

Bitcoin Power Law Research

A Comprehensive Survey

From Trolololo (2014) through Santostasi, Burger, Perrenod, and PlanC:
The complete intellectual lineage of Bitcoin's power law floor.

Scale Invariant Capital

BTC Power Law Observatory. Paper 6.

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Introduction

The Bitcoin Power Law Theory has generated a rich ecosystem of original research, academic validation, quantile refinements, and statistical critiques spanning 2014-2026. This survey catalogs every known researcher, paper, and analysis relevant to Bitcoin's power law floor. It is the most complete accounting of this literature assembled to date, covering: the origins of the power law observation, the theoretical derivation from Metcalfe's Law, the statistical debates around spurious regression, the quantile regression refinements, the cross-asset comparisons, and the practical tools built on these foundations.

The power law exponent for Bitcoin's price-vs-time relationship has been independently measured by at least ten researchers. Values cluster between 5.6 and 5.9, providing strong cross-validation. This survey organizes the literature by researcher, methodology, and contribution type.

1. Origins: From Trolololo to Santostasi

1.1 Trolololo (2014)

The intellectual lineage begins on BitcoinTalk in October 2014, when pseudonymous user Trolololo posted "Logarithmic (non-linear) regression -- Bitcoin estimated value" (thread #831547). His formula -- $\log_{10}(\text{Price}) = 2.66167 \times \ln(\text{days since Jan 9, 2009}) - 17.9183$ -- used mixed logarithmic bases that obscured the underlying power law. As Santostasi later demonstrated, this equation is algebraically equivalent to $\text{Price} = A \times \text{days}^n$ with $A \sim 10^{-17}$ and $n \sim 5.83$. Had Trolololo plotted both axes logarithmically, he would have seen a straight line.

1.2 Giovanni Santostasi

Giovanni Santostasi (PhD Astrophysics, Northwestern University; CEO and Director of Research, Quantonomy Fund) is the originator of the Bitcoin Power Law Theory (BPLT). His contributions span three phases:

March 2014: First Reddit post (r/Bitcoin, username Econophysicist1, post ID 21pujs) comparing Bitcoin to Metcalfe's Law and Zipf's Law. This is the earliest known application of Metcalfe scaling to Bitcoin.

September 2018: Foundational post on r/Bitcoin -- "Bitcoin power law, over 10 year period, all the way to Genesis Block" (post ID 9cqi0k). He predicted "BTC will be around 150K in 2025." R-squared = 0.92.

January 2024: "15 years of BTC Power Law" (r/Bitcoin, post ID 18z04kp), demonstrating R-squared improved to 0.95. This coincided with Andrei Jikh's YouTube video to 2.3M subscribers, bringing mainstream attention to the theory.

Santostasi's Theoretical Derivation

The core chain: (1) Network adoption follows $N \sim t^3$ -- the Difficulty Adjustment converts logistic growth into power law growth. (2) Value scales as $V \sim N^{1.95}$ (near-Metcalfe). (3) Combined: $P \sim t^{5.85}$, matching the empirical slope. The full feedback loop: Users -> Price (Metcalfe) -> Mining/Hash rate -> Security -> More Users -> repeat. Hash rate scales as Price^2 , yielding Hash rate $\sim t^{12}$ (empirically ~ 11.4).

Santostasi's formula: **Price = $10^{-17} \times (\text{days from Genesis Block})^{5.8}$** . The support/floor line is the lower bound of the corridor. He states: "The reason we see so strong and consistent a barrier at the bottom is because of 'miners capitulation' after the bubble crash." The model has only failed once: March 13, 2020 (COVID crash intraday). His comprehensive Medium articles include "The Bitcoin Power Law Theory" (March 2024), "The Physics of Bitcoin" (March 2024), "Understanding Bitcoin's Predictability: A Monte Carlo Simulation" (August 2024), and "S2F and the Zombification of the Bitcoin World" (May 2024).

2. Harold Christopher Burger: The Power Law Corridor

Harold Christopher Burger -- entrepreneur and engineer -- publishes at hcburger.com and on Medium under "Quantodian: Tracking Bitcoin." He is **not** affiliated with Porkopolis Economics (that is Matthew Mezinskis's project).

Key Publications

"Bitcoin's natural long-term power-law corridor of growth" (September 3, 2019). Formula: $\text{price} = 10^{-17.016} \times d^{5.845}$, R-squared = 0.931. Identified two power-law boundaries: a support line (floor) and a top line fitted through cycle peaks (slope = 5.029). Used RANSAC to identify "normal mode" and "bull mode" -- price spends ~50% of time in each.

"Bitcoin's power oscillator" (September 2019). Oscillator measuring log-price deviation from power-law fit. All four ATHs occurred in a narrow high oscillator band. **"Bitcoin's power-law really debunked?"** (February 2024, with Santostasi). Rebuttal to Tim Stolte: defended out-of-sample forecasts, stationary residuals, and Genesis Block starting point. **"Bitcoin's time-based power-law and cointegration revisited"** (January 2024, with Peter Vijn). Argued cointegration strictly cannot exist in time-dependent models because time is deterministic. Residuals are stationary, achieving the practical equivalent.

3. Matthew Mezinkis: Porkopolis Economics

Matthew Mezinkis operates Porkopolis Economics (porkopolis.io) and the Crypto Voices podcast. First published his power law chart December 31, 2018. Formula: $y = 1.6 \times 10^{-17} \times x^{5.77}$, R-squared > 95%.

His distinctive contribution: **percentile band methodology**. He explicitly states: "Finance is not a bell curve. The bands are calculated as percentiles." Red bands: 2.5th to 97.5th percentile (95% of observations). Blue bands: 16.5th to 83.5th percentile (67% of observations). These are NOT equidistant from the trend. In January 2025, he adjusted to expanding-window regression for more conservative forward estimates. His "13% doubling rule": for every ~13% increase in Bitcoin's age in days, the trendline price doubles.

4. Stephen Perrenod: Three-Layer Model and FGLS

Stephen Perrenod (astrophysicist; OrionX affiliate) publishes on the "Money or Debt Newsletter" Substack. He has produced the most statistically sophisticated treatment of Bitcoin's power law. Over 30 relevant articles identified.

FGLS Correction for Autocorrelation

"**Bitcoin heading to \$1 million sooner, FGLS vs. OLS**" (October 2024). First FGLS paper with AR(1) correction. Steeper power law slope: ~ 5.89 (vs OLS 5.68). "**Bitcoin Power Law with AR(2)-corrected GLS**" (December 2024). Definitive FGLS paper. AR(2) fit: $\text{Residual}(t) = 1.111 \times \text{Residual}(t-1) - 0.130 \times \text{Residual}(t-2) + 0.001$. Durbin-Watson improves from 0.03 to 2.01. Power law index preserved at 5.68 with proper statistics. Key insight: "Autocorrelation is not a bad thing per se -- think of a rocket ship."

Three-Layer Model and Volatility Decay

"**Bitcoin: from Heavy Tails to Gaussian**" (March 4, 2026). The definitive decomposition: Layer 1 (CSI): Power law spine via quantile regression, slope = 5.865. Layer 2 (DSI): Log-periodic oscillations with $\lambda = 2.07$ ($\omega = 8.63$), two modes, R-squared = 0.50, amplitude decay $\sim 1/(A+2.0)$. Layer 3: Exogenous noise decay: $\sigma = 6.1/(A + 27.1)$ for log10 price residuals. Layer 4: GARCH(1,1) removes remaining conditional heteroskedasticity. Conclusion: "Fat tails appear largely as structural or regime-mixing artifacts." After all layers removed, innovations are approximately Gaussian -- log-normal price movements.

Additional key articles: "Bitcoin in Gold ounces: Collapsing Volatility" (February 2026) -- volatility drops from 0.46 to 0.08 in log terms, a 5.7x compression. "Why is there no Bitcoin bubble in 2025?" -- log-periodic spacing $\lambda = 2.07$ confirmed across four methods; next fundamental bubble predicted late May 2027. "Bitcoin's Intrinsic Scaling" (January 2026) -- 368,821 pairwise scaling exponents yield $\mu = 5.74$. "A Proposed Grand Unified Theoretical Framework for Bitcoin" -- dam/reservoir analogy with Lagrangian.

5. Quantile Regression: PlanC, Sina, and Sminston

5.1 PlanC (@TheRealPlanC)

Anonymous researcher who built the Bitcoin Quantile Model, the most sophisticated quantile regression framework for Bitcoin. Quantile Model v2 (October 15, 2025): 133,000+ data points, 1,500 lines of code, 999 quantile levels ($\tau = 0.001-0.999$). Lower half uses linear quantile regression; upper half uses stretched-exponential decay -- a piecewise hybrid approach.

Key floor claim (March 9, 2026): 522 weekly fits over 10 years show "essentially zero change" in the 1st quantile slope. The floor doesn't decay. Meanwhile, the median does decay, meaning OLS overestimates fair value at $\sim \$118-130K$ when the true decay-adjusted fair value is $\sim \$100-101K$. The Bitcoin Quantile Index (BQI) transforms the model into a single intuitive number with five zones: Deep Value (1-20%), Discounted (20-50%), Premium (50-80%), Speculative (80-95%), Historic Peaks (95-99.9%).

5.2 Sina (@Sina_21st)

Professor, consultant, co-founder/COO of 21stCapital.com. Collaborates with PlanC. Developed the Volatility-Adjusted Power Law Index (VPLI). Three-zone framework: Cold (<33%), Warm (33-66%), Hot (66-99%). "The 33% quantile ranges coincide perfectly with Bitcoin phase transitions."

5.3 Sminston With (@sminston_with)

PhD Materials Science & Engineering. Created the Bitcoin Decay Channel (July 17, 2024). Critical design: bottom boundary is standard power law support, top boundary is an exponential decay function fitted to cycle tops -- the upper bound converges toward the support over time. PlanC credits Sminston as "by far the biggest influence" on the v2 hybrid approach.

6. Fred Krueger and Ben Sigman

Fred Krueger (Stanford PhD, @dotkrueger, 244K+ X followers) is the most prominent popularizer. His summary to Michael Saylor (April 2024): accounts (>0.01 BTC) follow power law at 2.49; price at 5.6-5.8 (R-squared = 0.95-0.97); hash rate at 12. Ben Sigman (@bensig) built the B1M platform (b1m.io) with formula: $\text{Price} = 10^{-1.848} \times (\text{Days}/365.25)^{5.616}$, R-squared = 95.65%. Together they co-authored "Bitcoin One Million: The Final Chapter of Fiat" (2025), an Amazon #1 bestseller in Macroeconomics, Monetary Policy, and Bitcoin categories.

7. Academic Papers on Metcalfe's Law and Bitcoin

7.1 Wheatley, Sornette et al. (2019)

"Are Bitcoin bubbles predictable? Combining a generalized Metcalfe's Law and the Log-Periodic Power Law Singularity model." **Royal Society Open Science**, Vol. 6, Issue 6, 180538. ETH Zurich; Swiss Finance Institute. The only peer-reviewed measurement of the Metcalfe exponent. **Beta = 1.69** (s.e. 0.0076), $\alpha = 1.51$, $R^2 = 0.95$, $N = 2,782$ daily values. Forcing $\beta = 2$ (standard Metcalfe) yields significantly worse fit -- "robustly rejected on moving windows."

7.2 Peterson (2018)

"Metcalfe's Law as a Model for Bitcoin's Value." **Alternative Investment Analyst Review**, Vol. 7, No. 2, pp. 9-18. SSRN: 3078248. $\beta = 2.0$ (exact Metcalfe). Bitcoin fits "exceptionally well" using Gompertz curve for inflationary effects. Three notable deviations correspond to documented manipulation.

7.3 Alabi (2017)

"Digital blockchain networks appear to be following Metcalfe's Law." **Electronic Commerce Research and Applications**, Vol. 24, pp. 23-29. Stony Brook University. Confirmed N^2 -scaling for Bitcoin, Ethereum, and Dash. Follow-up (2020): sustained correlation through January 2020.

7.4 Additional Academic Papers

Van Vliet (2018) "An alternative model of Metcalfe's Law for valuing Bitcoin." *Economics Letters*. Incorporates Rogers' diffusion of innovation. **Pele & Pele (2019)** "Metcalfe's law and log-period power laws in the cryptocurrencies market." *Economics E-Journal*. Bidirectional causality between price and network size. **Baquero (2026)** "Activity-Warped Power Laws for Bitcoin Price." Under review at *Digital Finance*. Walk-forward validated across 9 annual splits and 42 quarterly windows. **Senel (2024)** "Quantile Regression Sheds Light on Bitcoin's Hidden Metrics." *Medium*. Key finding: OLS sits at approximately the 55th percentile of the empirical distribution.

Summary of Metcalfe Exponents

Study	Year	Beta	Network Proxy	Venue
Santostasi	2014/24	~1.95	Non-zero addresses	Non-academic
Alabi	2017	~2.0	Daily addresses	Electronic Commerce Res.
Peterson	2018	2.0	Wallets	Alt. Inv. Analyst Review
Van Vliet	2018	~2.0	Wallets (Rogers)	Economics Letters
Wheatley/Sornette	2019	1.69	Active addresses	Royal Society Open Sci.
Shanaev et al.	2019	Rejects all	Tx count (IV)	SSRN working paper
Fulgur Ventures	2024	~2.0	Non-zero addresses	Industry report

8. Criticisms and Counter-Arguments

8.1 The Spurious Regression Critique

Marcel Burger (CIO, Amdax, MSc Econometrics): "Debunking Bitcoin's natural long-term power-law corridor of growth" (November 2019). Argued OLS assumptions violated. **Tim Stolte** (Amdax): "Bitcoin's power-law corridor debunked" (~2022). ADF tests show non-stationarity, regression is "spurious" per Phillips (1986). Called the model "logically and statistically invalid." **Nick Emblow** (@btconometrics): similar ADF/KPSS conclusions.

8.2 The Defenses

Burger & Vijn (2024): Cointegration cannot exist with deterministic time. Applying integration order to a deterministic function is "nonsensical." Residuals are stationary. **Burger & Santostasi (2024):** MSE decreases over time (inconsistent with spurious regression). Parameters stable since ~2017. Out-of-sample forecasts held since 2018. **Perrenod (2024):** FGLS with AR(2) directly corrects autocorrelation. D-W from 0.03 to 2.01. **Baquero (2026):** Walk-forward across 9 annual splits and 42 quarterly windows.

8.3 Shanaev et al. (2019)

"The Marginal Cost of Mining, Metcalfe's Law and Cryptocurrency Value Formation." SSRN 3432431. Northumbria/Leeds Trinity/Robert Gordon Universities. First paper to test Metcalfe models using instrumental variables on block-level data. Finding: "Previously reported strong positive relationships are spurious due to autocorrelation and endogeneity." Directly challenges Alabi, Peterson, Van Vliet. Formally unresolved in the academic literature.

8.4 Taleb (2021)

"Bitcoin, Currencies, and Fragility." **Quantitative Finance**, Vol. 21, No. 8, pp. 1249-1255. Central argument: Bitcoin has any non-zero probability of reaching zero; by backward induction from the "absorbing barrier at zero," its expected present value should be exactly zero. Additionally argues Bitcoin failed as currency, inflation hedge, and safe haven. **Burger's rebuttal** (September 2021): mining stopping temporarily is NOT an absorbing barrier; if applied to gold via DCF, Taleb would reach the same conclusion; antifragility supports Bitcoin.

9. Cross-Asset Power Law Research

No published systematic comparison applying the same power law methodology to gold, S&P 500, real estate, and Bitcoin was found. This represents a significant gap. Perrenod has analyzed BTC/gold (power law index 5.58, R-squared = 0.94). Santostasi informally claims the power law holds against gold, euro, and yen. But no rigorous cross-asset study with standardized methodology exists.

Geoffrey West's Scale (2017) provides the theoretical backbone: power laws are emergent properties of complex adaptive systems driven by optimized network structures. Metabolic rates scale to 3/4 power of body mass (Kleiber's Law). City infrastructure scales sublinearly (~0.85). Socioeconomic indicators scale superlinearly (~1.15). West does not discuss financial markets directly, but the framework applies. **Clauset, Shalizi & Newman (2009)** SIAM Review -- the gold-standard methodological reference for fitting power laws.

10. Mining Cost, Realized Price, and Structural Support

10.1 Production Cost Floor

Charles Edwards (Capriole Investments): "Bitcoin's Production Cost" (December 2019). Derives cost from Cambridge Electricity Index, global average price, and hardware efficiency. His "Energy Value Equivalence" model values BTC as $V = \text{Energy Input} / \text{Supply Growth Rate} \times \text{constant}$. **CoinShares**: Q4 2025 weighted average cash cost ~\$74,600/BTC; all-in ~\$137,800. **JPMorgan**: Production cost has "historically served as a soft price floor." Late 2025 estimate: ~\$92-94K; March 2026: ~\$77K following steepest difficulty drop since China ban.

10.2 Realized Price

Nic Carter & Antoine Le Calvez (Coin Metrics, September 2018): originated realized cap/realized price. Values each UTXO at the price when last moved. **MVRV Ratio** (Mahmudov & Puell, October 2018): Market Value / Realized Value. Below 1.0 at every major cycle bottom. **MVRV Z-Score** ("Awe and Wonder," October 2018): standardized version.

10.3 HODL Waves

Dhruv Bansal (Unchained Capital, April 2018): "Bitcoin Data Science Pt. 1: HODL Waves." Using UTXO age distribution: "after every great rally, there's been a great HODL." Long-term holders accumulate during bear markets, creating the "holder of last resort" dynamic.

11. Game Theory, Lindy Effect, and Systemic Mechanisms

Chen (2025) "A Game-Theoretic Foundation for Bitcoin's Price." arXiv:2508.06071. Introduces RESUNE (Rational-Expectations Security-Utility Nash Equilibrium). Proves existence via fixed-point argument. Predicts halving is fundamentally contractionary. **Lindy Effect**: Coined by Goldman (1964), formalized by Mandelbrot, popularized by Taleb in Antifragile (2012). No formal quantitative Lindy model for Bitcoin price exists, but the connection between Lindy and power law is natural: survival compounds expected future growth. **Difficulty Adjustment**: Satoshi's whitepaper Section 4. Recalibrates every 2,016 blocks. Ammous calls it Bitcoin's "secret ingredient."

12. Summary of Power Law Exponents

Researcher	Basis	Exponent n	R-squared
Trolololo (2014)	ln-log10 mixed	~5.83	N/A
Santostasi (2018/24)	Days from GB	5.8	0.95
Mezinskis (2018)	Days from GB	5.77	>0.95
Burger (2019)	Days from Jan 1 2009	5.845	0.931
Sigman/B1M (2025)	Years from GB	5.616	0.957
Perrenod QR (2024)	Block years	5.83-5.865	0.94
Perrenod OLS (2024)	Block years	5.68-5.69	0.94
Perrenod FGLS (2024)	Weekly data	5.68	0.999
Perrenod TLS (2026)	Weekly data	5.74	N/A
Observatory	Days from GB	5.688	0.95+

The convergence of independent measurements between 5.6 and 5.9, using different data windows, time bases, and regression methods, is itself strong evidence of a real underlying phenomenon.

13. Where the Observatory Fits

The BTC Power Law Observatory (Scale Invariant Capital) occupies a unique position in this landscape. While Santostasi provides the theory, Burger the empirical corridor, Perrenod the statistical correction, and PlanC the quantile framework, the Observatory contributes:

Paper 1 (Volatility Decay Analysis): First per-cycle measurement of percentile-anchored compression (~20% per halving cycle). Asymmetric: ceiling collapses 2.2x faster than floor rises. **Paper 2 (Bitcoin Floor Rate):** Introduces the BFR (~38%/year) as a structural analog to the risk-free rate, with M2-anchored benchmark and Gordon Growth Model infinity argument. **Paper 3 (Lump Sum vs DCA):** Demonstrates lump sum superiority due to persistent upward drift. **Paper 4 (Floor Bonds):** Fixed-income instrument priced off floor growth rate. **Paper 5 (Derisking Bitcoin):** Floor freedom inequality, storm years, capital efficiency comparison. **Paper 6 (This survey):** First comprehensive catalog of all power law research. **Paper 7 (The Case for the Floor):** Seven independent attacks, circularity resolution, cross-asset comparison, three-way convergence model, and the finding that P1 rises (contradicting PlanC).

The Observatory's distinctive approach: applied framework (portfolio tools, retirement planning, loan monitoring) built on the theoretical foundations laid by the researchers cataloged above. Validated with 20 Dutch families. The research is the credibility layer; the tools are the product.

The power law exponent converges. The researchers converge. The floor converges. The only question is whether you converge with them.

Scale Invariant Capital. BTC Power Law Observatory.

All code and data: github.com/JohnnyBCash/bitcoin-powerlaw-observatory