Cointime Economics

A New Framework For Bitcoin
On-Chain Analysis

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In 2022 and 2023, ARK Invest and Glassnode collaborated to develop a new economics framework for analyzing Bitcoin on-chain metrics—Cointime Economics. Our work together now offers two companion pieces: this white paper, which is written for a broad investor audience, and a [second version found at Glassnode's website](#), written for on-chain specialists.

Please note that the information presented in this paper represents a new concept that has not been widely used or adopted at the time of publication and should not be relied upon as a basis for any investment decision.

Cointime: A New On-Chain Framework and Unit of Measurement[1]

We are presenting Cointime Economics as a new way of modeling the dynamics of bitcoin's supply and demand based on a fungible unit of measurement of Bitcoin's economy—*coinblocks*. In addition to the traditional Unspent Transaction Output (UTXO)[2] models, we believe this framework captures the real economic weight of each bitcoin in the network and provides a suite of metrics to assess Bitcoin's fundamentals more accurately.

In this piece, we introduce "coinblocks" as the base unit of measurement in the Bitcoin economy and provide Cointime Economics as a framework complementary to the traditional, UTXO-based framework of on-chain analysis.

Based on this framework, we will provide:

1. A representation of Bitcoin's economic state.
2. Improvements to traditional Bitcoin valuation metrics.
3. A new set of on-chain analytics to measure Bitcoin's activity.

We also will provide three case studies illustrating the potential benefits of Cointime Economics:

1. A more precise version of the market-value-to-realized-value (MVRV) ratio, one of the most widely used on-chain metrics today.
2. A more accurate measurement of bitcoin's inflation rate over time.
3. Bitcoin's volume- and time-weighted cost basis.

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1   *On-chain analysis is a research field that leverages information found on public blockchains to inform investors about the economic state of a given cryptocurrency. On-chain data usually include information regarding all transactions that occur on a certain public blockchain network. For example, transaction details such as: sending and receiving addresses, transferred tokens or currencies, transaction amount, transaction time and date, transaction fees, and the remaining funds for a certain address.*
2   *UTXO is Bitcoin's accounting system at the protocol level. It indicates the amount of bitcoin remaining in each address after any given transaction. The UTXO system accounts only for number of coins as unit of account.*

Cointime Economics

Conceptually, Cointime Economics posits that the importance of a single bitcoin should vary based on the last time it moved. Upon its transfer, for example, the information value of a bitcoin that had been unmoved for 10 years is more important than one that had been unmoved for 1 week.[3] In addition, in this model of the Bitcoin economy, a lost bitcoin no longer counts as part of the outstanding supply or market cost basis.

While traditional UTXO-based solutions have attempted to make supply adjustments using industry-standard heuristics (such as adjusted supply and free-float supply), the adjustments have followed analyst-made decisions that may be prone to inaccuracies. In contrast, we believe the Cointime framework provides a highly consistent, mathematical framework measuring the economic importance of each bitcoin through time with a fungible unit of measurement that seems to better represent the economic state of the network—*coinblock*.

Coinblocks are the product of the number of bitcoin and the number of blocks[4] produced during the period in which those bitcoin remained unmoved. For example, 10 coins held during the time necessary to produce 10 blocks represents 100 coinblocks.
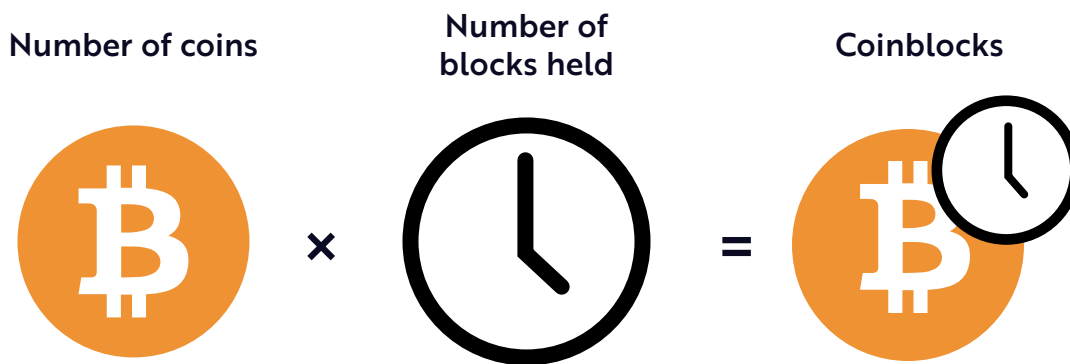
Number of coins × **Number of blocks held** = **Coinblocks**

Sources: ARK Investment Management LLC & Glassnode, 2023.

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Coinblocks can be expressed in alternative units by multiplying the number of bitcoin by the period during which they remain unmoved. For example, the commonly used "coindays" are the product of the number of bitcoin and the number of days they remain unmoved. Cointime can be

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3   *In our view, coins held for a prolonged period of time suggest ownership by the market cohort with the longest time investment horizon and the most profitable cost basis. They therefore display the market behavior of the largest capitalized and historically most savvy market participants in Bitcoin's history.*

4   *Blocks are data structures containing the transaction data in a shared cryptocurrency protocol. When blocks are added linearly, they are called a "blockchain." In the Bitcoin network, each block production is targeted to last 10 minutes.*

expressed in dollar terms—such as "dollardays"—by multiplying the number of bitcoin valued in USD by the number of days they remain unmoved.

Instead of using bitcoin's outstanding supply to characterize Bitcoin's economy, cointime uses coinblocks.

Coinblocks Created

Each unit of bitcoin's circulating supply generates one coinblock. "Coinblocks created" (CBC) represents the total cointime created in the Bitcoin network, independent of coin movement.

For example, if 4 coins are in circulation over a period of 4 blocks, they would create 16 coinblocks, as shown below.

	b=1	b=2	b=3	b=4
₿				
₿				
₿				
₿				

■ = Coinblocks created

Sources: ARK Investment Management LLC & Glassnode, 2023.

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Because the Bitcoin network produces a block every 10 minutes on average, one coin generates approximately 144 coinblocks per day: 6 blocks produced per hour multiplied by 24 hours.

The sum of all coinblocks created is the maximum cointime in the network, including the last coin minted and block produced. On block 788,709 during May 7, 2023, the network created 2.7 billion coinblocks, as shown below.

Bitcoin Coinblocks Created

— Price (USD)   — Coinblocks Created (7-Day Median)

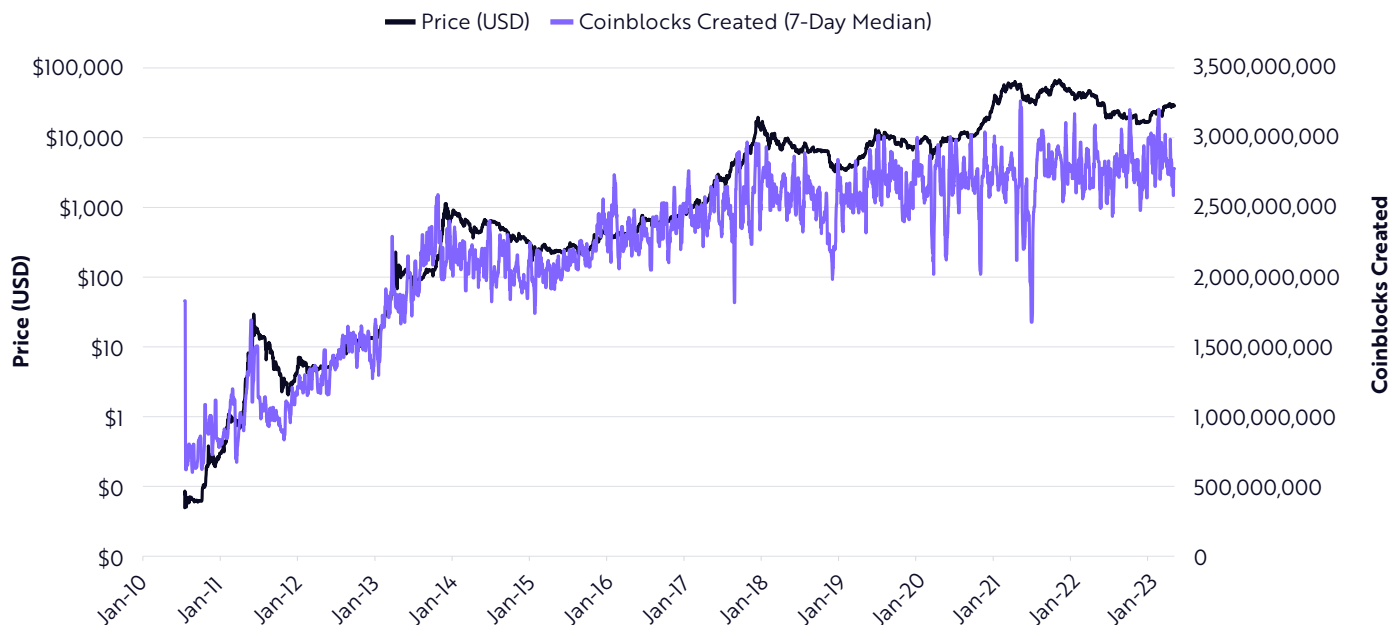*Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.*

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Coinblocks Destroyed

"Coinblocks destroyed" (CBD), more commonly presented as "coindays destroyed" (CDD), measures the time-weighted turnover of bitcoin: volume, or the number of bitcoin moved in a given period, and holding period, or the time held before moving. If two bitcoins had not moved in seven blocks and then transacted, for example, 14 coinblocks would have been destroyed. An increase in the number of coinblocks destroyed implies the movement of coins that had been static for a long time.

Whenever a coin is moved, it "destroys" all accumulated coinblocks up to that point in time, resetting its cointime back to zero. Coinblocks destroyed bases the economic weight of each coin on the time it last moved. In contrast, the UTXO model assigns the same weight to each coin, regardless of when it last moved.

In the example below, out of 16 coinblocks created, 6 coinblocks were destroyed.

	b=1	b=2	b=3	b=4
₿			Moved	
₿		Moved		
₿				
₿	Moved			

■ = Coinblocks destroyed

Sources: ARK Investment Management LLC & Glassnode, 2023.

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Heavy coinblock destruction suggests that long-term holders are selling. Bitcoin's "smart money"[5] typically hold larger bitcoin balances and trade from lower cost bases, generating higher profits. As a result, smart money trades tend to have a more profound economic impact than less seasoned trades. In other words, major spikes in coinblocks destroyed have had a high correlation with a peak in bitcoin's price, as shown below. On May 7, 2023, 739 million coinblocks were destroyed.

5   In this context, "smart money" refers colloquially to the cohort of market investors or traders who in aggregate tend to have a longer time horizon and higher profits relative to their cost bases.

Bitcoin Coinblocks Destroyed

— Price (USD)   — Coinblocks Destroyed (7-Day Median)

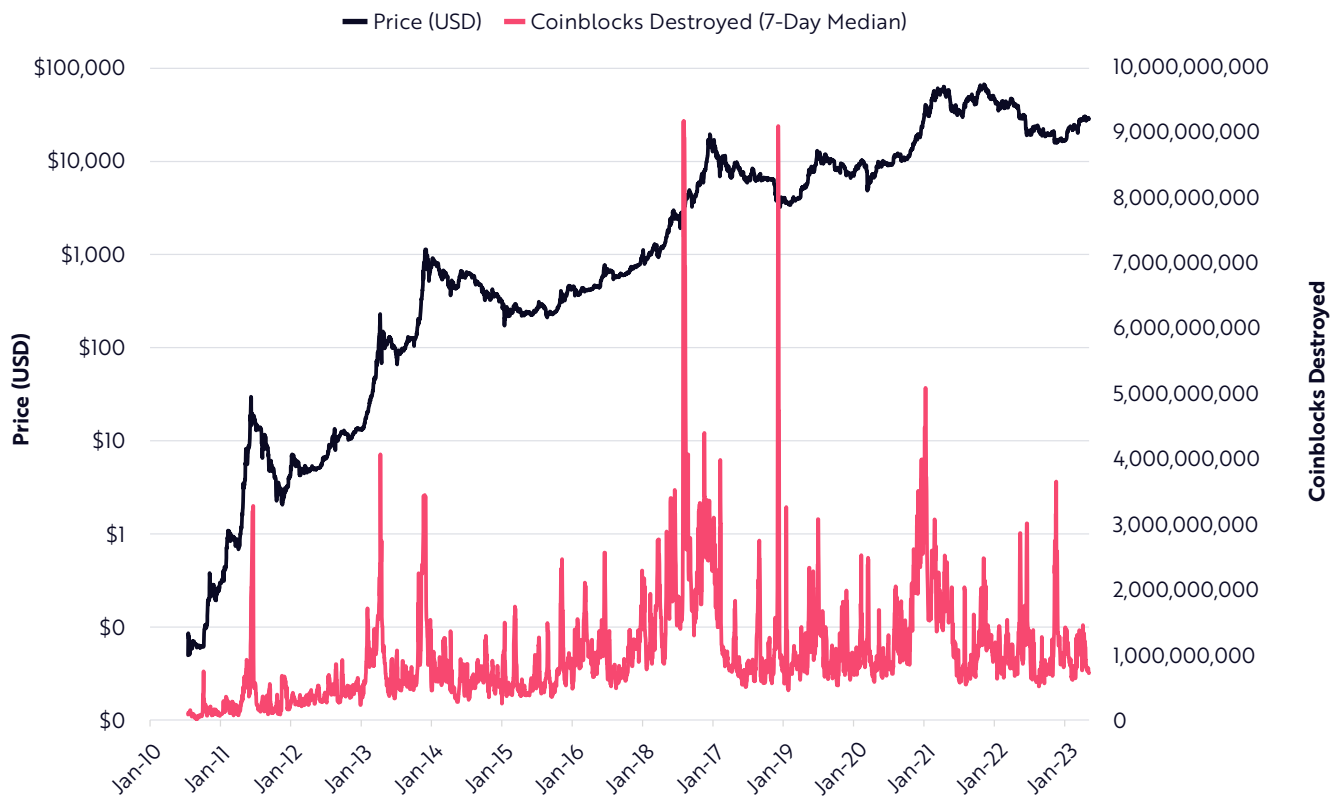Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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Coinblocks Stored

"Coinblocks stored" (CBS) represents the total number of coinblocks that have not been destroyed, or the difference between total coinblocks created and total coinblocks destroyed. The economic value of these coins is high because they belong to bitcoin's early adopters and typically are held at a profit.

When 6 out of a total of 16 coinblocks created are destroyed, as shown below, 10 coinblocks remain stored:

	b=1	b=2	b=3	b=4
₿			Moved	
₿		Moved		
₿				
₿	Moved			

= Coinblocks stored

Sources: ARK Investment Management LLC & Glassnode, 2023.

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On May 7, 2023, 1.9 billion coinblocks remained stored in the Bitcoin network, the daily values of which are shown through time in the chart below. When negative, in this case over a period of seven days, the number of coinblocks destroyed has surpassed the number created, suggesting the movement of a substantial number of old coins in a short period of time.
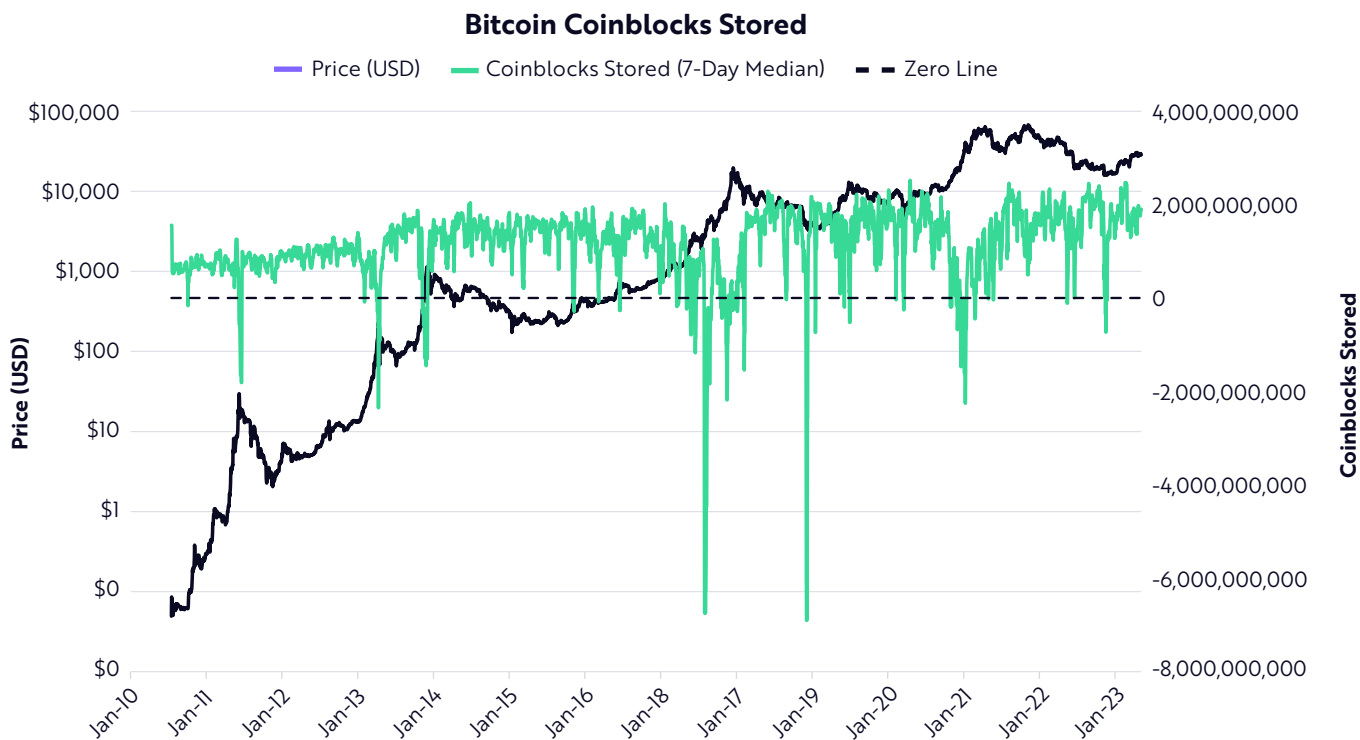
Bitcoin Coinblocks Stored

— Price (USD) — Coinblocks Stored (7-Day Median) - - Zero Line

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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The Big Picture

Putting the puzzle together, the following graphs illustrate that the 16 coinblocks created—on the left—equal 6 coinblocks destroyed plus 10 coinblocks stored—on the right.

From a long-term perspective, the chart below depicts each of the cointime economic building blocks over time. Interestingly, in 2017, coinblocks destroyed began to diverge from those stored, as the total quantity of coinblocks destroyed surpassed that of coinblocks stored. In other words, more coins were active in the market as opposed to lost or strongly dormant.

Bitcoin Total Coinblocks Created, Destroyed, and Stored
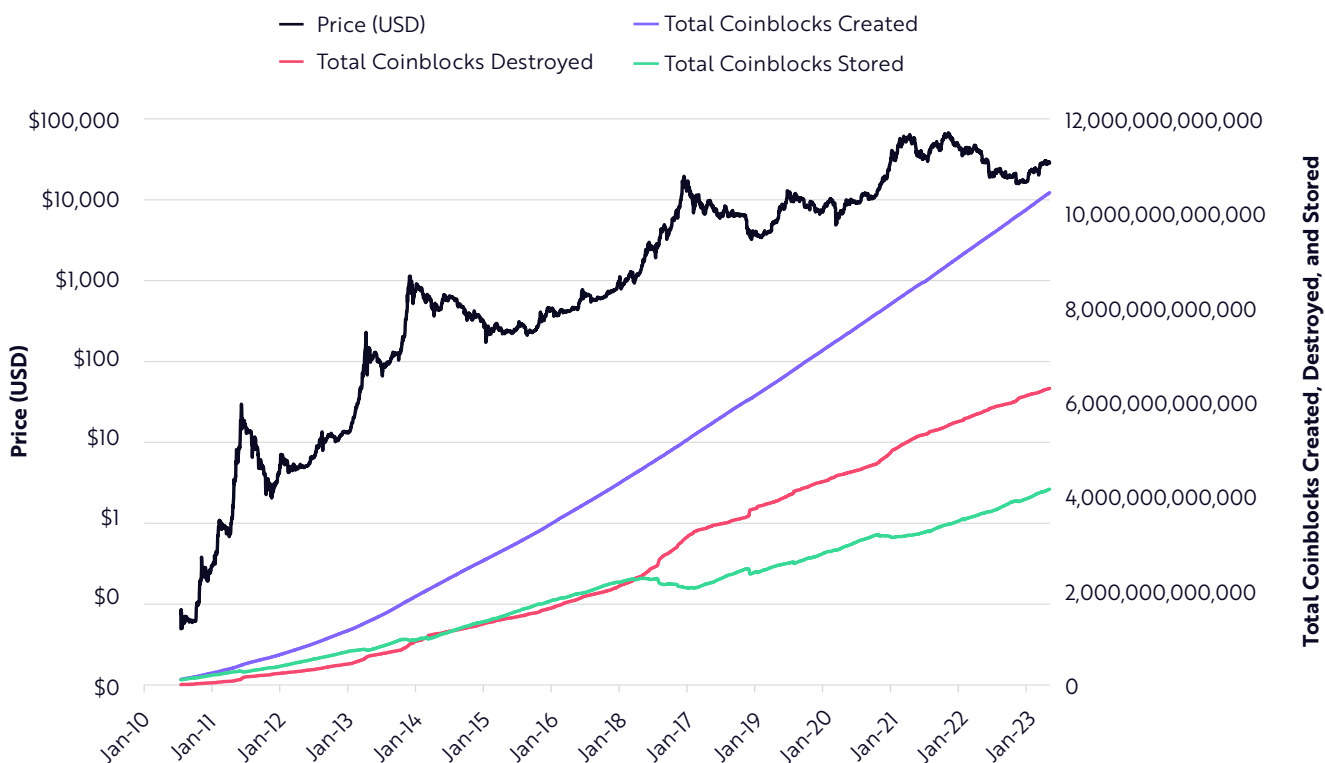
Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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To recap, each cointime building block has a corollary in the UTXO system:

UTXO-Based	Total Outstanding Supply	Moved Supply	Unmoved Supply
Cointime-Based	Coinblocks Created	Coinblocks Destroyed	Coinblocks Stored

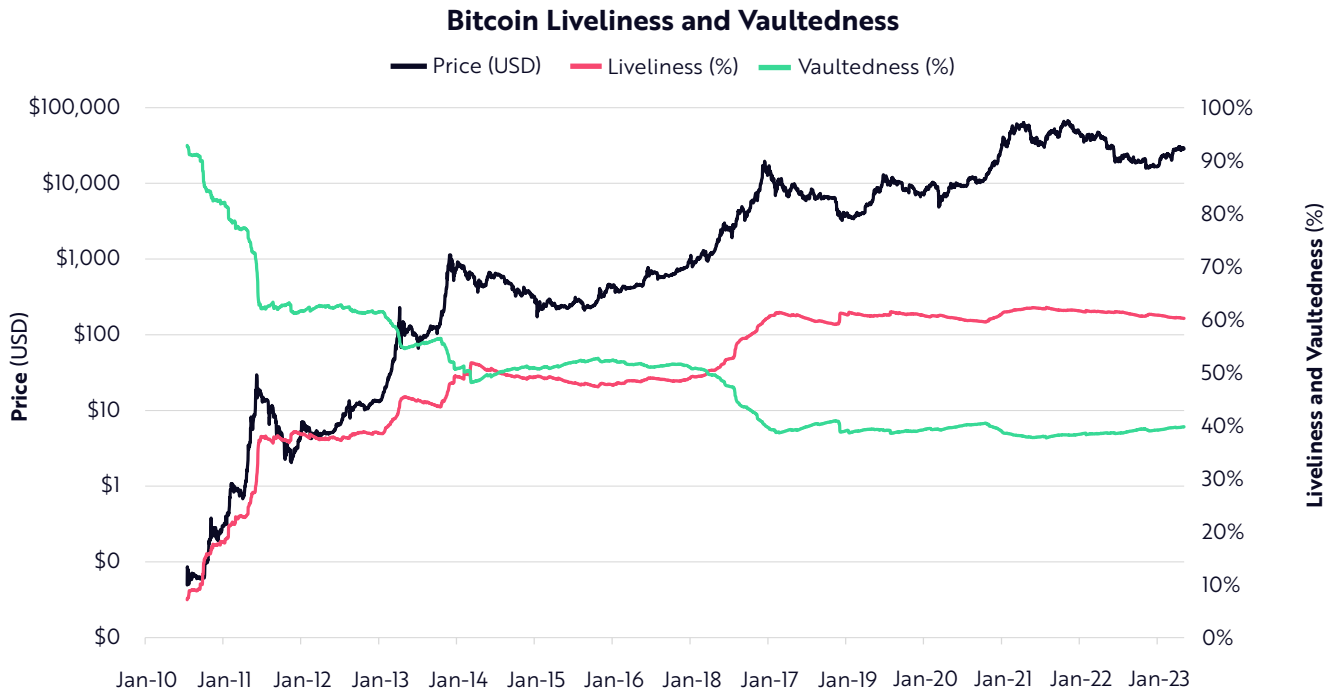That said, the UTXO system differs from the cointime system in the following ways:

	UTXO-Based System	**Cointime-Based System**
Unit of Measurement	Coins (or UTXOs)	Coinblocks (coin volume times blocks held)
Unit Fungibility	Non-fungible: coins have unequal economic weight	Fungible: coinblocks have equal economic weight
Complexity and Calculation Cost	Complex, engineering-intensive heuristics: entity adjustments, free-float supply, among others	Few inputs and heuristics provide a robust economic picture of Bitcoin
Popular Examples	Realized cap, SOPR [6], realized profits and losses	Coindays destroyed, liveliness

Using Cointime to Measure Bitcoin's Economic State

Based on cointime's building blocks, two metrics characterize Bitcoin's economic state—liveliness and vaultedness, as shown below.

- **Liveliness:** created by Tamás Blummer in 2018, it divides the total number of coinblocks destroyed by the total number ever created. From 0 to 1, liveliness measures how "active" or "alive" the network is. Coinblock "destruction" captures the activity—the "life"—among the bitcoin in the Bitcoin network. As of May 7, 2023, liveliness equals 0.6, meaning that 60% of all coinblocks created have been destroyed.
- **Vaultedness:** divides the total number of coinblocks stored by the total number created. From 0 to 1, vaultedness measures how "inactive" or "vaulted" the network is. As of May 7, 2023, vaultedness equals 0.4, meaning that 40% of all coinblocks created remain stored. Vaultedness always equals 1 minus liveliness.

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6   *"Spent output profit ratio" (SOPR) is computed by dividing the realized value (in USD) by the value at creation (USD) of a spent output: the ratio of the price sold and the price paid.*

Bitcoin Liveliness and Vaultedness

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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These ratios capture Bitcoin's economic "energy." Liveliness is the amount of energy released through time (kinetic energy), while vaultedness is the amount unreleased (potential energy).

Taken to their hypothetical extremes, if liveliness were to increase to 1, then all coins in the network would have moved in the last block, leaving no holders. Conversely, if vaultedness were 1, then no miner ever would have sold bitcoin.

Using Cointime to Measure Supply Activity

We apply liveliness and vaultedness ratios to the supply of bitcoin to measure active supply and vaulted supply, respectively, as shown in the chart below.

- **Active Supply:** multiplies outstanding supply times liveliness to measure the number of coins that have moved in the network at a point in time. As of May 7, 2023, active supply is 11.6 million, or 60% of the 19.3 million in bitcoin outstanding.
- **Vaulted Supply:** also known as "HODLed or lost coins," multiplies outstanding supply times vaultedness to measure the number of coins that have not been moved. Either they are in strong hands, or they are lost. As of May 7, 2023, vaulted supply is 7.7 million, or 40% of the 19.3 million in bitcoin outstanding.
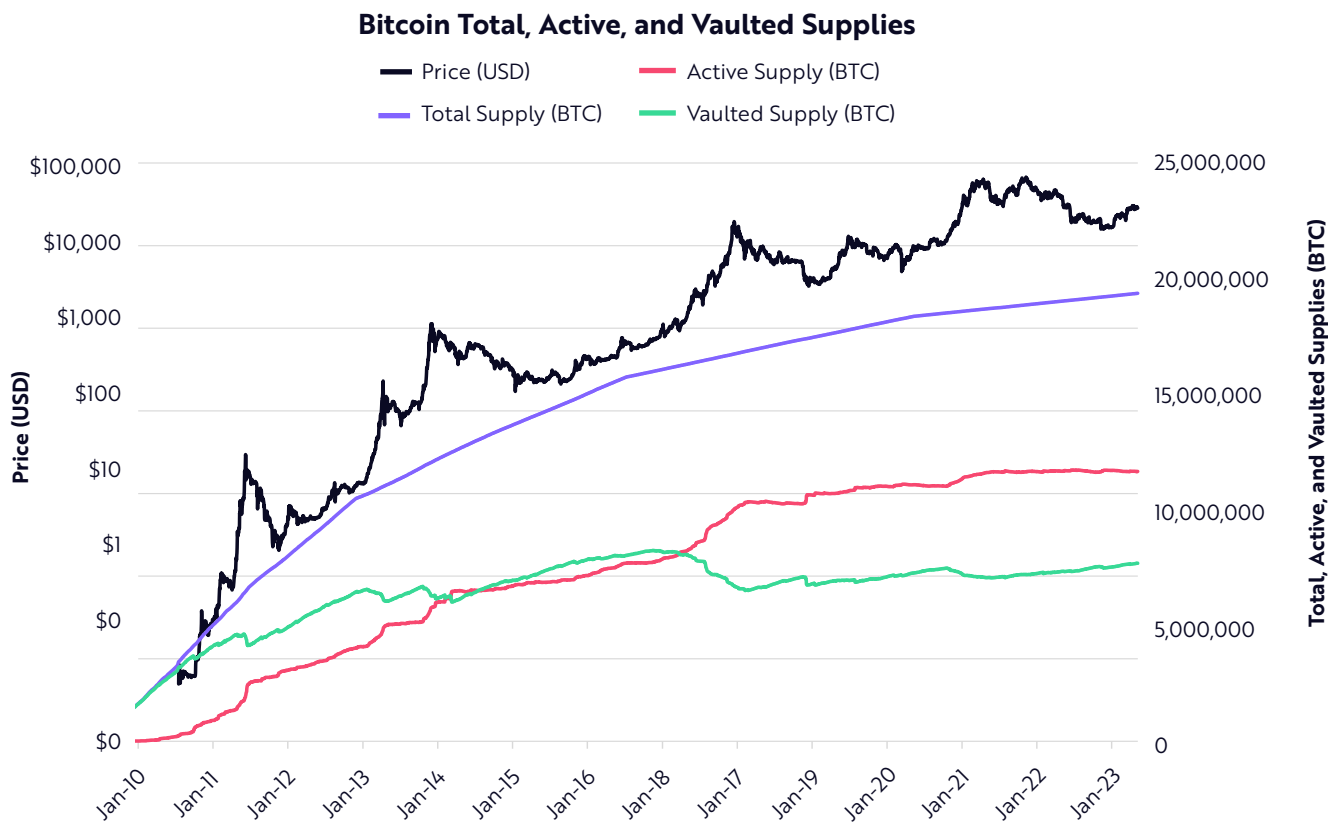
Bitcoin Total, Active, and Vaulted Supplies

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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Unlike the UTXO framework, which deems a coin as "moved" as it leaves its coinbase address[7], the cointime framework weights each coin by the time in which it has been static. In other words, if old coins move, they will have a larger impact on bitcoin's economic activity.

For example, in the UTXO framework, if a miner received a block reward coin and then moved it only one time ten years ago, the coin still is active. In the cointime framework, that same coin would be mostly inactive, weighted by ten coinyears of economic storage and cumulative economic energy.

Importantly, the UTXO framework and Cointime Economics have completely different concepts of inactive coins. In UTXO terms, inactive equals miner unspent supply; in Cointime Economics, inactive equals vaulted supply. In the real world of Bitcoin Economics, these differences can be significant. In the chart below, vaulted supply is 4.3x miner unspent supply. We believe vaulted supply is a better representation of inactive coins.

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7   *Bitcoin address corresponding to a miner's coinbase transaction, which is the first transaction in each block. It distributes the block reward and fees given to the miner for verifying that block successfully.*

Bitcoin Vaulted Supply vs. Miner Unspent Supply
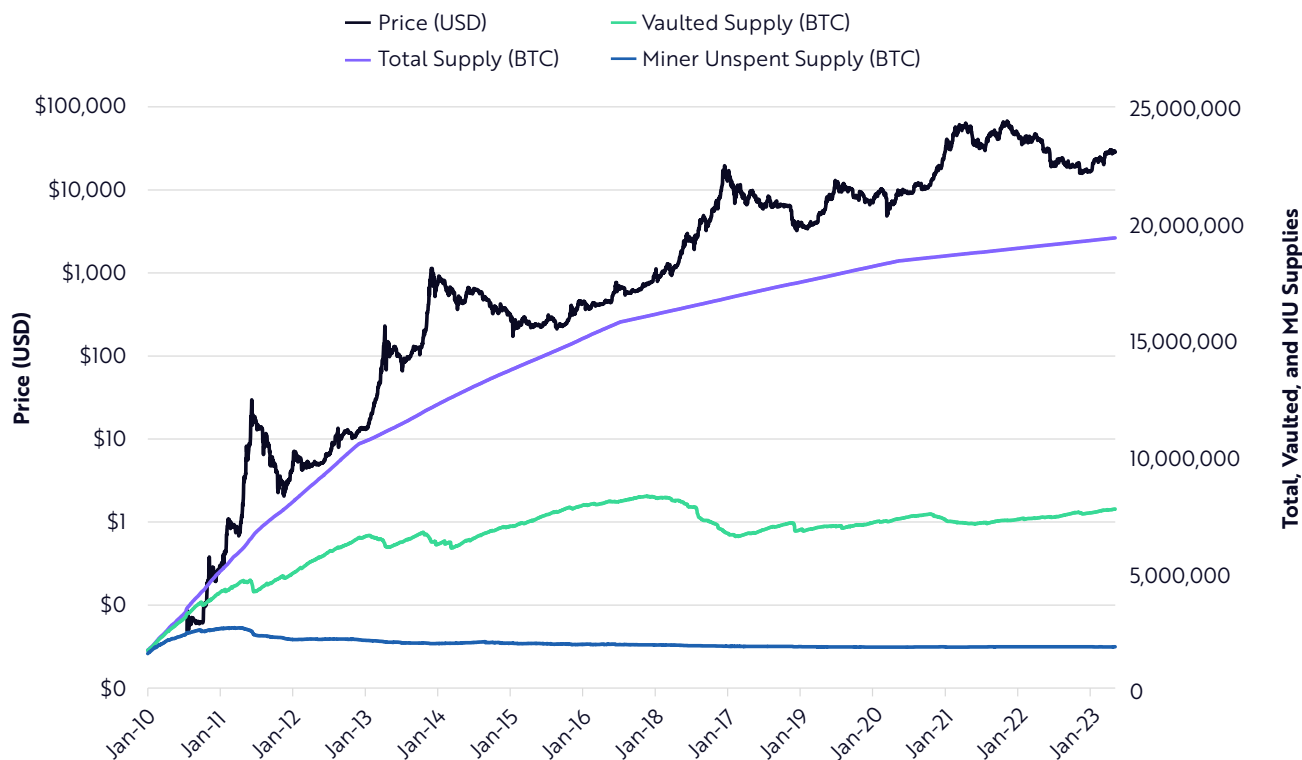
— Price (USD)   — Vaulted Supply (BTC)
— Total Supply (BTC)   — Miner Unspent Supply (BTC)

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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Now, we will highlight three value propositions of Cointime Economics in the form of three case studies:

1. Enhancing UTXO-based valuation models such as MVRV.
2. Enhancing classic UTXO-based economic models such as inflation rate.
3. Enabling the creation of cointime-based models.

Cointime Economics Case Study #1
Active-Value-to-Investor-Value (AVIV) Ratio: Enhancing MVRV

The first example enhances one of the most popular UTXO-based valuation models, the MVRV ratio (or market-value-to-realized-value ratio). The ratio of market cap to realized cap[8], MVRV attempts to capture long-term over- or under-valuation. While MVRV is useful, its quantitative signal has diminished over time, as shown by the dashed lines below.

8   *As opposed to market capitalization, which counts each coin at current market price (supply times price), realized capitalization counts each coin at the time it was last moved (and therefore bought).*
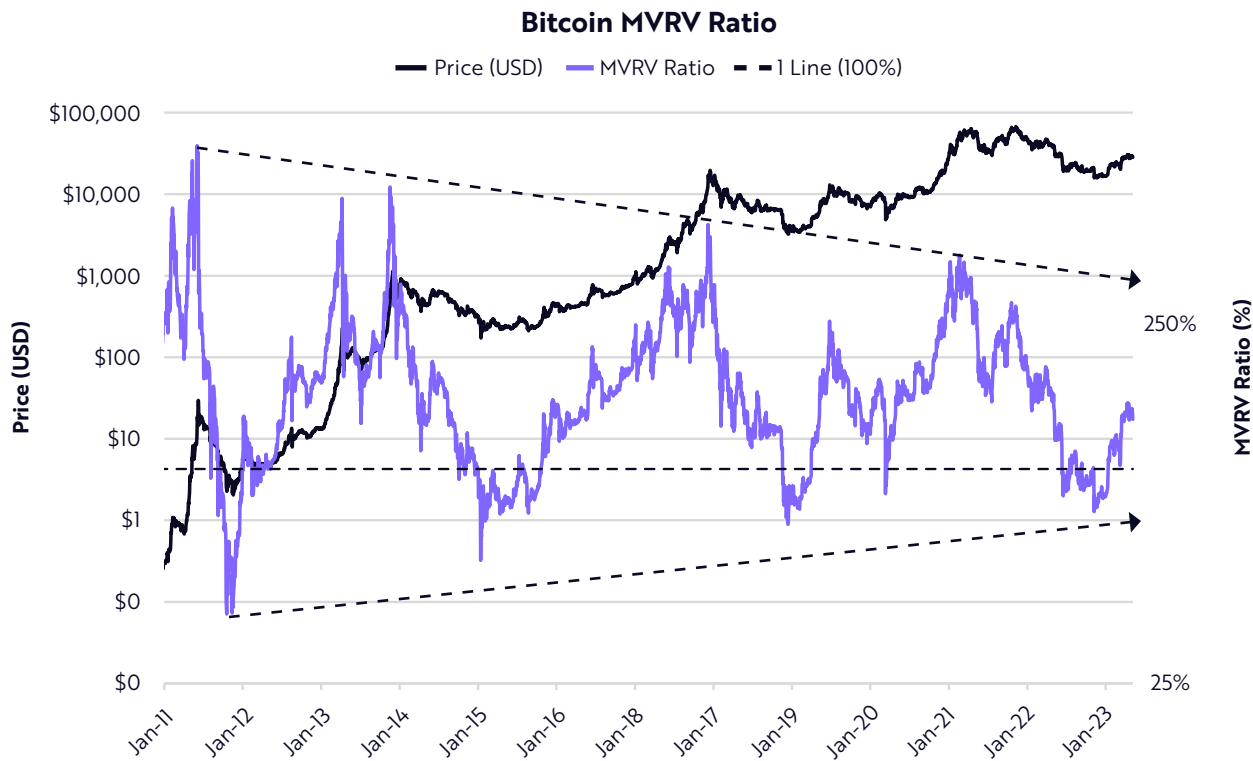
Bitcoin MVRV Ratio

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.
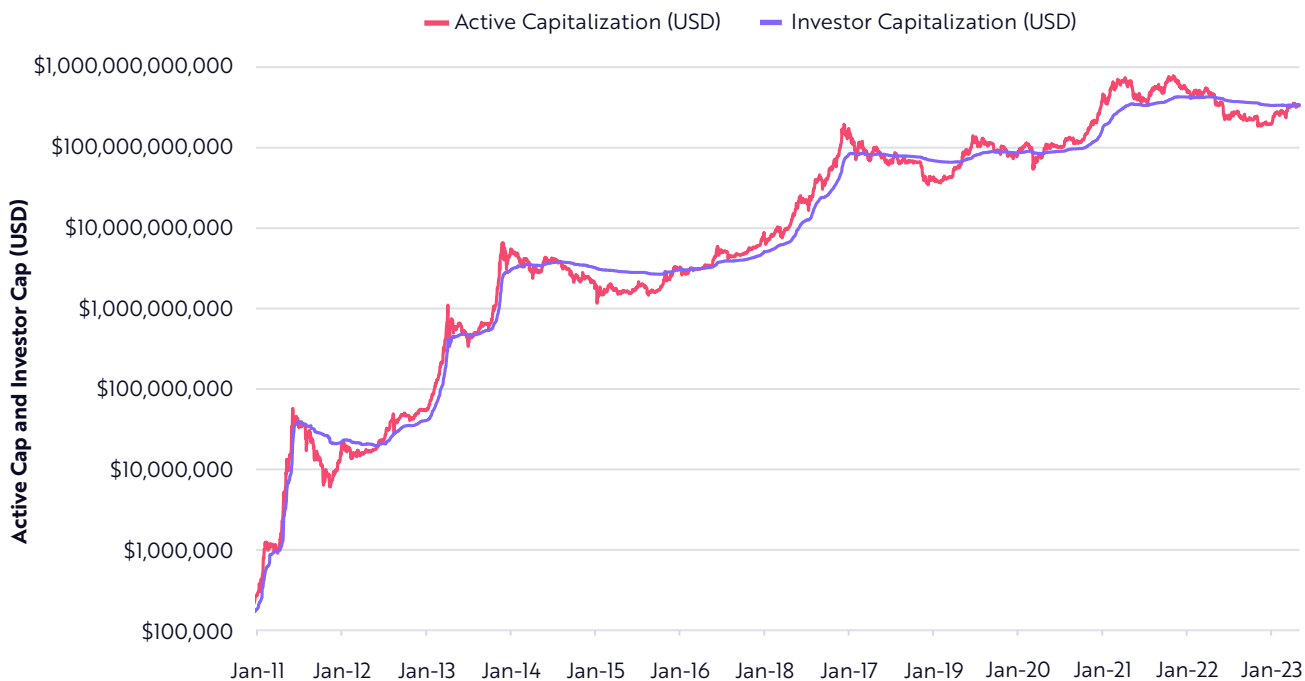
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Introducing cointime to the calculation, without the use of regressions or z-scores,[9] may improve the signal for over- and under-valuation. Active Capitalization weights the numerator—market cap—by liveliness, filtering out unmoved coins and isolating the USD value of active coins in the network. To measure Investor Capitalization, we subtract *thermo cap*—the cumulative USD value earned by miners over time—from *realized cap* to remove these transactions from the overall cost basis of the market and measure the cost basis for all active investors. ARK Invest developed this metric in 2021. As of May 7, 2023, Investor Capitalization is only 2.8% above Active Capitalization, denoting that the latter has returned to what seems its historical mean, as shown in the chart below.

9   *In statistics, regressions measure the relation of the mean value of one variable and the values of a reference population; z-scores measure the standard deviations from the mean value of a variable from a reference population. Regressions and z-scores typically are used in on-chain analysis for adjusting a metric for volatility over a time horizon.*

Bitcoin Active Capitalization and Investor Capitalization

— Active Capitalization (USD) — Investor Capitalization (USD)
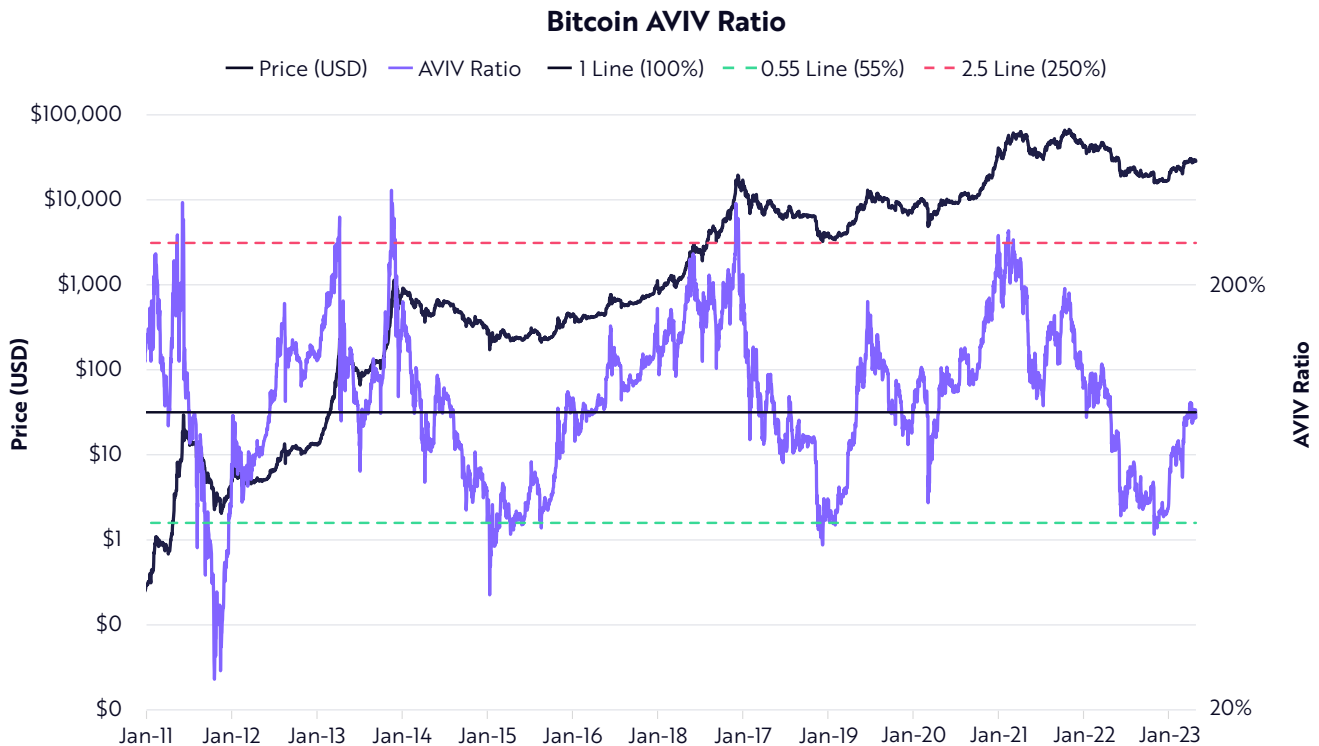

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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Dividing Active Cap (active-value, or AV) by Investor Cap (investor-value, or IV) results in the AVIV Ratio.

$$\text{AVIVRatio} = \frac{\text{MarketCap}_{\text{USD}} \cdot \text{Liveliness}}{\text{RealizedCap}_{\text{USD}} - \text{ThermoCap}_{\text{USD}}} = \frac{\text{ActiveCap}_{\text{USD}}}{\text{InvestorCap}_{\text{USD}}}$$

Active Cap can deviate from Investor Cap, as shown below:

17

Bitcoin AVIV Ratio

— Price (USD) — AVIV Ratio — 1 Line (100%) – – 0.55 Line (55%) – – 2.5 Line (250%)

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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Compared to MVRV, AVIV Ratio seems to assess bitcoin's over- or under-valuation more accurately; when the ratio stands at 1, the oscillator seems to be at its mean, the market at its "middle point," perhaps because AVIV measures actual transactions, as it does not incorporate lost or dormant coins, or coinbase transactions. According to our research, an AVIV above 2.5 (250%) suggests that bitcoin is overbought; an AVIV below 0.55 (55%) suggests oversold.

Cointime Economics Case Study #2

*Cointime-Adjusted Inflation Rate: Is Bitcoin's Inflation Underestimated?*

Cointime also can enhance the measurement of bitcoin's inflation rate. Typically, the inflation rate is calculated by dividing annualized issuance by total outstanding supply. The formula below incorporates cointime, weighting inflation by the ratio of active supply to vaulted supply.

$$\text{InflationRate}_{\text{CointimeAdj.}} = \left(\frac{\text{Issuance}_{\text{BTC, Annualized}}}{\text{TotalSupply}_{\text{BTC}}} \right) \cdot \left(\frac{\text{ActiveSupply}_{\text{BTC}}}{\text{VaultedSupply}_{\text{BTC}}} \right)$$

Inflation here is weighted by the ratio of active supply and vaulted supply, giving a sense, when compared to nominal inflation, if this measurement is under- or over-estimated at any time.

In the chart below, we can appreciate how active supply became larger than vaulted supply during the period between 2013 and 2017, making a major impact on bitcoin's economic state.
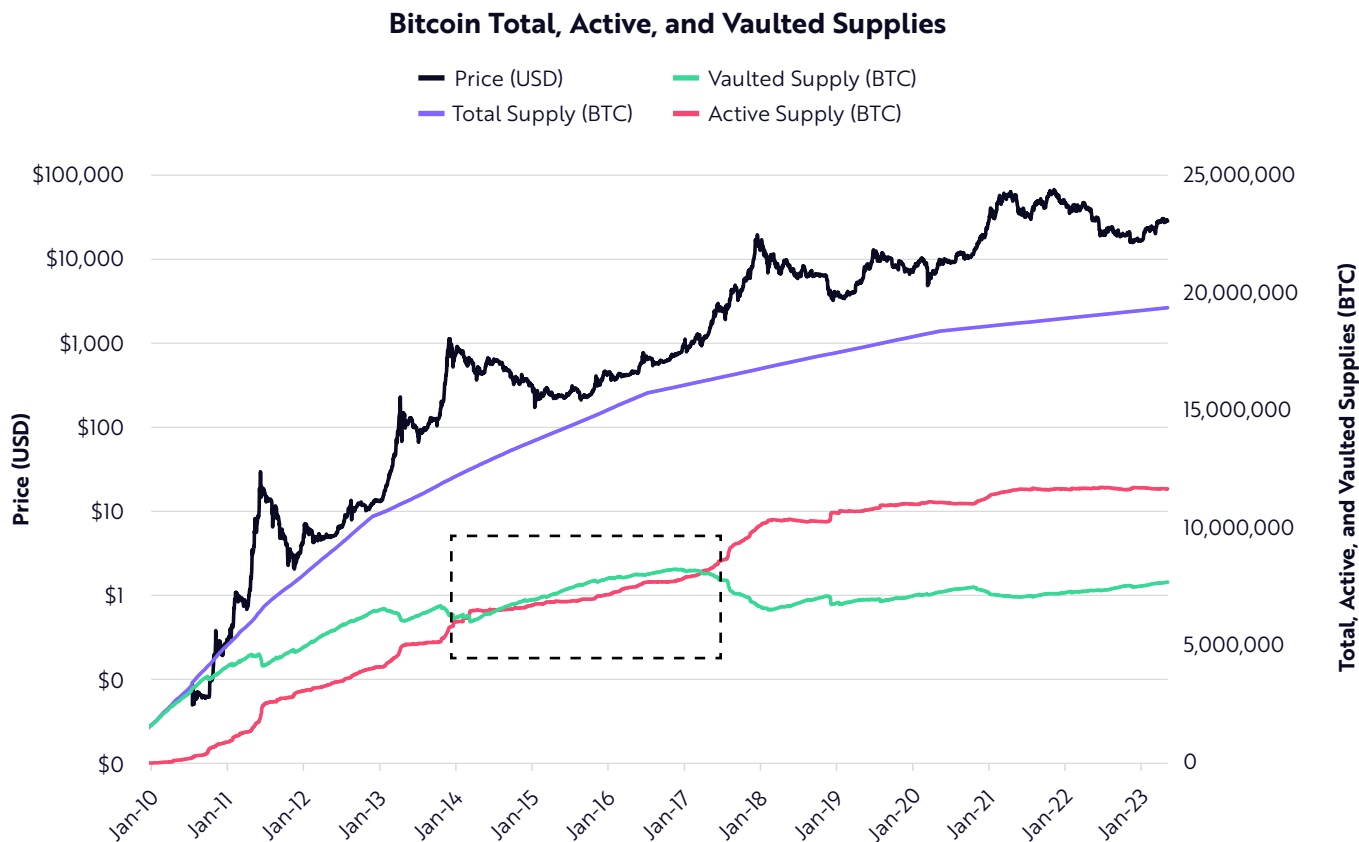
Bitcoin Total, Active, and Vaulted Supplies

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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By multiplying (normalizing) nominal inflation rate by the ratio of active and vaulted supplies, we believe we can better measure the true inflation of the Bitcoin network. As of May 7, 2023, nominal inflation stands at approximately 1.64%, compared to the cointime-adjusted inflation rate of 2.48%.
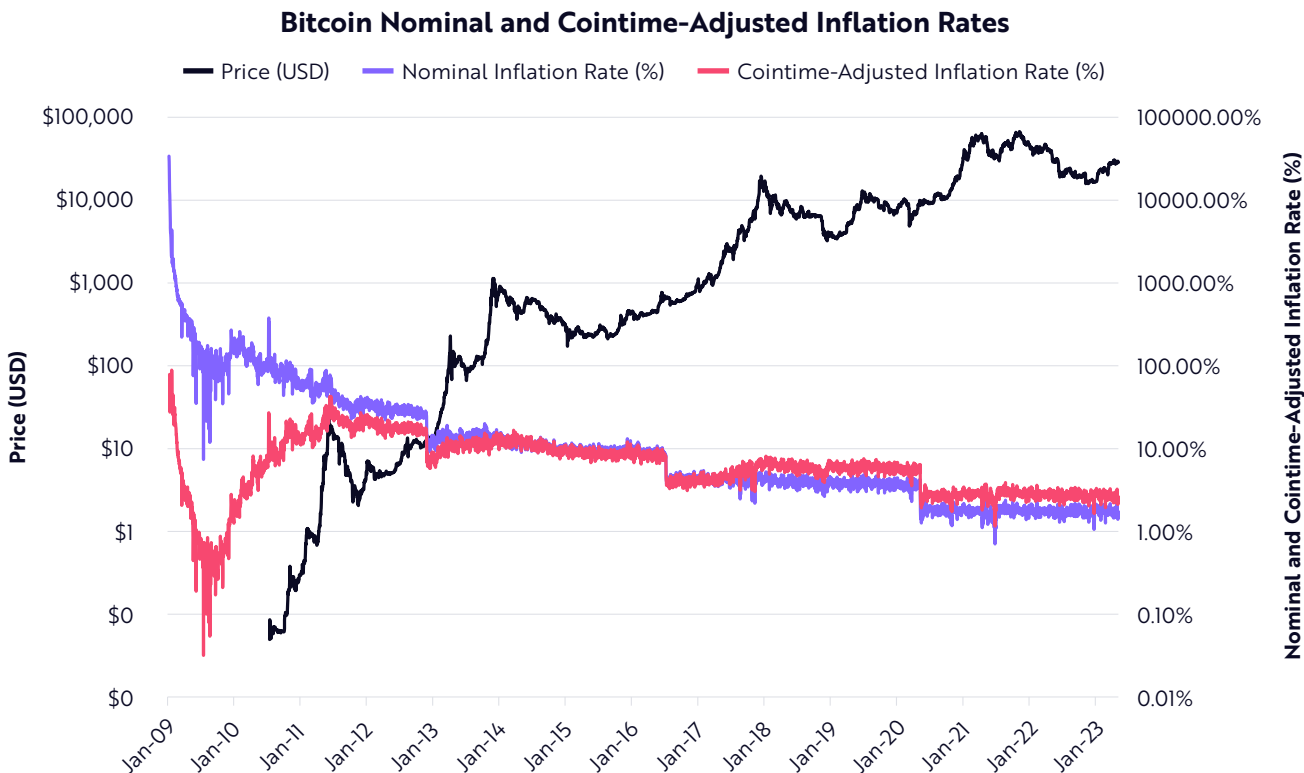
Bitcoin Nominal and Cointime-Adjusted Inflation Rates

Clearly seen in the early history of Bitcoin, between 2009 and 2011, when Satoshi[10] and early miners owned and vaulted most of bitcoin's supply, the cointime-adjusted inflation rate was much lower than the inflation rate as traditionally measured. Since most of the issuance remained vaulted proportionally as percentage of total supply, cointime-adjusted inflation was as little as 1/200th nominal inflation. Put another way, because the flow immediately became the stock[11] on a nearly 1:1 basis, the effective inflation rate was much lower than the network's nominal inflation rate.

Conversely, from 2013 to 2017, cointime inflation reached parity with nominal inflation, then has surpassed it as of the day of this publication. This shows how, since 2017, active supply became greater than vaulted supply, making the impact of new issuance on the market larger than previous nominal calculation recognized.

10   *Satoshi Nakamoto, creator of the Bitcoin network and bitcoin's first miner. Also known as the "Patoshi" entity.*
11   *In this context, "stock" refers to the economic concept of stock-to-flow, the ratio of the current stock, quantity, or supply of a given commodity and the flow of new issuance or production of that commodity. A high stock-to-flow ratio usually suggests scarcity of circulation.*

By adjusting via cointime, this metric suggests that inflation was severely overestimated in the early years of bitcoin—aligning with powerful price appreciation at the time—and moderately underestimated today—consistent with a slower bitcoin price appreciation.

Cointime Economics Case Study #3

Cointime Price: A New Floor Model for Bitcoin

Cointime Economics can provide unique metrics derived from just a few inputs like coinblocks, supply, and price. Cointime price, for example, is a new time- and volume-weighted floor model for bitcoin. Cointime price is calculated as follows:

$$\text{CointimePrice}_{USD} = \frac{\Sigma\ [Price_{USD} \cdot CoinblocksDestroyed]}{\Sigma\ CoinblocksStored}$$

Compared to bitcoin's realized price, which is an on-chain volume-weighted average price (VWAP), cointime price is both volume- and time-weighted, and it adjusts the market's cost basis by the time-held of each coin involved in a transaction. As of May 7, 2023, the cointime price is $17,568 USD, 12.6% below realized price and 38.2% below market price, as shown below.
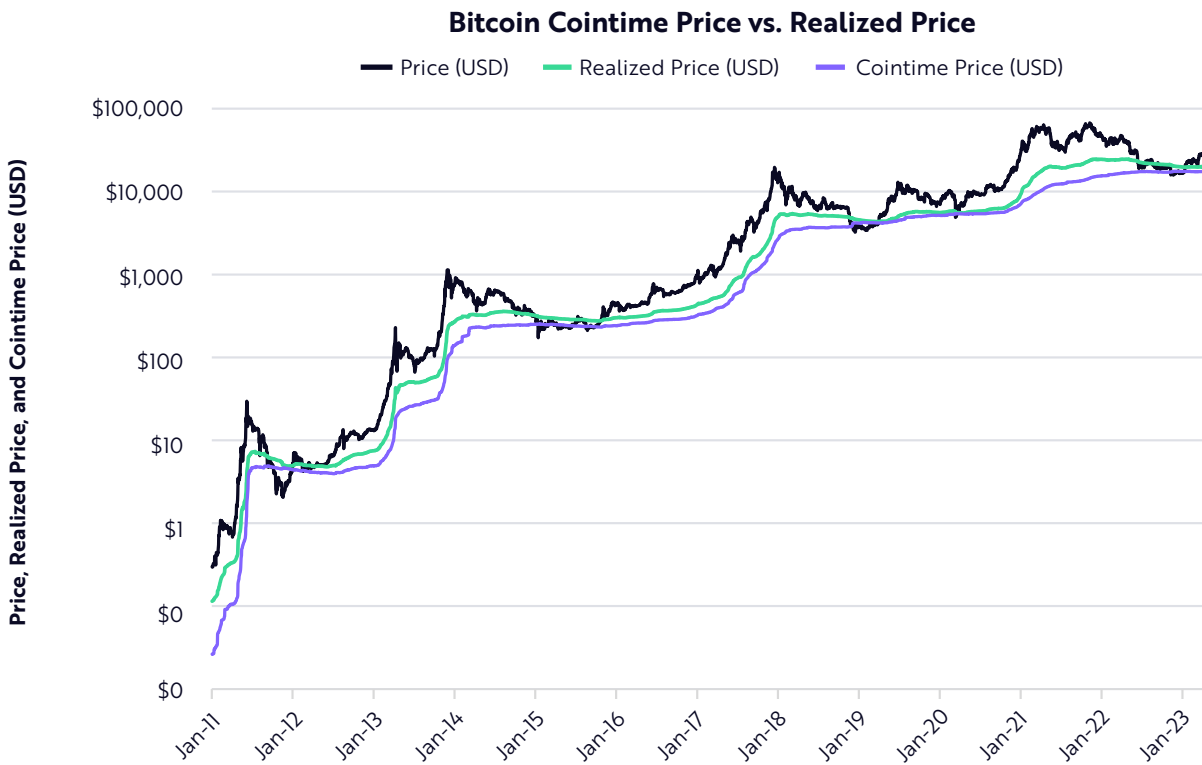
Bitcoin Cointime Price vs. Realized Price

Sources: ARK Investment Management LLC & Glassnode. Information as of May 7, 2023.

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Based on the three case studies presented above, Cointime Economics can be applied in a wide array of economic and valuation models. In the version of this paper written for on-chain specialists, we offer a wide array of technical descriptions, formulae, and case studies to elucidate these metrics further. Please also see our new suite of live Cointime Economics metrics, now live on Glassnode.

About the Authors
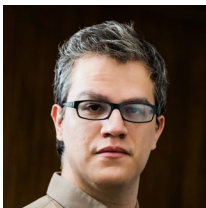
David Puell
Research Associate
ARK Invest

𝕏 *@dpuellARK*

David joined ARK in January 2022. As a Research Associate, he focuses on Bitcoin and cryptoasset on-chain and market research.

Prior to ARK, he was Head of Research at Adaptive Capital in 2019 and 2020. He is best known for pioneering the emergent field of cryptocurrency on-chain analysis and has created a dozen metrics used industry-wide today, including the MVRV Ratio and the Puell Multiple. His metrics are featured in most major cryptoasset data platforms such as Glassnode, Coin Metrics, and CryptoQuant. David has been quoted in Bitcoin Magazine, Coindesk, among other publications, and has been featured in the Bitcoin Magazine Podcast, Will Clemente's Blockware Intelligence Podcast, and The Pomp Podcast.

James Check
Lead Analyst
Glassnode

𝕏 *@_Checkmatey_*

James Check (pseudonym Checkmate) is the Lead Analyst for Glassnode and specializes in the study of the Bitcoin economy. He has a background in geotechnical engineering, and has experience in leading the design of a range of projects including tunnels, mine shafts, basements, and foundations.

He fell down the Bitcoin rabbit hole during 2018 bear market and began his research into the field of on-chain analytics as the discipline began to emerge later that year. He developed passion for macroeconomics, markets, and Bitcoin on-chain data, and started down the path of education, seeking to help curious investors understand more about what happens under the hood of Bitcoin.

James joined Glassnode as Lead Analyst in February 2021, where he manages a team of analysts responsible for conducting research, developing new metrics, analyzing markets, and creating educational content around the discipline of on-chain analytics.

ARK Invest Management LLC
200 Central Avenue | Suite 220
St. Petersburg, FL 33701

info@ark-invest.com
www.ark-invest.com

Glassnode Services AG
Neuhofstrasse 22
6340 Baar/Switzerland

contact@glassnode.com
www. glassnode.com

𝕏 Join the conversation on X
@ARKinvest
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