Invesco

Exploring Cryptocurrencies

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What started it all?

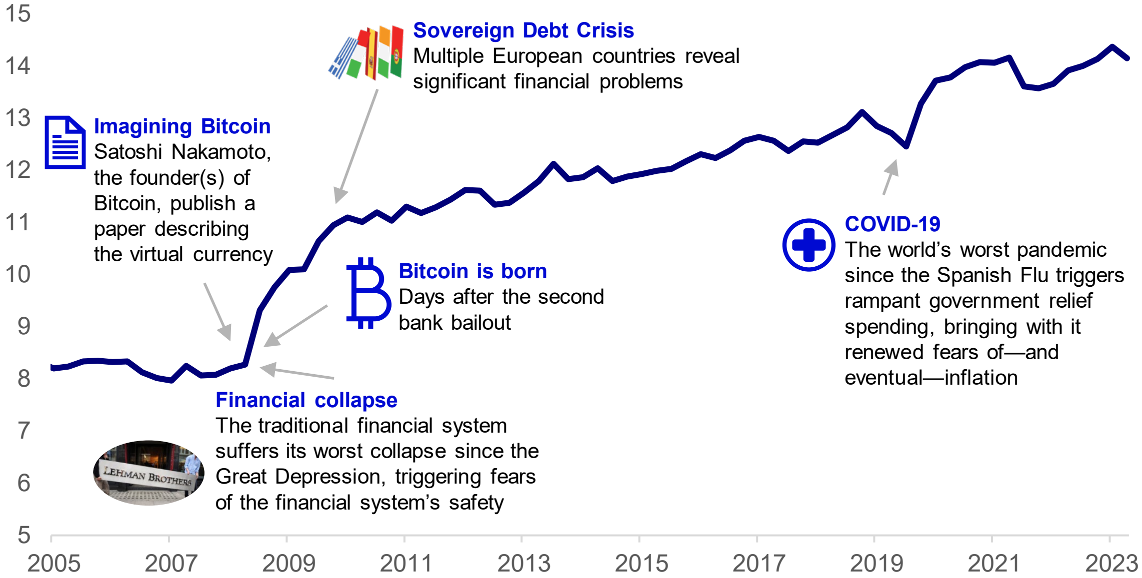
A financial crisis and a distrust in institutions

Bitcoin, the first cryptocurrency, was invented in the depths of the financial crisis as an alternative to the traditional banking system. Satoshi Nakamoto, the anonymous author(s) of the research paper that pioneered Bitcoin, approached the impending financial crisis like any other technologist: Take something fragile, inefficient, and far too large, and disrupt it. As banks were failing, Satoshi inscribed in the code of the first mined bitcoin block a message that reads, "The Times 3 January 2009 Chancellor on brink of second bailout for banks."

Since 2009, self-styled 'cryptocurrencies' have developed well beyond Bitcoin, becoming a vast and rapidly changing ecosystem. In January 2024, the first bitcoin spot exchange traded funds in the US were formally authorized and launched.

This paper offers an overview of the trend and technology behind cryptocurrencies, as well as an assessment of the risks, valuation, and potential long-term outcomes of cryptocurrencies. No matter Bitcoin's outlook, 15 years after the Bitcoin whitepaper and despite a pandemic, Satoshi would be surprised to see well-capitalized banks, US equities up 499%,* and a booming economy.

Distrust in the traditional financial sector spawns decentralized assets



Sources: Bloomberg, Macrobond, US Federal Deposit Insurance Corporation, latest available data as of 1 October 2023. *US equity performance measured by the S&P 500 index, an index of large capitalization stocks in the United States between the date of release of the Bitcoin white paper, 17 November 2008 and 29 February 2024.
Past performance does not guarantee future results. An investment cannot be made directly in an index.

Why is everyone paying attention?

“A bubble is only a trade that someone missed.” –Anonymous

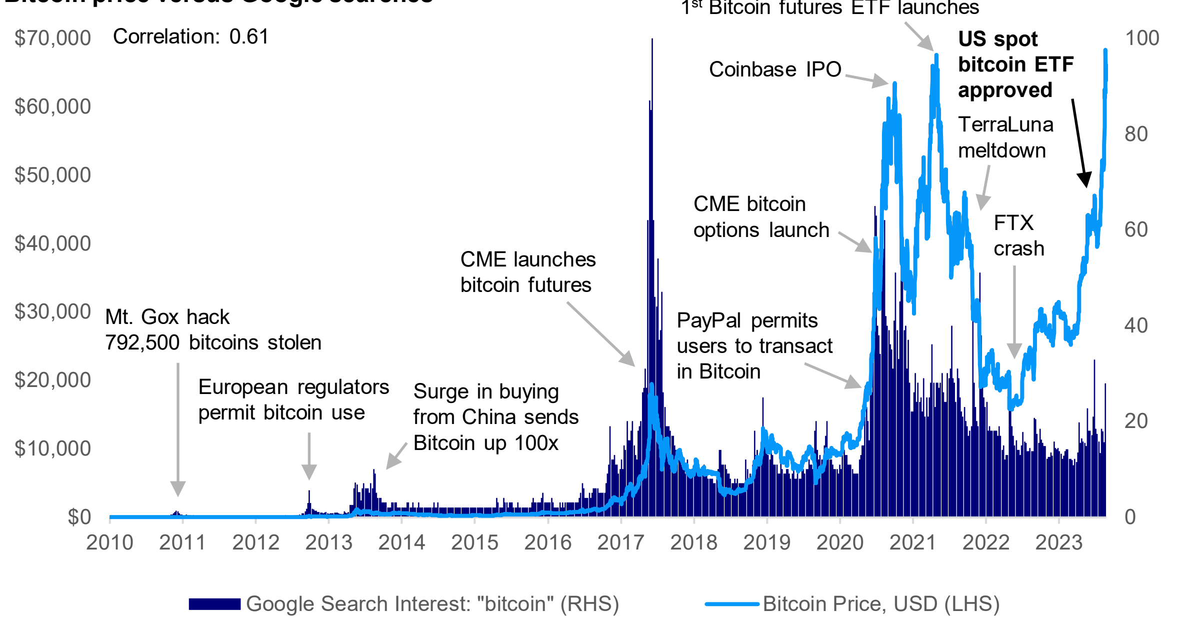
Between March 2020 and November 2021, Bitcoin increased from $8,000 to a high of about $68,000 (an 850% cumulative gain). Following the recent launch of spot Bitcoin ETFs in the US, Bitcoin recently made new all-time-highs above $70,000.

Although applications of Bitcoin’s underlying blockchain technology are interesting and may offer great potential, we argue that such applications are often an afterthought. Instead, many crypto-investors focus on Bitcoin’s potential for rapid price appreciation.

Cryptocurrencies are unique and deserve review. Finding assets that grow at exponential rates and have little correlation to traditional assets like stocks, bonds, and commodities is the Holy Grail for portfolio construction (but only if future returns are expected to be positive). At first glance, Bitcoin seems to fit this description. But this is changing.

In the past, price fluctuations could mostly be explained by retail interest. Yet, as cryptos have become more mainstream, their price behavior has increasingly mirrored traditional markets.

Bitcoin price versus Google searches



Note: Correlation is calculated on the change of average weekly Bitcoin prices versus the change of Google search interest over the same period. Sources: Google, Macrobond, and Invesco. As of 4 March 2024. **Past performance does not guarantee future results.**

Agenda

1. **Bitcoin and blockchain… How does it work?**
2. Putting bitcoin into perspective
3. How do you value a cryptocurrency?
4. An overview of major cryptocurrencies
5. Cryptos in a portfolio perspective

The Crypto Believer Manifesto

A dash of distrust of institutions and a pinch of cryptographic tech…

For many, the Global Financial Crisis—including the institutional and government responses to it—highlighted just how fragile and outdated financial systems had become. Satoshi Nakamoto's seminal paper, *Bitcoin: A Peer-to-Peer Electronic Cash System*, envisioned a financial system that put power and accountability in the hands of decentralized systems.

In his paper, Satoshi described a system which was decentralized, democratized, international and immutable. Bitcoin captures those primary characteristics. Cryptocurrencies developed after Bitcoin are often designed to fulfil a specific use-case or better reflect a specific belief about how financial systems ought to be structured. Naturally, some cryptocurrencies appear far more cozy with traditional financial structures than others.

Still, common themes tend to re-emerge, and they are usually based on a distrust of institutions and fiat currencies and the pursuit of a decentralized financial system ("DeFi").

Recurrent themes in cryptocurrencies

Decentralization

The lack of a central authority controlling the currency is an attractive trait in a world distrustful of traditional financial institutions.

Democratization

Cryptocurrencies are designed to operate with consensus. Majority decisions are required for structural changes to most coins or tokens.

Cross-Border Payment Facilitation

Existing in cyberspace, crypto-currencies can be exchanged outside government control on often under- or unregulated exchanges.

Blockchain Immutability

Cryptocurrencies rely on cryptography to preserve anonymity while preventing on-blockchain double-spend and ensuring settlement.

Finite Supply

With certain cryptocurrencies designed to have a finite supply, there is virtually no risk within such coins for a central authority diluting the value of assets.

Peer-to-Peer (Disintermediated)

Trades occur without intermediating authorities, such as banks or bookkeepers, which allows settlement to take place in real-time.

Source: Invesco. For illustrative purposes only. Note that not all cryptocurrencies exhibit the principles outlined above.

How do you get a bitcoin?
The circle of a bitcoin's life

Before exploring the technical details of blockchain technology, it is useful to first understand how one may obtain a bitcoin.

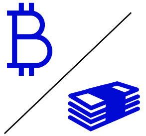
There are three options:

1. Buy bitcoins—and other cryptocurrencies—from centralized exchanges.
2. Participate in the "mining" process whereby new coins are generated.
3. Participate in blockchain-based transactions and receive bitcoins as part of an exchange.

Participants can trade bitcoins for other currencies or goods and services from a limited number of participating vendors. Crypto exchange rates (e.g. Bitcoin/USD) are determined by inter-exchange trading.

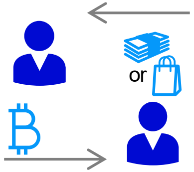
Bitcoin in motion: A diagram of bitcoin in use

1) Market Determines Exchange Rate



Similar to a market for a commodity or currency, the market determines the price in fiat currency of a bitcoin by supply and demand dynamics as well as expectations. This price is expressed through cryptocurrency exchanges.

2) User Transacts in Bitcoin

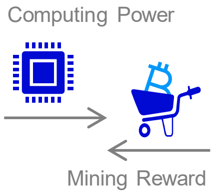


A user trades a bitcoin for a product, service or currency. Users can access their balance from their digital "wallets", where they hold single-use codes representing bitcoin and generate one-time use codes for receiving coins.

3) Blockchain Network Verifies Transaction

A network of computers verifies the transaction(s) in a digital ledger and appends the transaction(s) into the latest block, preserving a digital "paper trail". This step also represents trade settlement.

4) Miners Are Rewarded



Those contributing their computing power ("miners" or "validators") to verify the ledger of transactions are awarded with a number of bitcoins, an amount which gradually decreases over time to zero.

Sources: Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System*, 30 October 2008. Please refer to glossary for further definitions.

Understanding blockchain

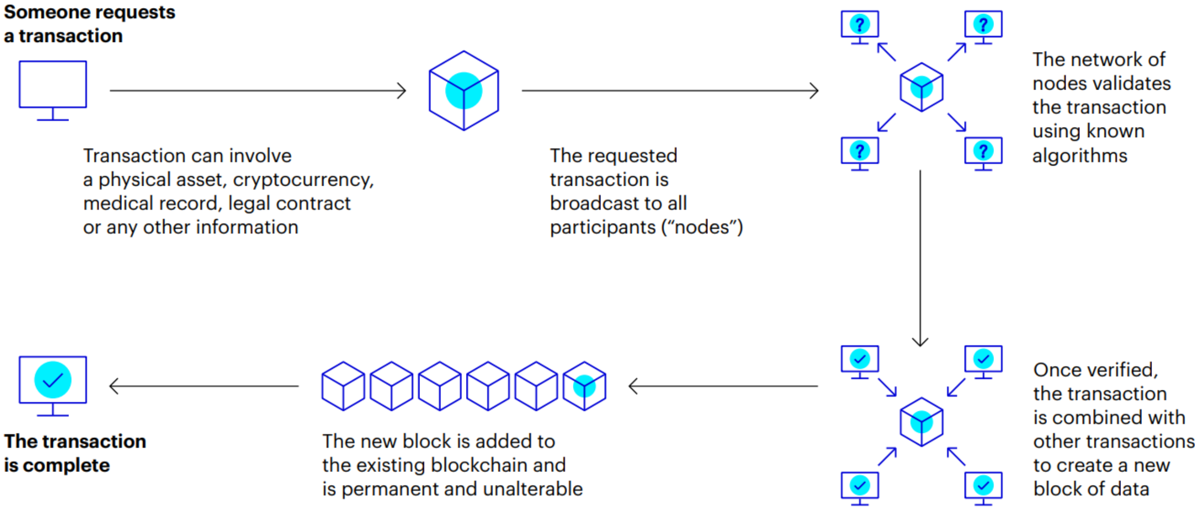
A blockchain is a decentralized database, maintained by a network of peers

Blockchain technology is the darling of the cryptocurrency phenomenon. In essence, a blockchain is a new kind of database, owned and maintained by a network of peers.

Each transaction—or change in data—is provided to the network and integrated into a packet of data called a "block". In contrast with a traditional centralized system, a decentralized database needs to have a mechanism whereby the various participants in the database agree on the current state of data (including any changes to it). To achieve this, each block undergoes an energy-intensive verification process using a series of cryptographic rules and puzzles. Newly verified blocks are broadcast to the network and appended to the blockchain.

To incentivize participation, new bitcoins are minted automatically and awarded to the participant(s) that successfully complete the cryptographic puzzle first. This "mining" process continually creates new "blocks" in the blockchain with new transaction data, forming a "distributed ledger" where each participant has record of every transaction.*

Blockchain in motion: A diagram of the bitcoin blockchain



* Technically, only nodes carry the full history of the blockchain; validators do not necessarily need to be nodes.
Source: Invesco. For illustrative purposes only.

Understanding blockchain

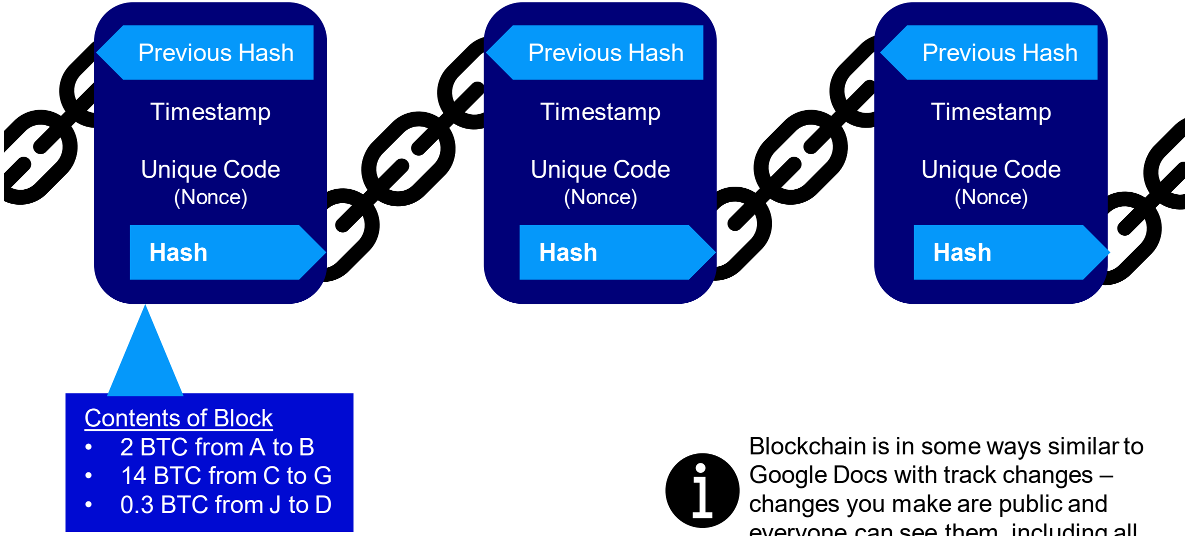
A blockchain is a linear log of records to which we append parcels of data

A blockchain is a growing list of records, or “blocks”, linked using cryptography. This linkage makes use of a hashing function, which is a tool in cryptography that takes input data and translates it into a unique, fixed-size code. Any input of data will have a unique hash. Identical data inputs produce identical hash outputs; different data inputs produce different hash outputs.

Each block contains a cryptographic hash of the previous block. If previous data is changed, the corresponding hash will change, breaking the chain and invalidating it. This principle is essential in maintaining the integrity of all past records.

Blocks also contain other data elements, including a timestamp, a unique identifier, and the transaction data contained within that block. Over time, new blocks are added, creating a linear log of data. For Bitcoin, the data stored in each block is transaction data, with a block containing around 2,000 transactions each. By design, a new block is created roughly once every 10 minutes.

Visualizing a blockchain and its contents



Blockchain is in some ways similar to Google Docs with track changes – changes you make are public and everyone can see them, including all previous changes.

*This statement applies to Proof-of-Work blockchains. The Proof-of-Stake consensus mechanism is more computationally efficient. We define these terms in the Glossary.
Source: Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System*, 30 October 2008. For illustrative purposes only. Please refer to glossary for further definitions.

Understanding blockchain

A blockchain's data can restrict access to data through private "keys"

In the original Bitcoin paper, Satoshi described the schematic of a blockchain transaction, reproduced on the right (with added notes). The idea was to create a ledger of transactions as private as the banking system and as public as the internet.

As al discussed, digital assets use cryptography to secure transactions. On a blockchain, each user has a public identity—a public key—associated with their transactions. This public key is like your blockchain username.

To spend crypto or transfer digital assets, you must authorize it by submitting your private key as part of a transaction. This private key is like a bank PIN. Pairing your private and public keys allows the blockchain to verify that you are the legitimate owner of that digital asset and can transact with it.

But can someone guess your private key? It is extraordinarily unlikely: a supercomputer running since the Big Bang would still not have guessed a private key. The security of one's Bitcoins, therefore, depends on how well kept one's private keys are.

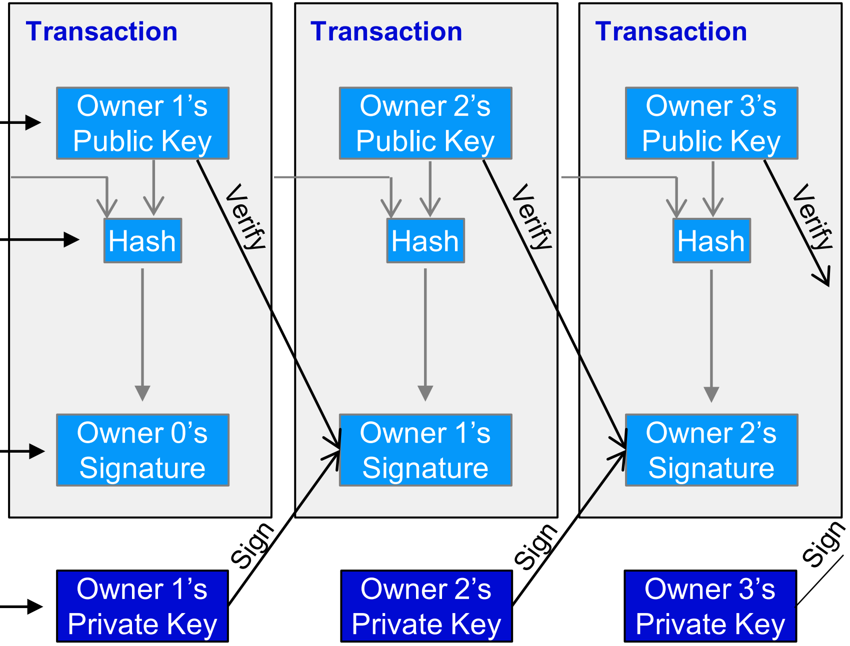
Blockchain schematic from Satoshi's original white paper

1 **Public key**
A unique personal address shared in the blockchain for receiving a transaction.

2 **Hash**
A cryptographic representation of input data, used to secure and preserve previous data. No matter the input length, the hash is always the same size.

3 **Signature**
The combination of public and private keys results in a digital signature, verifying the authenticity of a transaction.

4 **Private key**
A secret number identifying the bitcoin, allowing the holder to transact with it.



Source: Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System*, 30 October 2008. Notes are added. Please refer to glossary for further definitions.

Weighing the benefits and drawbacks of blockchain

Blockchain appears innovative, but there are tradeoffs to consider

	Fast	Distributed	Immutable	Open
Strengths	Unlike banking systems in which transactions may take days to verify, blockchain transactions allow rapid trade settlement (commonly termed "atomic settlement").	Cryptocurrencies were designed to be decentralized – there is no issuing authority and no centralized transaction processor. Third-parties and intermediaries are unnecessary. This may help the network appear more transparent in its governance and therefore trustworthy.	Bitcoin is theoretically impossible to counterfeit. All transactions are irreversible and unchangeable. To override the ledger, an attacker must obtain a majority of computing power used in maintaining the ledger, a tremendously arduous task given the scale of mining participation*.	All transactions can be tracked and verified on a blockchain; it is a public ledger.† It is also possible to analyze how much each address contains and with whom they have transacted.
Weaknesses	Rapid settlement comes at the expense of irreversible transactions – after the blockchain has confirmed a transaction, it cannot be reversed. Moreover, some blockchains have relatively limited network throughput, creating settlement delays during heavy blockchain activity.	'Distributed' does not necessarily mean efficient. For example, changes to the protocols that govern the system can be slow to implement, even if they are beneficial. In terms of scalability, distributed systems tend to be slower than equivalent centralized systems.	Immutability comes at great cost in terms of electricity and capital equipment (expensive mining computers that solve the cryptographic problems powering the blockchain).*	You can see the contents of an address, but you may not be able to identify its owner. Each user may even have multiple addresses. To the extent that users are visible, there are privacy concerns.

*Note: The above points on electricity use refer specifically to the Proof of Work blockchain model. Other consensus mechanisms exist.
†Exceptions exist, as is the case with so-called privacy coins that are designed to hide the transacting parties' information (e.g.: Monero).
Source: Invesco.

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Bitcoin is a truly non-inflationary asset

Estimates indicate that all bitcoin will be mined by around the year 2140

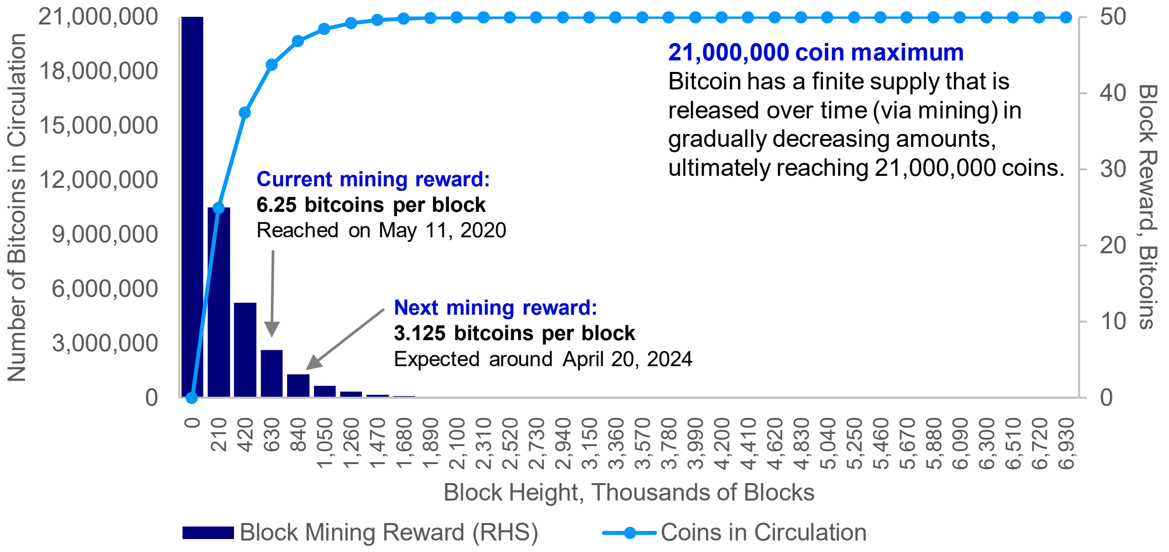
Bitcoin is a truly non-inflationary asset, with a total supply of 21,000,000 coins, due to be fully mined by around the year 2140. This finite supply element is important – investments views about Bitcoin are often centered around this idea of scarcity.

As of today, about 19.6 million bitcoins exist, of which an estimated 3.7 million coins are lost forever due to users forgetting their unique keys, losing access to their wallets.

New bitcoins are released according to a predetermined schedule. As the network reaches certain numbers of blocks, the mining reward decreases in what is known as a "halving."

As new bitcoins are the incentive for miners to participate, one might expect transactions fees to rise as compensation for a decreasing number of newly minted bitcoins. Indeed, transaction fees are already a part of Bitcoin and are paid to miners.

Bitcoin mining progression



Note: Halvings take place based on the total number of blocks that have been verified in the bitcoin blockchain, with the next halving due at the 840,000th block. As a block is confirmed approximately once every 10 minutes and the current total number of blocks is 832,550, then the next halving should take place on roughly 20 April 2024. The first bitcoin halving took place on 28 November 2012. Formally, a "halving" is when the mining reward paid out to miners for the successful verification of a block is cut in half. **Past performance does not guarantee future results**. Sources: Blockchain.com and Invesco, latest available data as of 29 February 2024. Chart reproduced from bitcoin.it. For illustrative purposes only.

Bitcoin is concentrated among few wallets

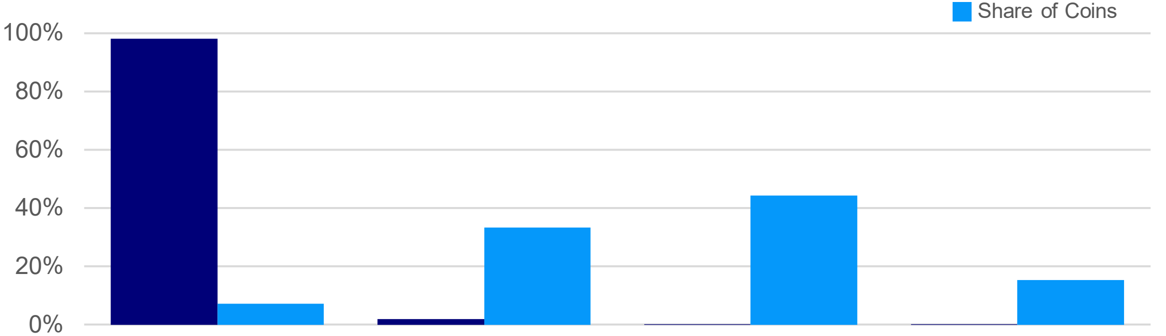
However, wallet data has become less reliable over time

Unlike the traditional banking system, the transparent nature of the Bitcoin blockchain shows exactly how many bitcoins are in each wallet. Some striking data we have found include the following:

- Satoshi owns roughly 5% of the wealth.
- 53.59% own less than 0.001 BTC.
- 98.07% of addresses own less than 1 BTC.
- Only 1.93% of addresses have more than 1 BTC. Combined they own 61.46% of all bitcoin.
- 4 addresses hold more than 100,000 BTC (3.44% of coins), with a value of $43.62B

However, wallet data is inherently limited. First, a person may own more than one wallet. Second, centralized exchanges typically hold cryptocurrencies on behalf of their clients, sometimes in just one or a handful of wallets, which would increase the average size of wallets.

Distribution of ownership of bitcoin



The Masses
98.07% of addresses
7.19% of total BTC
$1,709 average wealth

The Hopefuls
1.90% of addresses
33.22% of total BTC
$406,601 average wealth

The Rich
0.03% of addresses
44.32% of total BTC
$34.41M average wealth

The Wealthy
< 0.00021% of addresses
15.27% of total BTC
$1.72B average wealth

Notes: Here, we use “wallets” and “addresses” interchangeably as a simplification. ‘Average wealth’ = Weighted Average Wealth of wallets based on number of coins e.g.: wallets holding less than 1 coin, 1 – 10, 11 – 100, and so on. The weighted average $ value of bitcoin held in all known wallets is $23,309. The median wallet holds between 0.0001 - 0.001 BTC. Sources: https://bitinfocharts.com/top-100-richest-bitcoin-addresses.html and Invesco, as of 1 March 2024. Figures are based on a spot price of approximately 62,000 USD per bitcoin. Numbers of coins, wallets, and US dollar values are rounded amounts.

Bitcoin: Who’s mining?

Mining has shifted from emerging markets to more developed economies

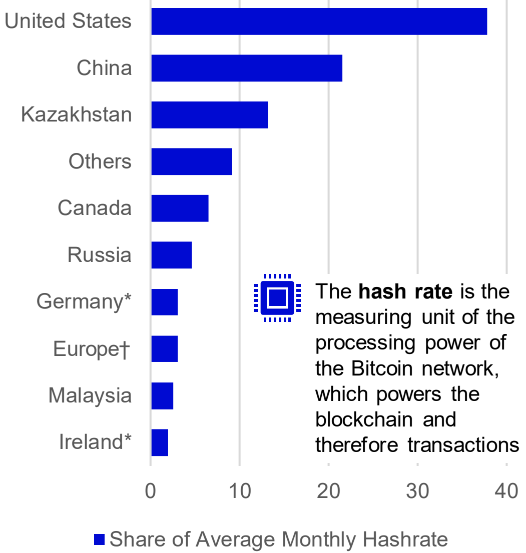
Bitcoin’s blockchain is powered by “miners,” or those users who contribute computational power to verify and maintain the blockchain ledger. By tracing the internet addresses of participating miners, it is possible to estimate the geographical shares of computational power.

Based on an analysis of the Cambridge Centre for Alternative Finance’s data, more than 45% of the bitcoin hash rate in 2022 originated from emerging markets, down from its 70% high before China cracked down on cryptocurrency mining.

Why is this? We believe that lower capital costs, cheap electricity, and the desire to capture mining revenue creates the appropriate incentives for miners to focus on a particular locality. Increasingly, miners are moving into developed markets where they can capitalize on cheap renewable energies.

Ultimately, the location of mining power is of little consequence for the Bitcoin network.

Computation power by geography



The **hash rate** is the measuring unit of the processing power of the Bitcoin network, which powers the blockchain and therefore transactions

*Data may be unreliable due to VPN usage
†Excludes German and Irish data

What drives the location of miners?

Lower Capital Costs

Cheap Electricity

Lower Fixed Costs (e.g., land)

What happens when mining power is turned off?

As mining power goes offline, the amount of computing power necessary to mine (confirm) a block decreases automatically. However, blocks may be mined more slowly for a brief period until this mechanism takes effect, meaning temporarily slower transaction speeds.

Sources: Bitcoin Mining Map from the Cambridge Centre for Alternative Finance, and Invesco, latest available data is from January 2022.

A power-hungry asset? Bitcoin electricity consumption poses challenge

Energy costs of computing power present a key issue

The electricity needs of Bitcoin are difficult to understate. If the Bitcoin network were a country, it would be the 34h largest electricity consumer in the world.

So, just how "green" is Bitcoin? The debate is nuanced. Some state that comparisons against traditional payments processors are unfair as the electricity intensity cited (as on the right) fails to account for ATMs, physical location costs, and other facets of traditional financial services that consume resources. Proponents may also suggest that renewables power a large portion of crypto mining.

Whatever one's view, it is worth noting that the amount of electricity used by a cryptocurrency is dependent on the consensus mechanism used. For Bitcoin, this is the mining process described earlier. Other cryptocurrencies can accomplish decentralized ledgers with far less energy inputs.

Mapping transaction speeds and costs

Medium	Transactions per Second	KWh per Transaction	Electricity Cost Per Transaction*
Cash†	Unlimited	0.08 KWh	$ 0.00989
Visa	56,000	0.0008	$ 0.00010
Mastercard	45,000	0.0008	$ 0.00007
Ripple (XRP)	1,500	0.0079	$ 0.00098
Bitcoin Cash	300	18.96	$ 2.34
PayPal	193	–	–
Litecoin	56	18.52	$ 2.29
Ethereum	25	87.29	$ 10.79
Bitcoin	7	1,173	$ 144.98

Striving for efficiency
"Layer 2" solutions

The base blockchain underlying cryptocurrencies like Bitcoin and Ether tend to be quite slow, as shown in the table on the left. However, so-called "layer 2" solutions offer an important scalability method. One way this may happen is by batching transactions in a separate blockchain, then taking the final, netted amounts onto the primary blockchain—thereby increasing transaction throughput and speeds.

This method is claimed to handle up to 40,000 transactions per second at a fraction of the electricity cost.‡

*Prices in USD, assuming 12.36 cents per KWh latest data available as of Nov 2023 based on the US Energy Information Administration (US EIA): www.eia.gov/electricity/state/. Prices are estimates and for illustrative purposes only. †Electricity intensity of printing a single bill. Sources: Deutsche Bank study, "Future of Payments: When digital currencies become mainstream", MoneySuperMarket.com, Ripple, Coinanalysis.io, Blockchain.com and Cambridge University Centre for Alternative Finance. ‡According to the Arbitrum network. **Past performance does not guarantee future results.** Note that "electricity cost per transaction" should be taken as the upper range of an estimate as multiple transaction settlements may be contained within a single on-chain transaction. Note: Ether is the native cryptocurrency of the Ethereum network.

Is bitcoin a currency? We don't think so

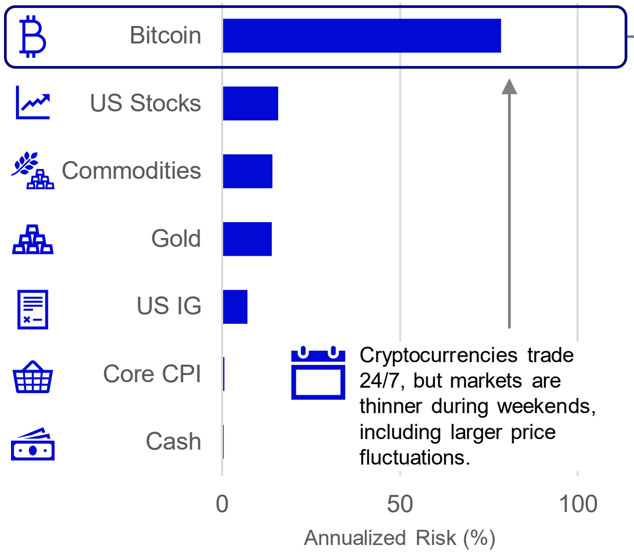
"I can't buy a latte with bitcoin."

In viewing Bitcoin as a financial instrument, it is necessary to decide how to categorize it. We take two perspectives in assessing whether Bitcoin – and other cryptocurrencies – is feasible as a currency: (1) an economic test, as on the right, and (2) its potential for scale as a means of transacting.

On the first point, we take the view that money is typically thought of in economics as satisfying three functions: a store of value, a unit of account, and a medium of exchange. Here, on all three accounts, we are left wanting, pointing us more to look at Bitcoin and similar cryptocurrencies as commodities.

On the second point, most cryptocurrencies fall victim to a specific scalability limitation. Cryptocurrencies are limited within their respective blockchains by the combination of block size and the average block creation time, which combine to yield a limited transaction throughput. In other words, each crypto is constrained to a certain maximum pace of transactions – which is often quite limited.*

Annualized monthly price volatility since 2015



Store of Value

- Bitcoin is far too volatile to be considered a reliable store of value
- Price behavior is erratic with 78% annualized volatility

Unit of Account

- Product prices are not quoted in bitcoin amounts. Instead, pricing is based on a fiat currency amount converted using bitcoin's spot rate

Medium of Exchange

- While some platforms permit the use of Bitcoin for payment, there is little evidence to suggest that this is what makes it attractive

*So-called "layer 2" scaling solutions can act as an additional settlement layer to batch transactions, thereby increasing network throughput. However, such solutions present their own limitations and challenges, including for privacy and interoperability of blockchains.

Sources: Bloomberg, as of 29 February 2024, and *Bitcoin – Currency of the Future or Speculative Asset*, John Greenwood and Adam Burton. Please see page 43 for index definitions. Note that "Core CPI" refers to the United States consumer price index, less the effects of food and energy. **Past performance does not guarantee future results.**

Is bitcoin digital gold? Maybe, maybe not

Bitcoin performed poorly during the inflation run-up in 2022, 2023

Another possible – and common – analogy for bitcoin is that it is a kind of digital gold. But is this the right comparison?

Crypto investors tend to group cryptocurrencies by their functions and consensus mechanisms. Bitcoin is usually thought of as “digital gold” due to the asset’s strong security protocols, limited supply, and a history of low correlations with traditional assets (including commodities like gold itself).

To investigate this thesis, we assess key qualities of gold against qualities of Bitcoin in the table on the right. We are unconvinced by the ‘digital gold’ thesis; Bitcoin does not appear to share gold’s most important qualities. An additional challenge for Bitcoin is that gold has a very long history that has cemented its role as an asset, whereas Bitcoin has only existed for a paltry 13 years.

However, Bitcoin and gold have one fundamental aspect in common: they are both zero-yielding assets. Therefore, both should be responsive to the effect of opportunity costs (real yields, for example).

	Gold			Bitcoin
Finite Supply	Supply increases about 1.8% per year	✓	✓	Supply increases less over time, with terminal limit of 21,000,000 coins
Liquid Markets	Gold has a highly liquid market with a huge variety of participants and contracts	✓	✓	Bitcoin appears to have liquid markets, including futures contracts*, though this can vary
Uncorrelated	Correlations with other assets are typically low, especially in times of economic distress	✓	?	Price behavior is still evolving, and correlations with other asset classes have increased recently
Inflation Hedge	Historically, gold tends to perform well in inflationary environments	✓	✗	Finite supply is attractive, but the asset has failed to prove itself so far as a hedge against inflation
Global Acceptance	Gold is a globally recognized store of value, held as reserve assets by most central banks	✓	✗	Bitcoin is banned in a number of countries and is regarded with skepticism by many authorities
Use in Goods	Gold is commonly used in high-tech manufacturing and jewellery	✓	✗	Bitcoin has no obvious uses beyond its value as an asset

*Bitcoin trades 24/7, resulting in periods of relative illiquidity. This appears to be especially true on Sundays, resulting in greater price volatility on these days.
Sources: Bloomberg and Invesco, latest data available as of 29 February 2024.

Bitcoin responds more to money supply than inflation, in our assessment

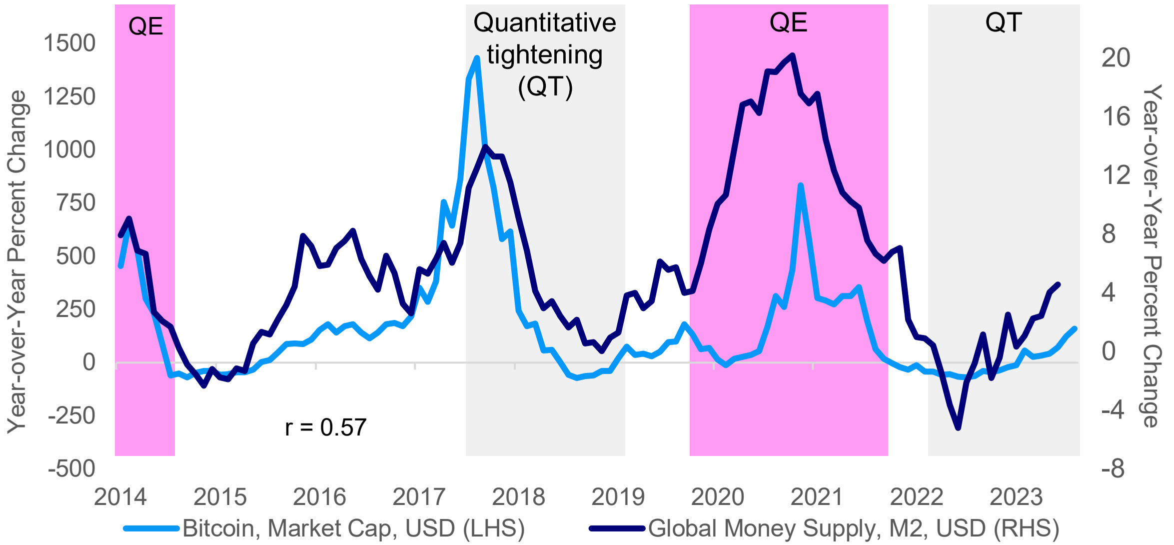
Global money supply growth and financial conditions may offer clues

In 2020 and 2021, global money supply growth surged, which helped send various asset classes—including bitcoin—to new highs. This period was followed by inflation in a variety of major economies, notably in the US, UK and Eurozone. Yet as inflation rose, central bankers leapt into action, leading to a tightening of financial conditions. At the same time, the monetary spigots were turned off—year-over-year global money supply growth turned negative in mid-2022.

Tighter financial conditions and falling money supply growth were felt in Bitcoin, which fell from around $68,000 in November 2021 to around $15,000 just 12 months later.

Based on this inflation episode, Bitcoin appears to have been more responsive to changes in money supply than inflation—which is likely to factor into how investors assess bitcoin's behavior.

Bitcoin market capitalization versus global money supply



Note: QE = Quantitative easing.
Sources: Macrobond, Bloomberg, and various central banks as of 31 December 2023. Quantitative easing and quantitative tightening callouts are for the Federal Reserve only. Note: "Other Coins" is calculated as total crypto market map less the market caps of Bitcoin and Ethereum. It will tend to overstate individual crypto prices due to the effects of supply changes, which are typically positive. Global money supply is the sum of M2 money supply figures for Australia, Brazil, Canada, China, Eurozone, Japan, South Korea, Switzerland, Taiwan, US, and UK, converted to US dollars based on spot exchange rates.

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Cryptocurrency market capitalization remains small

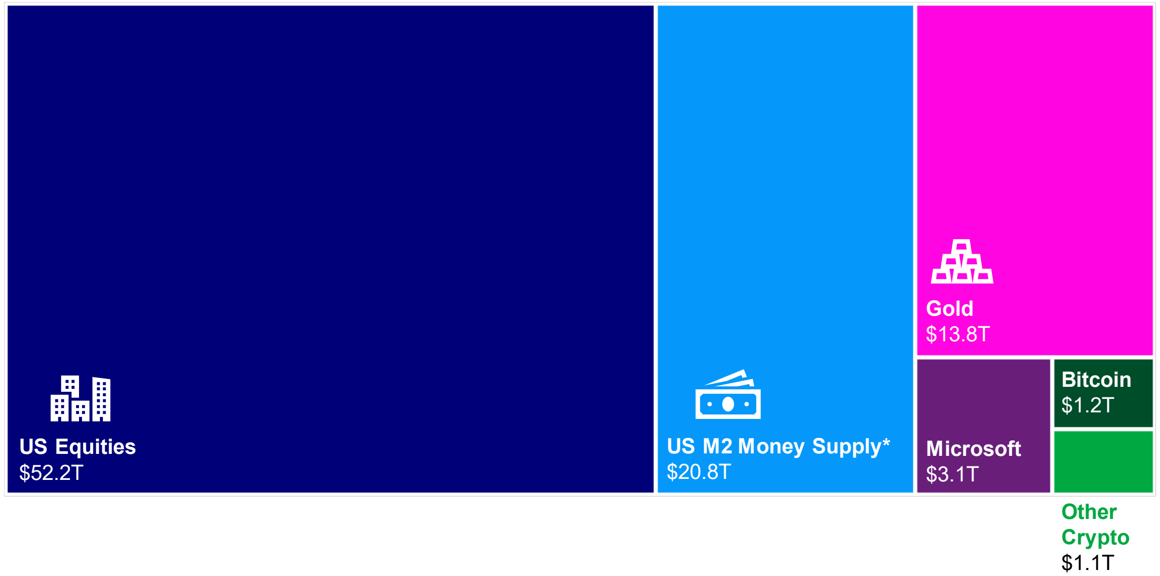
As cryptos grow, we expect traditional market drivers to dominate behavior

In the chart on the right, cryptocurrency market cap at $2.3 trillion is relatively small compared to other asset classes, such as US equities where the total market capitalization is around $52.2 trillion. However, there is potential for this to grow, as we have seen in the 14-year history of cryptocurrencies. Cryptocurrencies hit an all-time high market capitalization of around $3.0T in November 2021.

As cryptocurrencies have grown in popularity, we believe that crypto market capitalization has increasingly behaved more in line with traditional market drivers rather than idiosyncratic factors. Maturity, in other words, may make crypto less of a diversifier than once thought.

With this in mind, we will now turn our attention to methods of and approaches to valuation in the cryptocurrency space.

Market Capitalization Comparison



*US Money is represented by M2 for the United States, which measures highly liquid dollar deposits and select small-denomination time deposits and money market fund deposits
Sources: Macrobond, Bloomberg, CoinMarketCap.com, and US Federal Reserve as at 29 February2024; M2 as of 31 January 2024.

What is the value proposition of cryptocurrencies?

Every buyer has a thesis – which may include speculation

Digital means of transacting?

Cryptocurrencies can be spent and received by anyone, anywhere, and at any time without the need for an intermediating institution. Some assert that cryptos have value for this reason.

Others counter that Bitcoin is an inefficient mechanism of exchange due to its inability to scale. We note that other cryptocurrencies offer significantly faster network throughput.

A store of value?

Bitcoin has exhibited substantial price movements that have made it difficult to consider it as a store of value. Other crypto-currencies also fluctuate dramatically in value, often moving in tandem with Bitcoin. Stablecoins resolve this issue by tying their value to an underlying asset.

Decentralized finance?

Cryptocurrencies are emblematic of distrust in the traditional financial services industry. Some envision a new financial system in which the nature of fees and intermediaries is reconceive-ed. Others counter, however, that decentralized finance is already centralizing around key players, in essence recreating a paradigm similar to today's financial system.

New format of trust?

Some argue that Bitcoin and other crypto-currencies have value because they present a new method of establishing trust. The backstop of such systems is trust in the underlying cryptography. In fiat currencies, trust in the issuing government is the ultimate backstop.

This mechanism of trust may be appealing in a variety of use cases not limited to payments.

Avoiding government institutions?

Those desiring a financial system devoid of government and central bank involvement value the decentralized, internet-based nature of cryptocurrencies. For some, avoidance of government reach, including borders, regulation and taxation, is an attractive feature.

However, regulators are increasingly stepping into the space and imposing controls.

… or just speculation?

Source: Invesco. For illustrative purposes only as at 1 March 2024.

Principles of valuation & pricing in the crypto world

"Not everything can be valued, but almost everything can be priced." *

Valuing cryptocurrencies is a challenging topic, not least because of the immense variety of them. While typical financial valuation models rely on assumptions about expected cash flows and discount rates, investors in Bitcoin tend to look to supply and demand dynamics, not dissimilar to commodity valuation.

Other cryptocurrencies have different designs and consensus mechanisms. In these cases, some cryptos may even generate cash flows through a process known as "staking." In these cases, investors may earn cash flows denominated in a cryptocurrency by participating in the consensus mechanism.

Ethereum provides an interesting example, where users must spend Ether in order to make use of the platform's computing resources. These capabilities can justify use of these cryptos and contribute to their valuation.

On the right, we explore a sample of the variety of considerations involved in valuing cryptocurrencies.

Considerations and questions to ask of each cryptocurrency

Supply Dynamics

- How many coins are available?
- How often are new coins minted?
- How difficult is it to mine/create new coins?
- Is there an issuing authority or company?
- Are coins ever "burned" (destroyed)?
- Who receives transaction fees?

Demand Drivers

- Is there significant reputation and/or press coverage (as is the case for Bitcoin)?
- How scalable is the crypto? Does it suffer from limited network throughput?
- Is demand driven by speculation or for use?
- Do similar or undifferentiated coins exist?

Security Features

- Is the blockchain design secure and resistant to tampering?
- What consensus mechanism is used?
- Is ownership concentrated?
- Are the original developers the primary decisionmakers?
- Is the design of the crypto transparent?

Use Case Considerations

- Does the crypto support decentralized applications? If so, is there an active development community?
- Does the crypto serve a specific use case (e.g. payments facilitation, or value pegged to an asset like gold or the dollar)?

*Quote attributed to Aswath Damodaran, 24 October 2017.
Source: Invesco. **Past performance does not guarantee future results.**

Principles of valuation in a formulaic approach

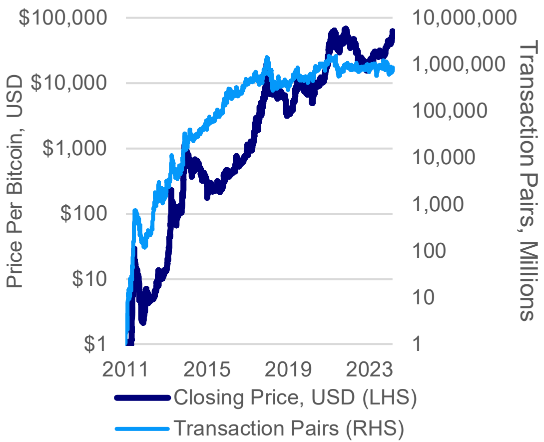
Can empirical models describe bitcoin's price behavior? Not likely

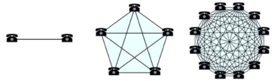
?

Network Effects: Metcalfe's Law

Metcalfe's law argues that value originates from network effects. As adoption increases, the value of the network – in this case, Bitcoin – also rises as the number of possible connections increases exponentially.

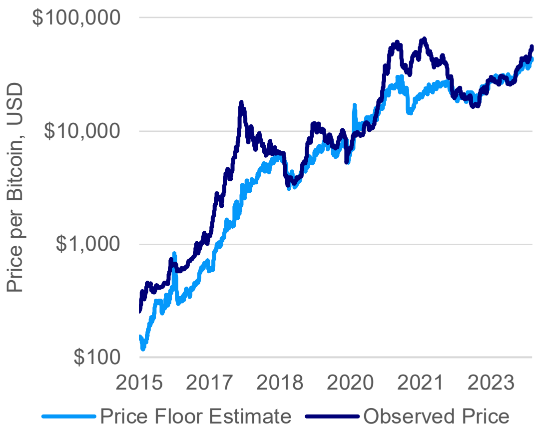
This approach is interesting but flawed as value is not defined within this model.





$$\text{Value of a Network} = \#\text{ of Nodes}^2$$

Embodied Costs of Production



A theory put forward by Adam Hayes argues for the value of Bitcoin having a floor of *at least* its costs of production – in other words, the marginal cost of mining each bitcoin.

We are skeptical of this approach – just because costs went into produc-ing something does not mean it has value.*

$$\text{Cost of Production} = \frac{\text{Electricity Cost of Hash Rate}}{\text{Bitcoins Mined Per Day}}$$

*From *Bitcoin – Currency of the Future or Speculative Asset*, John Greenwood and Adam Burton.
Note: Scales are logarithmic.
Sources: *Bitcoin price and its marginal cost of production: support for a fundamental value* by Adam S. Hayes, CFA, and *Metcalfe's Law as a Model for Bitcoin's Value* by Timothy F. Peterson, CFA, CAIA. Model recreated using estimates from Cambridge University Centre for Alternative Finance and data from Coinmetrics. Values on the right-hand chart are seven-day moving averages. Data as of 29 February 2024. **Past performance does not guarantee future results.**

Agenda

1. Bitcoin and blockchain… How does it work?
2. Putting bitcoin into perspective
3. How do you value a cryptocurrency?
4. **An overview of major cryptocurrencies**
5. Cryptos in a portfolio perspective

Not just Bitcoin: Cryptocurrencies are numerous and varied

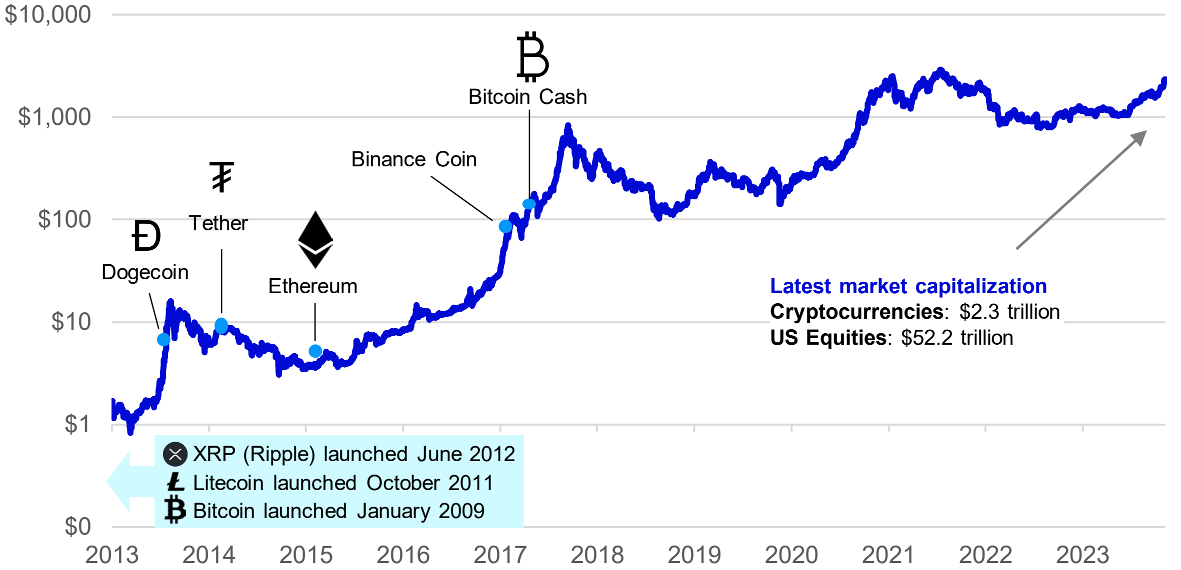
Since Bitcoin's launch in 2009, tens of thousands of "altcoins" have appeared

There are more than 20,000 cryptocurrencies out there* in various sizes and uses, and many more go unaccounted for or abandoned. In total, the market capitalization of all cryptocurrencies is about $1.0T.

Why so many? Each crypto is differentiated from every other by several factors, including…

- the way in which their blockchain works, including the speed and scalability of the platform
- total supply cap (capped, like Bitcoin, or uncapped, like Dogecoin)
- mining difficulty (and whether coins are mined or distributed by an entity) and release pattern of new coins
- whether the coin is tied to a business, such as XRP (Ripple) or Binance Coin (Binance)
- The ability to embed miniature, decentralized applications (called "dapps"), such as is the case with Ethereum

Market capitalization of cryptocurrencies (Billions USD, logarithmic)



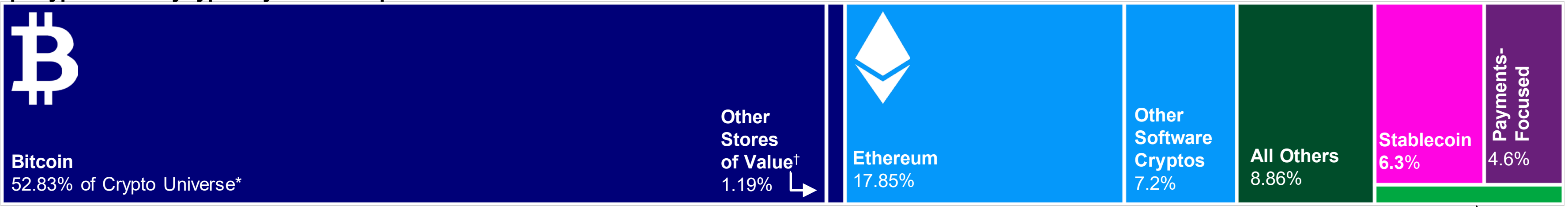
*The market capitalization above includes the data all cryptocurrencies that CoinMarketCap tracks. Additional coins exist, but their market capitalization is likely to be tiny. Survivorship bias may be present as the methodology of coin tracking may shift and reconstitute the available coin history.

Sources: CoinMarketCap.com and Macrobond, as of 6 March 2024. **Past performance does not guarantee future results.**

Not all cryptos are made equal

Cryptocurrencies are varied by design, use, and value propositions

Top cryptocurrency types by market capitalization



Stores of Value†

These cryptos seek to offer methods of storing value securely through a crypto, yet their values are quite volatile.

Top Contenders:
1. Bitcoin (52.83%)
2. Litecoin (0.27%)

Software Platforms

Such "software" cryptos act like a decentralized computer, with programs stored on and executed via blockchains.

Top Contenders:
1. Ethereum (17.85%)
2. Solana (2.55%)
3. Cardano (1.06%)

Stablecoins

Stablecoins sidestep the store of value debate by pegging their value to an underlying, such as the US dollar.

Top Contenders:
1. Tether (4.31%)
2. USD Coin (1.26%)
3. Dai (0.27%)

Payments-Focused

These cryptos focus on scalability for the sake of rapid payments and are often run or created by a business.

Top Contenders:
1. BNB (2.64%)
2. XRP (1.41%)

Memecoins

Born out of their namesake, memecoins are perhaps the easiest to criticize for lacking a key value proposition.

Top Contenders:
1. Dogecoin (0.78%)
2. Shiba Inu (0.36%)

* Market Share indicates the relative share of the market capitalization of the cryptocurrency universe, including both coins and tokens.
† As we discussed earlier in this deck, the claim that any of these cryptos is a store of value is a dubious one with numerous considerations.
Sources: CoinDesk, CoinGecko, CoinMarketCap.com, Coin.Dance and Invesco as of 1 March 2024. Cryptocurrency count is sourced from CoinMarketCap and CoinGecko.

Cryptos as a "software platform"?
At least 25% of crypto market cap is in decentralized software

While throughout this deck we have focused on Bitcoin, other developments in the digital assets space seek goals beyond a digital store of value or payments solution. Here we explore cryptocurrencies who's underlying blockchains act as a platform for software.

The idea appears complex at first but is ultimately simple: Rather than a central server fetching information and executing tasks, we have a decentralized network of computers that carry out those same functions in exchange for a small fee.

This is the same technology that powers a lot of the developments behind buzzwords we hear today, such as decentralized finance ("DeFi"), Web 3.0, and non-fungible tokens (NFTs). We explore briefly how this works on the right.

Exploring "software platform" cryptocurrencies

How can a blockchain power software?

The blockchain hosts applications and their data via participating computers. To run your application, you must have the right to utilize computing resources within the protocol.

Where does crypto come in?

The protocol prices computing power in terms of its native token (e.g. for Ethereum, this is Ether) based on the level of demand for computing resources. The price of this computing power is commonly called **gas fees** and are paid to the computers that carry out such computations.

What gives it value?

The market price of a blockchain's native token is based ultimately on demand for it, whether for the token for application execution or speculation.

Examples of applications built on blockchains

- **Decentralized automated exchanges**: Automatically match buyers and sellers.
- **Non-fungible tokens (NFTs)**: Represent ownership of an asset via a bearer-form token.
- **Lending platforms**: Provide credit via crypto.
- **Video games**: Execute in-game events, rules and transactions.

Top "software platform" cryptos by market cap

Ethereum **ETH**
Market Cap: $409 billion
First-mover and most popular software crypto.

Solana **SOL**
Market Cap: $58 billion
Relatively centralized but ultra-fast and efficient.

Cardano **ADA**
Market Cap: $24 billion
Prioritizes speed and interoperability of projects.

Avalanche **AVAX**
Market Cap: $15.7 billion
ETH rival for smart contracts and dApps*.

Notes: A decentralized application ("dApp") is composed of many smart contracts working together to provide a user experience and functionality, powered by a decentralized system.
Sources: Invesco and CoinMarketCap.com. As of 4 March 2024.

A World of Crypto: Digital assets infrastructure takes many forms

Tokens can be designed for a wide variety of uses and functions

Non-Fungible Tokens

Non-Fungible Tokens (NFTs) have been a highly popular—if controversial—use of blockchain.

An NFT is a unique identifier representing a particular underlying asset. Hypothetically, owning an NFT denotes ownership of the underlying asset. Therein lies the controversy; without real-world legal protections and property rights, some would suggest you can only own an NFT and not the asset it represents.

Security Tokens

Security Tokens are like a hybrid between NFTs and ordinary cryptocurrencies.

Like an NFT, Security Tokens represent an underlying asset. Like a cryptocurrency, Security Tokens of the same kind may be fungible with one another. For example: stocks could be tokenized, creating a Security Token which represents the underlying asset – the stock – and which is fungible within that set of assets.

Governance Tokens

Governance tokens aid collective decision-making and support ‘Decentralized Autonomous Organisations’ where token holders can vote on protocol changes A prominent example is MakerDAO, an open-source project on the Ethereum blockchain. MakerDAO users who hold its governance token, MKR, collectively make decisions about how the Maker Protocol operates and how their native currency, Dai, is valued and created.

Utility Tokens

Utility Tokens are used to pay for and/or access services on a specific blockchain.

FileCoin, for example, is used to access the FileCoin peer-to-peer cloud storage network.

Another example is Brave’s Basic Attention Token (BAT). BAT pays Brave users for turning off ad-blocking in their browsers, while touting a higher-quality marketing data for advertisers.

Sources: Documentation of FileCoin.io, MakerDao.com/en/whitepaper, and BasicAttentionToken.org. Commentary from Invesco. For illustrative purposes only as at 29 February 2024.

The many meanings of currency

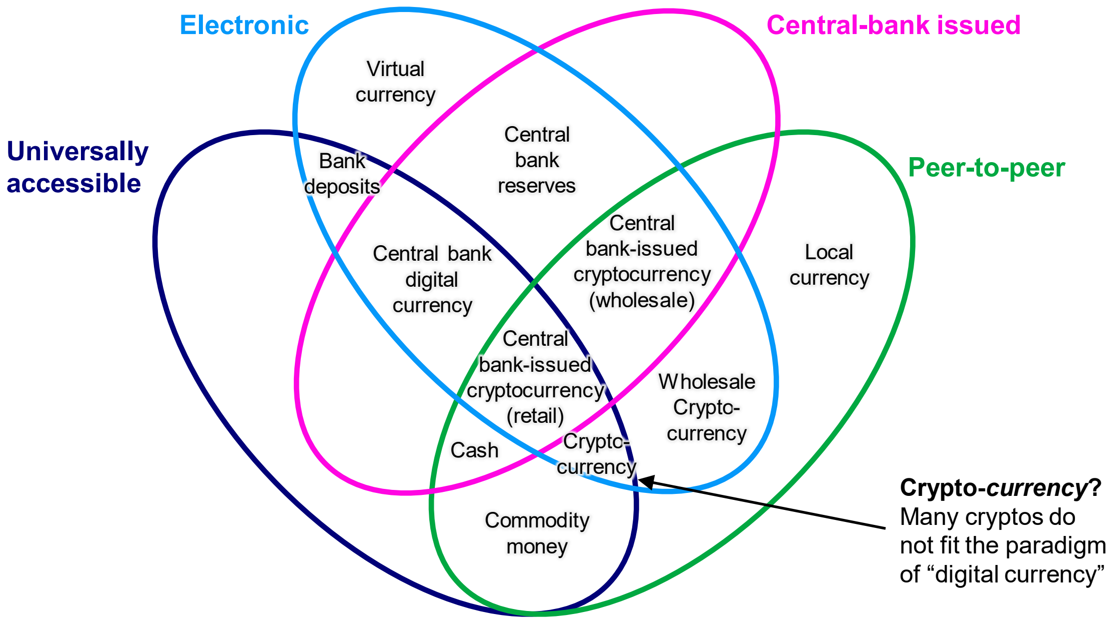
Are cryptocurrencies currency or just another kind of token?

While Bitcoin is ostensibly a "currency," it lacks key features to be valid as a currency in the traditional economic sense, as we explored earlier. But other forms of cryptocurrency may very well play this role, with better transaction throughput and greater supply. There is also talk about central bank digital currencies, which may or may not use blockchain technology.

Ultimately, "crypto*currency*" may be a misnomer as many cryptocurrencies were designed with intentions beyond a currency-like instrument.

Thinking about different cryptocurrencies (Bitcoin, Ethereum, etc.) like different fiat currencies (USD, EUR, GBP, etc.) is misleading. Instead, cryptocurrencies are united by the technology that underlies them, but each is seeking to accomplish a different objective. In this way, it may be helpful to think of each crypto like a software product rather than a currency. Keeping this in mind is helpful in considering other so-called cryptocurrencies.

"The Money Flower" – Categorizing kinds of money



Sources: Bank for International Settlements, Wikipedia. Adapted and reproduced from *Central bank cryptocurrencies* by Morten Linnemann Bech and Rodney Garratt as at 2017.

Agenda

Is bitcoin a diversifier? At first glance, maybe…

Crypto assets are often viewed as portfolio diversifiers

Bitcoin is often viewed as “digital gold” with enormous return potential and a safety from the tribulations of inflation—a point which we disputed in earlier pages. And for asset allocators, bitcoin is often initially viewed as a portfolio diversifier. Indeed, if one reviews the history of bitcoin performance on a monthly basis versus other asset classes, it does appear to offer uncorrelated returns.

That said, as Bitcoin and other cryptocurrencies have grown in popularity, their behavior has transformed into more of a traditional risk-on asset, as we explore in the next slide.

Monthly Asset Return Correlations, Since 2011

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Cash	1.00															
2	DXY	-0.08	1.00														
3	S&P 500	0.00	-0.43	1.00													
4	Int'l Stocks	0.02	-0.62	0.88	1.00												
5	EM Stocks	0.01	-0.64	0.71	0.82	1.00											
6	Global Gov Bonds	0.06	-0.77	0.40	0.50	0.55	1.00										
7	Tsy Bonds (7-10)	0.03	-0.14	-0.01	-0.01	0.02	0.62	1.00									
8	US IG	0.03	-0.39	0.50	0.53	0.53	0.75	0.69	1.00								
9	US HY	-0.01	-0.46	0.80	0.82	0.73	0.53	0.13	0.71	1.00							
10	Gold	0.09	-0.48	0.13	0.21	0.34	0.58	0.37	0.38	0.22	1.00						
11	TIPS	-0.03	-0.34	0.37	0.38	0.39	0.70	0.75	0.79	0.54	0.49	1.00					
12	Commodities	-0.07	-0.48	0.45	0.53	0.54	0.26	-0.21	0.14	0.52	0.36	0.20	1.00				
13	Oil	-0.09	-0.29	0.38	0.45	0.35	0.10	-0.28	0.10	0.49	0.06	0.04	0.64	1.00			
14	US REITs	-0.07	-0.34	0.75	0.70	0.59	0.49	0.28	0.66	0.72	0.21	0.57	0.34	0.22	1.00		
15	REITs ex. US	-0.05	-0.60	0.74	0.88	0.79	0.61	0.19	0.66	0.80	0.28	0.54	0.50	0.35	0.80	1.00	
16	Bitcoin	-0.09	-0.08	0.17	0.16	0.07	0.11	0.04	0.12	0.17	0.00	0.10	0.05	0.00	0.09	0.13	1.00

Sources: Bloomberg and Invesco, as of 29 February 2024. See page 43 for index definitions. **Past performance does not guarantee future results.**

Beware the correlations of bitcoin

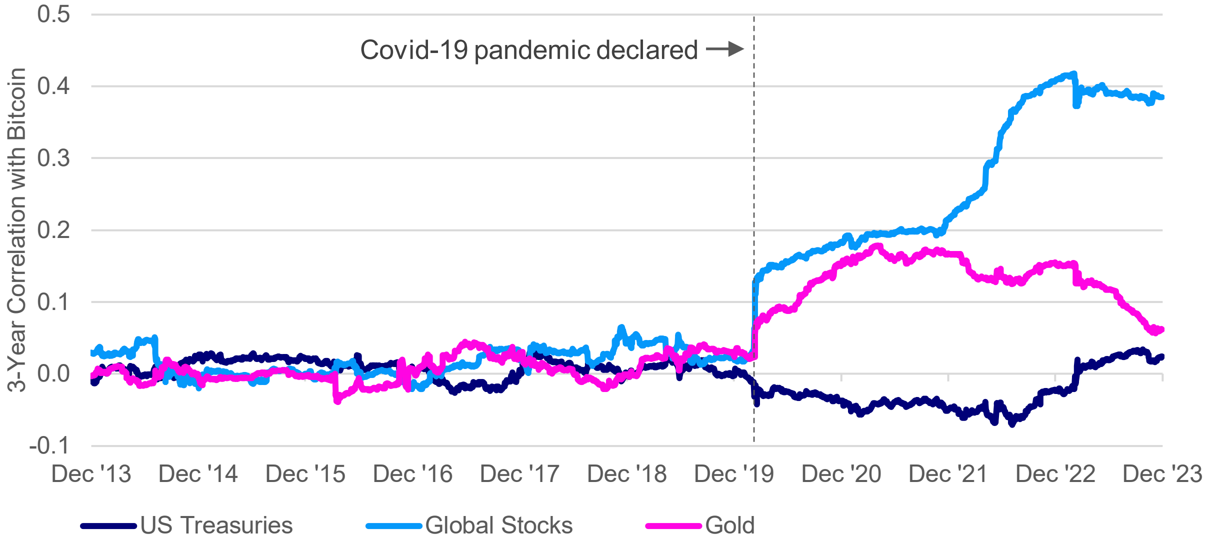
Drawing correlations since Bitcoin's inception can be misleading

Bitcoin bulls tend to praise the virtues of the asset's uncorrelated returns since its launch in 2009. However, over this timeframe Bitcoin had a market cap less than the net worth of many individuals. For example, in 2011 (when many correlation studies begin for Bitcoin), its market cap was just $1.4 million at the start of the year. In 2013, the market cap started the year at $142 million and reached as high as $11.9 billion, a level not reached again until the end of 2016.

As Bitcoin has grown, it has become more correlated with traditional asset classes. We caution against measuring correlations for Bitcoin and any young crypto. Indeed, with Bitcoin's inception in 2009 – and its market cap only becoming truly significant in 2017 – we have a limited amount of data with which to draw conclusions.

Since 2020, correlations with other assets have increased—arguably a result of the increasing role of traditional market factors in bitcoin prices.

Bitcoin correlations have increased since the pandemic (rolling 3-year correlations)



Note: US Treasuries = Bloomberg US Treasury Bond Index; Global Stocks = MSCI All-Country World Index; Gold = spot gold prices per Troy ounce.
Sources: Bloomberg and Invesco, as of 29 December 2023. **Past performance does not guarantee future results.**

Bitcoin: A store of value?

The volatility of bitcoin may understate the severity of drawdowns

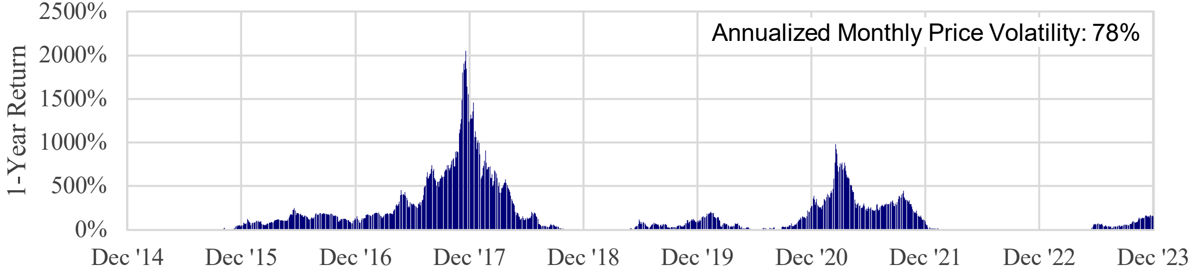
Is Bitcoin a viable store of value? To answer this question, we look to price volatility and, in this case, how frequently and at what magnitude it loses value.

Since 2014, US large capitalization equities have had an annualized monthly price volatility of 15.7%, while the same metric for bitcoin was 78.5%. Yet summary measures can fail to tell the whole story. As we explore in the charts on the right, bitcoin drawdowns have frequently wiped out a substantial portion of value, suggesting that bitcoin has frequently failed to be a reliable store of value.

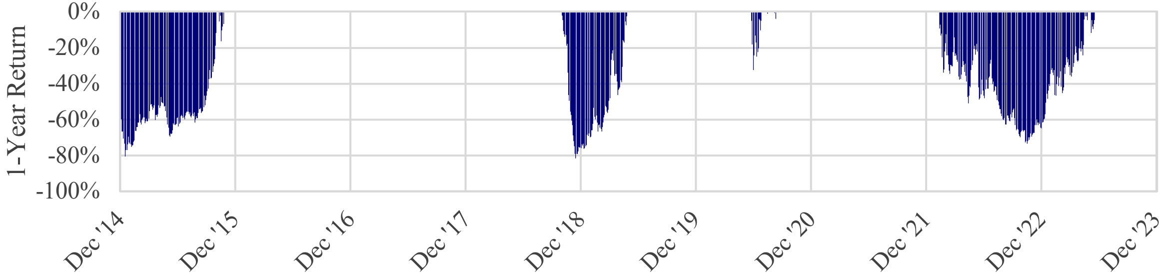
Since percentage changes are not symmetric—in other words, a 50% loss requires a 100% gain to fully offset it—we like to emphasize drawdowns separately from positive returns. In 2014 and 2018, 1-year drawdowns exceeded -80%; in 2022, bitcoin's 1-year returns fell below -72%.

In our view, these drawdowns mean that bitcoin is not for the faint of heart.

One-year bitcoin returns when returns are positive



One-year bitcoin returns when returns are negative



Sources: Bloomberg and Invesco, as of 31 December 2023. **Past performance is no guarantee of future results.** An investment cannot be made directly into an index. Based on *Bitcoin and Portfolio Choice: An Assessment of Bitcoin in Multi-Asset Portfolios*, Invesco Research working paper, February 2024.

The bitcoin portfolio perspective: rebalancing is essential

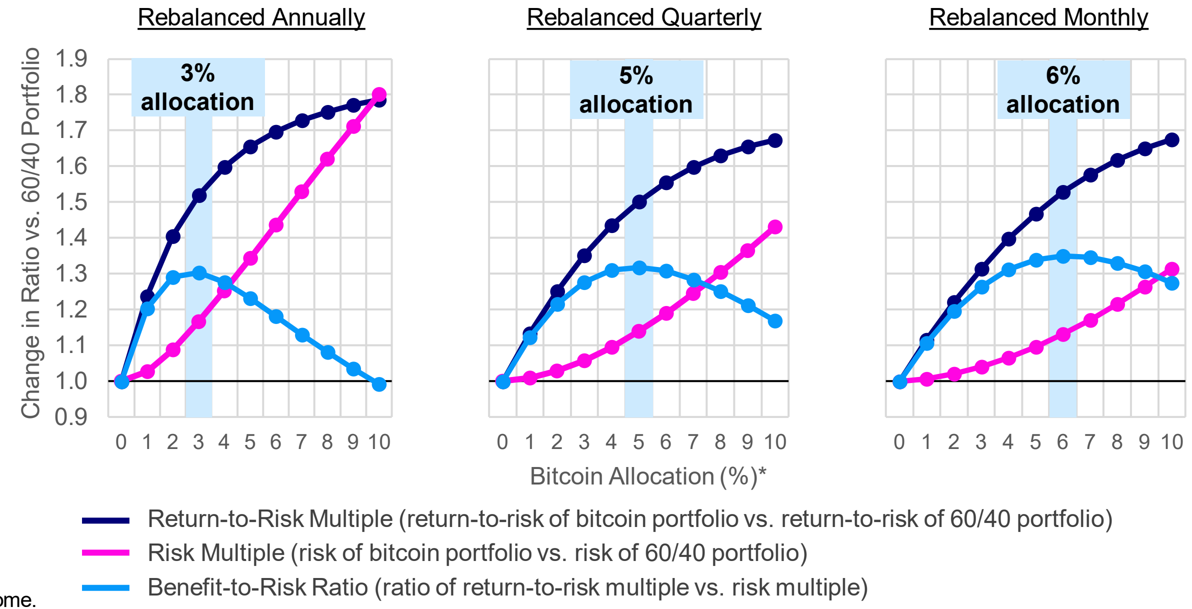
Bitcoin introduces volatility, but regular rebalancing can help mitigate risk

In reviewing Bitcoin in a portfolio context, we used historical data of a diversified portfolio of stocks (60%) and bonds (40%) and evaluated how incremental bitcoin allocations changed the return and risk characteristics of the portfolio.

An important result emerges. Modest bitcoin allocations (1 to 3%) tend to improve return-to-risk outcomes, but they also increase risk. Managing this risk is critical and regular rebalancing can meaningfully contribute to risk management.

In the data on the right, we find different rebalancing frequencies result in substantially different risk outcomes. To assess the benefits of bitcoin allocations, we consider the return-to-risk (as the benefit) and the risk of portfolios with bitcoin in terms of multiples of the same metrics for the initial 60/40 allocation (e.g., a risk multiple of 1.2 indicates an increase in risk of 20%). The benefit-to-risk metric allows us to assess increases in benefits against increases in risk. Maxima are highlighted in light blue.

Comparing historical 60% equity/40% fixed income portfolios with incremental bitcoin allocations



* Allocation is funded proportionally from equity and fixed income.

"Stocks" are represented by the MSCI All Country World Index, "Bonds" are represented by the Bloomberg Universal Bond Index, and Bitcoin is represented by the Bloomberg Galaxy Bitcoin Index. Returns displayed are total returns. No transaction fees are considered. Risk is measured as the standard deviation of returns. Returns and risk are measured from historical data. Sources: Bloomberg and Invesco, as of 31 December 2023. For illustrative purposes only. **Past performance is no guarantee of future results.** An investment cannot be made directly into an index. Based on *Bitcoin and Portfolio Choice: An Assessment of Bitcoin in Multi-Asset Portfolios*, Invesco Research working paper, February 2024.

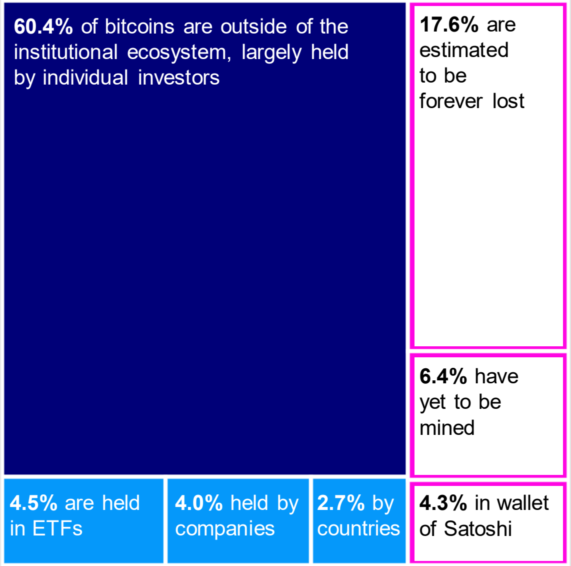
Bitcoin – The bull case
The idea: Adoption grows, and narrow supply helps bitcoin prices soar

Our bull case for bitcoin supposes increasing adoption of the cryptocurrency. By design, bitcoin has a limited supply, it is straightforward to draw sky-high price targets after assuming a level of demand. Some comparisons, for example, assume Bitcoin's market capitalization reaches that of gold, from which we can back out the per-coin price target.

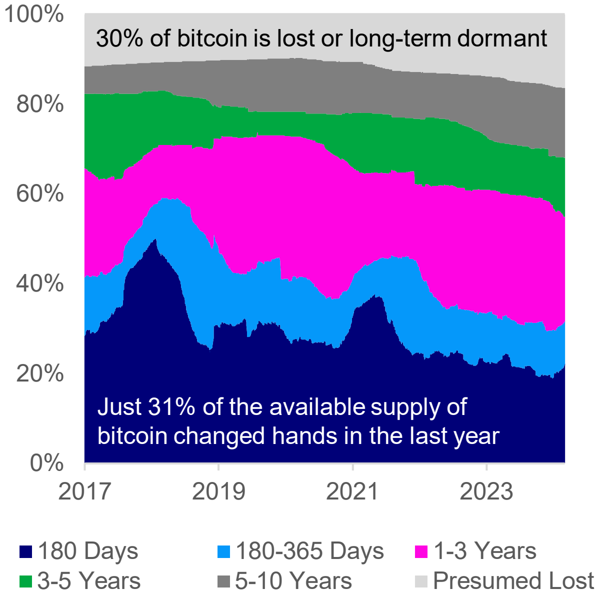
Helping bitcoin prices is the fact that so much of bitcoin has been forever lost or is inaccessible. Of the 21 million bitcoins that can possibly be mined, it is estimated that 17.6% are lost forever and 4.3% are locked in Satoshi's wallet. Moreover, just 31% of bitcoin supply has been actively traded in the last year, which since 2017 has shrunken by about 4 percentage points per year.

Assuming sustained buying momentum and a gradually increasing number of long-term holders, bitcoin prices may climb higher yet.

21,000,000 million bitcoins—by ownership



Bitcoin supply that has been traded in the last…



Note: "Available supply" is interpreted as 19.64 million bitcoins—the total number of all bitcoins ever mined, including lost bitcoins. "Presumed Lost" is comprised of bitcoins that have either never been traded after being minted or bitcoins that have not been traded for more than 10 years. "Wallet of Satoshi" refers to the original set of wallets created by Satoshi Nakamoto, the pseudonymous author(s) of bitcoin, which never traded after the first few months of bitcoin's original creation. Sources: Bloomberg, BitcoinTreasuries.org, and public filings. As of 29 February 2024. For illustrative purposes only.

Bitcoin – The bear case

The idea: Regulators remain hostile to bitcoin—and long-term outlook is uncertain

No discussion of cryptocurrency is complete without reviewing the regulatory outlook. "[Bitcoin] is not a stable store of value and it doesn't constitute legal tender," said Janet Yellen in the US. The UK's Financial Conduct Authority previously warned investors "should be prepared to lose all their money". In the EU, the European Securities and Markets Authority noted some cryptos are "highly risky and speculative." China has effectively banned cryptocurrencies. Clearly regulators are reluctant to encourage use of crypto assets, especially in light of regular crypto market booms and busts.

Bitcoin bears focus on these regulatory concerns as well as other factors including but not limited to:

- Rising correlations with traditional assets.
- Uncertain long-term outlook.
- Energy intensity of bitcoin.

The regulatory landscape across a selection of economies

United States ✓

- Aggressive SEC stance has been counterbalanced by court rulings with often favorable outcomes for crypto
- Crypto exchanges are permitted
- AML reporting applies to high value transactions & mining

Eurozone ✓

- Markets in Crypto Assets (MiCA) legislation provides EU-wide formalized structure
- EU law imposes AML & counter-terrorist financing rules across borders crypto transactions
- Bitcoin exempt from VAT

Global Outlook

- **29** have banned or restricted crypto-currencies.
- **100+** currently permit cryptocurrencies with specific guidance for their treatment.

United Kingdom ✓

- Mining revenues are taxed as income; capital gains also taxed when cryptos sold/ exchanged
- Crypto derivatives and exchange-traded notes (ETNs) are banned for retail investors
- Some UK-based banks restrict cryptocurrency purchases as a matter of policy.

China ✗

- Trading on exchanges banned
- Initial coin offerings (ICOs) are banned
- Mining is banned

Sources: United States Internal Revenue Service, United Kingdom Financial Conduct Authority and Her Majesty's Revenue and Customs, European Parliamentary Research Service, and various government agencies; Reuters, *'JPMorgan's UK bank Chase to ban crypto transactions'* 26 September 2023. The above is for illustrative purposes only and does not constitute legal or tax advice and is by no means a full summary of the existing regulatory structure. The cryptocurrency regulatory environment is subject to rapid change. Please see the glossary in the Appendix for definitions of terms. Data as of 29 February 2024 unless otherwise specified.

Accessing exposure to digital assets

Degree of exposure varies with different entry points

Exposure to cryptocurrencies and the ecosystem being developed around them may be an attractive opportunity. The range of exposure methods—from direct ownership of particular cryptocurrencies to broader market approaches—involves varying considerations and trade-offs.

Physical ownership typically provides the most direct exposure to movements in crypto prices at the expense of greater concentration and volatility. In more thinly-traded cryptocurrencies, fears of theft, proper custodianship and liquidity tend to dominate physical ownership considerations.

Derivative products traded on financial markets whose underlying are based on cryptocurrencies tend to fall under existing regulatory frameworks, yet their return structure (especially roll yield) adds a layer of complexity to accessing crypto market exposure.

Finally, the broadest exposure approach is in accessing cash flows resulting from the crypto ecosystem. This is a vast area but one that is perhaps more diversified. The so-called “picks and shovels” approach falls under this bucket as well.

Overview of exposure to digital assets

Broad Exposure ⟷ Targeted Exposure

Ecosystem Exposure	Derivative Ownership	Physical Ownership
Access to growth of the overall digital assets ecosystem (e.g., Blockchain technology, cryptocurrency) by investing in companies that engage in mining, enabling technology, and exchanges, among others	Access to cryptocurrencies via derivative instruments (e.g., exchange-traded futures, OTC swaps)	Direct ownership of crypto-currencies, typically through a major crypto exchange or via exchange-traded products or trusts

Source: Invesco. For illustrative purposes only. The risk and return considerations here capture only a selection of factors and do not constitute investment advice.

Food for thought: Blockchain may be a longer play

Distributed ledgers are the basis of more than just digital currencies

Blockchain is a decentralized authority of data, capable of exchanging and passing along data in a secure fashion and only with the permission of the data's owner (as identified by a private key). Use cases of this are not limited to cryptocurrencies.

If we also include smart contracts in this picture, we can see a variety of applications of this database technology which could be disruptive. We view this as an exciting space, as we briefly explore on the right.

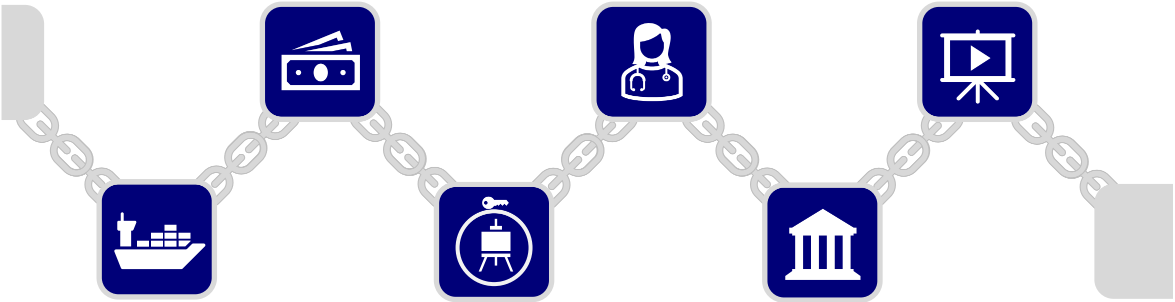
While blockchain technology suffers some limitations as we have discussed, there are nevertheless a growing number of businesses that are building products using distributed ledger technology. If you are skeptical of the ups-and-downs of cryptocurrencies, it is still worthwhile to consider the applications of blockchain technology and the ways in which it may disrupt industries and current methods of doing business.

Examples of blockchain use cases

Investments
Asset ownership, "atomic settlement", insurance

Healthcare
Health records, insurance coverage verification

Media
Royalties, advertising, content licensing



Logistics
Supply chain tracking, parcel tracking across carriers

Collectibles
Digital trading cards, art, gaming collectibles

Government
Voting, border control, title records, intellectual property

Source: Invesco. For illustrative purposes only.

Appendix

Glossary: Common terms in the cryptocurrency world

Cryptocurrency	A non-traditional, digital medium of exchange that uses cryptography to validate and secure transactions, typically through a blockchain. Importantly, some cryptocurrencies vary on this definition.
Bitcoin	The first and most popular cryptocurrency that is a reward for participating in the Bitcoin blockchain network.
Altcoin	Any cryptocurrency other than Bitcoin.
Token	A token is a crypto asset whose underlying value is based on another asset (e.g. gold or a title). This is different from a coin in that a coin's value is not directly related to the value of an underlying asset. Unfortunately, "token" and "coin" are often used interchangeably, perhaps improperly.
Stablecoin	A stablecoin is a cryptocurrency in which its market value is intended to be pegged to another asset, such as US dollars.
Blockchain	A digital ledger maintained by computers worldwide in a decentralized manner, where each "block" is a packet of data.
Mining	Users can participate in a blockchain network by verifying transactions and, in exchange, are rewarded with a particular cryptocurrency in a specified amount.
Wallet	Wallets are where Bitcoin and other cryptocurrencies are, in essence, held for use. Note that *wallets* facilitate holding cryptocurrencies, whereas an *address* is specific to each blockchain and is used in transactions, serving as an identity.
Exchanges	Where cryptocurrencies can be transacted with other people or currencies for a fee. • Decentralized Exchange – Users are matched with buyers/sellers algorithmically. Such exchanges tend to be less liquid compared to centralized exchanges but are generally more secure and involve lower fees. • Centralized Exchange – Users create an account with an exchange which typically holds their cryptoassets. These are considered more liquid and regulated, but less secure as the exchange acts as your custodian and can be hacked.

Source: Invesco.

Glossary: Common terms in the cryptocurrency world

1 "Satoshi"	A unit of measurement equal to one hundred millionth of a single bitcoin (0.00000001 BTC), often abbreviated as SATS.
Initial Coin Offering	An Initial Coin Offering (or ICO) is like an IPO but with digital coins. At the time that they became popular, they required no formal filings but served a similar purpose to equity securities. Today, they are almost non-existent.
Hash	The hash rate is the measuring unit of the processing power of a blockchain network operating with a Proof-of-Work consensus mechanism. It is essentially the number of guesses made per second in attempting to solve a cryptographic puzzle that is part of the mining process in Proof-of-Work cryptocurrencies.
Proof-of-Work (PoW)	A consensus mechanism that powers blockchains without a central party. Miners solve increasingly complex cryptographic problems and are rewarded with an amount of cryptocurrency for finding the correct solution. This process acts as a verification of the blockchain's integrity. To compensate for the costs involved in this computation, miners sell their earned cryptocurrency. The PoW model is notorious for being massively energy intensive and is most often associated with Bitcoin.
Proof-of-Stake (PoS)	An alternative to PoW, PoS requires that participating miners hold an amount of the cryptocurrency—their "stake"—in order to qualify for the ability to verify blockchain transactions. PoS is significantly less energy intensive than PoW.
Consensus mechanism	A consensus mechanism is required for every implementation of distributed ledger technology. It is the process by which state changes of the ledger are verified and validated by involved parties.

Source: Invesco.

Glossary: Common terms in the cryptocurrency world

Web 1.0	The first iteration of the Internet. In this era, web applications were simply read-only displays of information, such as a business webpage. Generally, users could not interact with such websites beyond searching for and reading information.
Web 2.0	The second generation of web experiences, commonly referred to as Web 2, was a revolution in the way in which users could interact with a website and web servers. In this case, users could participate and generate content, such as is the case with social media platforms, blogs, wiki pages, and more. It is commonly criticized for the centralization of data structures, where companies with large repositories of data could benefit by keeping such data for its own use and sale.
Web 3.0	Definitions of Web 3 are often nebulous and variable. However, the commonality across definitions and uses of the phrase is an idea of disintermediation of data structures, where decentralization is key. Cryptocurrencies are one expression of this, where no central party or actor governs the use and distribution of data.
Decentralized Finance (DeFi)	As with Web 3, definitions may vary. The general idea of DeFi is to change financial markets and products operated by transparent crypto-based protocols rather than by financial institutions.

Source: Invesco.

Index Definitions

Cash is represented by the Bloomberg 1-3 Month U.S. T Bill Index, which is designed to track the market for US Treasury bills with 1 to 3 months to maturity.

DXY is an index designed to capture the general international value of the US dollar by averaging exchange rates between the USD and major world currencies.

The S&P 500 Index is a market capitalization weighted index of the 500 largest domestic U.S. stocks.

Int'l (International) Stocks is represented by the MSCI World exluding US Index, which is designed to measure large and mid market capitalization stocks in developed markets, excluding the United States.

EM (Emerging Market) Stocks is represented by the MSCI Emerging Markets Index, which is designed to measure large and mid market capitalization stocks in emerging markets.

Global Gov Bonds is represented by the FTSE World Government Bond Index (ex-USD) index, which is designed to measure the performance of international developed bonds excluding US dollar denominated bonds.

Tsy (Treasury) Bonds (7-10) is represented by the Bloomberg US Treasury: 7-10 Year Index, which is designed to measure the US dollar-denominated, fixed-rate, nominal debt issued by the US Treasury with 7-10 years to maturity.

US IG (Investment Grade) is represented by the Bloomberg US Aggregate Bond Index, which is designed to measure the performance of investment grade bonds in the United States.

US HY (High Yield) is represented by the Bloomberg US High Yield Bond Index, which is designed to measure the performance of US corporate high yield bonds.

Gold is measured by the gold spot price quoted as US Dollars per Troy Ounce.

TIPS is represented by the Bloomberg US Treasury Inflation Notes Index, which is designed to measure the performance of the US Treasury Inflation Protected Securities (TIPS) market, excluding Federal Reserve holdings.

Commodities are represented by the Bloomberg Commodity Index, which uses futures contracts to reflect the returns on a basket of diversified commodities investments.

Oil is represented by the West Texas Intermediate spot price in US dollar terms.

US REITs (Real Estate Investment Trusts) are represented by the FTSE NAREIT All Equity REITS Total Return Index, which seeks to measure all tax qualified REITs listed in the NYSE, AMEX, and NASDAQ National Market.

REITs ex. US are measured by the FTSE EPRA/NAREIT Developed ex US Index, which is a market capitalization weighted index designed to measure the performance of real estate investment trusts in developed markets, excluding the United States.

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