Bitcoin-Seconds: A Temporal Framework for Economic Utility

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Abstract

Bitcoin-Seconds (BXS) is a temporal-economic construct for quantifying value persistence in a Bitcoin-denominated economy. By integrating Bitcoin flows across time, BXS captures both wealth magnitude and its duration of sustainment. Beginning with an instantaneous flow in $\mathrm{sats\,s^{-1}}$, integrating once yields cumulative Bitcoin (sats), and integrating again produces Bitcoin-Seconds ($\mathrm{sats\,s}$), representing the *temporal momentum of wealth*.

We introduce a dynamic definition of the network inflation rate $I(t)$, derived directly from block subsidy, circulating supply, and block cadence rather than a fixed annualized approximation. This ensures that Bitcoin-Seconds models remain valid across all epochs, from Satoshi-era mining to post-halving regimes and ultimately the post-2140 steady state.

The framework provides a unified calculus of *economic vitality in time*, enabling comparison of holders, entities, and macroeconomic states on a dimensionally consistent, Bitcoin-native basis.

1 Motivation

Traditional economic measures rely on fiat units subject to political inflation targeting. Bitcoin, as a fixed-supply and time-stamped monetary network, allows redefinition of value through time itself.

Bitcoin-Seconds (BXS) extends wealth accounting into the temporal domain, expressing how long Bitcoin-based value endures and compounds. If Bitcoin is economic energy, then BXS is its temporal momentum — measuring not only what is held, but for how long it sustains productivity.

2 Definitions and Notation

Let $t \in [0, T]$ denote time in seconds. We define:

- $I(t)$ — **Instantaneous network monetary expansion rate** [$\mathrm{s^{-1}}$], defined mechanically as

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

  where $\sigma(h)$ is the block subsidy (BTC per block) at height h, $S(t)$ is the circulating supply (BTC), and $\lambda(t)$ is the block arrival rate (blocks per second) estimated over a rolling window. This tracks halvings and variation in block times.
- $i(t)$ — Individual income rate [$\mathrm{sats\,s^{-1}}$].
- $U(t)$ — Average UTXO age [s].
- $s(t)$ — Current holdings [sats].
- r — Retirement horizon [s].
- $\mu(t)$ — Spending rate [$\mathrm{sats\,s^{-1}}$].
- $CP(t)$ — Cumulative CPI-weighted cost [sats].
- ρ — Discount rate [$\mathrm{s^{-1}}$].

All functions are assumed measurable, bounded on compact intervals, and integrable on $[0, T]$.

3 Hierarchical Flow Structure

We describe three cumulative levels of economic motion: instantaneous flow, stock, and temporal momentum.

3.1 Instantaneous Flow

$$f(t) = i(t)\,U(t)\,I(t)\,\frac{(s(t) + r\,i(t)) - CP(t)}{t\,\mu(t)}. \tag{1}$$

Units: $\mathrm{sats\,s^{-1}}$. This represents the *Bitcoin-per-second* economic throughput, scaling with income velocity, coin age, and the network's inflation state.

3.2 Cumulative Bitcoin Value

$$S(T) = \int_0^T f(t)\,dt, \tag{2}$$

Units: sats. Represents the lifetime Bitcoin-equivalent value generated or sustained.

3.3 Temporal Momentum (Bitcoin-Seconds)

$$BXS(T) = \int_0^T S(t)\,dt = \int_0^T \int_0^t f(\tau)\,d\tau\,dt. \tag{3}$$

Units: $\mathrm{sats\,s}$. The Bitcoin-Second formalizes persistence of value — wealth weighted by time.

4 Dimensional Chain

$$\mathrm{sats\,s^{-1}} \xrightarrow{\int dt} \mathrm{sats} \xrightarrow{\int dt} \mathrm{sats\,s}.$$

Each integration adds one unit of time, ensuring dimensional closure and physical interpretability.

5 Data Source Integration

Network constants (Nov 3, 2025, 20:55 EST) from the **Clark Moody Bitcoin Dashboard**:

- Price: \$106,880
- Market Cap: \$2.13 T
- Circulating Supply: 19,943,910.54 BTC
- Block Subsidy: 3.125 BTC
- Realized Monetary Inflation (annualized): 0.84% (context only)

Using the mechanical definition with $\lambda \approx (600\ \mathrm{s})^{-1}$:

$$I(t) \approx \frac{3.125}{19{,}943{,}910.54} \times \frac{1}{600} \approx 2.61 \times 10^{-10}\ \mathrm{s}^{-1}.$$

6 Historical Calibration of $I(t)$

For comparison across eras (block cadence assumed near 600 s average for back-of-envelope clarity):

Era	σ (BTC/block)	Supply S (BTC)	$I(t)$ [s^{-1}]
Genesis (2009, $h \approx 1{,}000$)	50	50,000	1.67×10^{-6}
Satoshi window (2010, $h \approx 54{,}000$)	50	2.7×10^{6}	3.07×10^{-8}
1st Halving (2012, $h \approx 210{,}000$)	50	1.05×10^{7}	7.94×10^{-9}
2025 Snapshot ($h \approx 922{,}000$)	3.125	1.994×10^{7}	2.61×10^{-10}

This shows a reduction of roughly five orders of magnitude in $I(t)$ since Bitcoin's inception.

7 Illustrative Examples

7.1 Example 1: Satoshi Nakamoto (Foundational Holder)

Holdings: $s = 9.68452 \times 10^5$ BTC (9.68452×10^{13} sats).
Average UTXO age $U = 4.0 \times 10^8$ s.
$I(t)$ (circa 2010): 3.07×10^{-8} s^{-1}.
Assume $\mu = 0.0001$ sats s^{-1}, $i = 0.001$ sats s^{-1}.

At $t = 4.0 \times 10^8$ s:

$$f(t) \approx i\,U\,I\,\frac{s}{t\,\mu} = 0.001 \cdot (4.0 \times 10^8) \cdot (3.07 \times 10^{-8}) \cdot \frac{9.68452 \times 10^{13}}{(4.0 \times 10^8) \cdot 0.0001} \approx 2.97 \times 10^{11}\ \text{sats}\,\text{s}^{-1}.$$

$$S(T) \approx 1.2 \times 10^{19}\ \text{sats}, \qquad BXS(T) \approx 4.8 \times 10^{27}\ \text{sats}\,\text{s}.$$

7.2 Example 2: Modest Holder (1.2 BTC)

Parameters: $s = 1.2 \times 10^8$, $U = 3.0 \times 10^7$ s, $I = 2.61 \times 10^{-10}$ s^{-1}, $i = 150$ sats s^{-1}, $\mu = 120$ sats s^{-1}, $r = 2.0 \times 10^9$ s, $CP = 10^6$ sats.

At $t = 3.15 \times 10^7$ s (approx. 1 year):

$$f(t) \approx 150 \cdot (3.0 \times 10^7) \cdot (2.61 \times 10^{-10}) \cdot \frac{1.2 \times 10^8 + (2.0 \times 10^9) \cdot 150 - 10^6}{(3.15 \times 10^7) \cdot 120} \approx 1.6 \times 10^6\ \text{sats}\,\text{s}^{-1}.$$

$$S(T) \approx 5.0 \times 10^{13}\ \text{sats}, \qquad BXS(T) \approx 7.8 \times 10^{20}\ \text{sats}\,\text{s}.$$

7.3 Example 3: Micro Holder (0.001337 BTC)

Parameters: $s = 133{,}700$, $U = 2.0 \times 10^6$ s, $I = 2.61 \times 10^{-10}$ s^{-1}, $i = 0.05$ sats s^{-1}, $\mu = 0.04$ sats s^{-1}, $r = 1.5 \times 10^9$ s, $CP = 500$ sats.

At $t = 2.0 \times 10^6$ s (approx. 23 days):

$$f(t) \approx 0.05 \cdot (2.0 \times 10^6) \cdot (2.61 \times 10^{-10}) \cdot \frac{133{,}700 + (1.5 \times 10^9) \cdot 0.05 - 500}{(2.0 \times 10^6) \cdot 0.04} \approx 3.3 \times 10^2\ \text{sats}\,\text{s}^{-1}.$$

$$S(T) \approx 6.6 \times 10^8\ \text{sats}, \qquad BXS(T) \approx 1.3 \times 10^{15}\ \text{sats}\,\text{s}.$$

Although small in absolute terms, a normalized index (e.g., a discounted BS_ρ) enables cross-scale comparison.

8 Local Implementation and Data Provenance

All blockchain data are sourced from a locally hosted **mempool.space** instance running on a **Start9** node. This ensures sovereign computation of $I(t)$, $\mu(t)$, and $U(t)$ using block timestamps and subsidy schedules in real time.

Benefits.

1. **Sovereignty:** No third-party APIs.
2. **Integrity:** Values reflect chain consensus validated by your node.
3. **Reproducibility:** Any full node can reproduce identical results.

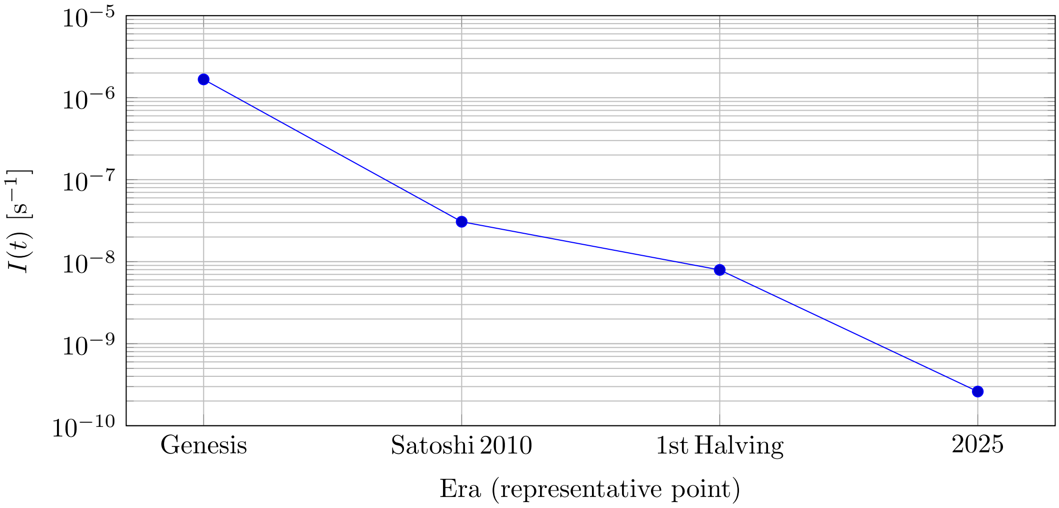
9 Conclusion

Bitcoin-Seconds (BXS) provides a temporal lens for analyzing value persistence in a Bitcoin economy. By defining inflation as a mechanical property of the protocol $\big(I(t) = \sigma(h)/S(t) \cdot \lambda(t)\big)$, the model remains valid across epochs and halvings. It bridges microeconomic income flows and macroeconomic supply dynamics under a unified, time-consistent framework.

In short: $f(t)$ measures economic flow ($\mathrm{sats\,s^{-1}}$), $S(T)$ measures accumulated value (sats), and $BXS(T)$ measures value persistence ($\mathrm{sats\,s}$). As $I(t)$ trends toward zero in the far future, BXS converges to a pure temporal reflection of human productivity.

Addendum A: Inflation Curve Visualization

This figure visualizes the decline of $I(t)$ across representative epochs using the mechanical definition. For clarity, block cadence is set to 600 s and supply snapshots are back-of-envelope values.



Log-scale decline of the instantaneous monetary expansion rate $I(t)$.

Addendum B: Notes for Peer Reviewers

- Please check dimensional consistency of $f(t)$, $S(T)$, and $BXS(T)$.
- Evaluate whether t in the denominator of Eq. (1) warrants smoothing for small horizons.
- Consider alternative normalizations (e.g., discounting, rolling averages) for stability in streaming implementations.
- Confirm that defining $I(t)$ mechanically (via σ, S, λ) is preferable to annualized snapshots for temporal modeling.