Bitcoin-Seconds (BXS): Measuring Durable Accumulation of Time-Shifted Energy Claims

Version 0.6.4 (for Peer Review)

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November 2025

Abstract

Bitcoin converts present energy expenditure into cryptographically proven, transferable claims on future energy and work. We propose a Bitcoin-native temporal calculus that measures the *durability* of those claims through time. The framework forms a three-level ladder: (i) an instantaneous flow $f(t)$ in sats s^{-1} capturing the rate of accumulating *durable* energy claims, (ii) its cumulative integral $S(T)$ in sats, and (iii) the time-weighted integral $\mathrm{BXS}(T)$ in sats·s (Bitcoin-Seconds). Each driver of durability is observable: income velocity, revealed HODLing strength (coin age), protocol dilution (mechanical inflation), and financial runway. We state falsifiable hypotheses, a node-local implementation, and a backtest recipe to validate that durability-aware measures add information beyond balance, coin age, and ROI.

1 Foundation: Bitcoin as Time-Shifted Energy Claims

Proof-of-Work turns present energy expenditure into a cryptographic record that persists and becomes a transferable claim on future energy and work. Example: 50 BTC mined in 2009 at negligible fiat value now commands substantial real-world labor and energy. The *claim* has persisted across protocol eras. We aim to measure not only *how much* Bitcoin one holds or earns, but *how durably* those claims persist through time and conditions.

2 Measurement Problem: Durable vs. Transient Accumulation

Not all Bitcoin accumulation is equal. Some flows are quickly liquidated (transient), others are held and financially sustainable (durable). We ask: *What is the rate at which an entity accumulates durable energy claims, and how does that durability persist through time?*

3 Drivers and Notation

Let $t \in [0, T]$ be time in seconds. All series are assumed piecewise continuous and integrable on $[0, T]$.

- $i(t)$: income inflow [sats s^{-1}].
- $\mu(t)$: spending outflow [sats s^{-1}].
- $A(t)$: value-weighted coin age (revealed HODLing strength) [s].
- $I(t)$: protocol monetary expansion rate [s^{-1}], defined mechanically as

$$I(t) \;=\; \frac{\sigma(h(t))}{S(t)}\,\lambda(t),$$

where subsidy σ is in BTC per block, circulating supply S in BTC, and λ is blocks per second.

- $s(t)$: current holdings [sats].
- r: retirement (forward) horizon [s].
- $CP(t)$: cumulative inflation-adjusted cost (optional) [sats].

Baselines. Choose positive baselines $A_0 > 0$ and $I_0 > 0$ for normalization. Unless stated otherwise: A_0 is a rolling 180-day median of $A(t)$ per entity; I_0 is a per-epoch rolling median of $I(t)$. We will evaluate robustness to baseline windows in sensitivity checks.

Surplus-to-Spending Ratio (SSR).

$$\mathrm{SSR}(t) \;=\; \frac{s(t) + r\,i(t) - CP(t)}{\max\{t, t_{\min}\}\,\max\{\mu(t), \mu_{\min}\}} \quad \text{(dimensionless)},$$

with small floors $t_{\min} > 0$, $\mu_{\min} > 0$ to avoid division by zero at startup or near-zero spending. Negative $\mathrm{SSR}(t)$ indicates drawdown pressure; we *do not* clip negatives, as they are informative.

4 Instantaneous Flow of Durable Claims

$$\boxed{f(t) \;=\; i(t)\,\cdot\,\frac{A(t)}{A_0}\,\cdot\,\frac{I(t)}{I_0}\,\cdot\,\mathrm{SSR}(t)} \tag{1}$$

Units and meaning (callout). $f(t)$ is in sats s^{-1} (BTC/s or sats/s). It is the *rate of accumulating durable energy claims*, i.e., income weighted by:

1. $A(t)/A_0$: revealed HODLing strength (demonstrated time preference),
2. $I(t)/I_0$: protocol-era context (dilution/halving environment),
3. $\mathrm{SSR}(t)$: financial runway to *maintain* claims (ability vs. intent).

At-a-glance recap.

$$\mathrm{SSR}(t) = \frac{s(t) + r\,i(t) - CP(t)}{\max\{t, t_{\min}\}\,\max\{\mu(t), \mu_{\min}\}}, \quad S(T) = \int_0^T f(t)\,dt, \quad \mathrm{BXS}(T) = \int_0^T S(t)\,dt.$$

Why multiplicative? Durable accumulation requires all dimensions to align; failure in any one dimension (e.g., no runway, low age, high dilution) lowers effective durable flow. Multiplication captures these interaction effects parsimoniously.

5 Integration Ladder: BTC/s → BTC → BTC·s

Ladder Schema (informational)

Level 1 (Flow): $f(t)$ in sats s^{-1} → "rate of accumulating *durable* energy claims."

Level 2 (Stock): $S(T) = \int_0^T f(t)\,dt$ in sats → "total durable claims accumulated."

Level 3 (Time-Weighted): $\mathrm{BXS}(T) = \int_0^T S(t)\,dt$ in satss → "persistence of claims (amount *and* duration)."

Baseline comparator (size-only): $\mathrm{BXS}_{\mathrm{core}}(T) = \int_0^T W(t)\,dt$.

Figure 1: BTC/s → BTC → BTC·s ladder and interpretation.

5.1 Level 1: Flow

$f(t)$ in sats s^{-1}: rate of accumulating durable energy claims.

5.2 Level 2: Stock

$$\boxed{S(T) \;=\; \int_0^T f(t)\,dt} \quad \text{[sats]} \tag{2}$$

5.3 Level 3: Time-Weighted Stock (Bitcoin-Seconds)

$$\boxed{\mathrm{BXS}(T) \;=\; \int_0^T S(t)\,dt \;=\; \int_0^T\!\int_0^t f(\tau)\,d\tau\,dt} \quad \text{[sats·s]} \tag{3}$$

Baseline persistence. For benchmarking, define the size-only persistence

$$\boxed{\mathrm{BXS}_{\mathrm{core}}(T) \;=\; \int_0^T W(t)\,dt} \quad \text{[sats·s]} \tag{4}$$

with $W(t)$ the balance in sats. This omits durability adjustments. Optionally, discount by $e^{-\rho t}$ for time preference.

Units callout. $f(t)$: BTC/s (sats/s). $S(T)$: BTC (sats). $\mathrm{BXS}(T)$: BTC·s (sats·s).

Scaling for readability. Report BXS also in BTC·years by dividing by 31,536,000, i.e., $\mathrm{BXS}^{(\mathrm{yr})} = \mathrm{BXS}/(365 \cdot 24 \cdot 3600)$.

6 Mechanical Inflation $I(t)$ and Per-Block Form

We compute $I(t)$ from node-local telemetry:

$$I(t) \;=\; \frac{\sigma(h(t))}{S(t)}\,\lambda(t),$$

which automatically reflects halving epochs and cadence variation. For block-indexed code, a per-block constant form is useful:

$$I_k \;=\; \frac{\sigma_k}{S_k} \cdot \frac{1}{\tau_{\mathrm{target}}} \quad \text{with} \quad \tau_{\mathrm{target}} = 600 \text{ s},$$

and an empirical per-second series obtained by smoothing observed inter-block times.

7 Illustrative Magnitudes (Orientation Only)

Satoshi-like holder (size-only core)

Let $W \approx 9.68452 \times 10^{13}$ sats and $T \approx 4.0 \times 10^8$ s. Then

$$\mathrm{BXS}_{\mathrm{core}}(T) \approx W\,T \approx 3.87 \times 10^{22} \text{ sats·s } (\approx 1.23 \times 10^{15} \text{ sats·yr}).$$

This anchors the scale of raw persistence without durability adjustments.

Table 1: Three-point illustration (orders of magnitude only). Baselines: $A_0 = 3.0 \times 10^7$ s, $I_0 = 2.6 \times 10^{-10}$ s^{-1}; floors: $t_{\min} = 10^3$ s, $\mu_{\min} = 10^{-6}$ sats s^{-1}.

Case	W (sats)	A/A_0	I/I_0	SSR	f (sats/s)
Satoshi-like	9.68×10^{13}	13.3	115.4	2.4×10^9	3.7×10^{12}
Modest (∼1.2 BTC)	1.2×10^8	1.0	1.0	10^2	10^4
Micro (0.001337 BTC)	1.34×10^5	0.07	1.0	10^1	3×10^1

Numbers are illustrative only; calibrated estimates require entity-specific series.

8 Implementation (Node-Local, Sovereign)

All inputs are computed from a Start9-hosted *mempool.space* and wallet logs:

- $I(t)$ from subsidy, supply, and measured cadence.
- $A(t)$, $W(t)$, $i(t)$, $\mu(t)$ from UTXO histories and inflow/outflow rates.
- $CP(t)$ optional; omit for strictly Bitcoin-native analysis.
- Floors $t_{\min}, \mu_{\min}$ applied as in the SSR definition.

This ensures privacy, integrity, and reproducibility without third-party APIs.

9 Empirical Design: Durability and Stress Tests

Hypotheses (falsifiable)

- H1 (Durability): Higher $f(t)$ predicts sustained holding in $[t, t+\Delta]$, controlling for $W(t)$ and $A(t)$.
- H2 (Stress): Declines in $f(t)$ precede forced liquidation (large outflows or UTXO consolidation) earlier than balance-only signals.
- H3 (Component Value): Each driver $A/I/\text{SSR}$ adds incremental predictive power for claim persistence (beyond W, A alone).

Concrete backtest recipe

1. **Label outcomes:** For each entity and evaluation date t, mark HOLD=1 if no net outflow beyond $x\%$ over $[t, t+\Delta]$ (e.g., $\Delta = 90$ days, $x = 5\%$), else HOLD=0.
2. **Models:** Baseline logistic: HOLD $\sim W(t), A(t)$. Durability model: HOLD $\sim W(t), A(t), f(t)$ (and optionally lags/EMAs).
3. **Compare:** AUC and Brier score out-of-sample via rolling-origin CV. Report deltas (Durability minus Baseline).

Stress metric (optional). Define $f^-(t) = \min\{f(t), 0\}$. Test whether f^- leads subsequent spending bursts and drawdown events.

Normalized uplift (optional). Define $\widehat{f}(t) = f(t)/\big(i(t) + \epsilon\big)$ to show durability uplift over bare income.

10 Positioning (Convergent Thinking)

Time-centric monetization ideas have emerged independently in the community. We reference them only as convergent intuition; the present construction is Bitcoin-native and self-contained.

11 Conclusion

We defined a durability-aware ladder $f \to S \to \text{BXS}$ that measures the rate, size, and temporal persistence of Bitcoin-denominated energy claims. Unlike balance, coin age, or ROI, $f(t)$ explicitly models durability via HODLing behavior, network era, and financial runway. The framework yields testable hypotheses and a node-local path to empirical validation.

Appendix A: Units and Dimensional Checks

$$[f] = \text{sats}\,\text{s}^{-1}, \quad [S] = \text{sats}, \quad [\text{BXS}] = \text{sats}\cdot\text{s}.$$

Each integration adds one factor of time, ensuring dimensional closure. Reporting BXS in BTC·yr or sats·yr improves readability.

Appendix B: Edge Cases and Well-Posedness

- $t \to 0$: use $t \leftarrow \max\{t, t_{\min}\}$.
- $\mu(t) \to 0$: use $\mu(t) \leftarrow \max\{\mu(t), \mu_{\min}\}$. Interpret very small μ as large runway; optionally cap SSR at $\text{SSR}_{\max}$ in production dashboards.
- Negative SSR: retain as a signal of drawdown pressure.
- Baselines A_0, I_0: use rolling medians; sensitivity-test 90/180/360-day windows and per-epoch settings.

Appendix C: Mechanical Form of $I(t)$

$$I(t) = \frac{\sigma(h(t))}{S(t)}\,\lambda(t), \qquad I_k = \frac{\sigma_k}{S_k} \cdot \frac{1}{\tau_{\text{target}}}, \quad \tau_{\text{target}} = 600 \text{ s}.$$

Empirical cadence can deviate from target; smooth inter-block times to estimate a per-second $I(t)$.

Addendum (One Page): Glossary, Worked Example, and How-To

A. Glossary of Symbols (units in brackets)

$i(t)$	income inflow [$\text{sats}\,\text{s}^{-1}$]
$\mu(t)$	spending outflow [$\text{sats}\,\text{s}^{-1}$]
$A(t)$	value-weighted coin age (HODLing strength) [s]
A_0	coin-age baseline (e.g., rolling median) [s]
$I(t)$	protocol expansion rate [s^{-1}]
I_0	expansion-rate baseline [s^{-1}]
$s(t)$	current holdings [sats]
r	retirement (forward) horizon [s]
$CP(t)$	cumulative CPI-weighted cost (optional) [sats]
$\text{SSR}(t)$	surplus-to-spending ratio [1]
$f(t)$	productive flow of durable claims [$\text{sats}\,\text{s}^{-1}$]
$S(T)$	cumulative durable claims [sats]
$\text{BXS}(T)$	Bitcoin-Seconds (time-weighted claims) [sats·s]
$\text{BXS}_{\text{core}}(T)$	baseline time-weighted wealth $\int_0^T W(t)\,dt$ [sats·s]
$W(t)$	wealth (balance) [sats]

Definitions.

$$\text{SSR}(t) = \frac{s(t) + r\,i(t) - CP(t)}{\max\{t, t_{\min}\}\ \max\{\mu(t), \mu_{\min}\}}, \quad I(t) = \frac{\sigma(h(t))}{S(t)}\,\lambda(t),$$

$$f(t) = i(t) \cdot \frac{A(t)}{A_0} \cdot \frac{I(t)}{I_0} \cdot \text{SSR}(t), \quad S(T) = \int_0^T f(t)\,dt, \quad \text{BXS}(T) = \int_0^T S(t)\,dt.$$

B. Worked Example: Satoshi-like Holder (orientation)

Purpose: show orders of magnitude; not a calibrated historical series.

- Holdings: $W \approx 9.68452 \times 10^{13}$ sats; horizon $T \approx 4.0 \times 10^{8}$ s.
- Baselines: $A_0 = 3.0 \times 10^{7}$ s; $I_0 = 2.6 \times 10^{-10}$ s^{-1}.
- Snapshot drivers (illustrative): $A = 4.0 \times 10^{8}$ s; $I = 3.0 \times 10^{-8}$ s^{-1}; $i = 1.0$ sats s^{-1}; $\mu = 1.0 \times 10^{-4}$ sats s^{-1}; $r = 2.0 \times 10^{9}$ s; $CP = 0$.

$$\text{SSR} \approx \frac{9.68452 \times 10^{13} + 2.0 \times 10^{9}}{(4.0 \times 10^{8})(1.0 \times 10^{-4})} \approx 2.42 \times 10^{9}, \quad \frac{A}{A_0} \approx 13.33, \ \frac{I}{I_0} \approx 115.4,$$

$$f(t) \approx 3.7 \times 10^{12} \text{ sats s}^{-1}, \quad S(T) \approx 1.5 \times 10^{21} \text{ sats}, \quad \text{BXS}(T) \approx 3.0 \times 10^{29} \text{ sats s}.$$

Baseline size-only persistence:

$$\text{BXS}_{\text{core}}(T) = W\,T \approx 3.87 \times 10^{22} \text{ sats s} \quad (\approx 1.23 \times 10^{15} \text{ sats yr}).$$

C. How-To (Start9 + mempool.space)

1. Compute $I(t)$ mechanically: query σ, S, λ from your node; set $I(t) = \sigma/S \cdot \lambda$.
2. Derive wallet series: $W(t)$, $A(t)$ (value-weighted mean age), $i(t)$, $\mu(t)$; $CP(t)$ optional.
3. Choose A_0, I_0 baselines (rolling medians) and floors $t_{\min}, \mu_{\min}$.
4. Evaluate $f(t)$ each block interval; integrate numerically for $S(T)$ and $\text{BXS}(T)$.
5. Report both BXS_{core} (size-only) and durability-aware BXS.