direct test of whether extreme funding states retain explanatory information for subsequent returns after recent price movement is taken into account.

Accordingly, the empirical design identifies funding extremes from each event's preceding historical distribution, aligns those events to intraday spot prices and evaluates several post-settlement horizons. The hypotheses are stated non-directionally because both continuation and correction are theoretically plausible.

H01: Bitcoin spot returns following extreme negative funding do not differ significantly from zero.

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H11: Bitcoin spot returns following extreme negative funding differ significantly from zero.
H02: Bitcoin spot returns following extreme positive funding do not differ significantly from zero.
H12: Bitcoin spot returns following extreme positive funding differ significantly from zero.
H03: Subsequent Bitcoin spot returns do not differ significantly between extreme negative and extreme positive funding states.
H13: Subsequent Bitcoin spot returns differ significantly between extreme negative and extreme positive funding states.
H04: Extreme funding states contain no incremental information for subsequent Bitcoin returns after controlling for the preceding four-hour Bitcoin return.
H14: Extreme funding states contain incremental information for subsequent Bitcoin returns after controlling for the preceding four-hour Bitcoin return.

3. Data and Methodology

3.1 Data and Sample

The study uses public Binance data for both the derivatives and spot markets. Funding observations are obtained for the Binance USD-M BTCUSDT perpetual contract, while price observations are taken from the Binance BTCUSDT spot market. Using the same exchange and quote currency reduces timestamp and cross-venue basis inconsistencies. The funding sample begins with the first usable observation on 10 September 2019 at 08:00 UTC and ends on 10 August 2026 at 16:00 UTC. The raw funding series contains 7,580 observations. Binance spot prices are sampled at 15-minute frequency and extend through 11 August 2026 so that a full 24-hour forward return can be calculated for the last funding events.

Funding timestamps are aligned to the corresponding 15-minute spot-bar boundary. The largest observed difference between the recorded settlement timestamp and its market-bar anchor is only 0.047 seconds. Of 7,580 funding observations, 7,555 have all required spot observations for event construction. A 180-day historical window and minimum of 300 prior funding observations are required before an event can be classified, leaving 7,255 observations in the final analysis sample.

Table 1: Sample and Funding-State Classification

Measure	Value
Funding sample	10 Sep 2019 08:00 UTC - 10 Aug 2026 16:00 UTC
Raw funding observations	7,580
Aligned funding-price events	7,555
Analysis observations after warm-up	7,255
Extreme negative events	867
Middle-state events	5,739
Extreme positive events	649
Spot price resolution	15 minutes
Historical classification window	180 days

3.2 Funding-State Classification

Funding rates can contain tied observations and their distribution can change through time. Quantile boundaries may therefore coincide with multiple identical values. To handle ties consistently while preserving an ex-ante classification, each funding observation is assigned a mid-rank empirical percentile using only funding observations from the preceding 180 days. The 180-day window provides a large recent reference sample while allowing the benchmark distribution to adapt over time.

$$Percentile_t = \frac{N(F_{t-j} < F_t) + 0.5\, N(F_{t-j} = F_t)}{N_t} \quad (1)$$

where F_t is the current funding rate, and the comparison set contains only prior observations within the 180-day historical window. An observation is classified as extreme negative when its mid-rank historical percentile is at or below 0.10, and as extreme positive when it is at or above 0.90. Observations between these boundaries form the middle state.

3.3 Intraday Return Construction

Let P_t denote the Binance BTCUSDT spot price at the funding-event timestamp. Cumulative log returns from settlement time t to horizon h are expressed in percentage terms as follows.

$$R_{t,h} = 100\, ln(\frac{P_{t+h}}{P_t}) \quad (2)$$

Five horizons are evaluated: 15 minutes, one hour, four hours, eight hours and 24 hours. The four- and eight-hour horizons correspond closely to the conventional funding cycle, while the 15-minute and one-hour horizons capture immediate adjustment and the 24-hour horizon captures persistence beyond a single settlement interval. To distinguish funding information from price dynamics already occurring before settlement, the preceding four-hour return is also calculated.

$$R_{t,-4h} = 100\, ln(\frac{P_t}{P_{t-4h}}) \quad (3)$$

3.4 Statistical Tests

For each extreme funding state and horizon, the analysis reports the number of events, mean return, median return, standard deviation and percentage of positive returns. A one-sample t-test evaluates whether the mean post-event return differs from zero, while the Wilcoxon signed-rank test provides a non-parametric assessment that is less dependent on distributional assumptions. An exact two-sided binomial test evaluates whether the frequency of positive returns differs from 50%. Because ten extreme-state/horizon combinations are examined, Benjamini-Hochberg false-discovery-rate adjustments are reported separately for the t, Wilcoxon and binomial test families.

Extreme negative and extreme positive observations are also compared directly at each horizon. Welch's unequal-variance t-test evaluates mean differences, while the Mann-Whitney U test provides a distributional comparison. False-discovery-rate adjustments are again applied across the five horizons.

3.5 Regression Specification

Two regression specifications are used. The continuous specification relates subsequent spot returns to the funding rate measured in basis points, with and without the four-hour pre-settlement return. The categorical specification identifies whether the two funding tails differ from the middle state while controlling for the preceding spot move.

$$R_{t,h} = \alpha_h + \beta_{1,h} D^-_t + \beta_{2,h} D^+_t + \gamma_h R_{t,-4h} + \varepsilon_{t,h} \quad (4)$$

The middle funding state is the omitted category. Therefore $\beta_{1,h}$ measures the incremental post-event return following an extreme negative funding observation, while $\beta_{2,h}$ measures the corresponding incremental return following an extreme positive observation. D^-_t and D^+_t are indicators for extreme negative and extreme positive funding states, respectively; $R_{t,-4h}$ is the four-hour pre-settlement Bitcoin return; and $\varepsilon_{t,h}$ is the disturbance term. Heteroskedasticity and autocorrelation consistent Newey-West standard errors are used because multi-hour outcome windows can overlap across settlements.

3.6 Non-Overlap Robustness

The headline 24-hour outcome overlaps across consecutive approximately eight-hour funding settlements. HAC inference addresses this dependence in regressions, but conventional one-sample tests would otherwise treat overlapping event returns as separate observations. A robustness design therefore partitions the complete chronological settlement sequence into the three possible phases obtained by retaining every third settlement. Each phase produces non-overlapping 24-hour return windows while preserving the pre-specified funding-state classification and avoiding selection based on whether funding itself is extreme. Results are reported for all three phases so that no favorable phase is selected ex post.

4. Results

4.1 Post-Event Returns by Funding State

The results show that the relation between extreme funding and subsequent Bitcoin returns is neither uniformly contrarian nor uniformly momentum based. The strongest pattern occurs after extreme negative funding and emerges gradually with the horizon. Mean returns are -0.014% after 15 minutes,

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+0.019% after one hour, +0.054% after four hours and +0.133% after eight hours. The corresponding positive-return frequencies are 51.33%, 49.02%, 49.02% and 52.25%, respectively, and none provides strong directional evidence at conventional levels. At the 24-hour horizon, however, the mean rises to +0.506%, the median is +0.219%, and 55.13% of observations end positive.

The 24-hour negative-funding result is statistically strong across both magnitude and direction. The t-test produces p=0.000023, the Wilcoxon test p=0.000103 and the exact binomial test of the 55.13% positive-return frequency p=0.002781. All three survive false-discovery-rate adjustment, with adjusted p-values of approximately 0.000226, 0.001025 and 0.027814 respectively. At eight hours the Wilcoxon p-value is 0.0359, but that result does not survive the FDR correction. The evidence therefore points to a response that is most clearly expressed over the full 24 hours rather than immediately after settlement.

Extreme positive funding produces a different profile. The mean 15-minute return is +0.040%, with 53.00% of observations positive; the raw t-test and Wilcoxon tests are significant at p=0.0161 and p=0.0069 respectively. After FDR adjustment, the t-test becomes insignificant at approximately 0.0805, while the Wilcoxon result remains significant at approximately 0.0344. Beyond the immediate horizon, mean returns are +0.043% at one hour, -0.052% at four hours, approximately zero at eight hours and +0.094% at 24 hours. Positive-return frequencies are 51.31%, 47.92%, 51.46% and 49.77%, respectively, all close to a neutral 50% benchmark. Thus, unusually positive funding does not provide evidence of a stable subsequent correction or continuation over the longer horizons.

Table 2: Post-Event Bitcoin Returns Following Extreme Funding

Funding State	**Horizon**	**N**	**Mean (%)**	**Median (%)**	**Positive (%)**	**t p**	**Wilcoxon p**	**Binomial p**
Extreme negative	15m	867	-0.014	0.008	51.33	0.3642	0.5884	0.4550
Extreme negative	1h	867	0.019	-0.009	49.02	0.4596	0.6731	0.5869
Extreme negative	4h	867	0.054	-0.014	49.02	0.2490	0.5445	0.5869
Extreme negative	8h	867	0.133	0.048	52.25	0.0715	0.0359	0.1968
Extreme negative	24h	867	0.506	0.219	55.13	<0.001	<0.001	0.0028
Extreme positive	15m	649	0.040	0.017	53.00	0.0161	0.0069	0.1357
Extreme positive	1h	649	0.043	0.017	51.31	0.1848	0.2110	0.5300

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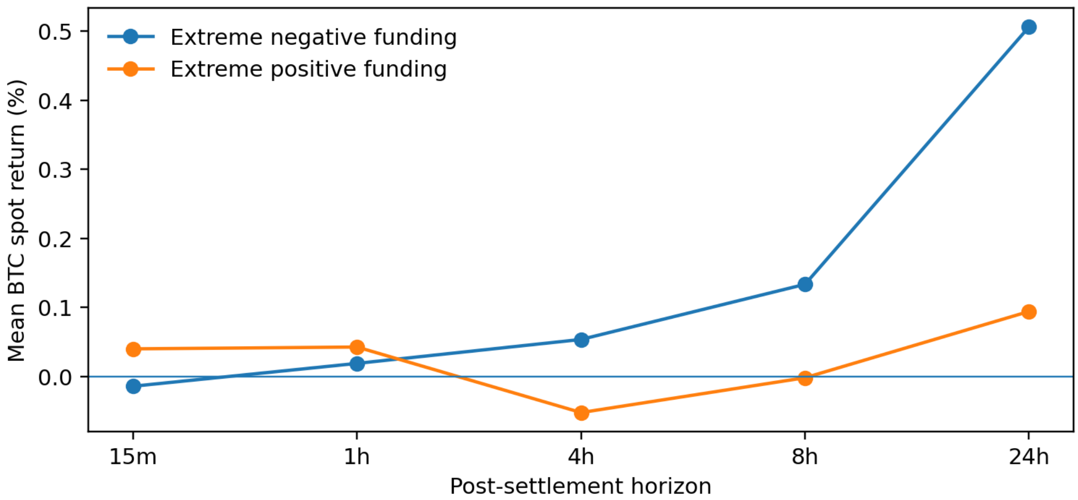
Funding State	Horizon	N	Mean (%)	Median (%)	Positive (%)	t p	Wilcoxon p	Binomial p
Extreme positive	4h	649	-0.052	-0.035	47.92	0.3506	0.4171	0.3074
Extreme positive	8h	649	-0.002	0.062	51.46	0.9809	0.9579	0.4799
Extreme positive	24h	649	0.094	-0.008	49.77	0.4627	0.5968	0.9374

Figure 1: Mean Bitcoin Spot Return Following Extreme Funding States



4.2 Extreme Negative versus Extreme Positive Funding

Direct comparisons provide weaker evidence than the within-state results. At 15 minutes, the mean return is -0.014% after extreme negative funding and +0.040% after extreme positive funding. Welch's test gives p=0.0173, but the non-parametric Mann-Whitney result is p=0.0684. At 24 hours, the corresponding means are +0.506% and +0.094%, a difference of approximately 0.412 percentage points. Welch's p-value is 0.0185 and remains just below 5% after FDR adjustment at approximately 0.0463, whereas the Mann-Whitney p-value of 0.0309 does not survive its FDR adjustment. The intermediate one-, four- and eight-hour comparisons are statistically insignificant.

This distinction is important for interpretation. Strong evidence that returns following extreme negative funding are positive does not automatically imply equally strong evidence that the conditional return distribution differs from the extreme-positive state. The data support the former claim more consistently than the latter.

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Table 3: Extreme Negative versus Extreme Positive Funding

Horizon	Negative Mean (%)	Positive Mean (%)	Welch p	Welch FDR	Mann-Whitney p	M-W FDR
15m	-0.014	0.040	0.0173	0.0463	0.0684	0.1710
1h	0.019	0.043	0.5651	0.5651	0.4807	0.4807
4h	0.054	-0.052	0.1457	0.2428	0.2980	0.3725
8h	0.133	-0.002	0.2005	0.2506	0.1659	0.2765
24h	0.506	0.094	0.0185	0.0463	0.0309	0.1545

4.3 Regression Evidence and Incremental Information

The regression evidence reinforces the conclusion that the funding-return relation is nonlinear and concentrated in particular states. In the continuous specification, one additional basis point of funding is associated with approximately +0.0123 percentage points of 15-minute return, with HAC $p<0.001$ and an FDR-adjusted p-value below 0.001. The coefficient becomes negative at four hours (-0.0224 per basis point), with raw p approximately 0.0255 after controlling for the pre-event return, but the FDR-adjusted p-value is approximately 0.0636. The one-hour and eight-hour coefficients are insignificant, and the 24-hour coefficient is negative but only suggestive (p approximately 0.0808). This pattern does not support a stable linear mapping from the level of funding to future returns.

The categorical specification is more informative at the 24-hour horizon. Relative to the middle funding state, extreme negative funding is associated with approximately +0.491 percentage points of additional 24-hour BTC return, with HAC $p=0.00155$. Extreme positive funding has a much smaller coefficient of +0.079 percentage points and is insignificant ($p=0.647$). The coefficient on the preceding four-hour return is -0.060 and is also insignificant ($p=0.183$). Consequently, the negative-tail result cannot be explained simply by a linear continuation or reversal of the four-hour price movement immediately before settlement.

Table 4: HAC Regression Evidence

Horizon	Funding Beta	HAC p	Funding FDR	Extreme Neg. Beta	Neg. HAC p	Extreme Pos. Beta	Pos. HAC p
15m	0.0123	0.0002	0.0010	-0.020	0.2139	0.034	0.0406
1h	0.0008	0.8894	0.8894	0.021	0.4473	0.044	0.1565
4h	-0.0224	0.0255	0.0636	0.060	0.2200	-0.045	0.4093
8h	-0.0226	0.1235	0.1544	0.119	0.1017	-0.017	0.8316
24h	-0.0627	0.0808	0.1346	0.491	0.0015	0.079	0.6474

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4.4 Non-Overlap Robustness

The non-overlap robustness check strengthens the main within-state conclusion. In each of the three possible every-third-settlement phases, the average 24-hour BTC return following extreme negative funding remains positive and statistically significant under the one-sample t-test. The mean is +0.516% in Phase 0 (p=0.011), +0.406% in Phase 1 (p=0.038) and +0.604% in Phase 2 (p=0.0066). The Wilcoxon test is significant in Phases 0 and 2 and marginal in Phase 1. Extreme positive funding does not generate a statistically significant mean return in any phase.

The direct negative-versus-positive difference is less stable. Welch's p-values are 0.418, 0.170 and 0.044 across the three phases. Hence the robustness exercise supports the claim that extreme negative funding is followed by positive 24-hour returns, but it does not support describing the between-tail difference as uniformly significant. This result is consistent with the cautious interpretation of the full-sample comparison.

Table 5: Non-Overlapping 24-Hour Robustness Subsamples

Phase	Funding State	N	Mean (%)	Median (%)	Positive (%)	t p	Wilcoxon p
0	Extreme negative	278	0.516	0.188	53.60	0.0114	0.0201
0	Extreme positive	235	0.265	0.168	53.19	0.2604	0.3301
1	Extreme negative	306	0.406	0.155	53.27	0.0379	0.0901
1	Extreme positive	200	0.009	-0.064	48.50	0.9680	0.9106
2	Extreme negative	283	0.604	0.383	58.66	0.0066	0.0083
2	Extreme positive	214	-0.013	-0.111	47.20	0.9495	0.9328

5. Discussion

The findings indicate that extreme funding contains information about subsequent Bitcoin spot behaviour, but the information is not captured by a simple rule in which positive funding predicts losses and negative funding predicts gains at every horizon. Instead, the most robust result is concentrated in the extreme negative tail and becomes visible over approximately one day. This matters because the funding mechanism is often treated informally as a contemporaneous barometer of leveraged positioning. The evidence suggests that the economic content of extreme funding depends on both the sign of the observation and the horizon over which subsequent spot adjustment is measured.

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The positive 24-hour return following extreme negative funding is notable not only in average magnitude but also in directional frequency. Approximately 55.13% of 24-hour outcomes are positive, and that frequency differs significantly from a neutral 50% benchmark. The convergence of mean-return, median and directional evidence strengthens the interpretation that the negative funding tail identifies a distinct subsequent price-adjustment pattern. Several mechanisms are possible. Deeply negative funding can occur when perpetual-futures positioning becomes strongly tilted toward the short side or when the perpetual contract trades at a meaningful discount relative to spot. If part of that condition reflects temporary market pressure, the subsequent spot response may include recovery as the imbalance is reduced. These interpretations are compatible with the broader literature showing information transmission and arbitrage links between Bitcoin derivative and spot markets [2]–[5], [7].

At the same time, the evidence should not be interpreted as proof of a causal short-squeeze mechanism. The study does not observe trader-level positions, liquidations, order-book depth or the decomposition of the funding formula into its underlying premium and interest components. Extreme negative funding could coincide with omitted market conditions that subsequently reverse. The regression control for the preceding four-hour spot return is useful because it shows that the 24-hour negative-tail coefficient survives a simple control for recent price movement, but it cannot eliminate every source of endogeneity.

The extreme-positive results reinforce the need for caution. A modest immediate positive response is visible at 15 minutes, particularly under the Wilcoxon test, but the positive-return frequency is only 53.00%. At the longer horizons, directional frequencies remain close to 50% and there is no stable continuation or reversal. If high positive funding were a universal indicator of crowded longs followed by correction, consistently negative subsequent returns would be expected; if it were a universal momentum indicator, longer-horizon positive outcomes should be more persistent. Neither pattern emerges. Negative and positive funding tails therefore appear to contain different degrees of subsequent-return information rather than acting as mirror images of the same mechanism.

The continuous regressions provide additional support for nonlinearity. The funding coefficient changes sign across horizons and is not consistently significant. A conventional linear regression would therefore give an incomplete description of the relationship. The categorical tail approach is better suited to the empirical question because it isolates historically unusual funding observations relative to the distribution prevailing before each settlement. The result that the extreme-negative dummy is significant at 24 hours while the continuous funding coefficient is only marginal indicates that much of the useful information is concentrated in rare negative states rather than spread smoothly across the full funding distribution.

From a practical perspective, the results imply that funding rates should not be used as stand-alone directional signals. Extreme negative funding is historically associated with stronger positive one-day spot returns in this sample, but the study does not model transaction costs, entry timing, leverage, liquidations or execution slippage and therefore does not establish a profitable trading strategy. The more defensible interpretation is informational: an unusually negative funding state is a market condition that appears to identify a subset of settlement events with different subsequent return behaviour. For traders, risk managers and researchers, this means that funding can be useful as a conditioning variable,

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particularly when evaluated relative to its recent historical distribution rather than by a fixed absolute threshold.

6. Limitations

The analysis has several limitations. First, it focuses on a single instrument and venue: Binance BTCUSDT perpetual funding and Binance BTCUSDT spot prices. Funding formulas, market participants and liquidity differ across exchanges, so the results cannot automatically be generalized to every Bitcoin perpetual market or to other cryptocurrencies. Second, the historical classification uses a 180-day window and decile cutoffs. These choices are transparent and ex ante but remain modelling choices; alternative historical windows could identify somewhat different events. Third, the study controls for the preceding four-hour spot return but does not include open interest, liquidation intensity, basis, order flow, volatility or news variables that might help explain why a funding observation becomes extreme. Fourth, funding and subsequent spot returns are observationally related, so the results should be interpreted as predictive association rather than causality. Finally, although the three-phase robustness check removes overlap from the 24-hour forward-return windows, clustered market stress can still create broader dependence across nearby calendar periods.

7. Conclusion

This study examines whether historically extreme Bitcoin perpetual-futures funding rates contain information about subsequent Bitcoin spot returns. Binance BTCUSDT funding settlements from 10 September 2019 to 10 August 2026 are aligned with 15-minute Binance spot prices, and each funding observation is classified using its mid-rank percentile within the preceding 180-day funding distribution. Post-settlement returns are evaluated over horizons ranging from 15 minutes to 24 hours, with statistical tests, false-discovery-rate correction, HAC regressions and non-overlapping robustness subsamples.

The evidence is strongest for extreme negative funding. Across 867 extreme-negative observations, the average 24-hour Bitcoin return is approximately +0.506%, with a positive-return frequency of 55.13%. The result is significant under t, Wilcoxon and exact binomial tests and remains significant after FDR adjustment. In the categorical regression, extreme negative funding is associated with approximately +0.491 percentage points of incremental 24-hour return relative to the middle funding state after controlling for the preceding four-hour Bitcoin return. The result also remains positive and statistically significant in each of three non-overlapping 24-hour settlement phases.

Extreme positive funding does not produce a comparable longer-horizon pattern. Although there is evidence of a small immediate positive response at 15 minutes, the one-, four-, eight- and 24-hour results are generally insignificant. Direct comparisons between the negative and positive tails are significant in parts of the full-sample analysis but are not uniformly robust across non-overlapping subsamples. The paper therefore does not conclude that the two tails are symmetric opposites. Instead, it identifies the extreme negative tail as the most informative funding state in the present sample.

Overall, the results suggest that the informational content of Bitcoin funding rates is nonlinear and horizon dependent. Treating funding as a continuous sentiment variable or applying a universal contrarian rule can obscure the fact that the strongest association is concentrated in historically unusual

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negative observations and develops over approximately one day. Future research can test whether this pattern generalizes across exchanges and cryptocurrencies and whether it can be explained by open interest, liquidations, basis dynamics, order flow or other measures of derivatives-market stress.

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