MarketScanner Research Laboratory

Bitcoin Structure Series · Notebook 002

Bitcoin Does Not Calm Down; It Stops Exploding

The Structural Compression of Bitcoin Volatility, 2009–2026

MarketScanner Research Laboratory

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Notebook LAB-002 · Bitcoin Structure Series · Version 1.1

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Nature of this work. This publication measures the historical behaviour of a market. It is not investment advice, it is not a recommendation to buy or sell any asset, and it is not a forecast of price. Any forward-looking or predictive modelling is conducted separately from the Laboratory and is not represented here.

Classification. Publication type: Research Notebook · Research mode: Exploratory (observational) · Evidence Level: 2–3 (Measurement toward Hypothesis) · Status: Supported · refined.

Archival Notice

This document is **Version 1.1** of Notebook LAB-002, archived permanently on the date of ratification of the Laboratory's Constitution.

In accordance with the Laboratory's Correction Policy, **this version shall not be altered.** It is preserved as a fixed scientific record. Should stronger evidence require correction or refinement, a new and separately identified version will be issued, and this record will remain unchanged and available.

The permanence of the record is itself a scientific commitment: the history of what was measured, and of how understanding changed, is never erased.

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Reproducibility — all figures and statistics in this
notebook derive from a single daily BTC/USD series
(6,018 bars, 2009–2026) and the definitions stated
within. No discretionary adjustments were made.
```

Publication Metadata

Notebook ID	`LAB-002`
Research series	Bitcoin Structure
Publication type	Research Notebook
Research mode	Exploratory · observational
Evidence level	Level 2–3 · Measurement toward Hypothesis
Status	Supported · refined
Confidence	★★★★☆ (statistical dimension; see §8)
Dataset	BTC/USD daily index (open, high, low, close)
Coverage	5 Oct 2009 – 27 Jun 2026
Observations	`6,018` daily bars
Data vintage	27 June 2026
Primary variable	RV_{30} — 30-day annualized realized volatility
Keywords	volatility, compression, structural maturity, halving epochs, Bitcoin
Question register	`Q-001 – Q-005`
Related research	Structural Age · Drivers of Compression · Gold Study
Reproducibility	Full · code & data
Governing charter	Constitution of the Laboratory (LAB-000)

✎ **Observation — where this began**

While studying Bitcoin's volatility, I noticed something strange. The average kept falling, year after year — and everyone reads that as "Bitcoin is calming down."

But when I actually looked, the quiet periods didn't seem much quieter than they used to be. Only the **violent** *periods were disappearing. The calm floor looked the same as it always had; the ceiling was falling toward it.*

That didn't match the story. So this notebook exists to ask one question honestly: **is that observation real, or was I seeing what I wanted to see?**

Abstract

Bitcoin is routinely called one of the most volatile assets ever created. That description is true but static; it never asks whether the volatility itself has *changed*. Using the complete daily price history — 6,018 bars spanning 2009 to 2026 — this notebook measures realized volatility identically across the entire record and tracks how its distribution has evolved through Bitcoin's five halving epochs.

The decline is real and statistically overwhelming (log-volatility trends down at **−5.3%/year**, `t = −36.8`), and it holds across every window tested. But the aggregate number hides the actual finding. When volatility is decomposed into its calm *floor* and its violent *ceiling*, they behave in opposite ways: the floor is a structural constant near **30%** that has scarcely moved in a decade, while the ceiling has collapsed from **257%** to **63%**. Bitcoin is not becoming calmer at its calmest. It is losing its capacity for chaos. The correct word is not *decay* — it is *compression*.

This is a descriptive study of historical behavior. It makes no forecast of price, and lower volatility is not read here as lower opportunity.

Why this notebook was written

Bitcoin is constantly described as becoming "less volatile." Yet that phrase is almost never defined. Does lower volatility mean the market is genuinely quieter — a lower floor? Or does it mean something more subtle: that the calm was always there, and only the extremes are vanishing? Those are different claims about what Bitcoin *is*, and they point to different futures. This notebook exists to measure that distinction rather than assert it.

§1 Research Question

Has Bitcoin's volatility changed in kind, not just in number?

Markets mature. Companies mature. If Bitcoin is genuinely evolving into a global monetary asset, its statistical fingerprint should evolve with it. The question is not the tired *"is Bitcoin volatile?"* — it plainly is — but the sharper one: has its volatility undergone a **measurable structural change** across its

lifetime, and if so, **what kind of change**? A lower average is one story. A change in the *shape* of volatility — where the calm and the chaos move independently — is a far more interesting one.

§2 Hypotheses & Falsification

Stated before the data was touched

H_0 Bitcoin's realized volatility is statistically unchanged through time. Any apparent trend is noise from its cycles.

H_1 Bitcoin's realized volatility has declined structurally over successive halving epochs.

> **Falsification condition — what would kill this**
>
> H_1 is rejected if the log-volatility time trend is statistically indistinguishable from zero ($|t| < 2$), or if the sign of the trend flips across reasonable measurement windows (30 / 60 / 90 days). A real structural effect must survive the choice of window; an artifact will not.

Declaring the kill-condition in advance is the line between research and narration. If the data had disagreed, this notebook would have said so.

§3 Data & Variable

One asset, one metric, one definition

Source. Daily BTC/USD index (open, high, low, close). **Coverage.** 4 Nov 2009 – 27 Jun 2026, 6,018 daily observations across the entire tradable history. **Variable.** Realized Volatility (30-day) — the annualized standard deviation of daily logarithmic returns over a rolling thirty-day window:

$$r_t = \ln\left(P_t / P_{t-1}\right)$$
$$RV_{30}(t) = \mathrm{stdev}\left(r_{t-29 \ldots t}\right) \times \sqrt{365} \times 100 \quad \text{// annualized, percent}$$

The 30-day window is the shortest that gives a stable monthly reading; §6 confirms the finding is unchanged at 60 and 90 days. Epochs are delimited by the four halving dates (Nov 2012, Jul 2016, May 2020, Apr 2024).

§4 Method

Measure → decompose → test

The procedure is deliberately simple, so it is reproducible and hard to fool:

Compute daily log returns across the full history; roll a 30-day annualized standard deviation; then, rather than reading the average alone, **decompose** each halving epoch into its calm floor (10th percentile of RV), its violent ceiling (90th percentile), and its median. The gap between floor and ceiling — the *compression ratio* — is the object of interest. Finally, measure **persistence**: what fraction of days sit in a

high-volatility state (RV > 80%), and how long the average such spike lasts. Every step is repeated identically at 30-, 60-, and 90-day windows as a robustness check.

§5 FINDINGS

The floor holds; the ceiling falls

Three results, in order of importance. The first establishes that something changed. The second and third establish *what*.

Finding 1 — the decline is real, and window-independent

Regressing log-volatility on time yields a firmly negative slope that survives every window tested. The magnitude grows and the significance deepens as the window lengthens — the opposite of what noise would do.

WINDOW	TREND / YR	T-STAT	R^2	HALF-LIFE
RV30	**-5.3%**	-36.8	0.184	12.7 yr
RV60	**-6.2%**	-50.1	0.296	10.8 yr
RV90	**-6.8%**	-60.4	0.381	9.9 yr

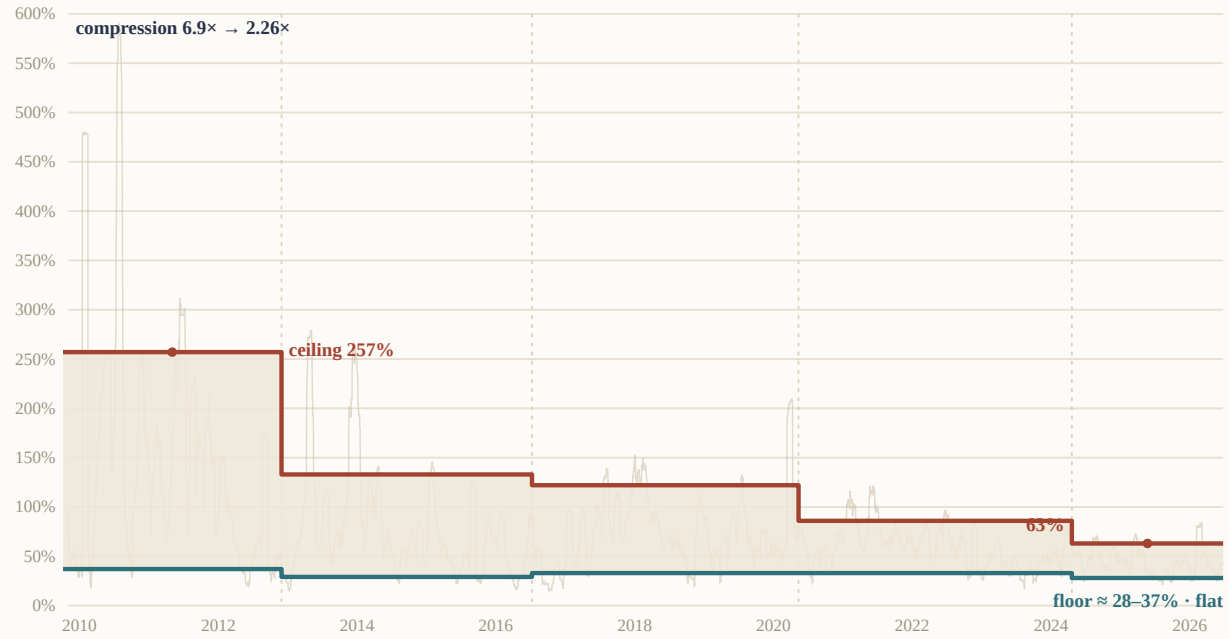
Table 1 · Log-volatility time trend by measurement window. $|t| > 2$ rejects H_0; all three clear it by an order of magnitude.

R^2 near 0.18–0.38 is honest: time alone does not explain most of volatility's day-to-day swing — cycles and events do — but the downward drift underneath them is unmistakable and highly significant.

Finding 2 — the compression

This is the heart of the notebook. Splitting each epoch into floor and ceiling reveals that the two edges of Bitcoin's volatility have moved in *opposite directions*. The floor is nearly flat; the ceiling has fallen by roughly three-quarters; and the ratio between them contracts, epoch after epoch, without exception.

FIGURE 1 RV30 · daily · 2009–2026

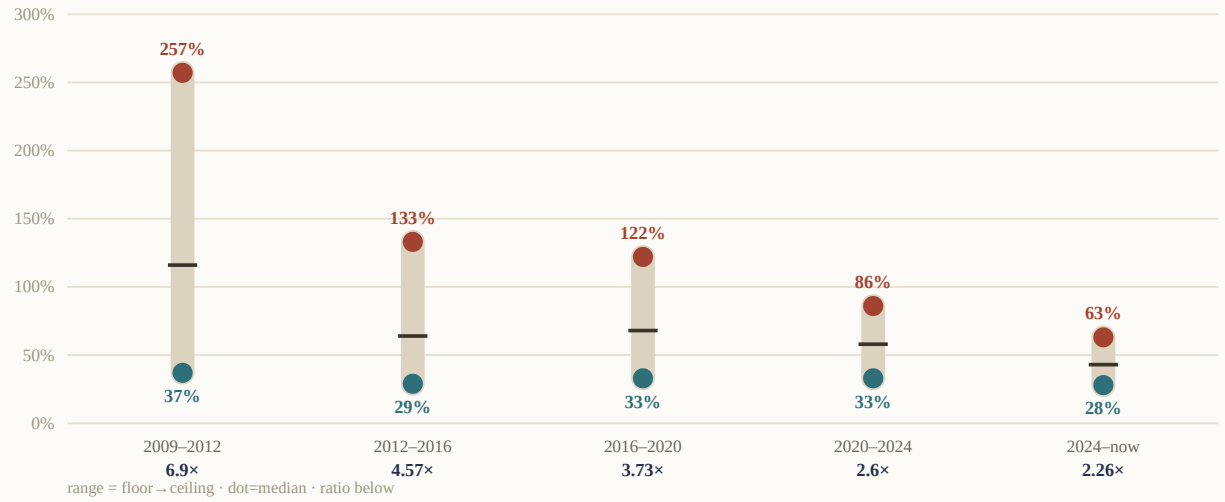


The wedge closes. Daily 30-day realized volatility (faint) with each epoch's floor and ceiling drawn as envelopes. The ceiling descends toward a floor that barely moves — volatility compressing from above.

Epoch	Floor p10	Median	Ceiling p90	Ratio
2009–2012	**37%**	116%	**257%**	6.9×
2012–2016	**29%**	64%	**133%**	4.57×
2016–2020	**33%**	68%	**122%**	3.73×
2020–2024	**33%**	58%	**86%**	2.6×
2024–now	**28%**	43%	**63%**	2.26×

Table 2 · Realized volatility by halving epoch. Floor stable, ceiling collapsing, compression ratio monotonically falling.

FIGURE 2 `floor → ceiling range per epoch`



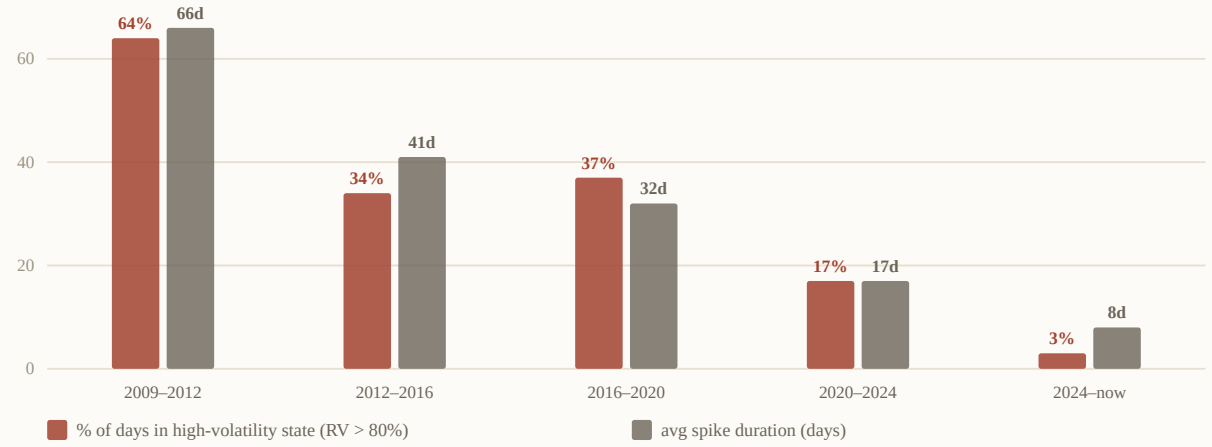
The same result, seen as ranges. Each bar spans an epoch's floor to ceiling; the dot marks the median. The bars shrink and descend — the distribution collapsing onto its own floor.

> ⓘ **UNEXPECTED FINDING**
>
> Going in, the expectation was a *lower* distribution — volatility drifting downward as a whole. That is not what the data shows. The floor barely moved (**37% → 28%**); only the ceiling collapsed (**257% → 63%**). Bitcoin's calm was already old — what changed was its capacity for chaos. That asymmetry, not the decline itself, is the discovery, and it was not the original hypothesis.

Finding 3 — chaos is also shortening in time

Compression is not only about height. The *duration* of Bitcoin's violent episodes has collapsed just as sharply. Days spent in a high-volatility state fell from **64%** of the time to **3%**, and the average volatility spike shrank from **66** days to **8**.

FIGURE 3 persistence of high-volatility states



The disappearance of chaos. Both the share of days in a high-volatility state and the length of the average spike fall steeply across epochs — violence is not only lower, it is briefer.

§6 INTERPRETATION

What this means — and what it does not

The popular story says Bitcoin is "maturing into a calmer asset," implying its whole distribution is drifting down. The data refuses that story and offers a more precise one. Bitcoin's **calm state is not new**: the quietest thirty-day windows have hovered near 20–30% for over a decade, and the single calmest reading in all of history (**14%**, in 2016) is no lower than calm periods long before. What has changed is the **ceiling** — the asset's capacity to erupt. Maturation, measured honestly, shows up not as a lower baseline but as the *disappearance of extremes*.

That reframes the vocabulary. "Volatility decay" suggests a level sliding uniformly downward; the evidence is **volatility compression** — a distribution contracting toward a fixed floor from above. It is worth naming precisely, because it is the first entry in a language this laboratory intends to build: *compression* may prove to be the same structural signature seen elsewhere in Bitcoin's behavior, where each cycle's peak magnitude has also diminished. Whether those two compressions share a cause is a question for a later notebook — posed here, not answered.

> **READ CAREFULLY**
>
> A lower and briefer ceiling is a statement about *behavior*, not *return*. Nothing here says Bitcoin's opportunity has shrunk; a more efficient market can compress volatility while still moving substantially. This notebook measures how Bitcoin behaves, not where it is going.

§7 LIMITATIONS

What this notebook deliberately does not claim

The scope is intentionally narrow, so the claim can be clean. This study does **not** attempt to explain *why* the ceiling has fallen, nor control for the forces most likely responsible — each is a separate investigation:

liquidity growth · market-capitalization scale · the ETF era and institutional participation · derivatives and options markets · macro regime. It also inherits ordinary caveats: a single asset with one price history (no cross-sectional control), index-level pricing rather than a single venue, halving epochs used as coarse buckets, and a modest R^2 that confirms time is only one of several forces acting on volatility. These are not weaknesses to hide; they are the next notebooks, named in §8.

§8 CONFIDENCE & QUESTIONS RAISED

What we trust, and where it points next

RESEARCH CONFIDENCE	
Dataset quality	★★★★★
Historical coverage	★★★★★
Reproducibility	★★★★★
Statistical confidence	★★★★☆
Further validation required	Yes
Hypothesis status: **H_1 supported**, refined from "decay" to "compression."	H_0 rejected at $\lvert t\rvert = 36.8$

Why four stars and not five. Statistical confidence is held at four *by choice*. It earns the fifth with two things, both planned: out-of-sample confirmation on an independent venue's price history, and a formal structural-break test (e.g. Bai–Perron) that dates the ceiling's decline rather than assuming the epoch boundaries. We would rather show you the ceiling than assume it.

The Question Register — opened here

This is where the laboratory begins to think out loud. Every question a notebook raises is entered into one running register — numbered once, carried forever. Future notebooks answer some and add others; the open questions *are* the laboratory's frontier. This notebook opens the register with its first five.

Q-001 Why has the ceiling fallen? Is the driver liquidity, market-cap scale, derivatives depth, or the ETF era? — DRIVERS OF COMPRESSION

Q-002	The volatility floor is a structural constant. Can that constant, and the rate of ceiling-compression, be combined into a single index of Bitcoin's *structural age*?	Structural Age
Q-003	Is volatility compression the same signature as cycle-peak compression seen elsewhere in Bitcoin? Do they share a clock?	Cycle Research
Q-004	Does Gold — a mature monetary asset — show the same floor-stable, ceiling-compressed profile, or a different one entirely?	Gold Study
Q-005	Does the ceiling contract *before* major tops, and do macro bottoms consistently follow volatility spikes?	Behaviour

Reproducibility. All figures derive from a single daily BTC/USD series (6,018 bars, 2009–2026). RV = annualized standard deviation of daily log returns, √365 convention. Epochs delimited by halving dates 2012-11-28, 2016-07-09, 2020-05-11, 2024-04-20. Floor = 10th percentile, ceiling = 90th percentile of RV within epoch. Trend by ordinary least squares on log RV vs. time. Every number in this notebook is regenerable from the source data and these definitions — no discretionary adjustments.

⚲ Laboratory Notes

During this research, one assumption changed — and the change is worth preserving, because it *is* part of the finding.

The working title was ~~*The Structural Decay of Bitcoin Volatility*~~. "Decay" carries a specific meaning: a level sliding uniformly downward. It felt right, and the falling average seemed to support it. But when the distribution was split into floor and ceiling, decay no longer fit. The floor was not decaying — it was holding near 30%, as it had for a decade. Only the ceiling fell. A distribution contracting toward a fixed floor is not decaying; it is compressing. The title was rejected and rewritten as **Compression**.

This notebook keeps the correction visible on purpose. The point of a laboratory is not to appear right from the start — it is to let the evidence change your mind in public.

v1.1 — Full history imported; realized volatility computed at 30 / 60 / 90-day windows; epoch decomposition and persistence established; working hypothesis revised from "decay" to "compression." Archived permanently; not to be altered.

Measure before you explain.

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