Bitcoin-Seconds: A Time-Valued Measure of Real Economic Utility

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1 Bitcoin-Seconds

1.1 Motivation

Traditional macroeconomic measures of "real" value rely on inflation-adjusted fiat units, whose calibration and publication are often politically influenced. In a Bitcoin-denominated economy, the unit of account is immutable, timestamped, and globally verifiable. We propose **Bitcoin-Seconds (BS)**: a continuous, time-based measure of individual or organizational economic efficacy, expressed in the derived unit of Bitcoin-Seconds (BXS), that integrates productive Bitcoin activity, inflation-adjusted consumption, and wealth accumulation over a lifetime horizon.

Bitcoin-Seconds quantifies *economic vitality in time*, echoing the metaphor of the film *In Time* (2011), where lifespan is measured in seconds of purchasing power. Here, the metric expresses how effectively one converts Bitcoin-denominated wealth into sustainable, inflation-resilient utility.

1.2 Definitions and Notation

Let $t \in [0, T]$ denote continuous time, measured in seconds. We define the following measurable functions:

- $A(t)$ — Expected UTXO (coin) age [seconds] (value-weighted mean age of coins held).
- $W(t)$ — Bitcoin stock (wealth) [satoshis].
- $Y(t)$ — Income rate [satoshis per second].
- $R(t)$ — Retirement income rate [satoshis per second].
- $c(t)$ — Consumption (spend) rate [satoshis per second].
- ι_t — Real inflation rate [per second], derived from the Truflation index.

- ρ — Discount rate [per second], modeling time preference.

All functions are assumed bounded, piecewise continuous, and integrable on $[0, T]$. The derived unit of Bitcoin-denominated time-value is the *Bitcoin-Second (BXS)*, defined as 1 BXS = 1 BTC $\times$ 1 s.

Units

BXS	Bitcoin-Second (one BTC sustained for one second)
SXS	Satoshi-Second (one satoshi sustained for one second)
BXS s^{-1}	Rate of Bitcoin-Seconds accumulation (economic vitality rate)

1.3 Instantaneous Utility Function

At any instant t, Bitcoin economic utility is given by

$$u(t) = \alpha A(t)Y(t) + \beta R(t) - \gamma \iota_t c(t), \tag{1}$$

where $\alpha, \beta, \gamma > 0$ are calibration constants controlling the respective contribution of productive coin-age, retirement inflows, and inflation drag. Each term in (1) has units of *Satoshi-Seconds per second (SXS/s)*, which correspond to the instantaneous rate of change of Bitcoin-denominated time-value.

1.4 Discounted Utility and Spending Integrals

Define the discounted total utility:

$$U_\rho(T) = \int_0^T e^{-\rho t} \big[\alpha A(t)Y(t) + \beta R(t) - \gamma \iota_t c(t)\big]\, dt, \tag{2}$$

Both $U_\rho(T)$ and $S_\rho(T)$ preserve dimensional consistency: $[U_\rho(T)] = \text{BXS}$ and $[S_\rho(T)] = \text{BTC}$, so the ratio $BS_\rho(T)$ remains dimensionless.

$$S_\rho(T) = \int_0^T e^{-\rho t} c(t)\, dt. \tag{3}$$

1.5 The Bitcoin-Seconds Index

The Bitcoin-Seconds Index is defined as the ratio of discounted productive utility to discounted expenditure:

$$BS_\rho(T) = \frac{\int_0^T e^{-\rho t} \big[\alpha A(t)Y(t) + \beta R(t) - \gamma \iota_t c(t)\big]\, dt}{\int_0^T e^{-\rho t}\, c(t)\, dt}. \tag{4}$$

This ratio is dimensionless, scale-invariant, and bounded for $\rho > 0$ under finite utility and consumption flows. The limit $BS_\rho(\infty)$ exists whenever both integrals converge.

1.6 Properties

1. **Dimensional Consistency:** All terms have identical units, ensuring BS_ρ is dimensionless.
2. **Scale Invariance:** $BS_\rho(\lambda W, \lambda Y, \lambda R, \lambda c) = BS_\rho(W, Y, R, c)$ for any $\lambda > 0$.
3. **Boundedness:** If A, Y, R, c, ι_t are bounded, and $\rho > 0$, then $BS_\rho(T)$ is bounded for all finite T.
4. **Monotonicity:** $\frac{\partial BS}{\partial A}, \frac{\partial BS}{\partial Y}, \frac{\partial BS}{\partial R} > 0$; $\frac{\partial BS}{\partial \iota}, \frac{\partial BS}{\partial c} < 0$.

1.7 Discrete Implementation

For discrete time steps $k = 1, \ldots, T$, with step size Δt and $\delta = e^{-\rho \Delta t}$:

$$BS_\rho(T) = \frac{\sum_{k=1}^{T} \delta^k [\alpha A_k Y_k + \beta R_k - \gamma \iota_k c_k]}{\sum_{k=1}^{T} \delta^k c_k}. \tag{5}$$

This form is suitable for monthly or daily updates from wallet logs and inflation feeds.

1.8 Unit Definition: The Bitcoin-Second (BXS)

To formalize the dimensional structure of the Bitcoin-Seconds framework, we define the **Bitcoin-Second (BXS)** as a derived economic unit representing one bitcoin of economic utility sustained for one second of real time.

Definition.

$$1 \text{ BXS} = 1 \text{ BTC} \times 1 \text{ s}.$$

Equivalently, in satoshi terms,

$$1 \text{ SXS} = 10^{-8} \text{ BXS},$$

where SXS denotes a *Satoshi-Second*—one satoshi of economic utility sustained for one second.

Interpretation. The Bitcoin-Second is analogous to the joule in classical mechanics, where *energy* is the product of force and distance. Here, *economic time-value* is the product of Bitcoin-denominated utility and the duration of its sustainment. A cumulative total of $U_\rho(T)$ therefore carries units of BXS (or SXS), while the ratio $BS_\rho(T)$ remains dimensionless:

$$[U_\rho(T)] = \text{BXS}, \quad [S_\rho(T)] = \text{BTC}, \quad [BS_\rho(T)] = 1.$$

Derived Quantities. The time derivative $\dot{U}_\rho(t)$ or $\dot{BS}_\rho(t)$ represents an *economic vitality rate* measured in BXS s^{-1}. For example, stating that an entity "generates 0.002 BXS s^{-1}" means that its lifetime store of Bitcoin-Seconds increases by 0.002 every real-world second.

Discussion. The introduction of BXS enables the consistent use of dimensional analysis across Bitcoin-native economic models. It allows higher-order constructs—such as "Bitcoin-Seconds momentum" or "Bitcoin-Seconds density"—to be expressed coherently, and clarifies that the Bitcoin-Seconds Index measures normalized efficiency rather than nominal currency flow.

1.9 Interpretation

The Bitcoin-Seconds index BS_ρ is dimensionless and should be interpreted as an *efficiency ratio* rather than a monetary flow. Values above zero indicate that productive accumulation and long-term income streams outpace the inflation-adjusted cost of consumption, while values below zero signify an erosion of purchasing power in Bitcoin-denominated terms.

Static Meaning. A positive BS_ρ means that, over the measured horizon, each satoshi spent has generated proportionally more *Bitcoin-time utility*—that is, value compounded by coin age and productivity—than it has lost to inflation drag. In this sense, BS_ρ measures *economic vitality* rather than direct earnings.

Dynamic Meaning. When tracked through time, the derivative $\dot{BS}_\rho(t)$ expresses the *instantaneous rate of change* of an entity's Bitcoin-Seconds index. Informally, this may be described as the rate at which an agent is "accruing Bitcoin-Seconds of utility" per real-world second. For example, saying that an entity *generates* 0.002 *Bitcoin-Seconds each second* means that its lifetime Bitcoin-Seconds score increases by 0.002 every second of wall-clock time. It does *not* mean the entity earns 0.002 BTC per second.

Relation to Monetary Flows. Actual Bitcoin throughput—income or expenditure in BTC/s—is captured by the variables $Y(t)$ and $c(t)$. Bitcoin-Seconds instead weight these flows by temporal and inflationary factors to yield a normalized measure of productive time value. In short, "Bitcoin per second" quantifies financial flow, whereas "Bitcoin-Seconds" quantify the *time-weighted effectiveness* of that flow.

Communication. For public or comparative reporting, the index may be expressed either as the dimensionless ratio BS_ρ or as its dynamic counterpart $\dot{BS}_\rho(t)$, with units of "Bitcoin-Seconds accumulated per second of real time." To prevent confusion with monetary rates, explanatory labels such as "time-value rate" or "economic vitality rate" are recommended in external dashboards and datasets.

Formal Definition. All references to "Bitcoin-Seconds" or their rates (BXS, BXS s^{-1}) henceforth follow the formal unit definition in Section 1.

Units

BXS	Bitcoin-Second (one BTC sustained for one second)
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1.10 Data Sources and Calibration

The inflation term ι_t is computed from a transparent, independent source such as the Truflation index:

$$\iota_t = \frac{1}{\Delta t} \ln\left(\frac{\text{Truflation}(t)}{\text{Truflation}(t-\Delta t)}\right). \tag{6}$$

The parameters α, β, γ may be calibrated so that $BS_\rho \in [-1, 1]$ under a chosen baseline.

1.11 Illustrative Example: Satoshi Nakamoto's Holdings

To illustrate the behavior of the Bitcoin-Seconds metric, consider the estimated ˜968,452 BTC attributed to the pseudonymous creator Satoshi Nakamoto. On-chain analysis[1] shows that these coins remain unspent since their creation between January and July 2009.

Let the average coin age be approximately $A(t) \approx 5.0 \times 10^8$ s (about sixteen years) and the holdings $W(t) \approx 9.68452 \times 10^5$ BTC. With no ongoing income or expenditure ($Y(t) \approx R(t) \approx c(t) \approx 0$), the discounted utility integral reduces primarily to the age component:

$$U_\rho(T) \approx \alpha\, A(t)\, W(t) = \alpha\,(5.0\times10^8 \text{ s})(9.68452\times10^5 \text{ BTC}) \approx 4.84\times10^{14}\,\alpha \text{ BXS}.$$

This magnitude represents the accumulated "Bitcoin-Seconds" of dormant economic potential embodied in Satoshi's original holdings.

If these coins were ever moved, their instantaneous $\dot{U}_\rho(t)$ would spike dramatically, converting a vast reservoir of stored time-value into active network utility. Conversely, their continued immobility exemplifies how BXS grows naturally with time, even in the absence of transactions, reflecting Bitcoin's intrinsic temporal dimension of value.

1.12 Conclusion

Bitcoin-Seconds (BXS) provides a unified temporal framework to quantify economic vitality within a Bitcoin-denominated economy. By weighting Bitcoin

[1] See https://charts.bitbo.io/satoshi-net-worth/

activity through time, coin age, income flows, and inflation-adjusted consumption, the metric captures a dynamic notion of *economic efficacy* that conventional fiat-based measures cannot.

The dimensional consistency of BXS—expressed as $\mathrm{BTC} \times \mathrm{s}$—anchors the measure in physical intuition while maintaining scale invariance across denominations. The resulting index BS_ρ offers a bounded, parameterized lens through which to compare productivity across individuals, organizations, or even national Bitcoin economies, without reliance on fiat exchange rates or political inflation indices.

Beyond its theoretical coherence, the Bitcoin-Seconds model has several practical implications:

- **Measurement of Temporal Utility:** BXS introduces a direct analog to "energy" in economics—quantifying the capacity of Bitcoin-denominated capital to perform productive work over time.
- **Transparency and Reproducibility:** Because $A(t)$, $Y(t)$, $c(t)$, and ι_t can be derived from on-chain data and transparent indices such as Truflation, the metric is empirically verifiable and open to peer replication.
- **Cross-Disciplinary Extensions:** The BXS unit enables a coherent dimensional system for emerging *Bitcoin-econometrics*. Future research may define secondary constructs such as Bitcoin-Seconds momentum, Bitcoin-Seconds density, or time-value fields that mirror energy conservation and entropy principles.
- **Policy and Risk Analysis:** Institutions or nodes may use $BS_\rho(T)$ to evaluate the efficiency of long-term holdings, miner strategies, or treasury operations under different inflation environments. As a normalized indicator, it could inform macroeconomic models for Bitcoin-standard economies.

Conceptually, BXS reinterprets *time* as a conserved dimension of economic life. Where fiat systems measure wealth in depreciating units, Bitcoin-Seconds measure *duration-weighted value* in incorruptible time. This framing positions BXS as both a scientific and philosophical tool: a step toward a time-based economics rooted in verifiable data and self-sovereign measurement.

In future work, we intend to test the sensitivity of BS_ρ across multi-decade simulations, calibrate α, β, γ under empirical data, and explore the predictive validity of BXS for assessing individual and network-level economic health. Ultimately, the Bitcoin-Seconds paradigm seeks to replace inflation-prone monetary abstractions with a *temporal metric of truth*—one that treats time not as a cost, but as the fundamental unit of economic value.